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A THREE-MONTH PROSPECTIVE STUDY OF RISK FACTORS FOR STRESS FRACTURES SUSTAINED BY SOLDIERS DURING BASIC TRAINING

by

PAOLA SILVIA WOOD

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DEDICATION

To my husband, Alec, and our children, Fabio and Alexia, who inspire and enrich my life.

"May the Lord continually bless you with heaven's blessings."

- Psalms 128:5

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"Thy word is a lamp unto my feet, and a light unto my path."

- Psalms 119:105

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SYNOPSIS

TITLE	**A three-month prospective study of risk factors for stress fractures sustained by soldiers during Basic Training**
CANDIDATE	**Paola Silvia Wood**
PROMOTER	**Prof. P.E. Krüger**
DEGREE	**PhD (HMS)(Biokinetics)**

Stress fractures represent one of the most common and serious overuse injuries in the military environment.

The aim of this prospective study was to determine the incidence of stress fractures during 12 weeks of Basic Training (BT) by comparing the results of the intrinsic risk indicators obtained from a group of participants who suffered stress fractures, with the rest of the original group (controls) who did not suffer from any stress fractures, and to assess any changes in physical markers whilst following a progressive, scientifically designed, Physical Training (PT) Programme during the BT. The intrinsic risk factors investigated included sex, age, race (measured via questionnaire), foot morphology (wet test), Q angle, leg length discrepancy, bone density (dual-energy X-ray absorptiometry(DEXA), physical fitness (standardized military fitness test, isokinetic upper and lower leg strength, handgrip strength), flexibility (ankle plantarflexion and dorsiflexion, hip internal and external rotation), anthropometry (skinfold method and DEXA), female menstrual disturbances and lifestyle behaviours including smoking, female contraception use and medical history of previous injury (questionnaire). The cohort (n=183), also refered to as the Experimental Group (EG), was measured at the beginning and at the end of the BT period. The standardized physical fitness test was also completed in the fifth week of training. The latter's results

were compared to the results obtained by a Control Group (CG), who had undergone BT the year prior to this cohort.

The size of the cohort, the intrinsic risk factor profile and the control of certain extrinsic risk factors may have contributed to zero incidences of stress fractures found. Within the intrinsic risk factor profile, sex, age, race, foot morphology, Q angle, hip external rotation and bone density were normal whilst the measured leg discrepancy and limited ankle dorsiflexion appeared to not have a sufficient risk for stress fracture development. The small sample of the cohort that reported having menstrual irregularities, smoked and had a history of previous fractures, did not place this cohort at risk for stress fracture development. The cohort did, however have lower isotonic, isokinetic and isometric strengths than the other cohorts who reported a relatively high stress fracture incidence.

The BT period found statistically significant changes in bone density, flexibility, body composition, muscle strength and endurance. Female participants showed an increase in the T- and Z-scores of the left femur area, a deterioration in left ankle dorsiflexion and hip external rotation, whilst their plantarflexion increased. Their mesomorph component increased, and decreases in % body fat (BF) as well as in the ectomorph and endomorph component were also found. Male participants' plantarflexion and hip external rotation decreased whilst their dorsiflexion increased. Lean body mass and mesomorph component increased whilst %BF, ectomorph and endomorph component decreased.

The new cyclic-progressive PT programme controlled for risk of injury by allowing sufficient periods of recovery, by gradually increasing the duration, frequency, and intensity of training, by reducing repetitive weight-bearing activities and by including a variation of exercises. Running shoes, rather than combat boots, were also worn during PT. Marching on concrete was eliminated. Significant improvements were shown by both male and female participants in aerobic fitness and muscular endurance and muscular strength.

Future research should include a larger size cohort, who developed stress fractures utilising BT groups from different corps and units in the South African Military environment. Other potential extrinsic risk factors, such as surface and equipment, should also be investigated.

Key words: stress fractures, intrinsic risk factors, extrinsic risk factors, Basic Training, sex, age, race, foot morphology, Q angle, leg length discrepancy, bone density (DEXA), physical fitness, isokinetic upper and lower leg strength, handgrip strength, ankle plantarflexion and dorsiflexion, hip internal and external rotation, body composition, Physical Training programme, South African Military environment.

SAMEVATTING

TITEL	**Risikofaktore vir spanningsfrakture opgedoen deur soldate gedurende drie maande van Basiese Opleiding**
KANDIDAAT	**Paola Silvia Wood**
PROMOTER	**Prof. P.E. Krüger**
GRAAD	**PhD (HMS)(Biokinetika)**

Spanningsfrakture verteenwoordig een van die algemeenste en ernstigste beserings weens oorgebruik in die militêre omgewing.

Die doel van hierdie voornemende studie was om die voorkoms van spanningsfrakture gedurende die twaalf weke van Basiese Opleiding (BO) te bepaal: om die resultate van die intrinsieke risiko-aanwysers, verkry van die groep deelnemers wat spanningsfrakture opgedoen het, te vergelyk met die res van die oorspronklike groep (kontrole) wat geen spanningsfrakture opgedoen het nie, en om enige veranderings in fisiese merkers te assesseer terwyl 'n progressiewe, wetenskaplik ontwerpte Fisieke Opleidingsprogram (FO) gedurende die BO gevolg is. Die intrinsieke risikofaktore wat ondersoek is, het geslag, ouderdom, etnisiteit (bepaal deur middel van 'n vraelys), voetmorfologie (nat toets), Q-hoek, afwykingsverskil in beenlengte, beendigtheid (DEXA), fisieke fiksheid (gestandaardiseerde militêre fiksheidstoets, isokinetiese bo- en onderbeenkrag, handgreepkrag), fleksiteit (enkelplantaarfleksie en -dorsifleksie, heup interne en eksterne rotasie), antropometrie (velvoumetode en DEXA), menstruele versteurings en leefstyl insluitend rook, kontrasepsie en mediese geskiedenis van vorige beserings (vraelys) ingesluit. Die kohort (n=183), ook aangedui as die Experimentiele Groep (EG), is gemeet aan die begin en aan die

einde van die BO-periode. Die gestandaardiseerde fiksheidstoets is ook in die vyfde opleidingsweek voltooi. Die resultate van laasgenoemde is vergelyk met die resultate verkry deur ’n Kontrolegroep (KG), wat die jaar voor hierdie kohort BO ondergaan het.

Die grootte van die kohort, die intrinsieke risikofaktorprofiel en die kontrolering van sekere ekstrinsieke risikofaktore kon bygedra het tot die nulvoorkomste van spanningsfrakture wat gevind is. Binne die intrinsieke risikofaktorprofiel was geslag, ouderdom, voetmorfologie, Q-hoek, heup eksterne rotasie en beendigtheid normaal, terwyl die gemete beenafwykingsverskil en beperkte enkeldorsifleksie skynbaar nie voldoende risiko vir spanningsfraktuurontwikkeling ingehou het nie. Die klein steekproef wat menstruele ongereeldheid gerapporteer het en wat gerook en ’n geskiedenis van vorige frakture gehad het, het nie die kohort ’n risiko laat loop vir spanningsfraktuurontwikkeling nie. Die kohort het wel laer isotoniese, isokinetiese en isometriese krag gehad as die ander kohort wat ’n relatief hoë spanningsfraktuurvoorkoms gerapporteer het.

In die BO-tydperk is statisties beduidende veranderings in beendigtheid, lenigheid, liggaamsamestelling, spierkrag en uithouvermoë gevind. Die vroulike deelneemers het ’n toename in die T- en Z-telling van die linkerfemurarea getoon, ’n agteruitgang in linkerenkeldorsifleksie en heup eksterne rotasie, terwyl hul plantaarfleksie toegeneem het. Hul mesomorfkomponent het toegeneem en ’n afname is in hul % liggaamsvet (LV), asook in die ektomorf- en endomorfkompent gevind. Die manlike subjekte se plantaarfleksie en heup eksterne rotasie het afgeneem, terwyl hul dorsifleksie verbeter het. Hul vetvrye liggaamsmassa en mesomorfkomponent het toegeneem, terwyl hul %LV, ektomorf- en endomorfkomponent verminder het.

Die nuwe siklies-progressiewe FO-program het gekontroleer vir beseringsrisiko deur voldoende tydperke toe te laat vir herstel, deur geleidelik die duur, frekwensie en intensiteit van opleiding te vermeerder, deur herhalende gewigdraende aktiwiteite te verminder en deur ’n verskeidenheid van oefeninge in te sluit. Hardloopskoene, eerder as gevegstewels, is ook gedurende FO gebruik, terwyl marsjeer op beton uitgeskakel is. Betekenisvolle verbeterings is deur sowel die manlike as vroulike subjekte in aërobiese fiksheid en spieruithouvermoë en -krag getoon.

Toekomstige navorsing behoort ’n groter kohort in te sluit wat stresfrakture opgedoen het, en die gebruik van BO-groepe van verskillende korpse en eenhede in die Suid-Afrikaanse Militêre omgewing. Ander potensiële risikofaktore, soos oefen oppervlakte en toerusting, behoort ook ondersoek te word.

Sleutelwoorde: stresfrakture, intrinsieke risikofaktore, ekstrinsieke risikofaktore, Basiese Opleiding, geslag, ouderdom, etnisiteit, voetmorfologie, Q-hoek, beenlengte-afwykingsverskil, beendigtheid (DEXA), fisieke fiksheid, isokinetiese bo- en onderbeenkrag, handgreepkrag, enkelplantaarfleksie en -dorsifleksie, heup interne en eksterne rotasie, liggaamsamestelling, Fisieke Opleidingsprogram, Suid-Afrikaanse Militêre omgewing.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Since 1885, when Breithaupt (Jones *et al.*, 1989) first described the painful swollen feet associated with marching in Prussian soldiers, stress fractures have been considered a hazard of military life. Stress fractures represent one of the most common and potentially serious overuse injuries (McBryde, 1985; Hulkko & Orava, 1987; Matheson *et al.*, 1987; Jones *et al.,* 1989; Sterling *et al.*, 1992, Beck *et al.,* 2000; Jones *et al.,* 2002; Shaffer *et al.,* 2006; Trone *et al.,* 2007). In order to prevent injury within the military environment, such as the high incidence of stress fractures sustained by military trainees during BT, the causative factors and the mechanisms by which they interact must be clearly understood. It is only through this understanding that clear guidelines for prevention can be established and followed.

A stress fracture is a partial or complete fracture of a bone resulting from its inability to withstand stress applied in a rhythmic, repeated, subthreshold manner (McBryde, 1985; Bennell *et al.*, 1999). It is a common injury in athletes, dancers and military recruits (Beck *et al.*, 2000; Välimäki *et al.*, 2005). Bone adapts to mechanical loads by the remodeling process in which the lamellar bone is reasorbed by osteoclasts, creating resorption cavities, which are subsequently replaced with more dense osteoblasts. However, since there is a lag between the increased osteoclastic activity and osteoblastic activity, bone is weakened during this time, increasing the risk of microdamage (Roub *et al.*, 1979; Li *et al.*, 1985).

If microdamage accumulates, repetitive loading continues, and remodeling cannot maintain the integrity of the bone, a stress fracture may result (Burr *et al.*, 1985; Schaffler *et al.*, 1989; Schaffler *et al.*, 1990). This develops if the microdamage is too extensive to be repaired by normal remodeling or if depressed remodeling cannot repair normally (Schaffler *et al.,* 1989). On the other hand, there is both in-vitro and in-vivo evidence that metatarsal stress fractures can occur secondary to pure cyclic overloading, without the bone remodeling response (Sharkey *et al.*, 1995; Milgrom *et al.*, 2002).

Understanding the pathophysiology underlying the development of stress fractures is only the first step in its prevention. Despite the general knowledge that stress fractures are one of the leading causes of lost training time, medical expenses, attrition, and decreased readiness in military recruits training and combat readiness, clarity regarding the risk factors for stress fractures has yet to be obtained (Shaffer *et al.*, 2006). To prevent stress fractures, modifiable causes and risk factors must be identified.

Risk factors for exercise and sports-related injuries, including stress fractures, are commonly categorized as intrinsic or extrinsic. Intrinsic factors are characteristics of the individual, sports participant or military recruit, including demographic characteristics, anatomic factors, bone characteristics, physical fitness, and health risk behaviors. Extrinsic risk factors are factors in the environment or external to the individual participant that influence the likelihood of being injured, such as equipment used, PT undertaken and environment or surface on which training occurs (Jones *et al.*, 2002). What makes the clarity regarding risk factors for stress fractures so difficult to obtain is that stress fractures are often a result of various extrinsic and intrinsic factors at a given point in time and not necessarily only intrinsic or extrinsic in nature.

Since the first few citations of case studies with soldiers incurring stress fractures in the nineteenth and early twentieth centuries, potential intrinsic and extrinsic risk factors for stress fractures have been researched (Bernstein *et al.*, 1946; Belkin, 1980; McBryde, 1985; Markey, 1987; Jones *et al.*, 1989; Sterling *et al.*, 1992; Beck *et al.,* 2000; Jones *et al.,* 2002; Shaffer *et al.,* 2006; Trone *et al.,* 2007).

1.2 INTRINSIC RISK FACTORS

1.2.1 Demographic characteristics

These encompass:

- **Sex** - Female sex has been the most commonly identified intrinsic demographic risk factor for stress fractures (Proztman & Griffis, 1977; Reinker & Ozbourne, 1979; Kowal, 1980; Brudvig *et al.*, 1983; Lloyd *et al.*, 1986; Barrow & Saha, 1988; Zahger *et al.*, 1988; Brunet *et al.*, 1990; Myburgh *et al.*, 1990; Friedl *et al.*, 1992; Jones *et al.*, 1993a; Goldberg & Pecora, 1994; Bennell *et al.*, 1996; Bijur *et al.*, 1997; MacLeod *et al.*, 1999; Beck *et al.,* 2000; Bell *et al.,* 2000; Shaffer *et al.*, 2006).
- **Age** - Several studies have examined the association of older age with the risk of stress fractures and have indicated that older age may heighten the risk of stress fractures (Brudvig *et al.*, 1983; Gardner *et al.*, 1988; Shaffer *et al.*, 1999b).
- **Race** - Although race as a risk factor requires further study, it appears as if Caucasians may have a higher risk factor in both athletes as well in military personnel (Brudvig *et al.*, 1983; Barrow & Saha, 1988; Gardner *et al.*, 1988; Friedl *et al.*, 1992; Shaffer *et al.*, 1999b; Shaffer *et al.*, 2006).

1.2.2. Anatomic factors

- **Foot morphology** - Limited available research suggests that foot arch height may influence the risk of incurring stress fractures associated with vigorous PT (Giladi *et al.*, 1985; Montgomery *et al.*, 1989; Kaufman *et al.*, 1999).

- **Q angle** - Contradictory results exist with regard to the Q angle. Some studies have found no relationship between Q angle and stress fracture occurrence, whilst others have found that individuals with a Q angle greater than 15º have a relative risk of stress fracture development that is 5.4 times that of individuals who have an angle less than 15º (Montgomery *et al.*, 1989; Cowan *et al.*, 1996).
- **Leg length discrepancy** - Most studies indicate that the risk for stress fracture development increases if a leg length discrepancy of more than 0.5 centimeters exists (Brunet *et al.*, 1990; Cowan *et al.*, 1996).

1.2.3 Bone characteristics

- **Geometry** - Limited costly studies have shown a trend that smaller bone widths, smaller cross-sectional areas, smaller moments of inertia and a smaller modulus have a higher risk for stress fracture occurrence (Margulies *et al.*, 1986; Milgrom *et al.*, 1988; Milgrom *et al.*, 1989; Pouilles *et al.*, 1989; Beck *et al.*, 1996; Beck *et al.*, 2000; Esterman & Pilotto, 2005).
- **Bone density** - The relationship between bone density and stress fracture development has not clearly been defined. However, evidence exists that the risk factor of low bone density may be more common in women (Margulies *et al.*, 1986; Carbon *et al.*, 1990; Giladi *et al.*, 1991).

1.2.4 Physical fitness

- **Aerobic physical fitness** – Is defined as the body's ability to utilize oxygen efficiently, over an extended period of time in any activity that uses large muscle groups and is rhythmic in nature (American College of Sports Medicine, 2006). Military studies have shown significant associations between low aerobic fitness and a higher risk of stress fracture during BT (Jones *et al.*, 1993a; Shaffer *et al.*, 1999a) muscle strength and muscle endurance (Kaufman *et al.*, 1999; Beck *et al.*, 2000).

- **Flexibility** – Defined as "*…the ability to move a joint through its complete range of motion"* (American College of Sports Medicine, 2006:85). From the numerous flexibility variables that have been assessed to determine the association between flexibility and stress fractures, only range of hip external rotation and range of ankle dorsiflexion have been associated with stress fracture development (Giladi *et al.*, 1987; Montgomery *et al.*, 1989; Giladi *et al.*, 1991; Kaufman *et al.*, 1999).
- **Body composition and stature** – Can be expressed as *"…the relative percentage of body mass that is fat and fat-free tissue"* (American College of Sports Medicine, 2006:57) whilst stature refers to the Height, defined as the distance between the soles of the feet and the vertex, was taken whilst the participant stood up straight, barefoot, with heels, gluteus maximus, upper-back and back of head against the anthropometer (Smit, 1979; Eston & Reilly, 2001). No consistent relationship has been observed between body size and composition and stress fracture risk. However, a bimodal trend, with both the least 'fat' and the most 'fat' individuals, are at greater risk of incurring stress fractures (Finestone *et al.*, 1991; Giladi *et al.*, 1991; Friedl *et al.*, 1992; Beck *et al.*, 1996).

1.2.5 Health risk behaviours

- **Lifestyle behaviours** - Data from military studies indicate that persons who engage in more physical activity, particularly running, will experience fewer stress fractures than their sedentary counterparts (Gardner *et al.*, 1988; Swissa *et al.*, 1989; Taimela *et al.*, 1990; Cowan *et al.*, 1996; Shaffer *et al.*, 1999a).

- **Smoking** - Several studies have found a statistically significant association between cigarette smoking and an overall risk of training-related injuries (Friedl *et al.*, 1992; Altarac *et al.*, 2000; Moroz *et al.*, 2006).
- **Female contraception** – To date, poorly designed studies indicate that the use of oral female contraception may reduce the incidence of stress fracture development (Lloyd *et al.*, 1986; Barrow & Saha, 1988; Myburgh *et al.*, 1990).
- **Medical history of previous injury** - Some authors have reported that an individual with a medical history of stress fractures has a relatively greater risk of developing stress fractures. However, it has been speculated that the association between past injuries with current risk is not simple and may be confounded by other factors such as adequacy to recover and levels of past physical activity (Kuusela, 1984; Milgrom *et al.*, 1985; Giladi *et al.*, 1986; Shaffer *et al.*, 1999a).

1.3 EXTRINSIC RISK FACTORS

1.3.1 Type of physical activity

Military studies indicate that different units and different types of training may place military personnel at different degrees of risk (Kuusela, 1984; Goldberg & Pecora, 1994; Shaffer *et al.*, 1999b).

1.3.1.1 PT

- **Total amount of training done** - Limited studies have found that higher amounts or running are associated with higher incidences of stress fractures (Giladi *et al.*, 1985; Jones *et al.*, 1999; Almeida *et al.*, 1999; Popovich *et al.*, 2000; Armstrong *et al.,* 2004).
- **Duration, frequency and intensity** - Weekly overall injury rates have been shown to be significantly correlated to higher total volumes of total

training including running and marching (Jones *et al.*, 1994; Shaffer *et al.*, 1999a).

1.3.2 Equipment

- **Training shoes** - It appears that the stress fracture risk increases with the age of the training shoes, whilst the price of running shoes is not associated to risk (Gardner *et al.*, 1988; Finestone *et al.*, 1991).
- **Boots and orthotic inserts** – Researcher have found that the incidence of stress fractures may be reduced if the military recruit changes from wearing a military boot to wearing an athletic shoe, as well as if certain orthotic inserts are utilised (Milgrom *et al.*, 1985; Gardner *et al.*, 1988).

1.3.3 Environment

The terrain or surface of the environment on which the activity takes place has also been investigated. Reports have suggested that a change of running surface (particularly hard, rocky terrain) may increase the incidence of stress fractures. The difficulty involved in accurately quantifying running surface parameters, makes it difficult to clearly establish a relationship between training surface and stress fracture development (Zahger *et al.*, 1988; Brunet *et al.*, 1990).

1.4 PROBLEM SETTING

All of the above mentioned markers have been researched, yet few have been clearly identified and many of the findings have been contradictory, especially within the military population (Bennell *et al.*, 1999). The only physical requirement for enlistment and acceptance into voluntarily military service in South Africa has been to pass a basic medical examination (to ensure that the recruit is physically healthy). No additional biomechanical factors are evaluated, nor is a minimum level of physical fitness a requirement for acceptance. Thus it is imperative that research be done to determine:

a. Whether or not intrinsic factors affect the development of stress fractures during BT (Jones & Knapik, 1999; Kaufmann *et al.*, 2000; Bemben *et al.,* 2004; Shaffer *et al.*, 2006) and
b. How extrinsic factors, such as PT, affect the final outcome of both fitness levels and stress fracture development (Jones & Knapik, 1999; Kaufmann *et al.*, 2000; Popovich *et al.*, 2000; Rosendal *et al.*, 2003; Rauh *et al.*, 2005; Rauh *et al.*, 2006; Shaffer *et al.*, 2006).

The specific approach to achieving higher levels of physical fitness while minimizing injury rates depends on the populations being considered (Kaufman *et al.*, 2000; Snyder *et al.,* 2006). As BT is the first step in a military career, there is limited access to the trainees prior to the start of BT. The most effective way to improve the level of physical fitness and, subsequently, improve combat readiness, needs to be developed and researched (Jones & Knapik, 1999; Popovich *et al.,* 2000; Rosendal *et al.*, 2003; Rauh *et al.*, 2006; Snyder *et al.*, 2006).

1.5 RESEARCH QUESTION

For this study, the following research question was used:

"Will the incidence of stress fractures in South African soldiers, who have risk factors, as highlighted in thecurrent literature, be greater than in the South Afrcian soldiers who are not at risk during BT?"

1.6 RESEARCH HYPOTHESIS

In the light of the aim of this study, the following research hypothesis was formulated:

Incidence of stress fractures in military recruits with intrinsic risk factors, as highlighted in the current literature, will increase during BT.

A sub-hypothesis was also formulated from the main hypothesis:

By following clear guidelines, as laid out in the literature on how to prevent stress fracture development, it will assist in explaining the low incidence of stress fracture occurrence.

1.7 GOAL OF THE STUDY

The following goal was set before the study commenced:

To determine the incidence of stress fractures during 12 weeks of BT, by analyzing and monitoring any changes in the military recruits' intrinsic risk factors, from when they reported for training to when they completed the training.

1.8 OBJECTIVES OF THE STUDY

This study aimed to achieve the goal through the following objectives:

1.8.1 Primary objectives

- To determine the incidence of stress fractures during 12 weeks of BT;
- To compare the results of risk indicators obtained from the group of participants who suffered stress fractures during their 12 weeks of BT, to the rest of the original group (controls) who didn't suffer from any stress fractures.

1.8.2 Secondary objective

- To determine whether 12 weeks of BT results in any changes in physical markers whilst following a progressive, scientifically designed, PT programme.

1.9 RESEARCH APPROACH

This study followed a quantitative research approach and the two quantitative research techniques that were used are known as observation and experimentation technique.

1.9.1 Observation technique

This technique provides a means of obtaining data and is a descriptive method of researching certain problems. In this study, the observation technique was used to keep record of all military recruits who developed a stress fracture. This was done through the military medical computerized system as all military medical visits to the unit sick bay are captured onto this system. Additionally, the diagnosis, as well as the results of any radiology scans, is also captured (together with treatment given) (Thomas & Nelson, 2001).

1.9.2 Experimentation

This technique attempts to establish a cause-and-effect relationship. That is, an independent variable (in this case the PT Programme) is manipulated to judge the effect upon a dependant variable (fitness results). Additionally, correlation statistics were used to establish the cause-and-effect relationship (Thomas & Nelson, 2001).

1.10 RESEARCH DESIGN

A research design is the basic plan that guides the data collection and analysis phases of the research project. *It is the framework that specifies the type of information to be collected, the sources of data, and the data collection procedure* (Kinnear & Taylor, 1996: 129). The current study was done in the form of an experiment. Pre-test and Post-test measures were taken for the prospective experimental cohort group (who all underwent BT) on biokinetic and bone density measurements. Fitness test results were also compared to a CG who had undergone BT in the year prior to the EG. The limitations of the findings of this study are that they could only be generalised to the people from the same sample group.

The prospective design implies that the participants were assembled at the beginning of the study (in this case at the start of 12 weeks of BT according to their exposure to a (risk) factor. They were followed over the predetermined 12-week period, and any injury occurrence was monitored and recorded. This was considered a ‘strong’ design as it enabled accurate comparisons to be made between injured and uninjured groups. These comparisons then lead to true assessment of the incidences and risks which could have lead to casual inferences been drawn. The limiting factor of this type of design is that in order to have enough statistical power, particularly for detection of small differences, sample sizes need to be large. Additionally, rigorous inclusion criteria, as well as drop out rates over the course of the study, limit the number of available, suitable participants.

1.11 RESEARCH PROCEDURE AND STRATEGY

- Identify risk factors for the development of stress fractures in the literature.
- Identify potential intrinsic risk factors for stress fractures in the literature.
- Develop a 12-week PT Exercise Programme for BT.

- Determine if these intrinsic risk factors are measurable and quantifiable.
- Develop a physical testing battery of all possible intrinsic risk factors to be measured.
- Give information regarding the study, and answer all questions that may arise from the cohort group starting 12-week of BT.
- Ask for volunteers for the study and have all volunteers complete and sign the inform consent form.
- Ask participants to read and sign informed consent and then complete questionnaires on their history of sport participation and medical questionnaires.
- Randomly divide participants into five groups and undergo a week of Pre-test physical testing of battery developed above.
- Collect data and participants commence 12 weeks of BT.
- Conduct mid-course fitness tests.
- Follow identical Post-test physical testing and data collection.
- Draw medical records from the military medical main-frame to determine the incidence of stress fractures amongst the group.
- Complete statistical analysis of pre/post test analysis.
- Explain findings.

As stress fractures represent a serious concern within the South African Military environment the first step is to study the literature of research already in existence regarding the definition, diagnosis and the pathophysiology of stress fractures. Additionally a thourough literature review also needs to be done in order to identify possible intrinsic and extrinsic risk factors and attempt to understand the potential relevance to the South African context.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

PT forms an integral part of the physical preparation and conditioning of military personnel. Military historians have repeatedly emphasised the importance of a high level of physical capability as necessary for soldiers to perform their main functions, namely: to protect their country, its territorial integrity and its people, and to contribute positively to peacekeeping as well as peace-enforcing operations (McGaig & Gooderson, 1986; Nye, 1986; Dubik & Fullerton, 1987; Shvartz & Reibold, 1990; Legg & Duggan, 1996; Dyrstad *et al.,* 2006).

New recruits, making the transition from civilian to military life undergo a period of initial BT to equip them with the required optimum physical capability and skill training needed to execute their tasks effectively (Gordon *et al.,* 1986a; Jordaan & Schwellnus, 1994; Knapik *et al.,* 2005; Schaffer *et al.,* 2006). The excessive demands imposed on the musckuloskeletal system during military BT continues to be of utmost concern, as this period of training is often related to high levels of training-related injuries (Gordon *et al.,* 1986c; Jones & Knapik, 1999; Jones *et al.*, 2002; Armstrong *et al.,* 2004; Välimäki *et al.*, 2005; Snyder *et al.,* 2006). Besides imposing substantial medical costs, injuries can prevent the recruit from training for extended periods, as well as reduce the morale of the injured and the group.

2.2 STRESS FRACTURES

Stress fractures represent one of the most common and potentially serious training-related injuries (McBryde, 1985; Hulkko & Orava, 1987; Matheson *et al.*, 1987; Jones *et al.*, 1989; Sterling *et al.*, 1992; Beck *et al.,* 2000; Jones *et al.,* 2002; Shaffer *et al.,* 2006; Trone *et al.,* 2007).

2.2.1 Definition

A stress fracture can be defined as a partial or complete bone fracture that results from its inability to withstand stress applied in a rhythmic, repeated, subthreshold manner (McBryde, 1985; Bennell *et al.*, 1999).

2.2.2 A historical perspective

Stress fractures were first described in 1855 by Brietpaupt (Jones *et al.*, 1989), a Prussian military physician, who observed foot pain and swelling in young military recruits unaccustomed to the rigors of BT. He considered this to be an inflammatory reaction in the tendon sheaths as a result of trauma, and he called the condition *Fussegeshwulst* (Brukner *et al.,* 1999). In 1887, Pauzat (1887) suspected that the periosteum was involved in the condition, but it was not until the advent of radiographs that the signs and symptoms could be attributed to the metatarsals (Stechow, 1897). The condition then became know as a 'march fracture' because there was a close association between marching and the onset of symptoms (Brukner *et al.,* 1999).

The first few cited reports of stress fractures were case studies of soldiers incurring such fractures in the nineteenth and early twentieth centuries (Bernstein *et al.*, 1946; Belkin, 1980; McBryde, 1985; Markey, 1987; Jones *et al.*, 1989; Jones *et al.*, 2002). However, it was not until 1956 - more than a century after they had been identified in military recruits- that they were recognised in athletes and reported in the non-military population with increasing frequency (Hartley, 1943; Burrows, 1948; Devas & Sweetman, 1956; Blazina *et al.,* 1962; Berkebile, 1964; Devas, 1969).

Throughout the literature, stress fractures have been described by a variety of terms, which include 'march fracture', 'pied force', 'fatigue fracture', 'crack fracture', 'spontaneous fracture', 'insufficiency fracture', 'pseudofracture' and 'exhaustion fracture' (Jansen, 1926; Dodd, 1933; Roberts & Vogt, 1939; Hullinger, 1944; Burrows, 1948).

Following the radiographic description of metatarsal stress fractures, many and varied attempts were made to develop theories in order to explain the etiology of the injury (Brukner *et al.,* 1999). These theories included spasticity and spasm of the interossei (Jansen, 1926); flat forefoot (Sloane & Sloane, 1936) and non-supportive osteomelytis (Roberts & Vogt, 1939).

2.2.3 Pathophysiology

Bone, a specialized form of dynamic connective tissue, is the hardest tissue in the human body and functions primarily as a supportive structure and secondarily as a protective structure. It adapts to hormonal changes, mechanical stress and nutritional states (Voss *et al.,* 1998), and has gained increasing attention in the past two decades due to the increased incidence of osteoporosis, osteoporotic fractures as well as stress fractures.

Bone is comprised of organic material (mainly Type I collagen) and minerals (mainly calcium hydroxyapatite). Similar to other connective tissue of the musculoskeletal system, bone is able to adapt to repeated mechanical loading by changing its microscopic and macroscopic configuration. In order to understand the development of stress fractures, it is necessary to understand bone's basic biologic and mechanical responses to physical loading (Brukner *et al.,* 1999).

2.3 BONE BIOLOGY

2.3.1 Bone structure and gross anatomy

Taking the body as a whole, the skeleton is divided into two groups- the axial skeleton (bones of the trunk) and the appendicular skeleton (the long bones, ie the limb bones). There are two types of bone - The outer, more dense bone (cortical bone) and the inner, less dense, but more metabolically active bone, (trabecular bone) (Voss *et al.*, 1998).

On the basis of general shape, bones can be classified into three groups: short, flat, and long or tubular. Short bones, such as the vertebral bodies, measure approximately the same in all directions, have relatively thin cortices and are trapezoidal, cuboidal, cuneiform, or irregular in shape. Flat (such as the scapula, lamina of the vertebrae) and tubular bones have one dimension that is much shorter or longer than the other two. Long or tubular bones (such as the femur, tibia), have an expanded metaphysis and an epiphysis at either end of a thick-walled tubular diaphysis (Buckwalter *et al.*, 1995).

Mature bones consist of a central hematopoietic marrow supported and surrounded by bone tissue and periosteum. Most injuries of the skeleton and most orthopaedic treatments, primarily affect the bone tissue and the periosteum.

Eighty percent of the skeleton comprises cortical bone whilst trabecular (cancellous) makes up the remaining twenty percent. Although cortical and cancellous bone have the same composition and material properties, differences in distribution and arrangement are responsible for the differences in the mechanical properties of specific bones and parts of bones (Buckwalter *et al.*, 1995). Appendicular, long bones are mainly cortical; the exception is at the metaphysis and epiphysis. The pelvic bones and vertebral bodies are largely trabecular (Brukner *et al.*, 1999). Cortical bone of the diaphysis provides maximum resistance to torsion and bending whilst in the metaphyses and epiphyses, the thinner cortices and subchondral bone supported by cancellous bone, allow greater deformation to occur under the same load. Thus, the complex formed by the subchondral bone and epiphyseal-metaphyseal trabeculae and cortices not only broadens the bone to form an articular surface, it also helps to absorb impact loads applied across synovial joints, thereby protecting the articular cartilage and subchondral bone from damage (Buckwalter *et al.*, 1995).

On the other hand, trabecular bone is less able to withstand compressive forces due to its greater porosity, higher rate of metabolic activity and greater surface-to-volume ratio (Brukner *et al.*, 1999). Clinically, BMD studies measure areas containing mostly cancellous bone (vertebral bodies, femoral Trochanter, and sacrum) because of its earlier and higher rate of bone turnover and its greater likelihood of demonstrating changes in BMD (Buckwalter *et al.*, 1995).

2.3.2 Microscopic structure of bone

Cortical or trabecular bone consists of woven (fiber or primary) or lamellar (secondary) bone. Woven bone forms the embryonic skeleton and is then resorbed and replaced by mature bone as the skeleton develops. Woven bone is rarely present in the normal human skeleton after the age of four or five years. It can, however, appear at any age in response to osseous or soft-tissue injury, treatments that stimulate the formation of bone, metabolic and neoplastic diseases, or inflammation (Buckwalter *et al.*, 1995, Martini *et al.*, 2001).

Lamellar bone consists of highly oriented, densely packed collagen fibrils found in trabecular bone, the inner and outer circumferential lamellae of cortical bone, the interstitial lamellae of cortical bone, and the lamellae of osteons (Brukner *et al.,* 1999). The fibrils and adjacent lamellae run in different directions, similar to the alternating directions of the wood grain in plywood. The collagen fibrils frequently interconnect, not only within but also between lamellae, thereby increasing the strength of the bone (Buckwalter *et al.*, 1995).

The structural unit of compact bone is called the osteon or Haversian system. Each osteon consists mostly of hard bone matrix arranged in concentric rings, or lamellae, around a central canal (the Haversian canal), orientated along the long axis of the bone. Volkmann's cannals run at right angles to the long axis of the bone, connecting the vascular and nerve supply of the periosteum to those of the Haversian canals and the medullary cavity. Spider-shaped osteocytes lie in small concavities, or lacunae, between the lamellae. Canaliculi, hairlike canals, connect the lacunae to each other and the Haversian canal. These canaliculi tie all the osteocytes in an osteon together, permitting easy diffusion of nutrients and wastes to and from the blood vessels in the Haversian canal. Matrix areas between intact osteons contain incomplete lamellae called interstitial lamellae. These fill gaps between forming osteons or represent remnants of osteons that have been cut through by bone remodeling (Marieb, 1995).

2.3.2.1 Bone cells

Bone is made of both organinc and inorganic components. The organic components include the cells (osteoblast, osteocytes and osteoclasts) and approximately one-third of the matrix. The organic matrix elements are the proteoglycans, glycoproteins and collagen fibres, all of which are secreted by osteoblasts (Marieb, 1995). Their main function is to synthesise and secrete bone's organic matrix. Once they stop forming bone, they both decrease their synthetic activity and remain on the bone surface (bone-lining cells) or they surround themselves with matrix and become osteocytes (Brukner *et al.,* 1999).

The organic constituents of the bone matrix account for the flexibility and resilience that is so characteristic of bone, whilst the bone's macromolecules contribute to the bone's structure and functional qualities (Buckwalter, 1995;

Brukner *et al.,* 1999). Bone-lining cells' main function is to contract and secrete enzymes that remove the thin layer of osteoid that covers the mineralized matrix. Osteoclasts are thereby able to attach to bone and begin resorption (Buckwalter *et al.*, 1995). The interconnections (canniculi) between the various osteocytes, active osteobalsts and bone-lining cells' are said to enable the cells to sense bone deformation by mechanical loads and to coordinate the remodeling process (Brukner *et al.,* 1999). Osteoclasts are giant cells with fifty or more nuclei and are derived from the extraskeletal, hematopoietic stem cells. They are found on bone surfaces undergoing resorption and secrete acids which then dissolve the bony matrix and release stored minerals (Martini *et al.*, 2001).

The remaining 65% of the matrix consists of hydroxypatities or inorganic mineral salts, made up largely by calcium phosphate, calcium carbonate and calcium hydroxide (Marieb, 1995; Brukner, 1999). The matrix's main functions include acting as an ion reservoir and accounts for most of bone's strength and stiffness (Buckwalter, 1995; Brukner *et al.,* 1999). It is the proper combination of organic and inorganic matrix elements that allows for bones to be durable and strong without been brittle (Marieb, 1995).

According to Nattiv and Armsey (1997), the expected age range of peak bone mass accrual is between 25 and 30 years, after which both men and women gradually lose bone mass. Men acquire most of their bone mass at a later age than women do (age 13-17 years compared to 11–14 years). Postmenopausal women or women who are hypoestrogenic for other reasons, have accelerated bone loss caused by increased bone resorption compared with formation.

2.3.3. Bone loading

As PT forms an integral part of the physical preparation and conditioning of military personnel, especially during BT, it is important to understand the effect of the PT on bone and how bone reacts to the training. According to Brukner (1999: 2)

> *"…during physical activity, forces from ground impact and muscle contraction result in bone stress, which is defined as the load or force per unit area that develops on a plane surface, and in bone strain, which is defined as deformation of, or change in, bone dimension. In clinical terms, stress is a measure of the load applied, and strain is the measure of the amount of lengthening or deformation that occurs in a given direction."*

During such military activities as drilling, running and marching, contact with the ground generates forces within the body. The magnitude of these ground-reaction forces varies depending on the activity undertaken, (eg. running) results in ground-reaction forces that are two to five times body weight, whilst jumping and landing activities have been shown to elicit ground-reaction forces up to 12 times body weight (Cavanagh & LaFortune, 1980; McNitt-Gray, 1991). These ground-reaction forces result in transient forces, due to the impact of the foot with the ground, in both walking and running and following the heel strike are transmitted up the skeleton. Newton's three laws can then be used to explain exactly what happens to these transient forces and their path up the skeleton (Whittle, 1999).

> *"…When the downward-traveling foot contacts the ground, an upward force is applied by the ground to the foot (the ground-reaction force), to decelerate it and bring it to rest. This upward force is transmitted through the ankle joint to the tibia and through the knee joint to the femur, so that a 'wave' of force passes up the skeleton, which (in accordance with Newton's second law) must necessarily be associated with acceleration"* (Whittle, 1999: 2).

In the literature, this transient acceleration and its associated force is generally referred to as a 'shock-wave' or 'stress-wave'. Any bone subjected to such an upward force will experience an upward acceleration; if it is traveling downwards at the time, this will cause a reduction in its downward velocity. Since the tibia is typically traveling downwards at the time of initial contact, this upward force will generally stops its downward motion. In addition to these forces applied from below, the bones of the lower limb are also subjected to forces from above, from muscular contraction and body weight, which are transmitted through the hip and knee joints (Whittle, 1999).

Various factors will influence the magnitude and the pathway followed up the skeleton by the above-mentioned forces (Brukner *et al.,* 1999; Umemura *et al.,* 2002; Ducher *et al.,* 2006). These include: the running speed, body weight, mass of foot, velocity of foot, interface thickness, interface elasticity, interface viscosity, type of foot strike, surface, terrain, fatigue and footwear (Nigg & Segesser, 1988; Dufek & Bates, 1991; Whittle, 1999; Umemura *et al.*, 2002; Ducher *et al.*, 2006).

According to Brukner *et al.* (1999) the factors that influence bone's response to mechanical loading are:

- the loads direction
- bone geometry
- bone microarchitecture
- bone density and muscle contraction

2.3.3.1 Loads direction

Bone's stress/ strain behavior is dependant on the bone's orientation to the direction of the force applied (loading). Cortical bone is stronger and stiffer in the longitudinal direction than in the transverse direction, whilst trabecular bone is stronger along the lines of the trabeculae (Brukner, 1999).

Forces load the bone through tension, bending, shear and torsion. Human cortical bone, in both the transverse and longitudinal direction, can withstand greater load in compression than in tension and greater load in tension than in shear. During bending, a combination of tensile loads on one side of the bone and compressive loads on the other side, resulting in the bone giving in on the tensile side (as adult bone is weaker in tension that in compression) (Hall, 2003).

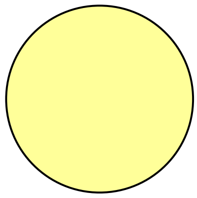
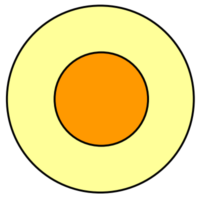
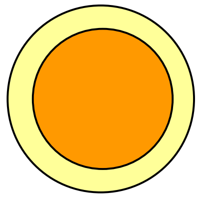
2.3.3.2 Bone geometry

A bone's strength is greatly determined by its geometry. A bone's strength is directly proportional to the bone's cross-sectional area when either tension or compression loads are applied to it. This implies that a larger bone, such as the femur, is more resistant to fracture, than for example, the tibia, as the internal forces are distributed over a larger surface area resulting in lower stresses (Hayes & Gerhart, 1985; Ammann & Rizzoli, 2003).

With bending forces, the bone's cross-sectional area, bone's tissue distribution around a neutral axis as well as the length of the bone will influence the bones' strength (Brukner *et al.,* 1999; Ammann & Rizzoli, 2003). "If the bone tissue is distributed further away from the neutral axis (the axis where the stresses and strains are zero) there is a greater area of inertia which means that it is more efficient in resisting bending." (Brukner et al., 1999: 52).

Each of the cross-sectional areas of the above bones (Table 2.1) are roughly equivalent, yet their bending strengths differ vastly as they have different moments of inertia. This occurs as a result of the way in which the bone is distributed in relation to the central axis of the bending or rotation force applied to the bone. The solid bone on the left has the same amount of area (bone) as the one in the centre, but the latter has a higher moment of inertia as the bone is distributed further away from the central axis; its bending strength is 50% greater (Brukner *et al.,* 1999).

Table 2.1: Bone's moment of inertia properties (Brukner et al., 1999)

			
Area (cm ^{2})	2.77	2.77	2.77
Moment of inertia (cm ^{4})	0.61	1.06	1.54
Bending strength (%)	100	149	193

Studies on Israeli Army Recruits using radiographic methods, showed that stress fracture cases had narrower tibiae (Giladi *et al.*, 1987) and smaller tibial mediolateral cross-sectional moments of inertia (Milgrom *et al.*, 1989). In a previous study of male U.S. Marine Corps recruits using the DEXA method, Beck *et al.* (1996) similarly found that stress fracture cases had lower mediolateral cross-sectional moments of inertia and section moduli in both the distal third of the tibia and the midshaft of the femur. Even though the fracture cases in this study of men were, on average, physically smaller in body weight and anthropometric dimensions, the diaphyseal dimensions remained significantly smaller in fracture cases even after bone shaft geometries were corrected for body size (weight).

Additionally, the length of the bone is directly proportional to the bending moment caused by the loading applied. Thus, the femur, tibia and fibula are subjected to higher bending moments and therefore higher tensile and compressive stresses than the shorter bones of for example, the forearm (Brukner *et al.,* 1999).

2.3.4 Bone microarchitecture

2.3.4.1 Bone density

According to Carter and Hayes (1977), skeletal tissue's compressive strength is approximately proportional to the square of the apparent density. This implies that a small reduction in bone density is associated with a large reduction in bone strength. Clinically, low bone density is associated with greater risk of osteoporotic fracture (Martini *et al.*, 2001).

2.3.4.2 Muscle contraction

Muscles attached to bone also influence the stress distribution and magnitude. According to Brukner *et al.,* (1999) it can both increase as well as decrease the magnitude of stress applied to bone.

Warden *et al.,* (2002) suggested that stress fractures of the ribs in elite rowers may be the result of repeated high-force muscular contractions during the rowing stroke. Different injury mechanisms involving the serratus anterior, obliquus externus abdominis, and the shoulder retractors either alone or in concert, have been presented (Warden *et al.*, 2002). Further evidence that muscle contraction is a potential cause of exercise-induced rib stress fractures is present in work done by Vintheri *et al.,* (2006).

2.3.5 Bone response to loading

The dramatic bone loss which occurs with immobilisation, disuse and weightlessness is evidence that the maintenance of normal bone mass is dependant on repetitive strains (Brukner *et al.,* 1999). Exercise is recognized as usually having a beneficial effect on bone density because of the mechanical loading forces on the skeleton (Snow, 1996; Stewart *et al.,* 2005).

However, Brukner *et al.*, (1999: 6) states that

> *"…bone can also lose strength as a result of repetitive loads imposed during normal daily activity. This loss of strength is attributed to formation and propagation of microscopic cracks within bone. If the load is continually applied, these 'microcracks' can spread and coalesce into 'macrocracks'. If repair does not occur, a stress fracture may eventually result*."

Loading of bone is expressed in microstrain (Duncan & Turner, 1995), with 1000 microstrain representing a force causing a 0.1% change in length. Physiologically, in normal bone, 4000 microstrain is 1/6th of a fracture strain. With less than 50-200 microstrain (the trivial loading zone), normal stimuli to bone is withdrawn, and remodelling is stimulated. This is seen in prolonged bed rest, and leads to a net loss of bone over time.

Strains in the physiological loading zone (about 200-2000 microstrain) are sufficient to maintain bone. When 2000-3000 microstain is exerted onto bone, modelling is stimulated (in this overload zone) resulting in accretion of bone. During modelling the architecture of bone material is controlled by adding *or* removing bone from a surface to create drifts of the material in space. The cells must be activated by some stimulus and then function to form *or* resorb bone.

Functional adaptation to increased loading (eg a new exercise programme) generally occurs via modelling so that the geometry of the bone is altered to improve its resistance to applied loads. The detection of mechanical signals and translation into a biological response is termed mechanotransduction and involves signal transduction between osteocytes and cells at the bone's surface (Duncan & Turner, 1995; Martini *et al.,* 2001). Finally, forces above 4000 microstrain (the pathological overload zone) stimulate repair and adds bone in an unorganized manner (Duncan & Turner, 1995).

Remodelling refers to the process through which fatigue damaged bone is replaced by new bone. It occurs in both growing and adult bones, and determines bone shape and mass in adults. Remodelling occurs in cycles, which involve the breakdown of bone by osteoclasts and the laying down of new bone matrix by osteoblasts or through a coupled process, over time, filling in of the resorped areas may be incomplete. Remodelling occurs at many simultaneous sites throughout the body where bone is experiencing growth, mechanical stress or fractures, or breaks. About 20% of all bone tissue is replaced annually by the remodelling process (Martini *et al.,* 2001). Remodelling occurs in cortical bone on its endosteal and periosteal surfaces, and on the surface of trabeculae bone.

The three main functions of remodelling are: (1) to adapt bone to mechanical loading, (2) to prevent accumulation of microfractures or fatigue damage and (3) to maintain constant blood calcium levels.

There are five phases (Table 2.2) in the bone remodelling process, namely activation, resorption, reversal, formation, and quiescence. The total process takes about four to eight months, and occurs continually throughout life.

Table 2.2: Phases of bone remodelling

PHASE	PHASE EVENTS	
Activation	1	Small area of bone surface is converted from rest to activity by an initiating hormonal, chemical or physical stimulus.
	2	Pre-osteoclasts are attracted to the remodelling sites.
	3	Pre-osteoclasts fuse to form multinucleated osteoclasts.
Resorption	4	Osteoclasts dig out a cavity, called a resorption pit, in spongy bone or burrow a tunnel in compact bone.
	5	Calcium can be released into the blood for use in various body functions.
	6	Osteoclasts disappear.

PHASE	PHASE EVENTS	
Reversal	7	Mesenchymal stem cells, pre-cursors to osteoblasts, appear along the burrow or pit.
	8	Here they proliferate (increase in numbers) and differentiate (change) into preosteoblasts.
	9	This normally lasts 1-2 weeks and during this time, the bone site is weakend. Continued mechanical loading during the reversal phase could therefore result in microdamage accumulation and the beginning of clinical symptomatology.
Formation	10	Osteoblasts then mature into osteoblasts at the surface of the burrow or pit.
	11	Osteoid is released at the site, forming a new soft nonmineralized matrix.
		The new matrix is mineralized with calcium and phosphorous.
Quiescence		Site, with resting lining cells, remains dormant until the next cycle.

2.3.5.1 Microdamage

Above a high loading threshold, fatigue failure of bone can occur causesing microscopic damage of bone. This damage is termed microdamage to bone (Duncan & Turner, 1995). This microdamage accumulates in human bone when repeated loading is undertaken. According to Frost (1989), the progression can be classified into four stages, namely:

- **Stage 1:** Known as the molecular and ultrastructural stage; this is the earliest stage and is characterised by disruption of some intermolecular bonds in the mineralised matrix and a measurable loss in bone stiffness (not visible under direct microscopy).
- **Stage 2**: Increasing physical damage with wholesale disruption of molecular bonds, creates pre-failure planes in the previously impermeable matrix.

- **Stage 3:** The accumulation and progression of pre-failure cracks leads to frank physical cracks that are visible under light microscope. The marked reduction in bone mechanical properties, seen when repetitive loading is undertaken, is attributed to these small cracks (Brukner *et al.,* 1999).
- **Stage 4**: Pre-failure planes and cracks accumulate with continued repetitive loading and at some stage, reach a size whereby so little bone remains to carry the load that a complete fracture results.

During any of these stages, the microdamage is then repaired by "targeted" remodelling to the sites of damage.

2.3.5.2 Microdamage to stress fracture

The insufficient repair of microdamage may be one mechanism leading to the creation of stress fractures. Models for initiation and progression of fatigue fractures (Figure 2.1) suggest that muscle fatigue allows greater strains to be engendered in the bones, leading to initation of microdamage. Repair of microdamage initially creates resorption pits at the start of remodelling. This creates a transient increase in porosity of the tissue and a corresponding reduction in mass and strength. If there is inadequate rest between loading bouts, a positive feedback loop is created that either progresses to a "stress fracture" or weakens the bone sufficiently for a fracture to occur at relatively low magnitudes of loading (Brukner *et al.,* 1999).

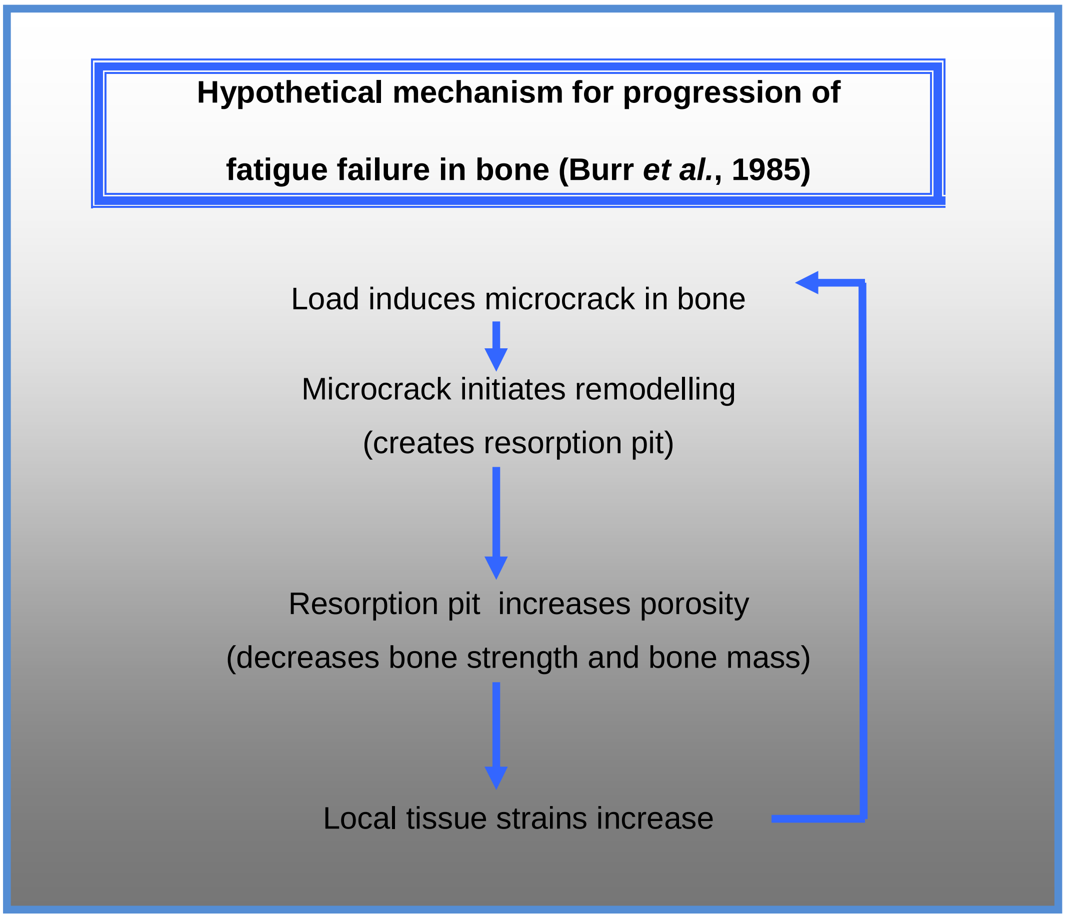


Figure:2.1: Hypothetical mechanism for progression of fatigue failure in bone (Brukner *et al.,* 1999).

The pathogenesis of a stress fracture is presented in Figure 2.2. Loading via ground-reaction force and muscle contraction results in bone strain. This leads to both accelerated remodelling and to microdamage. Remodelling also makes the bone more vulnerable and so increased microdamage can occur at bone sites undergoing remodelling. If the microdamage cannot be repaired by remodelling, then a symptomatic bone injury can occur (Bennell & Brukner, 2005).

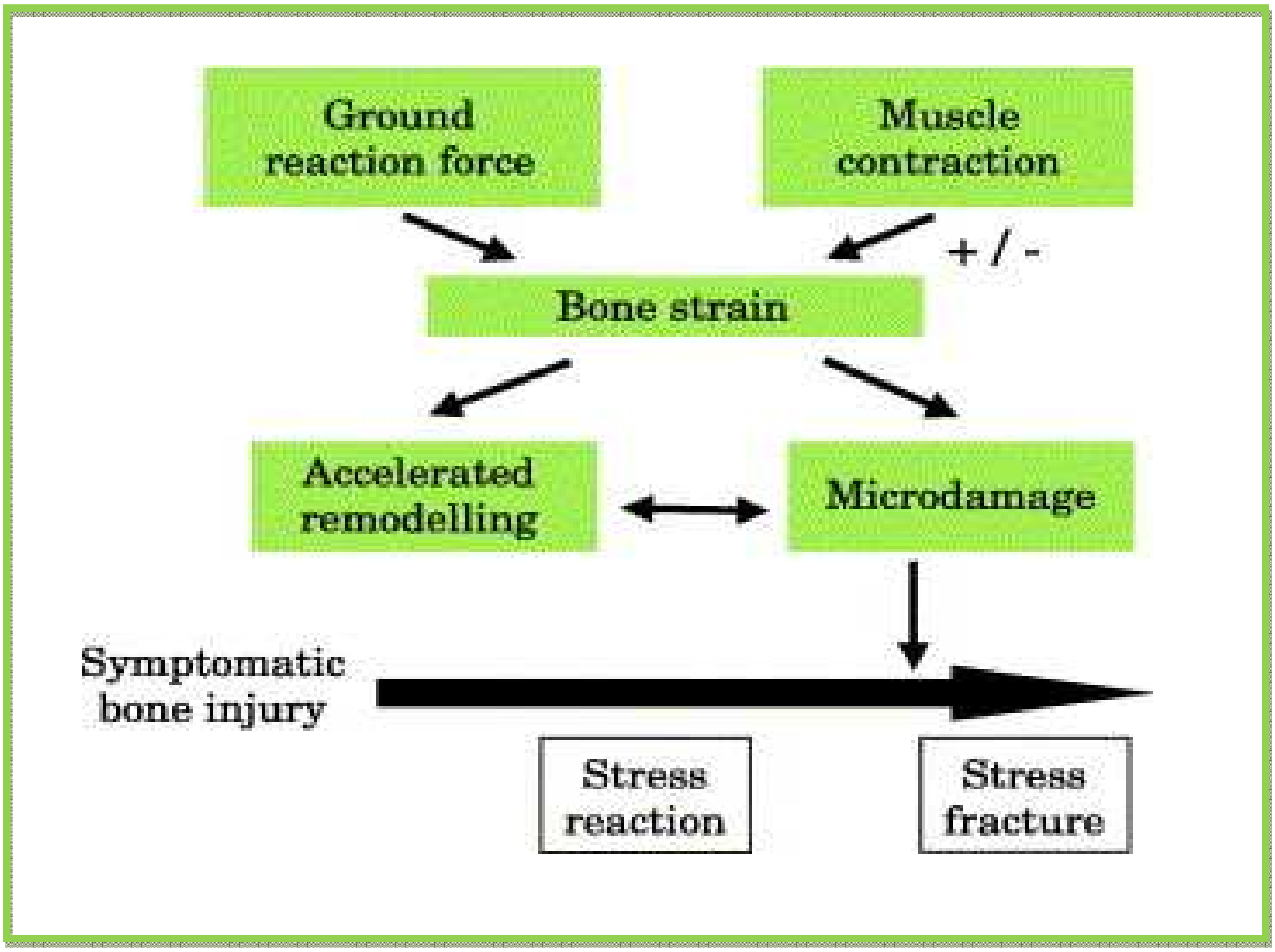


Figure 2.2: Pathogenesis of a stress fracture (Bennell & Brukner, 2005)

2.4 EPIDEMIOLOGY OF STRESS FRACTURES

Epidemiology is the study of diseases in populations, including the relationship between exposure and outcome. Epidemiological data about stress fractures include stress fracture rates, characteristics and stress fracture morbidity. According to Brukner *et al.* (1999) research methods and techniques in the basic sciences are used to isolate the factors under study (independent variables) and the outcomes being measured (dependant measures). In stress fracture research, the most important aim is to establish a causal relationship. This establishes whether a given association is valid, and, by extension, whether an intervention might be effective. The ability to make valid conclusions regarding stress fracture depends on the study design. The following six types of research designs have been used in the study of stress fractures, namely: clinical trials, prospective cohort studies, case-control studies, case series, cross-sectional studies, or surveys and 'mixed' study designs.

2.5 RESEARCH DESIGNS

2.5.1 Clinical trials

These types of studies are best used for evaluating treatment strategies once stress fractures have occurred and are a good design to assess injury prevention strategies. However, if the study's goal is to understand the cause of stress fractures, an observational design is best. The remaining five study designs are considered to be 'observational' as they make observations about the injuries and related factors (Brukner *et al.,* 1999; Thomas & Nelson, 2001).

2.5.2 Prospective cohort studies

The participants of these types of studies are assembled at the beginning of the study according to their exposure to a (risk) factor. They are followed over a predetermined period of time, during which injury occurrence is monitored and recorded. This is considered a 'strong' design as it enables accurate comparisons to be made between the injured and the uninjured groups. These comparisons then lead to true assessment of the incidences and risks which may lead to casual inferences been drawn (Brukner *et al.,* 1999; Thomas & Nelson, 2001).

The limiting factor of this type of design is that in order to have enough statistical power, particularly for detection of small differences, sample sizes have to be large. Additionally, rigorous inclusion criteria, as well as drop-out rates over the course of the study, limit the number of available, suitable participants (Kinnear & Taylor, 1996; Brukner *et al.,* 1999; Thomas & Nelson, 2001).

2.5.3 Case-control studies

Here participants are assembled according to whether or not they have sustained a stress fracture, whereby the injured couples form the cases and the uninjured, the controls. Prior exposure to a risk factor is then determined in each group.

This design allows for stress fracture rates to be calculated yet, may be biased, as a result of selection factors that affect the participants' enrolment and of inaccurate recall of prior exposure. This type of design also allows for risk to be calculated as an odd of exposure in the injured compared with the non-injured controls (Kinnear & Taylor, 1996; Brukner *et al.,* 1999; Thomas & Nelson, 2001).

2.5.4 Case series

A case series can be classified as being either diagnostic or clinical (Jones *et al.*, 2002). Case series are single study groups that consist of individuals who have a stress fracture and who present at a treatment facility. This design allows for the frequency of stress fracture occurrence to be compared to other injuries in the same population of patients. Additionally, they also describe various characteristics which then give an indication of morbidity and lead to conclusions regarding etiology and treatment.

This design is commonly found in the literature however, is limited in that it cannot provide the true incidence of stress fractures, drawing inferences about risk of injury or assessing treatment methodologies ((Kinnear & Taylor, 1996; Brukner *et al.,* 1999; Thomas & Nelson, 2001).

2.5.5 Cross-sectional studies, or surveys

As with case-controlled and cohort studies, these studies document the presence of risk factors and of stress fractures. However, as the presence of a risk factor and the stress fracture are measured at the same time, these studies cannot show whether the risk factor proceeded, caused or resulted from the stress fracture's development. Thus, they cannot establish cause-and-effect relationships (Kinnear & Taylor, 1996; Thomas & Nelson, 2001).

2.5.6 'Mixed' study designs

Aspects of the cohort and case-control studies are combined in this type of study. The findings are limited as they can only be generalised to the people from the same sample group (Brukner *et al.,* 1999; Thomas & Nelson, 2001).

2.6 STRESS FRACTURE RATES IN MILITARY POPULATION

Numerous investigations of military populations have reported the incidence of stress fracture among recruits, cadets, trained soldiers and marines (Protztman & Griffis, 1977; Reinker & Ozbourne, 1979; Kowal, 1980; Black, 1982; Scully & Besterman, 1982; Brudvig *et al.,* 1983; Milgrom *et al.,*1985; Gardner *et al.*, 1988; Gordon *et al.*, 1986c; Jones *et al.*, 1989; Montgomery *et al.*, 1989; Pester & Smith, 1992; Taimela *et al.*, 1990; Jones *et al.*, 1993b; Jodaan & Swellnus, 1994; Milgrom *et al.,* 1994; Shwayhat *et al.,* 1994; Beck *et al.*, 1996; Cowan *et al.*, 1996; Heir & Glomsaker, 1996; Bijur *et al.*, 1997; Rudzki, 1997; Winfield *et al.,* 1997; Almeida *et al.*, 1999; Jones *et al.,* 1999; MacLeod *et al.*, 1999; Shaffer *et al.*, 1999a; Shaffer *et al.*, 1999b; Beck *et al.*, 2000; Lappe *et al.,* 2001; Armstrong *et al.*, 2004; Välimäki *et al.*,2005; Shaffer *et al.*, 2006).

Several of these studies have been specifically geared towards the incidence during the recruits' initial-entry which starts with BT. The stress fracture incidences reported have been sex specific, with the incidence rate during BT ranging from 0.9 to 5.2% in males, and 3.4% to 21.0% in female trainees (Reinker & Ozbourne, 1979; Kowal, 1980; Brudvig *et al.,* 1983; Jones *et al.*, 1993b; Jones *et al.,* 1999).

Various factors must be responsible for the large ranges in incidence occurrence. Possible factors include: recruit type (Army, Air force and Marines); sex and chronogical age; the length and type of BT; the country involved; the diagnostic criteria for stress fractures and the method of injury tracking (Brukner *et al.,* 1999). Most studies done on the incidence of stress fractures were conducted out in the United States of America and most of these studies have had an incidence of less than 10% (Brukner *et al.,* 1999).

Two studies involving the Israeli Military have shown stress fracture incidences as high as 31% and 24% (Milgrom *et al.*, 1994). These high incidences were attributed to meticulous follow-up, high incidence of suspicion, and the use of the isotope bone scan for diagnosis.

There are only two published studies which have looked at stress fracture incidence among South African recruits. The first was carried out in 1982 and formed part of a three-part article (Gordon *et al.*, 1986a; Gordon *et al.*, 1986b; Gordon *et al.,* 1986c). The participants of this study were "**…**young adult South African Servicemen' (Gordon *et al.*, 1986a: 483) reporting for military conscription at the South African Defence Force BT Centre. It appears that all recruits, regardless of their mustering (recruit type), underwent a joint BT period of ten-weeks. This changed since and BT the South African National Defence Force now occurs within mustering, meaning that the Army will have its own BT, the Air Force its own and so forth. Gordon *et al.* (1986c) reported a stress fracture incidence of 4.12% amongst the 947 recruits studied.

The second study by Jordaan and Schwellnus (1994) documented the incidence of overuse injuries sustained by the 1151 recruits during nine weeks of BT in 1989. As with the above study, the recruits underwent a joint BT and the study reported a 1.2% incidence of stress fracture (Table 2.3).

Table 2.3: Incidence of stress fracture rate in military studies undergoing BT

Year of publication	Reference	Population	Participants	Observation period (weeks)	Stress fracture rate
1977	Protzman & Griffis	U.S.-Army	102-F	8	F# = 9.8%
			1228-M		M# = 1.0%
1979	Reinker & Ozbourne	U.S.-Army	NS-F	8	F# = 2.2%
			1198-M		M# = 0.8%
1980	Kowal *et al.*	U.S.-Army	202-M	8	F# = 21.0%
			327-F		M# = 4.0%
1982	Scully & Besterman	U.S.-Army	6677-M	8	M# = 1.3%
1983	Brudvig *et al.*	U.S.-Army	151-F	8	F# = 3.4%
			144-M		M# = 0.9%
1985	Milgrom *et al.*	Israeli –Army	295-M	14	F# = 62.0%
					M# = 31.0%
1988	Gardner *et al.*	U.S.- Marine	3025-M	12	M# = 1.3%
1986c	Gordon *et al.*	South African Defence Force	947-M	10	M# = 4.12%
1989	Jones *et al.*	U.S.-Army	186-F	8	F# = 13.9%
			124-M		M# = 3.2%
1989	Jones *et al.*	U.S.-Army	323-M	13	M# = 2.2%
1989	Montgomery *et al.*	U.S.-Navy Sea, Air, and Land	505-M	8	M# = 6.3%
1990	Taimela *et al.*	Finnish.-Army	823-M	12	M# = 2.7%
1992	Pester & Smith	U.S.-Army	33,059-F	8	F# = 1.1%
			76,237-M		M# = 0.9%
1993	Jones *et al.*	U.S.-Army	186-F	8	F# = 12.3%
			124-M		M# = 2.4%
1993	Jones *et al.*	U.S.-Army	303-M	12	M# = 3.0%

Year of publication	Reference	Population	Participants	Observation period (weeks)	Stress fracture rate
1994	Jordaan & Swellnus	South African Defence Force	1261-M	9	M# = 1.2%
1994	Milgrom *et al*	Israeli –Army	783-M	14	M# = 24.0%
1994	Shwayhat *et a.*	U.S.-Navy Sea, Air, and Land	224-M	25	M# = 6.7%
1996	Beck *et al.*	U.S.-Marine	626-M	12	M# = 4.3%
1996	Cowan *et al.*	U.S.-Infantry	294-M	12	M# = 5.0%
1996	Heir & Glomsaker	Norwegian-Army, Air Force and Navy	6488-M	6-10	M# = 0.2%
1997	Bijur *et al.*	U.S.- Army	85-F	6	F# = 15.0%
			473-M		M# = 2.3%
1997	Rudzki	U.S.-Australian	180-M	12	M# = 1.1%
1997	Winfield	U.S.-Navy	104-F	10	F# = 11.5%
			NS-M		M# = 7.9%
1999	Shaffer *et al.*	U.S.-Marine	1286-M	12	M# = 4.0%
			1078-M		M# = 3.7%
1999	Shaffer *et al.*	U.S.-Navy	8862- F	9	F# = 3.9%
1999	Shaffer *et al.*	U.S.-Marine	2766- F	13	F# = 5.7%
1999	Shaffer *et al.*	U.S.-Marine off.	303- F	10	F# = 9.6%
2000	Beck *et al.*	U.S.-Marine	693-F	12	F# = 5.3%
2001	Lappe *et al.*	U.S.- Army	319-F	8	F# = 8.5%
2004	Armstrong *et al.*	U.S.-Navy	203-F	9	F# = 8.4%
			1021-M		M# = 2.3%
2005	Välimäki *et al.*	Finnish.-Army	179-M	8	M# = 8.4 %
2006	Rauh *et al.*	U.S.- Marine	824	13	F# = 6.8%
2006	Shaffer *et al.*	U.S.- Marine	2962-F	13	F# = 6.1%

Key: # = Stress fracture rates; M = Males; F= Females; NS = Not Stated

The methods used in the diagnosis of a stress fracture play a vital role in the final incidence rate of the various studies. For example, when Bone Scans are used to classify stress fractures, the incidence rate appears to be inflated as more falsepositive results are also likely to be yielded by Bone Scans. This was possibly the case with the Milgrom *et al.*, (1994) study.

Conversly, a radiographic diagnosis may result in a lower incidence rate being reported due to its poor sensitivity (Berger *et al.,* 2007). The different levels of sensitivity and specificity of bone scans and radiographs in detecting stress fractures are relevant to clinicians and researchers. The delayed confirmation of stress fracture diagnoses by radiographs must be factored into both clinical and research protocols (Jones *et al.*, 2002). Regardless of the diagnosis method used, stress fractures are a common problem within the military environment.

What is evident from Table 2.3 and Figure 2.3 is that the stress fracture rates in female military recruits undergoing BT seem to be much higher than in males. This point has been a subject of investigation in the United States Army (Brukner *et al.,* 1999) and, more recently, in the South African Defence Force (Wood & Krüger, 2007).

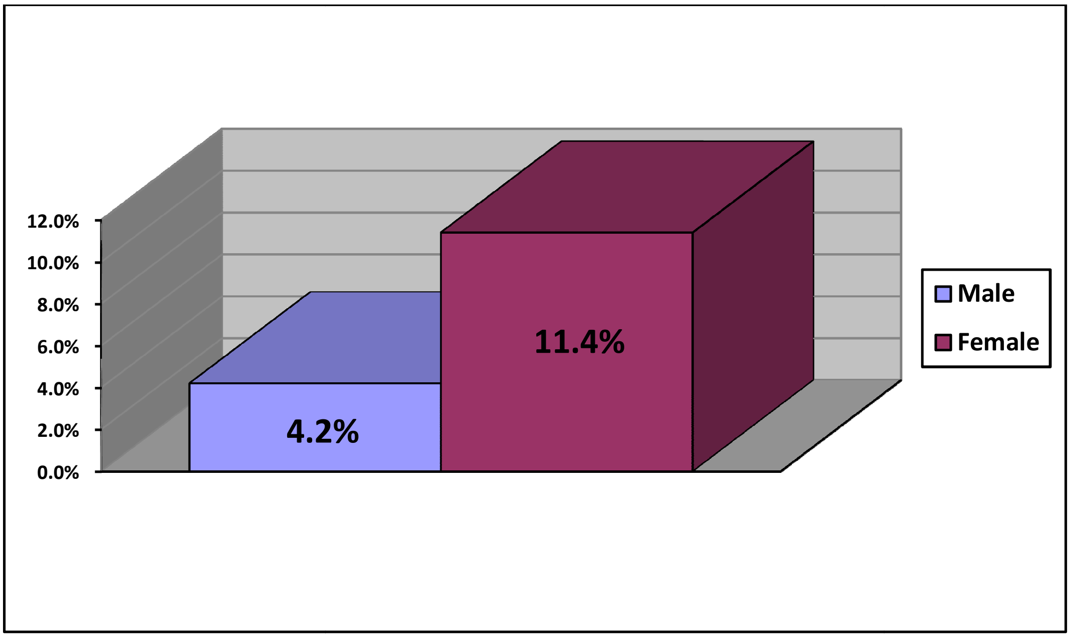


Figure 2.3: Average % stress fracture incidence during BT 1977-2007

2.7 SITE DISTRIBUTION OF STRESS FRACTURES IN MILITARY POPULATIONS

Changes that have occured over the years in military training methodology have had an influence on the site distribution of stress fractures. These changes include emphasizing running rather that marching and using athletic shoes during the initial part of training rather than the army combat boot. Additionally, advances in imaging technology have also influenced the diagnosis of previously undiagnosed injuries (Brukner *et al.,* 1999; Jones *et al.*, 2002; Rauh *et al.*, 2006).

Table 2.4: Site distribution, expressed in percentage, of stress fractures incurred by military recruits undergoing BT

Study	Stress fracture rate	% of Stress Fracture per Anatomic Site					
		Foot	Tibia	Fibula	Femur	Pelvis	Not specified
Reinker & Ozbourne, 1979.	F# = 2.2%	60	40				
	M# = 0.8%	90	10				
Kowal *et al.*, 1980.	F# = 21.0%	11	62		27		
	M# = 4.0%						100
Scully & Besterman, 1982.	M# = 1.3%						100
Brudvig *et al.,* 1983.	F# = 3.4%	43	31	5	11	10	
	M# = 0.9%	65	19	4	8	3	
Milgrom *et al.*, 1985.	M# = 31.0%	9	56		34	1	
Gardner *et al.*, 1988.	M# = 1.3%	37	63 above the foot				
Gordon *et al.*, 1986c.	M# = 4.12%	5	83	None	12		
Jones *et al.*, 1989.	F# = 13.9%						100
	M# = 3.2%						100
Jones *et al.*, 1989.	M# = 2.2%						100
Montgomery *et al.*, 1989.	M# = 6.3%	3	84		13		
Taimela *et al.*, 1990.	M# = 2.7%	50		38	12		
Pester & Smith, 1992.	F# = 1.1%	13	27				
	M# = 0.9%	86	13				
Jones *et al.*, 1993a.	F# = 12.3%						100
	M# = 2.4%						100

Study	Stress fracture rate	% of Stress Fracture per Anatomic Site					
		Foot	Tibia	Fibula	Femur	Pelvis	Not specified
Jones *et al.*, 1993b.	M# = 3.0%						100
Jordaan and Schwellnus, 1994.	M# = 1.2%	21	71	None	8	None	None
Milgrom *et al.*, 1994.	M# = 24.0%		70		30		
Shwayhat *et al.*, 1994.	M# = 6.7%						100
Beck *et al.*, 1996.	M# = 4.3%	41	41	None	19	None	None
Cowan *et al.*, 1996.	M# = 5.0%						100
Heir & Glomsaker, 1996.	M# = 0.2%						100
Bijur *et al.*, 1997.	F# = 15.0%		46				64
	M# = 2.3%		41				59
Rudzki , 1997.	M# = 1.1%		100				
Winfield, 1997.	F# = 11.5%						100
	M# = 7.9%						100
Shaffer *et al.*, 1999a.	M# = 4.0%	45	46	5	2	2	
	M# = 3.7%	67	26		7		
Shaffer *et al.*, 1999b.	F# = 3.9%						100
Shaffer *et al.*, 1999b.	F# = 5.7%						100
Shaffer *et al.*, 1999b.	F# = 9.6%						100
Beck *et al.*, 2000.	F# = 5.3%	35	27	None	27	27	None
Lappe *et al.,* 2001.	F# = 8.5%						100
Armstrong *et al.*, 2004.	F# = 8.4%	None	100	None	None	None	None
	M# = 2.3%	11	72	6	11	None	None
Välimäki *et al.*, 2005.	M# = 8.4 %	73	27	None	None	None	None
Rauh *et al.,* 2006.	F# = 6.8%	10.6	57.6	6.1	10.6	15.2	None
Shaffer *et al.*, 2006.	F# = 5.1%	29.8	24.9	3.9	19.9	21.6	

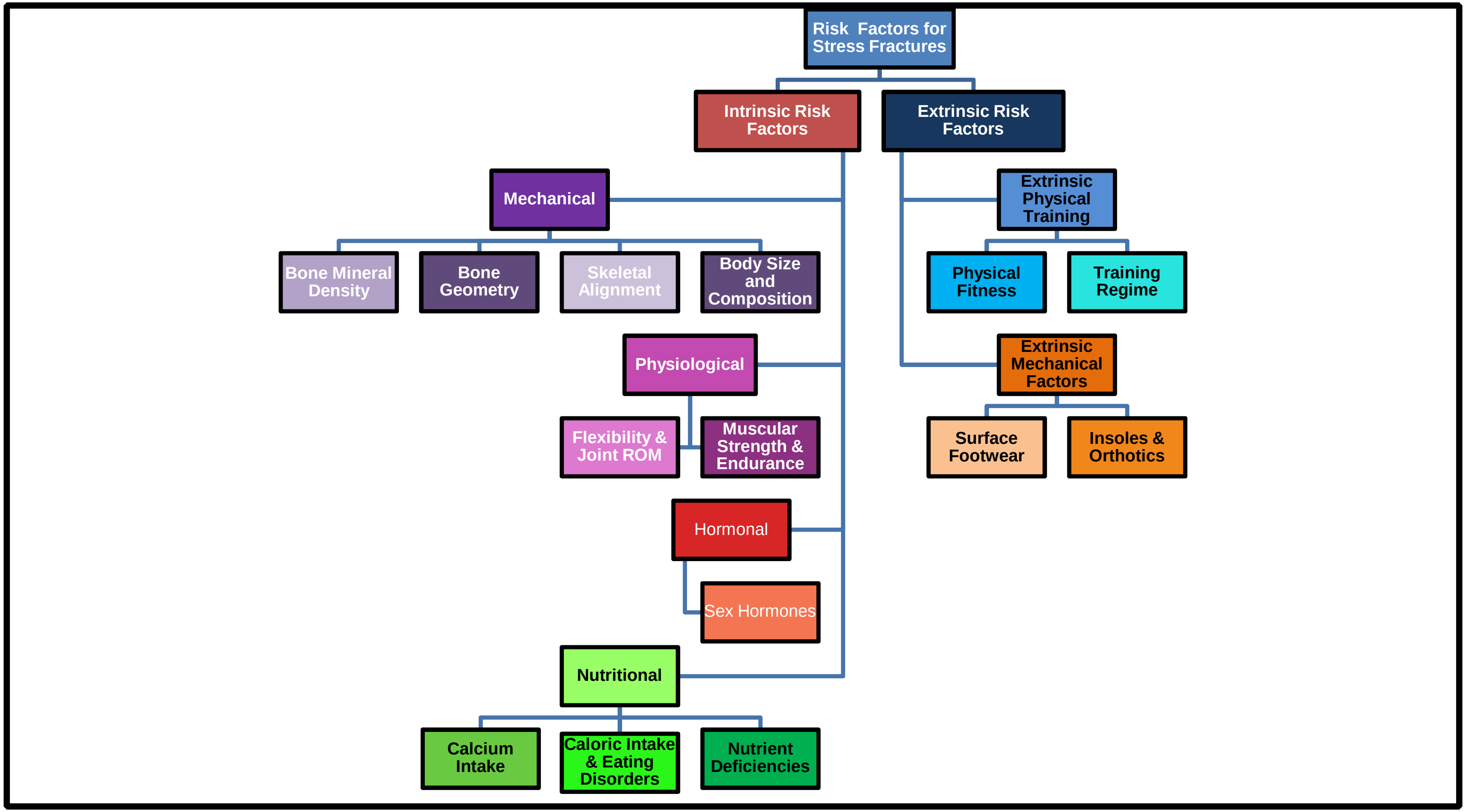
Key: # = Stress fracture rates; M = Males; F = Females; Foot = includes stress fractures of the metatarsal, tarsal, navicular and calcaneus.

From the 1940's through to the early 1990's most of the stress fractures were diagnosed in the foot, mainly in the metatarsals and calcaneus (Hullinger, 1944; Pester & Smith, 1992). During this period, stress fracture incidences in the lower leg, although reported, where not the most common. Studies ranging from the late 1980's through to the present, have reported a greater number of stress fractures in the leg. Stress fractures in the pelvis have also been reported especially amongst the female recruits (Wood & Krüger., 2007).

2.8 RISK FACTORS

Risk factors in exercise and sport-related injuries, including stress fractures, are commonly categorized as intrinsic or extrinsic (Jones *et al.*, 2002). Intrinsic factors are the characteristics of the individual sport or exercise participant, and include demographic characteristics, anatomic factors, bone characteristics, physical fitness and health risk behaviors. Extrinsic risk factors are factors in the environment or external to the individual participant, that influence the likelihood of being injured, such as equipment used or type of sport. Figure 2.4 reflects common intrinsic and extrinsic risk factors for which stress fracture research was identified.

Figure 2.4: Identified intrinsic and extrinsic risk factors within the stress fracture literature



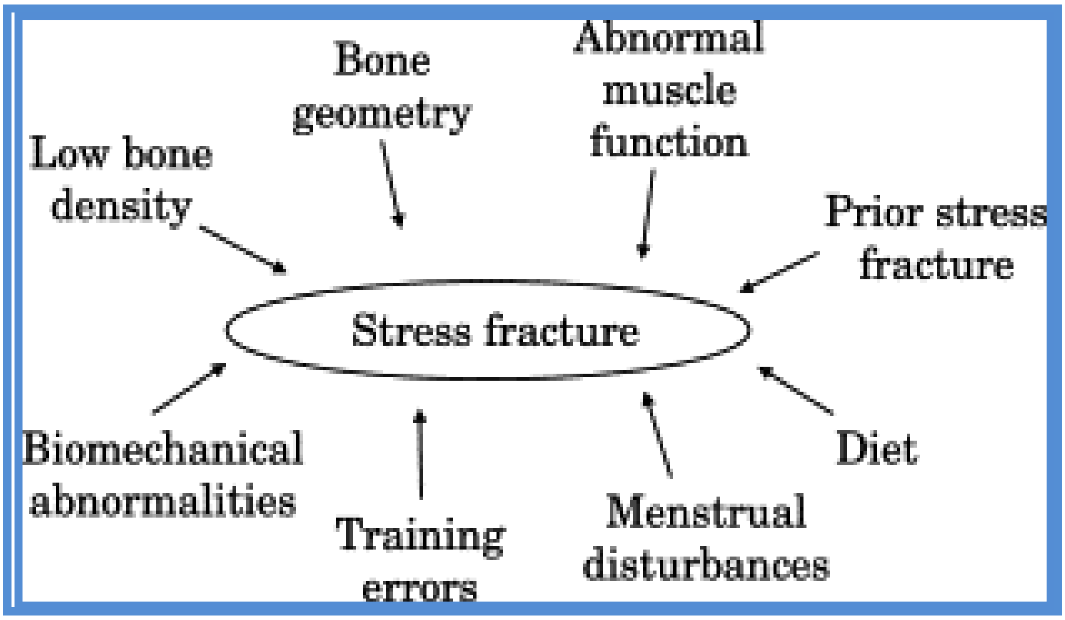


Figure 2.5: Factors that can influence the risk of stress fractures

2.8.1 Intrinsic risk factors

The reviewed studies that generate interest because of their obvious potential application to prevention of stress fractures, are those that look at the potentially modifiable intrinsic risk factors, such as physical fitness, sedentary lifestyle behaviours, or oral contraceptive use. However, possible unchangeable risk factors, such as sex, age, or race, should not be overlooked. These may influence the degree of risk for persons engaged in exercise, sports, or military training as well as play an important role when drawing up a study design and analysis (Jones *et al.*, 2002).

2.8.1.1 Demographic characteristics

2.8.1.1.1 Sex

Amongst demographic factors, the female sex is the most commonly identified intrinsic risk factor for stress fractures (Proztman & Griffis, 1977; Reinker &

Ozbourne, 1979; Kowal, 1980; Brudvig *et al.,* 1983; Lloyd *et al.*, 1986; Barrow & Saha, 1988; Zahger *et al.*, 1988; Brunet *et al.*, 1990; Myburgh *et al.*, 1990; Friedl *et al.*, 1992; Jones *et al.,* 1993a; Goldberg & Pecora, 1994; Bennell *et al.*, 1996; Bijur *et al.*, 1997; MacLeod *et al.*, 1999; Beck *et al.,* 2000; Bell *et al.,* 2000; Jones *et al.*, 2002; Shaffer *et al.*, 2006).

Researchers have shown that women performing the same prescribed physical activities as men during BT, incur stress fractures at incidences 2–10 times higher than those of men (Proztman & Griffis, 1977; Reinker & Ozbourne, 1979; Kowal, 1980; Brudvig *et al.,* 1983; Jones *et al.*, 1993a; Bijur *et al.*, 1997; MacLeod *et al.*, 1999; Armstrong *et al.*, 2004). Bell *et al.* (2000) found that although the crude injury rates indicated that women were at higher risk of injury than men, when the injury rates were adjusted for fitness, no significant difference existed between the two sexes. It therefore appears that much of the relationship between the injury and the sex of the individual may be explained by physical fitness, in particular, aerobic fitness, as opposed to the sex of the individual per se.

Investigation examining risk factors have suggested that this higher incidence of stress fractures in young women may be secondary to decreased BMD associated with eating disorders and irregular menses (Black, 1982; Myburgh *et al.;* 1990; Milgrom *et al.,* 1991). Studies of female runners with amenorrhea and irregular menses have shown greater risks of stress fractures. A retrospective review of medical records for 207 female collegiate athletes found that women with a history of menstrual irregularity experienced an incidence of stress fracture 3.3 times higher than that of women with regular menses (Lloyd *et al.*, 1986).

A survey conducted by Barrow and Saha (1988) on 241 female collegiate distance runners, reported that prevalences of stress fractures among female distance runners with very irregular and irregular menses were 1.3 and 1.7 times higher, respectively, than the prevalence among women with regular menstruation. A study of female college athletes found that seven of 25 women with cases of stress fractures had a history of menstrual irregularity, whilst none of the 25 uninjured controls had such a history (Myburgh *et al.*; 1990). A survey of 1,630 women in the US Army showed that those with a history of amenorrhea lasting more than 6 months were more likely to have experienced one or more stress fractures in their lifetime (Friedl *et al.*; 1992).

While studies, both of civilians and military groups strongly suggest that such an association exists, Armstrong *et al.* (2004) found no significant difference between female participants and female controls in terms of age at menarche onset or the number of reported menstrual periods in the previous 12 months.

2.8.1.1.2 Chronological age

Several military studies have examined the association of older chronological age with a higher risk of stress fractures (Brudvig *et al.,* 1983; Tomlinson *et al.,* 1987; Gardner *et al.*, 1988; Knapik *et al.,* 1993; Jones *et al.,* 1993b; Shaffer *et al.,* 1999a). The data is contradictory with respect to chronological age as a risk factor of stress fractures. Studies in military recruits have had conflicting results as to whether recruits in their late 20's and early 30's are at an increased risk for stress fractures compared to their younger counterparts (Brudvig *et al.,* 1983; Gardner *et al.*, 1988; Milgrom *et al.*, 1994).

Investigation of 15,994 male and 4,428 female Army trainees found that rates of stress fractures during eight weeks of Army BT were significantly higher for successively older chronological age groups (Brudvig *et al.,* 1983). Amongst 3,000 male Marine recruits, during 12 weeks of BT, the cumulative incidence of stress fracture was found to be 1.7 times higher in men over the chronological age of 21 years (Gardner *et al.*, 1988). A separate study of 1,296 male Marine recruits demonstrated a relative hazard of 1.07 per year of greater chronological age, after data was controlled for potentially confounding factors such as race, physical fitness, and physical activity level (Shaffer *et al.,* 1999a). The military studies reviewed indicated that older chronological age may heighten the risk of stress fractures, starting at an early chronological age, and that chronological age should be adjusted for when other risk factors are being assessed.

According to Snyder *et al.* (2006), the distribution of fractures among chronological age groups is more likely to be associated with training volume and intensity than with the chronological ages of the participants. There are no studies in athletes that suggest an independent effect of chronological age on the occurrence of stress fractures. Recently, Maquirriain and Ghisi (2006) found that the stress fracture incidence was significantly higher in male junior tennis players (20.3%) than in professional players (7.5%). They concluded that there was a high absolute risk (12.9%) of stress fractures in elite tennis players over a two year period with junior players having the highest risk.

2.8.1.1.3 Race

Several military studies have examined race as a potential risk factor for stress fractures (Brudvig *et al.,* 1983; Barrow & Saha, 1988; Gardner *et al.,* 1988; Jones *et al.* 1989; Friedl *et al.*, 1992; Milgrom *et al.,* 1994; Shaffer *et al.*, 1999a; Kelly *et al.*, 2000; Lappe *et al.,* 2001; Shaffer *et al.*, 2006).

Brudvig *et al.* (1983) documented that during eight weeks of BT, the cumulative incidence of stress fractures was higher for Caucasian male Army trainees (1.1%) than for African (0.6%) or other Non-White (0.1%) trainees. In this study, Caucasian female trainees during BT had the highest stress fracture rates of any group — 11.8%, compared to 1.4% for African women and 4.3% for other Non-White women.

Gardner *et al.* (1988) showed, in a study of more than 3,000 male Marine recruits followed during eleven weeks of BT, that Caucasian recruits experienced 2.5

times as many stress fractures as Non-White recruits. Friedl *et al.* (1992) conducted a survey of 1,630 women in the Army and found that the lifetime prevalence of self-reported stress fractures among Caucasian or Asian women was 1.6 times higher than that of African women.

Additionally in the Israeli Army, there was a significant difference in the stress-fracture incidence when Ethiopian recruits were compared with both Israeli-born and non-Israeli-born recruits. None of the Ethiopians sustained a stress fracture, in contrast to 24.8% of the other racial groups (Milgrom *et al.,* 1994).

On the contrary Winfield *et al.* (1997) found no significant difference between three racial groups (Caucasians, Africans and others) and their 101 female Marine Corp recruits. However, it must be noted that in this study, only nine stress fractures were sustained overall and the numbers in the Non-White groups were small. Additionally, Shaffer *et al.* (1999b) found no significant differences between Caucasian and Non-White racial groups after a multivariate analysis of data from 1,296 male Marine recruits that controlled for age, physical fitness, physical activity level, and other factors.

Shaffer *et al.* (2006) not only found that the lowest rates of stress fractures were among African women undergoing military training, but also that the Hispanic women were twice more likely to suffer a stress fracture than African women. Kelly *et al.* (2000) observed that Hispanic Navy female recruits had a significantly higher incidence of pelvic stress fractures than do African Navy female recruits. Shaffer *et al.* (2006) also observed a higher incidence rate of stress fractures amongst Asian and Caucasian women when compared to African women, but these rates were not statistically significant.

In the sporting world, a survey of female collegiate distance runners documented that Caucasian runners had a higher career prevalence of stress fractures (diagnosed by radiograph or bone scan) This prevalence that was 2.4 times higher than that of African runners and 1.9 times higher than that of other Non-White runners (Barrow & Saha, 1988). Although the study had a low response rate, the results suggest that the Caucasian race may be a risk factor among both collegiate athletes as well as among military personnel.

Generally, these military studies suggest that risk for stress fractures is greater for both male and female Caucasians than for other racial groups, including Afro-Americans, Hispanics and Ethiopians (Brukner *et al.,* 1999). Although the literature strongly suggests that Africans and Hispanics are less likely to develop stress fractures, the reasons for this are not clear. Even though it has been surmised that in these racial groups, protection may be offered in the form of higher bone density and larger bones, none of the studies have included bone mass or bone geometry as covariates during statistical analysis in order to evaluate the independent effects of race (Kelly *et al.,* 2000; Bennell & Brukner, 2005).

Lappe *et al.* (2001) found the incidence rate of stress fractures to be higher in Caucasians than in Africans. And this risk remained even when it was adjusted for Speed Of Sound (SOS) to account for the higher bone mass of the Africans compared to the other race groups.

Additional explanations for the increase protection offered to the African race include different biomechanical features that may protect against stress fracture development such as foot type and lower limb alignment, or anthropometrical features such as the amount of lean body mass (Giladi *et al.,* 1991; Shaffer *et al.,* 2006).

2.8.1.2 Anatomic factors

A few studies have obtained prospective data on anatomic factors that potentially could influence the risk of stress fractures. These anatomic factors can also be viewed as biomechanical factors as they are surmised to be those characteristics that alter the biomechanics of a movement and in this way, create stress-concentration areas in bone or promote muscle fatigue - possibly predisposing the individual to the development of a stress fracture (Hall, 2003). The biomechanical parameters studied include foot morphology, the Q angle and the discrepancy in leg length.

2.8.1.2.1 Foot morphology

The foot's structure will help determine how much force is absorbed by the foot and how much force is transferred to bone during ground contact. The high - arch foot (pes cavus) is more rigid and less able to absorb shock, so more force passes to the tibia and femur. The low-arch (pes planus) foot is more flexible, as stress is absorbed by the foot's musculoskeletal structures. This type of foot is also less stable during weight bearing and as the muscles have to work harder in order to control the excessive motion. This is surmised to contribute to muscle fatigue. Theoretically either foot type could predispose a person to a stress fracture (Brukner *et al.,* 1999).

The studies in which the link between foot morphology and stress fractures were investigated are summarized in Table 2.5. From the table it appears that that the risk for stress fractures is greater in male recruits who have a high foot arch than in males with a low foot arch (Giladi *et al.,* 1985; Simkin *et al.,* 1989; Brosh & Arcan, 1994; Kaufmann *et al.,* 1999). Giladi *et al.* (1985) found that among 287 Israeli Defense Force (IDF) trainees, persons with the highest foot arches sustained 3.9 times as many stress fractures as those with the lowest arches (pes planus or flat feet) (95% CI: 1.02, 15.38). These finding were supported by the Brosh and Arcan (1994) study in which a contact pressure display method was used to provide foot-ground pressure patterns and derived stress-intensity parameters. This study found that recruits with a high - arch were more likely to have sustained a stress fracture than recruits who had a low - arch.

Table 2.5: Studies that have investigated the association between foot morphology and stress fractures

Reference	Participants	Sample size	Sex	Measurement method	Results
Giladi *et al.*, 1985	Army-Israel	295	Males	Observation-NWB	SF risk greater in high - arch than in low - arch
Matheson *et al.* 1987	Athletes	320	Males	NS	Pronated - tibial and tarsal SF; Cavus - metatarsal and femoral F
Montgomery *et al.*, 1989	SEAL- US	505	Males	Observation-NWB	No relationship to SF
Simkin *et al.*, 1989	Army-Israel	295	Males	X-ray-WB	High – arch - higher risk for femoral and tibial SF Low - arch - higher risk for metatarsal SF
Brunet *et al.* 1990	Athletes	375 1130	Females Males	Self-report questionnaire	No relationship to SF
Brosh & Arcan. 1994	NS	42	Males	Contact - pressure display	High – arches - higher risk of SF
Ekenmann *et al.* 1996	Athletes	29 29	Males Females	Contact pressure during gait	No relationship to SF
Bennel *et al.*, 1996	Athletes	53 58	Females Males	Observation - WB	No relationship to SF
Kaufman *et al.*, 1999	US Navy	449	Males	Observation - WB	No relationship to SF
Constantini *et al.*, 2004	Army-Israel	83	Females	Observation - WB & footprints	No relationship to SF

In contrast, the association between foot type and stress fracture risk has not been reported in all studies investigating this association (Montgomery *et al.,* 1989; Bennel *et al.,* 1996; Ekenmann *et al.,* 1996; Kaufmann *et al.,* 1999). Montgomery *et al.* (1989) found that the incidence of stress fractures was similar in recruits who had cavus, neutral or plantus feet. Additionally, Kaufmann *et al.* (1999) conducted a 25-week prospective study on 449 trainees at the US Naval Special Warfare Training Center, who were classified into three equal-sized groups with high, normal, or low arch height, but found no significant difference between groups. In athletes it appears that foot type, whether assessed visually (Bennel *et al.,* 1996) or with the use of a pressure platform (Ekenmann *et al.,* 1996), is not a predictor of the likelihood of stress fractures.

However, the site of the stress fracture may play a role in the relationship between the foot type and incidence of stress fractures. Simkin *et al.* (1989) found, through the use of radiographs, that femoral and tibial stress fractures were more prevalent when higher arches were present, whilst higher incidences of metatarsal stress fractures were found in recruits with a lower arch. Additionally, researchers may fail to prove an association between specific foot types and stress fractures, because they have not grouped the data according to site of the stress fracture (Brukner *et al.,* 1999).

Available research suggests that foot arch height may influence the risk of incurring stress fractures associated with vigorous PT, but more research will be needed to define the nature of the association between arch type and stress fracture risk, particularly for women.

2.8.1.2.2. Genu varum, genu valgum and genu recurvatum

Other alignment features that have been assessed in relation to stress fractures include the presence of genu varum, genu valgum and genucurvatum. The majority of research assessing this relationship has not found any association with stress fractures (Giladi *et al.,* 1987; Matheson *et al.,* 1987; Montgomery *et al.,* 1989; Milgrom *et al.,* 1994; Bennell *et al.,* 1996). However, a prospective study of 294 male infantry recruits demonstrated a significant trend in stress fracture risk, increasing from persons with varus knees (bowed legs) to persons with the most valgus knees (knock-knees) (Cowan *et al.,* 1996). Additional research, that includes women, on knee morphology and leg alignment is needed.

2.8.1.2.3 Q angle

A second measure of knee alignment, namely, Quadriceps angle or Q angle, showed that male recruits with quadricep angles greater than 15° experienced a cumulative incidence of stress fracture 4.3 times higher than that of male recruits with quadricep angles of 10° or less (Cowan *et al.,* 1996). An analysis of the data obtained on 392 male trainees showed that greater valgus alignment of the knee was a significant risk factor for tibial stress fractures (Finestone *et al.,* 1991). A need exists for further study on this anatomic characteristic in women trainees. The exact degrees of anatomic malalignment will depend on the amount and intensity of training (Cowan *et al.,* 1996).Conversely, in other studies, no relationship has been found between Q angle and stress fracture occurrence (Montgomery *et al.,* 1989; Winfield *et al.*, 1997).

2.8.1.2.4 Leg - length

A leg - length discrepancy is theoretically postulated as a potential risk factor for stress fractures. As a result of the ensuing skeletal realignment and asymmetries in loading, body tortion, and muscle contraction, a leg length discrepancy is theoretically postulated as a potential risk factor for stress fractures (Ammann & Rizzoli, 2003). The majority of studies assessing the association between differences in right and left leg length and risk of stress fracture do suggest an association (Friberg, 1982; Brunet *et al.,* 1990; Bennell *et al.,* 1996).

Friberg (1982) found that in 130 cases of stress fractures in military male recruits, the longer leg was associated with 73% of tibial, metatarsal, and femoral stress fractures, whereas 60% of fibular fractures were found in the shorter leg. Similar findings have been reported in a cross-sectional survey of distance runners which found that the self-reported prevalence of stress fractures was 2.4 times higher amongst men reporting leg length differences, than amongst men without them. Amongst women with leg length differences, the prevalence was 2.3 times higher (Brunet *et al.,* 1990). Additionally, Bennell *et al.* (1996) found that 70% of the women who developed a stress fracture had a leg - length difference of more than 0.5 centimeters (measured in a supine position with a tape measure), compared with 36% of the women who did not have a stress fracture. Contrarily, in a study of 294 Army trainees, no difference in stress fracture incidence was found between persons with measured leg length discrepancies and persons without them (Cowan *et al.,* 1996).

2.8.1.3 Bone characteristics

A number of military and civilian studies have examined the relation between bone characteristics (geometry or density) and the occurrence of stress fractures (Margulies *et al.,* 1986; Milgrom *et al.,* 1988; Milgrom *et al.,* 1989; Pouilles *et al.,* 1989; Carbon *et al.,* 1990; Giladi *et al.,* 1991; Grimston *et al.,* 1991; Beck *et al.,* 1996; Beck *et al.,* 2000; Jones *et al.,*2002). Bone strength is related to both bone density as well as to bone geometry (Brukner *et al.,* 1999; Ducher *et al.,* 2006).

2.8.1.3.1 Bone density

Studies in which the relationship between bone density and stress fracture risk were investigated are contradictory. Several reasons for this have been documented, namely: differences in populations (military or athlete), types of sport, measurement techniques and bone regions under study. Another concern in interpretation of the data is that normally only lumbar spine, radius and/or proximal femur measurements are taken but ideally, to provide evidence for a causal relationship between low bone density and stress fracture, measurements should be taken at bone sites in which stress fractures occur. Unfortunately the prospective cohort study designs do not always make this possible.

With reference to men, contradictory evidence exists to support a causal relationship between bone density and risk of stress fractures. In 91 recruits who developed a stress fracture and in 198 controls no difference was found between their tibial bone densities (Giladi *et al.,* 1991). This finding was echoed in studies by Bennell *et al. (*1996). However, Beck *et al.* (1996) found significantly lower tibial and femoral bone density in 23 male recruits who developed a stress fracture compared to 587 controls who did not. This result may be flawed as the fractured recruits' weight, which was 11% less than the controls, was not statistically controlled for. Since weight is a major predictor of bone density, the groups should have been matched with reference to their weight or the weight should have been statistically controlled for.

Beck *et al.* (2000) conducted another prospective study of 693 female Marine recruits and 626 male Marine recruits and found that those with stress fractures had significantly lower mean bone mineral densities and narrower tibial widths than their controls. Another study reported that BMD was significantly lower among 41 stress fracture patients than among 48 recruits from the same units (matched for age, height, and weight), and that mean bone mineral content (BMC) increased significantly during 12 weeks of military training among 35 uninjured recruits (Pouilles *et al.,* 1989). Marguiles *et al.* (1986) found that mean BMC increased significantly, during fourteen weeks of BT, for both the 105 persons whose training was interrupted by stress fractures and other conditions, and the 144 persons who completed training. However, tibial bone width did not increase. The mean BMC of participants (with stress fractures) in these studies, was lower before training than that of persons who completed the training, but not significantly so.

The results of several of the military studies on BMD, bone width, and other bone parameters would have been much more meaningful and powerful if the investigators had determined the risk or incidence of stress fractures in recruits exhibiting different levels of bone strength (Jones *et al.,* 2002). Nevertheless, an association between lower measures of bone strength and higher risk of stress fractures is strongly suggested by these studies.

Results of civilian studies on the relation between stress fractures and BMD amongst athletes are mixed. Carbon *et al.* (1990) examined nine female athletes with stress fractures and compared to their nine controls, found no differences in mean BMD. Grimston *et al.* (1991) however reported that six female runners with a history of stress fractures had higher mean bone mineral densities in the lumbar spine and femoral neck than eight runners without stress fractures.

2.8.1.3.2 Bone geometry

When bones are loaded in tension or compression, several geometric measurements of lower limb bones (femur, tibia, fibula) provide potential resistance to injury. These measures include:

- the cross-sectional area of long bones - an indicator of the axial strength and resistance to compressive and shear forces;
- the Cross-Sectional Moment Of Inertia (CSMI) - a measure of bones' resistance to bending along either the anterior-posterior axis or the mediolateral axis of the bone;
- the section modulus; and
- BMD and bone width (Jones *et al.,* 2002).

The amount of load the bone can withstand before failing is directly proportional to the cross-sectional area of the bone (Brukner *et al.,* 1999). Bones that have a larger cross-sectional area and in which bone tissue is distributed further away from the neural axis, will be stronger when subjected to a load and will be less likely to fracture (Buckwalter *et al.,* 1995; Hall, 2003; Greene *et al.,* 2005). The strength in bending of the long bone shaft to bending and torsional stresses should be proportional to its section modulus and inversely related to its length.

> *"Current studies show that, independent of body size, those who suffer stress fractures, in both genders, have smaller section moduli in the femur and tibia. Additionally, when section moduli are normalized to bone length in the strength indices, values remain 7% lower in cases of both men and women and in both bones when compared to controls" (Beck et al., 2000: 441).*

These findings are consistent with previous studies (Giladi *et al.,* 1987; Milgrom *et al.,* 1989; Beck *et al.,* 1996; Giladi *et al.,* 1997).

A prospective study performed on 295 Infantry trainees reported that 31% developed 184 stress fractures confirmed by bone scans (Milgrom *et al.,* 1988). A multivariate analysis identified the anterior-to-posterior axis of the CSMI to be the variable most highly associated with stress fracture occurrence. In a follow-up analysis of this data, cumulative incidences of tibial, femoral and total stress fractures were found to be significantly higher in the low-CSMI group, with risk ratios 1.8–3.6 times higher than those in the high-CSMI group (Milgrom *et al.,* 1989). The fact that Army trainees with high tibial CSMIs around the anterior-posterior axis experienced a lower incidence of stress fracture, suggests that bending in the mediolateral direction is a cause of stress fractures (Milgrom *et al.,* 1988; Milgrom *et al.,* 1989). This may also explain why the most common location of tibial stress fractures is the medial cortex (Jones *et al.,* 2002).

Similarly, in a prospective study of 626 male Marine recruits conducted during 12 weeks of BT, 3.7% developed stress fractures, confirmed by bone scans.

Investigators found that mean values for the cross-sectional area, the section modulus, smaller moment of inertia and the width of the tibia, were significantly lower among trainees who developed stress fractures (Beck *et al.,* 1996). Additionally,

> "**…***the smaller dimensions were limited to the long-bone diaphyses, not joint size, which suggest specificity in the structural deficit in the fracture group. Evidence exists that compared with joint size, diaphyseal cross-sectional dimensions are more environmentally influenced. This could indicate that the stress fracture group's bones had not been sufficiently loaded before Basic Training in order to develop cortices strong enough to withstand the subsequent stresses. In military recruits who are subjected to intense, unaccustomed physical activity, the presence of smaller and weaker bones may lead to a higher rate of bone microdamage. If there is inadequate time for adaptive cortical remodeling to occur, a stress fracture could result"* (Brukner *et al.,* 1999:53-54).

2.8.1.4 Physical fitness

Total fitness, also termed wellness, includes mental, emotional, social and physical aspects. It is a broad term denoting dynamic qualities that allow one to satisfy needs regarding mental and emotional stability, social consciousness and adaptability, spirituality and physical health (Weaver *et al.*, 2001).

Physical fitness can be defined as the healthy and efficient functioning of various body systems that allows one to engage in activities of daily living, recreation and leisure. Important components of health-related physical fitness include cardiorespiratory endurance (aerobic physical fitness), muscular strength, muscular endurance, flexibility and body composition (Jones *et al.*, 1999).

Within the military setting, recruit physical fitness is assessed through a standardised physical fitness test. These physical fitness tests differ from country to country and between service corps; however, they are all comprised of a combination of muscle endurance and aerobic fitness tests, such as 2,4km run, maximal push-ups and sit-ups in two minutes, shuttle runs and 4km walk

(Gordon *et al.*, 1986a; Gordon *et al.*, 1986b; Shaffer *et al.*, 1999a; Beck *et al.*, 2000; Bell *et al.*, 2000; Rosendal *et al.*, 2003; Knapik *et al.*, 2005; Dyrstad *et al.,* 2006).

Two methodologies have been utilised to assess the correlation between lack of prior physical activity and/or poor physical conditioning, with the incidence of stress fractures. The first is through the use of questionnaires where the participants report on past and current levels of activity (Montgomery *et al.*, 1989; Gardner *et al.*, 1988; Cline *et al.,* 1998). The second method is comprised of various aerobic fitness tests which indirectly measure the fitness component. Cardiorespiratory endurance is typically measured indirectly by a timed run, where predicted VO_2 max is then calculated; muscle strength and endurance is often measured in the number of sit-ups, push-ups and pull-ups in a specific time frame; flexibility is often assessed using the sit-and-reach method or various goniometric measurements of joints, whilst the body composition is assessed using the skin fold method or DEXA (Jones *et al.,* 1993a; Bijur *et al.,* 1997; Beck *et al.,* 2000; Bell *et al.*, 2000; Knapik *et al.*, 2001;Jones *et al.*, 2002; Rauh *et al.,* 2006; Shaffer *et al.*, 2006).

Some military studies have reported a correlation between self-reported previous physical activity levels and rate of stress fracture during BT, while others have failed to corroborate a relationship. Montgomery *et al.* (1989) found that male trainees, with a running history averaging at least 25 miles per week in the previous year, had a lower incidence of stress fractures (3%) than trainees averaging less than 4 miles per week (11.5%). Similarly, Gardner *et al.* (1988) found the stress fracture rate to be 24 times greater in the previously inactive group than in the very active group. In a prospective cohort study in female US Marines, those who reported running less than 2.8 miles per session, had a 16.3% incidence of stress fractures during BT compared with 3.8%, who ran more than 2.8 miles per session (Winfield *et al.*, 1997).

In a study of female US military recruits, the authors reported that higher leisure activity energy expenditure tended to be associated with a lower stress fracture risk ($p = 0.06$) (Cline *et al.,* 1998). Similarly, Shaffer *et al.* (1999a) revealed, with the use of an algorithm of five physical activity questions and a 2.4km run time, that 21.6% of 'high risk' individuals experienced more than three times as many stress fractures as 'low risk' individuals. This suggests that the risk of stress fractures is increased by poor physical fitness and low levels of physical activity prior to entering into recruit training.

2.8.1.4.1 Aerobic physical fitness

The most consistently documented risk factor for injuries in US Army studies is low cardiorespiratory endurance, measured by running performance. Both men and women with increasingly low running time, indicate trends of increasing risk of injury (Jones *et al.,* 1993a; Bijur *et al.,* 1997; Shaffer *et al.*, 1999a; Beck *et al.*, 2000; Bell *et al.*, 2000; Jones *et al.*, 2002; Rauh *et al.,* 2006; Rosendal *et al.*, 2003; Knapik *et al.*, 2005; Shaffer *et al.,* 2006). Stress fractures were included amongst the injuries documented, however the link between poor aerobic fitness and stress fracture development was unclear as some studies showed a clear association whilst others did not (Brukner *et al.,* 1999).

The majority of recent researchers tend to suggest that physical fitness or prior physical activity may be a predictor of stress fracture risk in individuals undergoing BT. A study of 1,078 Marine recruits found that lower aerobic fitness, as measured by longer running time on a 1.5 mile (2.4 km) run, was strongly associated with higher cumulative incidence of bonescan or radiographically confirmed stress fractures. Shaffer *et al.* (2006) reaffirmed this in a study that found that low aerobic fitness, as measured by the timed run, was strongly associated with consequent stress fracture injury. As the running time increased (slower runners), the risk of stress fractures increased.

This finding was consistent with three other studies that reported that slower run times were associated with greater risks of lower extremity injury amongst women undergoing military training (Jones *et al.,* 1993a; Bijur *et al.,* 1997; Bell *et al.,* 2000). Jones *et al.* (1993a) reported than in female Army recruits, the slower half of women on an initial entry one mile (1.6 km) run test, experienced significantly more clinically identified stress fractures than the faster women. In the same study, investigators observed that amongst male Army trainees in the slower half of the initial entry one mile run test, 4.8% developed stress fractures as compared to none of the faster recruits.

It seems logical that low aerobic fitness, as measured by a timed run, would be associated with a higher risk of injury during military training. Recruits must repeatedly perform activities such as walking, marching or running, which might increase overuse mechanisms of the musculoskeletal system. Those who are more aerobically fit, may be protected from injury as they may have performed similar types of activities that allowed the body to adapt to the increasingly intense demands on the musculoskeletal system that occur during military training (Shaffer *et al.,* 2006).

A low running distance per week has also been associated with an increase in stress fracture incidence. A study of female Marine Corps officer candidates, who ran 4.5 or fewer kilometers per week before entering officer training, had a higher incidence of stress fractures (Windfield *et al.,* 1997). This finding is similar to that of a study of women undergoing BT that did not run, or reported running less than a mean of 2.4km per run, prior to the start of BT. Because of this, they had an increased risk of overall stress fractures (Shaffer *et al.,* 2006).

Conversely, in a large study of 295 male recruits aged 18 to 20 years neither aerobic fitness, measured by calculating the predicted VO_2 max, nor self-reported pre-training participation in sport activities was related to stress fractures (Swissa *et al.,* 1989). This lack of association was confirmed in other large studies of male recruits (Giladi *et al.,* 1991; Hoffman *et al.,* 1999).

Poor physical conditioning does not seem to apply to athletes, as stress fractures often occur in well conditioned individuals who have been training for years (Välimäki *et al.,* 2005). Although the data is conflicting, low levels of aerobic fitness before BT have been consistently identified as a risk factor amongst women (Jones *et al.,* 1993a; Winfield *et al.,* 1997; Bell *et al.,* 2000; Shaffer *et al.,* 2006). As baseline fitness is a modifiable factor it is an area which requires more attention. Shaffer *et al.* (2006) suggest that objective measures, such as run time, previous aerobic and high activity levels, are consistent in predicting stress fractures during military training for both male and female soldiers.

2.8.1.4.2 Muscle strength and muscle endurance

Although the effect of muscle strength and endurance on injury rates and risks has been well documented, the effect of muscle strength and endurance on injury rates and stress fracture risk in military and athletic populations, has not been the subject of intensive study (Jones & Knapik*,* 1999; Jones *et al,* 2002).

Research on 289 Israeli infantry trainees found that persons who developed stress fractures performed fewer leg thrusts on a timed test, indicating lower muscle endurance (Giladi *et al.,* 1991). An investigation conducted by Beck *et al.* (2000) on 626 male and 693 female Marine recruits found that male and female recruits who sustained stress fractures, performed lower mean numbers of sit-ups on a timed test, indicating lower muscle strength and endurance.

Muscle fatigue is a likely contributor to stress fractures in military recruits (Burr, 1997; Beck *et al.,* 2000; Jones *et al.,* 2002; Armstrong *et al.,* 2004). Muscle fatigue and the resulting increased bone strain, may contribute to stress fracture injury after daily strenuous exercise. Thus, fatigue in the musculature of the lower leg is consistent with the observed incidence of stress fracture and ankle sprain injury in military recruits undergoing rigorous BT (Almeida *et al.,* 1999; Beck *et al.,* 2000; Armstrong *et al.,* 2004). Additionally, significantly smaller thigh girths were reported in recruits who developed stress fractures than those who did not (Beck *et al.,* 2000; Armstrong *et al.,* 2004). In another study, six female runners who had sustained stress fractures, exhibited higher impact and propulsive forces on a force plate than did eight runners who did not have stress fractures (Grimston *et al.,* 1991).

This provides evidence that leg muscles in fracture participants are less likely to generate enough force to protect bone from unnecessary bending (Beck *et al.,* 2000; Armstrong *et al.,* 2004). This finding is supported, in part, by the fact that male participants performed 25 fewer push-ups than the male controls did an indication of lower whole body muscular strength and endurance in the injured male recruits (Armstrong *et al.,* 2004). The effect of muscle strength and endurance on stress fracture risk in military and athletic populations needs further study.

2.8.1.4.3 Flexibility

Flexibility of muscles and joints may directly influence stress fracture risk by altering the forces applied to bone. Numerous variables have been assessed, including range of rear-foot inversion-eversion, ankle plantarflexion-dorsiflexion, knee extension-flexion and hip rotation-extension, together with length of calf muscles, hamstring muscles, quadriceps muscles, hip adductor muscles and hip flexor muscles (Brukner *et al.,* 1999).

Of the variables, only hip external-rotation and ankle dorsiflexion range of motion have been associated, albeit inconsistently, with stress fracture development (Hughes, 1985; Giladi *et al.,* 1987; Giladi *et al.,* 1991; Milgrom *et al.,* 1994).

An Israeli study prospectively assessed hip range of motion among 289 Israeli infantry trainees, of whom 89 subsequently developed stress fractures (Giladi *et al.,* 1987; Giladi *et al.,* 1991). Recruits with external rotation of the hip greater than 65°, experienced an incidence of stress fracture 1.8 times higher than that of recruits with lower degrees of rotation (Giladi *et al.,* 1987). Hip range of motion persisted as a risk factor in a multivariate analysis of the data (Giladi *et al.,* 1991). The risk for tibial stress fracture increased 2% for every 1° increase in hip external-rotation range. However, in three prospective studies, these findings failed to be confirmed (Montgomery *et al.,* 1989; Bennell *et al.,* 1996; Kaufmann *et al.,* 1999). It is possible that the Israeli recruits represent a separate population as their average hip external-rotation range was much higher than that reported by other populations (Brukner *et al.,* 1999).

Hughes (1985) found that restricted ankle-joint dorsiflexion was related to an increased risk of metatarsal stress fractures. The recruits who had a reduced range were 4.6 times more likely to develop a metatarsal stress fracture. Conversely, two studies of more than 400 Navy Special Warfare trainees investigated the association of several measures of lower extremity flexibility, including plantarflexion-dorsiflexion, with stress fractures. Neither found associations between these variables (Montgomery *et al.,* 1989; Kaufmann *et al.,* 1999). This may be because the data was analysed for all stress fracture sites combined, thereby masking a true relationship (Brukner *et al.,* 1999).

The difficulty involved in assessing the role of muscle and joint flexibility in stress fractures, may be related to a number of factors, including the relative imprecise measurement methods, the heterogeneity of these variables and the fact that both increased and decreased flexibility may contribute (Brukner *et al.,* 1999).

According to Shaffer and Uhl (2006), lower extremity stretching before training does not offer a protective effect from stress fractures or reactions. Studies involving stretching concluded that pre-exercise stretching did not reduce the incidence of muscle soreness or lower extremity injuries, including stress fractures, in young active adults involved in running and marching (Yeung & Yeung, 2001; Herbert & Gabriel, 2002). This raises questions about the efficacy of pre-exercise stretching for the prevention of lower extremity injuries, including stress fractures.

2.8.1.5 Body size and composition

Theoretically, body size and soft-tissue composition could affect stress fracture risk both directly, by influencing the forces applied to the bones and indirectly by influencing bone density or menstrual function (Brukner *et al.,* 1999). Various potential risk factors related to body size and composition have been investigated including height, weight, skinfold thickness, Body-Mass Index (BMI), total and regional lean mass and fat mass, limb and segment lengths and body girths and widths. Simple anthropometric techniques have usually been used as measurement tools, however, DEXA is being used with more frequency (despite its cost) due to its high accuracy rate.

Among the athletic population, the role of body-habitus variables has been evaluated, but no researchers have reported differences in height, weight, BMI or fat mass for athletes who have sustained a stress fracture, compared to their matched controls (Barrow & Saha, 1988; Bennell *et al.,* 1996).Failure to show an association may be due to the fact that athletes who play a specific sport tend to be homogenous in body composition and somatotype (Brukner *et al.,* 1999).

In military populations, body size may be a risk factor as the size variations amongst recruits are likely to be greater than those amongst athletes. A few military studies have investigated the relation between the occurrences of stress fractures and body composition and body stature.

BMI has been both directly and inversely associated with stress fracture rates (Zanker & Cooke, 2004). Discrepancies in the literature occur, in part, because of the operational definition of BMI and its application. In studies in which a high BMI has been linked with an increased risk for stress fractures, it is tied to poor physical conditioning (Jones *et al.,* 1993a). In contrast, Drinkwater *et al.* (1986) reported that weight gain - and a resultant increase in BMI - increases BMD and resumption of menses.

A number of prospectively measured indicators of body stature, including weight, height, neck girth, waist girth, thigh girth and calf girth, were found smaller among 23 Marine recruits, who developed stress fractures during 12 weeks of BT than among the 587 recruits who did not develop stress fractures (Beck *et al.,* 1996). BMI (weight (kg)/height (m) ^{2}), a surrogate measure for percentage of body fat, was also significantly lower among stress fracture patients. The authors concluded that "**…***both small body weight and small diaphyseal dimensions relative to body weight are factors predisposing to the development of stress fractures"* (Beck *et al.,* 1996: 645). The researchers surmised that weight packs, and other equipment, were carried regardless of the recruits' body weight. It is also possible that the fracture group's lower BMI was indicative of relatively lower muscle mass and/or poorer physical conditioning before training started.

Similarly, others have reported a risk association between stress fractures and shorter stature (Jones *et al.,* 1993a; Beck *et al.,* 1996), and higher BMI (Lauder *et al.*, 2000).

Conversely, a large study of 392 infantry trainees prospectively assessed height, weight, thigh and calf girths and found no association with stress fracture incidence (Finestone *et al.,* 1991). Similarly, BMI was not significantly associated with the odds of injury in a multivariate analysis of data from another study of Israeli recruits (Giladi *et al.,* 1991). Shaffer *et al.* (2006) also reported no significant association between height, body weight and BMI with stress fracture incidence. Other military studies have also failed to show an association between stress fractures and various parameters of body size (Giladi *et al.,* 1991; Taimela *et al.,* 1990; Winfield *et al.,* 1997; Cline *et al.,* 1998).

Rauh *et al.* (2006) did not show a significant association between height, body weight, or BMI and stress fractures. They did however observe increased, but not significant, trends for stress fractures in those considered overweight and underweight. Their lack of significant findings, however, may be partially due to small numbers of recruits classified as overweight (2.4%) and underweight (7.7%).

Percentage of body fat and BMI could have a bimodal association with injury risk, with both the least "fat" and the most "fat" persons being at greater risk of incurring a stress fracture (Jones *et al.,* 1993a). Therefore, comparisons of mean values for injured and uninjured persons will be especially misleading, as will multivariate analyses that treat BMI as if its association with injury risk were linear.

Acute weight loss was found to be a significant risk factor for stress fracture injuries in both male and female recruits (Armstrong *et al.,* 2004). Whilst, in a study of 2591 Israeli soldiers, those with stress fractures weighed less than the controls (Givon *et al.,* 2000).

In female Marine recruits undergoing BT, a narrow pelvis(widest point from the left to the right side of the iliac crest (≤ 26 cm) was associated with a greater risk of stress fracture (p, 0.09) (Winfield *et al.,* 1997). Women recruits who had a narrow pelvis had a stress fracture incidence of 14% compared to 4% in the women who had a wider pelvis. Thus they had a relative risk of 3.57 greater compared with the 'normals'. An explanation for this finding is not clear, as a wider pelvis has typically been attributed to increased biomechanic stresses through an increased Q angle. However, it is possible that a narrow pelvis in this group of Marines, is a marker for some other risk factor for stress fractures (Brukner *et al.,* 1999).

2.8.1.6 Menstrual disturbances

2.8.1.6.1 Sex hormone

Compared to the general female population, female athletes have a higher prevalence of menstrual disturbances including anovulation, oligomenorrhoea, and delayed onset of menarche, abnormal luteal phase and amenorrhoea (Nattiv *et al.,* 1997). Stress fractures may, in fact, be more frequent in female athletes with menstrual disturbances (Brukner *et al.,* 1999). Menstrual disturbances may also predispose female recruits to stress fractures.

In a study of 101 female Marines, the incidence of stress fractures in those with fewer than 10 periods per year was 37.5% compared with 6.7% in those with 10 to 13 periods per year (Winfield *et al.,* 1997). Similar results, that suggest a history of amenorrhea as a risk factor for stress fractures support these findings (Friedl *et al.,* 1992, Rauh *et al.*, 2005; Rauh *et al.,* 2006; Shaffer *et al.,* 2006). However, Shaffer *et al.* (2006) found that only women who reported no menses during the whole year before commencing with BT had a greater likelihood of stress fracture than did women who reported 10 to 12 menses per year. They also found that female recruits who reported secondary amenorrhoea during the year before training, were at higher risk for pelvic or femoral stress fractures. It suggests that prolonged lack of menses may be a better predictor of stress fracture incidence during a structured military training programme (Rauh *et al.*, 2005; Rauh *et al.,* 2006).

Conversely, Kelly *et al.* (2000) found no association between secondary amenorrhoea and pelvic stress fractures in navy recruits. Cline *et al.* (1998) also found that the menstrual patterns did not differ in a study of 49 female soldiers with stress fractures compared to the 78 soldiers with no orthopaedic injuries, although the number of soldiers, with menstrual disturbances, was relatively low.

The cause for the above may be attributed to lowered estrogen levels resulting in lower bone density, accelerated bone remodeling or negative calcium balance, or the interaction of these variables. Studies have shown lower axial bone density in athletes with amenorrhoea or oligomenorrhoea compared with their eumenorrhoeic counterparts and/or sedentary controls (Drinkwater *et al.,* 1984; Rutherford, 1993; Micklesfield *et al.,* 1995; Tomten *et al.,* 1998).

Estrogen deficiency leads to accelerated bone remodelling. The bone is in a weakened state and hence more likely to accumulate micro damage if subjected to repeated loading, as bone resorption occurs before bone formation during the bone remodeling process. Estrogen loss also causes increased calcium excretion, which can result in a negative calcium balance if dietary calcium is inadequate (Brukner *et al.,* 1999).

2.8.1.6.3 Onset of menarche

The relationship between onset of menarche and risk of stress fracture is unclear. Some authors have found that athletes with stress fractures have a later onset of menarche (Carbon *et al.,* 1990; Bennell *et al.,* 1996), while others have found no relationship (Myburgh *et al.,* 1990; Armstrong *et al.,* 2004). Onset of menarche was an independent risk factor for stress fractures in female track and field athletes, with the risk increasing by a factor of 4.1 for every additional year of age at menarche onset (Bennell *et al.,* 1996). The relationship between onset of menarche and bone density in female athletes is unclear, with some investigators finding significant negative correlations at a number of bone sites (Dhuper *et al.,* 1990; Warren *et al.,* 1991; Robinson *et al.,* 1995) and others not (Myburgh *et al.,* 1990; Rutherford, 1993).

An association between delayed onset of menarche and stress fractures may be explained by a lower rate of bone mineral accretion during adolescence and a resultant decreased peak bone mass (Brukner *et al.,* 1999). A later onset of menarche has also been found in association with menstrual disturbance, decreased body fat or bodyweight, lowered energy intake and excessive pre-menarcheal training (Frisch *et al.,* 1981; Moisan *et al.,* 1990). All of these could feasibly influence stress fracture risk (Brukner *et al.,* 1999).

2.8.1.7 Health risk behaviours

Questionnaires have been used to study associations of injury risks with lifestyle behaviours and habits (eg physical activity and smoking) among military populations (Jones *et al.,* 1999; Popovich *et al.,* 2000; Heir & Eide, 1997 ; Lappe *et al.,* 2001). Questions about levels of physical activity prior to entering the service and the frequency of the activity, have provided important clues on the effect of past activity on current risk of PT related injuries and stress fractures (Jones *et al.,* 1999)

2.8.1.7.1 Lifestyle behaviours

Several military studies have examined the association between previous levels of physical activity and risk of stress fractures during military training (Gardner *et al.,* 1988; Montgomery *et al.,* 1989; Jones *et al.,* 1999; Shaffer *et al.,* 1999a).

Several prospective studies of US Army recruits and US Marine Corps recruits have reported that sedentary lifestyle behaviour prior to entering the military is associated with higher risks of injury during the initial BT (Gardner *et al.,* 1988; Jones *et al.,* 1993a; Jones *et al.,* 1993b). Before the start of training, 3010 Marine recruits completed a survey on past health and health behaviors, rating their previous physical activity level in five categories from inactive to very active. The study documented a significant trend of higher cumulative incidence of nine (radiographically confirmed) stress fractures among those recruits with successively lower levels of previous activity (Gardner *et al.,* 1988).

Another study of Marine recruits showed higher rates of stress fractures among those least physically active prior to BT (Shaffer *et al.,* 1999a). Marine recruits who reported never or only occasionally sweating experienced significantly more stress fractures, along with those with fewer months of running before entering BT. A survey of 449 Navy special warfare trainees (Montgomery *et al.,* 1989) and a study of Finnish Army recruits reported similar findings (Taimela *et al.,* 1990).

Conversely, a military study found no relation between the duration of training or the amount of running prior to BT and stress fracture risk (Swissa *et al.,* 1989).

The preponderance of the data from military studies indicates that person, who engages in more physical activity, particularly running, will experience fewer stress fractures when beginning a physically demanding training programme. Additionally, a college sports medicine clinic reported that, over a three-year period, 67% of stress fractures treated occurred among freshmen, while only 17% occurred amongst sophomores, 9% amongst juniors, and 7% amongst seniors. This suggests that previous activity is protective against future injuries associated with PT (Goldberg & Pecora, 1994; Jones *et al.,* 1999).

2.8.1.7.2 Smoking

Tobacco smoking is another behavioural health risk factor reported to be associated with a higher risk of injury among military recruits. A study investigating the impact of lifestyle behaviours on stress fractures in female army recruits found that both a current and a past history of smoking increased the risk of stress fractures in their cohort of young women. Furthermore, the relative risk increased with increasing packets of cigarettes per day and increased years of smoking. This study was unique as it provided an opportunity to evaluate the association between smoking and risk of stress fractures as the other group normally at risk for stress fractures, such as athletes, usually do not smoke (Lappe *et al.,* 2001).

Similarly, a pre-training survey of 915 female Army trainees determined that those who smoked one or more cigarettes during the year prior to eight weeks of BT incurred stress fractures or stress reactions of bone more frequently than those who did not smoke (RR = 2.2, 95% CI: 1.4, 3.6) (Altarac *et al.,* 2000). Among 1,087 male Army trainees in the study, the risk was higher for those who smoked (RR = 1.4, 95% CI: 0.7, 2.9). A survey of 1,630 women in the Army found that current smokers had increased risks of stress fractures (RR = 1.7, 95% CI: 1.2, 2.1) (Friedl *et al.,* 1992). Similarly, several studies of male Army trainees and soldiers in operational units, found a statistically significant association between cigarette smoking and overall risk of training-related injuries in general (Jones *et al.,* 1993b; Reynolds *et al.,* 1994).

Numerous investigators have reported an inverse relationship between BMD and smoking (Daniell, 1976; Pocock *et al.,* 1989; Slemenda *et al.,* 1992). Slemenda *et al.* (1992) found that the rate of change in radial bone mass was negatively correlated with the number of cigarettes smoked per day. An association of smoking with osteoporotic hip fractures has also been reported (Williams *et al.,* 1982; Grisso *et al.,* 1994; Cummings *et al.,* 1995). Former smokers have a fracture risk that is intermediate between that of people who have never smoked and current smokers (Grisso *et al.,* 1994: Cummings *et al.* 1995). Since both osteoporotic hip fractures and stress fractures are fragility fractures, (they occur during activities which most participants complete without fracturing) it is plausible that smoking might also increase the risk of stress fractures. This aspect merits attention as more than 30% of women in active duty are smokers (Lappe *et al.,* 2001).

Smoking is also predictive of stress fractures even when adjusted for bone density, supports an analysis by Law and Hackshaw (1997) who found that the risk of hip fracture in elderly smokers may be slightly greater than expected from their lower bone density. This suggests that nicotine and/or other smoking products, directly affect the strength of bone (Lappe *et al.,* 2001).

2.8.1.7.3 Alcohol

Long-term excessive alcohol intake has been associated with low bone mass in both male and female groups (Johnell *et al.,* 1982; Diamond *et al.,* 1989; Seeman, 1996). It is also well established that alcohol abuse confers a high risk for fragility fractures, although this risk is said to be more pronounced in men than in women (Johnell *et al.,* 1982; Hemenway *et al.,* 1988; Seeman, 1996).

In persons who drink moderate amounts of alcohol, the association between alcohol intake and fracture is equivocal (Felson *et al.,* 1988; Hemenway *et al.,* 1998). Lappe *et al.* (2001) reported that excessive intake of alcohol, defined as a self-report of ten or more alcoholic drinks a week, is a risk factor for stress fractures, even when controlled for age, bone density and race.

Some researchers have reported a dose response to alcohol for bone loss and fractures (Felson *et al.,* 1988; Hemenway *et al.,* 1998). However, many of the studies of alcohol and bone do not control for smoking. Since the consumption of alcohol often goes hand-in-hand with smoking, it is difficult to ascertain how much of the increased risk of osteopenia and osteoporosis is due to alcohol alone, and how much may be attributed to the additional effects of smoking (Lappe *et al.,* 2001).

In female recruits on BT, excessive alcohol intake was associated with stress fractures even when controlled for smoking (although the relative risk was much less than the unadjusted risk) (Lappe *et al.,* 2001). Alcoholism has been associated with a number of factors known to increase the risk for osteoporotic fractures, namely: liver disease, poor nutrition, malabsorption, parathyroid dysfunction, hypogonadism, vitamin D deficiency, sub-optimal nutrition and increased cortisol output (Carter *et al.,* 1981). Additional, a study investigating the direct effect of ethanol on bone formation found that excessive alcohol consumption decreases bone formation and leads to defective mineralization (Diamond *et al.,* 1989).

2.1.8.7.4 Female contraception

Some authors have claimed that the use of an Oral Contraceptive Pill (OCP) may, theoretically, protect against stress fracture development by providing an additional source of estrogen. This reduces the remodelling rate and in turn, improves bone quality and/or density. However, studies have failed to prove a protective effect between birth control hormone use and the incidence of stress fractures (Bennell *et al.,* 1996; Cline *et al.,* 1998; Rauh *et al.,* 2006; Shaffer *et al.,* 2006).

A two year prospective study found that oral contraceptive treatment in combination with an exercise programme was associated with significant decreases in spine BMC in young sedentary women. Therefore, oral female contraception use may not be as protective for bone as theoretically claimed (Weaver *et al.,* 2001).

Conversely, a cross-sectional study found that runners using the OCP for at least one year, had significantly fewer stress fractures (12%) than non-users (29%). (Barrow & Saha, 1988). This was supported by the findings of Myburgh *et al.* (1990). The weaknesses of study design in both of these investigations suggest the need for more and larger studies on the impact of estrogen - containing oral contraceptives on the incidence of stress fractures (Jones *et al.,* 2002).

2.1.8.7.5 Medical history of previous injury

Studies on risk factors for injury amongst athletes, have shown prior injury to be related to subsequent injury (Macera *et al.,* 1989; Rauh *et al.,* 2000). However, in military studies, the relationship between prior injury and the risk of stress fractures during BT appears to be equivocal (Milgrom *et al.,* 1985; Giladi *et al.,* 1986; Ross & Woodward, 1994; Shaffer *et al.,* 1999b; Rauh *et al.*, 2005; Rauh *et al.,* 2006; Shaffer *et al.,* 2006).

Shaffer *et al.* (1999a) reported a lower risk of stress fracture occurrence amongst male recruits who reported a prior injury with full recovery as compared to male recruits who reported a prior injury without full recovery or no prior injury. They suggested that prior injury may serve as an indicator of past physical activity and that past activity is protective against stress fractures. Similarly, results of a one year medical follow-up study of 66 of 91 recruits who had sustained one or more stress fractures during 14 weeks of BT, was reported on by Milgrom *et al.,* (1985) and Giladi *et al.,* (1986). Their study found that 10.6% of persons with a previous stress fracture, developed a new stress fracture during the year after BT, a risk considerably lower than the original risk of 31%.

However, Milgrom *et al.* (1985) reported that only 1.7% of 60 controls in the study sustained stress fractures. Thus, both groups had lower incidences of stress fracture during the year after BT, but the previous stress fracture group experienced a significantly higher risk than the controls.

Other studies have, however, shown no association between lower-extremity injury and stress fracture or non-stress fracture overuse injury during BT (Rauh *et al.,* 2006; Shaffer *et al.,* 2006).

Authors speculate that the difference in findings may be related to the severity of the previous injury, differing types of injuries as well as the difference in how men and women entering BT report prior injuries (Rauh *et al.*, 2005; Rauh *et al.,* 2006; Shaffer *et al.,* 2006).

2.8.2 Extrinsic risk factors

Although it would seem that extrinsic risk factors would be of great interest, because of their potential impact on risk of injury and their applicability to prevention, few studies have examined this category of factors. Extrinsic risk factors that have been considered include: type of physical activity, PT (which includes training methodologies regarding intensity, duration and frequency as well as training errors), training surfaces and footwear. These should be modifiable and of value for prevention (Brukner *et al.*, 1999; Rosental *et al.*, 2003; Välimäki *et al.*, 2005; Rauh *et al.*, 2006; Shaffer *et al.*, 2006).

2.8.2.1 Type of physical activity/ sport

Goldberg and Pecora (1994) quantified the rates of the relative frequency of stress fractures for different sports. The top ten sports evaluated and the percentage of athletes per season (year) who had stress fractures were as follows: softball, 6.3%; track, 3.7%; basketball, 2.9%; tennis, 2.8%; gymnastics, 2.8%; lacrosse, 2.7%; baseball, 2.6%; volleyball, 2.4%; crew, 2.2%; and field hockey, 2.2%. Of these athletes approximately 60% were male. The authors failed to specify sex when recording the stress fracture incidence amongst college freshman in the different sporting codes.

Military studies indicate that different types of units and different types of training may place military personnel at varying degrees of risk. A study of 120 Finnish male military recruits suggested that paratroopers may be at greater risk of incurring stress fractures than regular or light infantry soldiers (Kuusela, 1984). A medical surveillance report on stress fractures incidence among women undergoing Navy BT, Marine Corps BT or Officer Cadet Training, indicated higher risks among female Marine recruits and Officer Cadets (Shaffer *et al.,* 1999b).

A shortfall in military studies outside of the United States, is that research may be reported on, provided that the anonymity of the study participants and the units or the bases involved is ensured. This then renders it difficult to ascertain the corps as most literature will only provide the level of military training, namely BT, Officers Training, Special Forces Training and so forth. However as BT differs between units and between corps, comparisons are then rendered difficult and in most cases impossible.

All military training is characterised by military activities such as marching, drilling and PT. These activities are critical to operational readiness (Kaufman *et al.,* 2000). However, it is important to understand that the duration and intensity, as well as activity, can differ between countries, within countries between corps and within corps between units.

2.8.2.2 PT

Stress fractures are a common overuse skeletal injury in young military recruits (Black, 1982; Scully & Besterman, 1982; Milgrom *et al.,* 1985; Giladi *et al.,* 1991; Beck *et al.,* 2000), and there appears to be a relationship between the development of such fractures and the level and pattern of activity (Milgrom *et al.,* 1985; Milgrom *et al.,* 1988; Almeida *et al.,* 1999).

However, the contribution of each training component (type, frequency, intensity, volume and rate of change) to the risk of stress fractures is not yet clear. Training may also influence bone indirectly, through changes in levels of circulating hormones, associations with menstrual disturbances and effects on soft tissue composition.

2.8.2.2.1 Type of PT

Almost any athlete or exerciser, who engages in frequent, repetitive activity, may develop a stress fracture (Matheson *et al.*, 1987; Ha *et al.,* 1991; Jones *et al.*, 2002; Rauh *et al.*, 2006; Schaffer *et al.,* 2006). Repetitive weight-bearing activities such as running and marching are the most frequently reported causes of stress fractures (Belkin, 1980; Hulkko & Orava, 1987; Matheson *et al.*, 1987; Jones *et al.*, 1989; Ha *et al.*, 1991).

A number of studies on both female and male individuals in both civilian and military populations have demonstrated a dose–response curve in relation to running and weight-bearing activities and injuries (Pollock *et al.,* 1977; Koplan *et al.*, 1982; Marti *et al.,* 1988; Macera *et al.,* 1989; Jones *et al.,* 1994;). Furthermore, as the frequency, duration or total amount of training increases, the injuries also increase, until a point is reached at which injuries increase disproportionately with changes in physical fitness (Pollock *et al.,* 1977).

At present, little is known about the possible effects of heavy resistance exercise, such as weight lifting, and the likelihood of stress fractures. Resistance training leads to an increase in muscle mass and strength as well as BMD and bone strength, as indicated by measures of bone geometry in female athletes and premenopausal women (Heinrich *et al.,* 1990.; Lohman *et al.,* 1995; Engelke *et al.,* 2006). Theoretically then, progressive heavy resistance training of the musculoskeletal system should induce positive adaptations in bone, that are proportional to the increased load (ie resistance), resulting in an increase in muscle mass and in the bone's resistance to stress fractures. Rauh *et al.* (2006) found that women who had participated in weight-training activities on a regular basis for seven or more months, were less likely to incur a stress fracture but found no significant association between lower-extremity muscle weight-training and non–stress fracture overuse injury. These findings are similar to those of a previous study (Lohman *et al.,* 1995).

2.8.2.2.2 Amount, duration, frequency and intensity of PT

Few military or civilian studies have examined the association between amount of PT or exercise and the incidence of stress fractures. The effect of the amount of running on the risk of stress fractures was investigated in a survey that found that male and female runners, who ran more miles per week, experienced an increased risk of radiograph - or bone scan - diagnosed stress fractures (Brunet *et al.,* 1990). Although the survey design had limitations, these findings were consistent with studies of runners that indicated that higher amounts of running were associated with higher incidences of training injuries in general (Koplan *et al.,* 1982; Marti *et al.,* 1988; Macera *et al.*, 1989; Walter *et al.,* 1989; Jones *et al.,* 1994).

Military studies have shown that various training modifications can decrease the incidence of stress fractures in recruits. These interventions include rest periods (Scully & Besterman, 1982), elimination of running and marching on concrete (Reinker & Ozburne, 1979; Greaney *et al.,* 1983), use of running shoes rather than combat boots (Proztman, 1979; Greaney *et al.,* 1983) and reduction of high impact activity (Scully & Besterman, 1982; Taimela *et al.,* 1990; Pester & Smith 1992). These may reduce stress fracture risks by allowing time for bone microdamage to be repaired and by decreasing the load applied to bone (Brukner *et al.,* 1999).

A preliminary report on alterations in the amounts of running and marching performed by Marine recruits, showed that training units that reduced running mileage experienced lower incidences of stress fractures (Jones *et al.,* 1993b). Additionally, trainees doing the least running not only experienced a 50% lower incidence of injury but performed as well on a final physical fitness test (Jones *et al.,* 1993b). Rudzki (1997) also found that by reducing the running distance in the PT programme of the Australian Army recruits, there was a significant reduction in both the incidence of lower-limb injury and the overall severity of injury.

Armstrong *et al.* (2004) found that the stress fracture incidence increased in their recruits with the cumulative number of miles run during the morning exercise training periods. They found that in the tibias of the susceptible individuals, increased weight-bearing physical activity (eg approximately four weeks of PT) was likely to create localized peak strains that could result in a stress fracture secondary to muscular fatigue (Burr, 1997; Beck *et al.,* 2000; Loucks, 2001).

Conversely, a study of marching mileage and risk of stress fracture, reported that less marching did not result in lower stress fracture rates (Milgrom *et al.,* 1985). The limitation of this study was that it did not control for the amount of running by recruits in the high and low marching mileage units. This hinders interpretation, as stress fracture risks are probably proportionate to total weight-bearing training miles (running, marching, drilling, ceremonial activity) (Jones *et al.,* 2002).

Training errors are a frequent cause of stress fractures. They are typically associated with training volume that is increased too rapidly (eg mileage, frequency) and hill running (Matheson *et al.,* 1987; Almeida *et al.,* 1999). Brunet *et al.* (1990) surveyed 1505 runners and found that increasing mileage correlated with an increase in stress fractures in women but not in men. In a study of ballet dancers, those who trained more than five hours daily, had an estimated risk for stress fracture that was 16 times greater than those who trained less than five hours per day (Kadel *et al.,* 1992).

It has been suggested that training regimens for athletes be individualised. What may be appropriate for most members of a team may be excessive for some (Bennell & Brukner, 2005). However, in a BT military set-up, this is not easily achieved due to the large amount of recruits that need to achieve acceptable levels of combat readiness in an allocated time-frame. This situation is compounded further by the large variation in the entry fitness and conditioning levels of the BT recruits.

Bennell and Brukner (2005: 173) advocate

> *"….it is important to allow adequate recovery time after hard sessions or hard weeks of training. This can be accommodated by developing micro - and macrocycles. Alternating hard and easy training sessions is a microcycle adjustment but graduating the volume of work or alternating harder and easier sessions can also be done weekly or monthly. During periods of increases in training, it is worth introducing these on a step wise basis. For example, introduce the increase then remain at this level for a few weeks until bone becomes adapted to the load".*

2.8.2.3 Equipment

Most studies on the impact of exercise equipment have focused on footwear and orthotic insoles by means of intervention trials (Jones *et al.,* 2002). The aim is to reduce and absorb shock when ground contact is made and to control the motion of the ankle and foot (Brukner *et al.,* 1999).

2.8.2.3.1 Footwear

Although footwear is believed to contribute to stress fractures, the available research is equivocal (Milgrom *et al.,* 1996; Milgrom *et al.,* 1998). Anatomic foot structures, biomechanical factors and stability vary greatly amongst military recruits, however, due to logistical and financial constraints all recruits wear the same type of training footwear. The use of Zohar boots (manufactured in Tel Aviv, Israel) by the Israeli Defense Force reduced tibial strain contributing to stress fractures (Milgrom *et al.,* 1996; Milgrom *et al.,* 1998).

In military training, running in boots is commonplace. Boot manufacturers have modified components to produce a boot that is more lightweight, shock absorbent and has running-shoe characteristics (Bennell *et al.,* 1999). Changing from military boots to athletic shoes may reduce the incidence of stress fractures in the foot (Finestone *et al.,* 1992). An experimental study on 390 infantry recruits investigated whether the incidence of overuse injuries was affected by the type of footwear. Basketball shoes were provided to 187 randomly selected recruits while the remainder wore standard military boots. After 14 weeks of BT, there was no significant difference between overall stress fractures rates in the two footwear groups. However, those training in basketball shoes had a significantly lower incidence of overuse injuries of the foot, suggesting that the effect may be limited to injuries resulting from vertical impact loads (Finestone *et al.,* 1992, Brukner *et al.,* 1999).

The age of a shoe provides an indication of the condition of the midsole of the shoe. Gardner *et al.* (1988) found a significantly higher stress fracture rate in recruits wearing shoes older than six months or worn running shoes. While this could be because of decreased shock absorption in older shoes, age also has a detrimental effect on the mechanical support provided by the shoe (Cook *et al.,* 1990). One study of Marine recruits reported that using running shoes more than one month old at the onset of BT, appeared to be associated with greater risks of stress fractures, while the price of running shoes was not associated with risk (Gardner *et al.,* 1988). No civilian studies, investigating the effect of shoe type, age, or quality on risk of stress fractures, have been identified (Bennell & Brukner, 2005).

2.8.2.3.2 Orthotic insoles

Insole use has gained widespread consideration. Shock absorbing insoles are often used in an attempt to reduce the incidence of overuse injuries. There are many different types of insoles on the market which vary in their ability to absorb shock and change foot biomechanics (Milgrom *et al.,* 1985; Gardner *et al.,* 1988; Jones *et al.,* 2002; Bennell & Brukner, 2005).

Milgrom *et al.* (1985) noted a reduction in stress fractures with the use of a shock-absorbing orthosis. In contrast, Gardner *et al.* (1988) found that the incorporation of an insole, with good shock absorption properties, did not reduce stress fracture incidence in military recruits. The authors of a review evaluating the effect of insoles or other footwear modifications on prevention of stress fractures in the military, concluded that 'the use of insoles inside boots in military recruits during their initial training appears to reduce the number of stress fractures and/or stress reactions of bone by over 50%' (Gillespie & Grant, 2000). Another study published since then also found that various types of orthotic insoles were associated with less foot stress fractures (Mundermann *et al.,* 2001).

2.8.2.4 Surface

Training surface has long been considered a contributor to stress fracture development (Devas & Sweetnam, 1956). Various theories exist regarding the role of training surfaces on stress fracture incidence. Training on hard surfaces increases the mechanical shock to the bone and potentially increases the incidence of stress fractures. Running on soft surfaces requires greater muscular activity, induces early muscle fatigue and contributes to stress fractures (Nattiv & Armsey, 1997). Anatomical and biomechanical problems can be accentuated by cambered or uneven surfaces, while ground - reaction forces are increased by less compliant surfaces (McMahon & Greene, 1979; Steele & Milburn, 1988).

A survey of distance runners found that among those who had been injured, 13% of men and 13% of women attributed the injury occurrence to a change in the type of running surface; 7% of women and 6% of men attributed their injuries to running on hilly terrains (Brunet *et al.,* 1990). The sudden increase of stress fracture incidence, from the usual 1.0–3.5% to 11.4%, prompted Zahger *et al.* (1988) to investigate possible reasons for this occurrence. The only change in PT that could be identified by the investigation was a switch to marching on hilly, rocky terrain instead of the usual flat, predictable terrain. When marching returned to flat, smooth terrain, the incidence of injuries returned to 2.5%.

2.9 BT PROGRAMME

In some countries like Israel, Norway, Italy and Greece, military service is compulsory, whilst in others, like South Africa, military service is done on a voluntary basis (Jordaan & Schwellnus, 1994; Dyrstad *et al.,* 2006). Regardless of whether it is voluntary or compulsory, all military recruits undergo an initial form of military training known as Basic Military or Combat Training. During the BT period, the first two to three months of military service, recruits participate in basic military lessons and PT. This includes drill, regimental aspects, general military aspects, musketry, signal training, shooting, map reading, buddy aid, fire-fighting and PT. The BT Programme used by this cohort is available in Appendix Copy Disk - A.

Some studies have investigated changes that occur with BT (Kowal *et al.,* 1978; Vogel *et al.,* 1978; Daniels *et al.,* 1979; Patton *et al.,* 1980; Marcinik *et al.,* 1985; Legg & Duggan, 1996; Faff & Korneta, 2000). Some studies have found that VO_2 max increases with BT (Kowal *et al.,* 1978; Vogel *et al.*, 1978; Patton *et al.,* 1980) whereas others have documented no changes (Daniels *et al.,* 1979; Marcinik *et al.,* 1985; Faff & Korneta, 2000) or even a reduction (Legg & Duggan, 1996).

2.9.1 PT within the BT programme

Physical fitness is a critical and necessary element of soldiering. Military historians have repeatedly emphasized the importance of a high level of physical capability for the occupational tasks that soldiers are required to perform (Nye, 1986; Dubik & Fullerton, 1987; Knapik *et al.,* 2005; Dyrstad *et al.,* 2006).

Within the South African setting, PT, Sport and Recreation (PTSR) forms an integral part of the physical and psychological preparation and conditioning of members of the military. Adequate physical condition and physical skills are necessary for soldiers to perform their main functions to defend and protect the country, its territorial integrity and its people in accordance with the Constitution and the principles of international law regulations for the use of force. Physical fitness is achieved through mandatory Physical Fitness Training (PT) programmes, which include sport and physical recreational activities (DOD policy on Physical Training, DOD Instruction: SG no 00006/2000).

From an occupational point of view, physical fitness for military personnel may be defined as

> *"…the degree of ability to execute specific physical tasks under specific ambient conditions. Because of the wide variety of physically demanding situations the soldier may be confronted with, it is obvious that a high level of endurance alone will not suffice. Muscular strength, power, power-endurance, speed and flexibility are all likely to be essential facets of physical fitness in the military context"* (Gordon *et al.,* 1986b: 483).

Interestingly, it has been reported that modifications of training schedules prevented soft tissue injuries in the lower extremities of young adults (Shaffer & Uhl, 2006). It is common for healthcare providers and coaches to advise their athletes to start slowly and to progressively build up training to avoid injury. The same approach should be followed in military training. Unfortunately, it is not yet clear whether progressive exercise actually prevents stress reactions and fractures as a result of a void in this literature (Shaffer & Uhl, 2006).

Kaufmann *et al.* (2000: 59) state that

> *"…the most effective way to improve the level of physical fitness may be to alter the training regimen by increasing the duration, frequency, and intensity of the initial training events gradually. This approach accommodates the incoming, poorly fit recruits without compromising the fitness of the graduating recruits. To reduce injuries and maintain fitness*

> *of Marine recruits, the San Diego MCRD conducted a training intervention trial. The intervention included reduction in the amount of running miles, gradual build-up of exercise and military hiking, and emphasis on aerobic activities in early training phases before progressing to anaerobic activities and strength conditioning. Evaluation of this intervention demonstrated a significant reduction in all overuse type injuries. Lower extremity stress fractures were reduced by 55%, which resulted in 370 fewer stress fractures per year with a cost savings of over $4.5 million at the San Diego MCRD. Outgoing recruit fitness, as measured by the 3-mile timed run at the end of training, remained equally high compared to before the intervention (20':53" versus 20':20")".*

These suggestions have also been echoed by other researchers' studies (Heir & Eide, 1997; Rudzki & Cunningham, 1999; Rosendal *et al.,* 2003; Armstrong *et al.,* 2004; Knapik *et al.,* 2004). These researchers stated that reductions in running distance with progressive PT in the early weeks, would avoid overtraining in the early weeks as well as reduce lower limb injuries.

Wood and Krűger (2007) monitored the changes that the PT Instructors course had on selected anthropometrical and physical fitness variables / fitness components. They found positive changes on many fitness and anthropometrical variables, however, a larger strength component should be included in the training to ensure greater positive changes, specifically in muscular strength and muscular endurance. Although this was not PT in BT but in a more specialized military training group (and it was three-weeks shorter than BT), it was also conducted in the South African military setting. Similar findings were determined with regard to aerobic capacity by Cilliers and Gordon (1983).

Marcinik *et al.* (1985) highlighted that the attitudes of the company commanders towards exercise, participation in scheduled exercise sessions and overall leadership style can affect final fitness results. However, the most important factors for improvement in physical fitness are training volume, frequency, intensity and mode of training (Dyrstad *et al.,* 2006).

The South African Defence Force PT Policy states that during the period of BT, four 40 - minute PT periods per week are compulsory. A standardised cyclic-progressive PT programme is followed by all instructors presenting BT, in order to achieve the required results, within the prescribed time with the minimum occurrence of injuries (DOD policy on Physical Training, DOD Instruction: SG no 00006/2000). A new cyclic-progressive PT programme for BT was developed by the author of this study in the capacity of Wing Commander in charge of Research and Development at the Joint PT Sport and Recreation Centre. It was implemented for the first time for the period of this study. This programme with its manual can be seen in Appendix Copy Disk - B and C.

PT has, however, also been shown to be associated with a high rate of injury (Jones *et al.*, 1994; Jones & Knapik, 1999; Trank *et al.*, 2001; Knapik *et al.,* 2004). To counter negative effects of overtraining recent efforts to reduce injuries have focused on modifications in the PT Programme (Knapik *et al.*, 2003; Knapik *et al.,* 2004; Knapik *et al.,* 2005; Dyrstad *et al.*, 2006).

The modification of training programmes has been partially investigated. Two studies evaluated the effect of periods of recovery from weight-bearing stress during the early weeks of Army BT (Scully & Besterman, 1982; Popovich *et al.,* 2000). The first of these studies, a “field trial” conducted at Fort Knox in 1974, divided 880 male trainees into equal-sized test and control groups and compared normal training with training interrupted by a recovery week, with no running, marching or jumping taking place during the third week of the eight weeks of US Army BT (Scully & Besterman, 1982). A 67% decrease in stress fractures in the group given recovery time suggested a possible benefit from this intervention.

Popovich *et al.* (2000) tested the effect of recovery weeks, with no running during the second to fourth weeks of the eight weeks of US Army BT on 1357 male recruits. The study compared the stress fracture incidence of persons from three test companies, that provided a period of recovery from running during the second, third, or fourth week of BT, with the stress fracture incidence of persons from two control companies conducting normal, uninterrupted PT. A sixth company performed more running than usual in the early weeks of training and then had a hiatus in running during the fourth and fifth weeks. The results suggested that a recovery period with limited vigorous weight-bearing training (ie no running) is not likely to make a significant difference in stress fracture incidence. However, the variation in stress fracture rates among units within the test and control groups, was large enough to mask apparent differences between the training modification group and the controls (Bennel & Brukner, 2005).

2.10 STUDY DESIGN

In cohort studies, a group of participants (military or civilian) are monitored longitudinally or prospectively over a predetermined length of time and the presence of specific risk factors (before an injury occurs) is measured. The prospective cohort design's greatest strength is that each individual's risk profile is established before the stress fracture has occurred. Its disadvantages are that it is costly and time consuming, as many military recruits must be sampled so that enough injuries can be generated in order to support meaningful statistical analysis (Brukner *et al.,* 1999).

2.10.1 Advantages of using the military population

Conducting studies to investigate risk factors for stress fractures on military recruits within a military setting has various advantages. Firstly, military training provides a controlled environment and studies are scientifically attractive because they can provide insight into how bone strength differs among otherwise healthy young individuals (Beck *et al.,* 2000). Secondly, it is suggested that the uniformity and consistency of military recruit training provides natural controls for selection bias (Macera, 1992; Jones *et al.,* 1994). Finally, military groups provide the unique opportunity to investigate a large and very homogeneous cohort of young men and women of the same age, enrolled independently of socioeconomic criteria (Casez *et al.,* 1995).

2.10.2 Disadvantages with using the military population

Several disadvantages also exist when conducting research on stress fracture risks within the military. Firstly, military studies have to follow the rules and habits of the military, often resulting in logistical problems which, in turn, often result in no proper randomization, no true control group and difficulties in exact quantification of exercise (Casez *et al.,* 1995). Secondly, when BT recruits have a medical problem, they are seen by a number of different medical care providers in the clinic during the study period and although they are guided by policy, each may have different criteria for assigning restricted duty. Finally, due to the large groups studied in the military set-up, multiple variables are often examined which makes it difficult to determine which interventions are most effective. The multiple strategies may have been successful because different individuals responded to different aspects.

A vast amount of research exists on stress fractures. However fewer studies have investigated the role that potential intrinsic and extrinsic risk factors may play in the development of these fractures, specifically during BT. No studies have been done within the South African military environment in this regard. Additionally a program specifically designed to minimize stress fractures in soldiers during BT has never been documented. Thus in the following chapter the methodlogy employed and procedures followed by the researcher will be outlined and explained.

CHAPTER 3

METHODS AND PROCEDURES

3.1 INTRODUCTION

In this chapter the methods and procedures followed in this study will be discussed. The research approach used in stress fracture research can be quantitative or qualitatitive in nature ((Kinnear & Taylor, 1996; Thomas & Nelson, 2001).

The qualitative paradigm concentrates on investigating subjective data, in particular, the perceptions of the people involved. The intention is to illuminate these perceptions and, thus, gain greater insight and knowledge. The quantitative paradigm concentrates on what can be measured. It involves collecting and analysing objective (often numerical) data that can be organised into statistics (Kinnear & Taylor, 1996; Thomas & Nelson, 2001). This study utilized a qualitative research approach which will be discussed further in this chapter.

Additionally several methods have and can be used to investigate stress fractures as outlined in 2.5. These include clinical trials, case-control studies, case series, cross-sectional studies, or surveys, ‘mixed’ study designs and prospective cohort studies (Brukner *et al.,* 1999; Thomas & Nelson, 2001).

The latter was the chosen for this study as it is considered a ‘strong’ design as accurate comparisons can be drawn between the injured and the uninjured groups. These comparisons then lead to true assessment of the incidences and risks which may lead to casual inferences been drawn (Brukner *et al.,* 1999; Thomas & Nelson, 2001).

3.2 RESEARCH APPROACH

This study followed a **quantitative research approach** and the two quantitative research techniques that were used are known as Observation Technique and Experimentation.

3.2.1 Observation Technique

This technique provides a means of obtaining data and is a descriptive method of researching certain problems. In this study, the Observational Technique was used in keeping record of all military participants who developed a stress fracture. This was done via the military medical computerised system, as all military medical visits to the unit sick bay are captured onto this system. Additionally the diagnosis, as well as the results of any radiology / scans, was also captured together with treatment given (Thomas & Nelson, 2001).

3.2.2 Experimentation

This technique attempts to establish a cause-and-effect relationship. That is, an independent variable (in this case the PT Programme) is manipulated to judge the effect upon a dependant variable (fitness results). Additionally, correlation statistics were used to establish the cause-and-effect relationship (Thomas & Nelson, 2001).

3.3 RESEARCH DESIGN

A research design is the basic plan that guides the data collection and analysis phases of the research project. "It is the framework that specifies the type of information to be collected, the sources of data and the data collection procedure" (Kinnear & Taylor, 1996: 129).The current study was done in the form of an experiment. Pre-test and Post-test measures were taken for the EG (who all underwent BT) on biokinetic and bone density measurements. Fitness test results were also compared to a CG who had undergone BT in the year prior to the EG. The limitation of the findings of this study is that it can only be generalised to the people from the same sample group.

The prospective design implies that the participants were assembled at the beginning of the study, in this case at the start of 12 weeks of BT, according to their exposure to a risk factor. They were followed over the predetermined 12-week period, during which, injury occurrence was monitored and recorded. This is considered a 'strong' design as it enables accurate comparisons to be made between the injured and the uninjured groups. These comparisons then lead to true assessment of the incidences and risks which may then lead to casual inferences been drawn. The limiting factor of this type of design is that in order to have enough statistical power, particularly for detection of small differences, sample sizes have to be large. Additionally rigorous inclusion criteria, as well as drop out rates over the course of the study limit the number of available, suitable participants.

3.4 A 12-WEEK PT PROGRAMME FOR BT

Prior to the start of BT, a 12-week PT Programme was designed and developed by the researcher. The reason for the new 12-week PT Programme was two-fold:

- Firstly, no clearly outlined, formal, PT Programme was being followed by BT participants during BT in the South African Military Health and Medical Service, and
- Secondly, to ensure that all participants undergoing BT followed a scientifically based progressive exercise programme.

A detailed daily 12-week PT Programme was developed in conjunction with a PT Manual. Due to the length and size of both the detailed PT Programme as well as the PT manual, they have been included electronically in the enclosed CD. The purpose of the PT manual was to clearly explain all the exercises used in the PT Programme, so that the PT Instructors would know exactly how to execute the exercises, as well as to ensure uniformity in the methodology of instruction.

3.4.1 Aim of the PT Programme

The main aim of the PT Programme was to develop the physical fitness of the participants in order to assist in making them combat ready. Physical fitness can be defined as the healthy and efficient functioning of various body systems that allows one to engage in activities of daily living, recreation and leisure (DOD policy on Physical Training, DOD Instruction: SG no 00006/2000). Physical fitness can be classified into seven fitness components, namely: cardiorespiratory endurance, muscular strength, muscular endurance, flexibility, speed, power and agility (American College of Sports Medicine, 2006). (Please refer to pp.1-10 in the PT Manual on the enclosed CD for the detail regarding the definition and method of developing each specific component).

Based on previous practical undocumented experience, the researcher found that many BT recruits had very little experience with formal exercise instruction and that their activity levels, prior to the start of BT, were low. This group indicated, in a questionnaire prior to their start of BT that their previous activity levels included participation in sport (84%).

The types of sport mostly included soccer (49.3%), followed by netball (15.1%) and running (13.2%). Only 1.1% indicated that they participated in gymnasium activity. Additionally, the level of participation was mostly on a social level (66.9%) with the remaining third competing at club, provincial or national level. Participants were divided in their opinion regarding the intensity of participation with 39.2% indicating low intensity, 29.1% reporting medium intensity and the remaining 31.8% reporting high intensity of participation.

This lack of previous experience with formal physical activity, combined with the relatively short period of 40 minutes 5 times per week for 12 weeks (available for formal PT) resulted in the aim of the PT Programme then to develop the basic fitness components, namely cardiorespiratory endurance, muscular strength and muscular endurance (American College of Sports Medicine, 2006). Additionally, flexibility training was included due to its possible role in injury prevention (Hughes, 1985; Giladi *et al.*, 1987; Giladi *et al.*, 1991; Milgrom *et al.*, 1994).

3.4.2 Design of the PT Programme

The design of the BT PT Programme had to comply with the following logistical limitations present in the BT environment:

- Large groups need to undergo the training simultaneously, thus the exercises needed to be simple, clear and be completed within a small personal space.
- No individual training weights were available, thus exercises were designed based on resistance offered by own body weight and progressed to the use of solid timber wooden poles (2.1m in length by 25cm in diameter).
- As already mentioned in 3.4.1, many of the new participants had no previous experience in formal exercise activities, thus exercises needed to be simple and be easily corrected by the PT instructor. Consequently, the main aim of the PT Programme was to develop the basic fitness components.

The PT Programme was designed based on the scientific principles of specificity, overload, FITT (Frequency, Intensity, Time and Type) and progression (Rudzki & Cunningham, 1999; American College of Sports Medicine, 2006).

The principle of specificity, technically, states that the type of demand placed in the body, controls the type of adaptation that will occur. Specificity suggests that the activities selected should provide the outcome represented by that day's class objectives (DOD policy on Physical Training, DOD Instruction: SG no 00006/2000).Thus all training programmes, in the military context, must be specific to developing the energy system(s) predominantly used during the performance of the activity in question (Fox *et al.*, 1989).

The energy systems used during military combat cannot be isolated, as the situation determines the specific activity required. Additionally, it is only after BT that the participants then pursuit a more specific form of military training, eg medical orderly or foot soldier. The Programme followed during BT therefore needed to evenly develop all three energy systems, namely, ATP-PC strength, oxygen system and the ATP-PC/ lactic acid system (Fox *et al.*, 1989).

The principle of overload - progressively placing greater – than - normal demands on the musculature of the body - suggests that individuals involved with activities designed to improve muscular strength, and/or muscular endurance, will need to increase their workload periodically throughout the course of the programme. Specifically, to develop muscular strength, the overload principle dictates increasing the resistance against the muscles involved to a level greater than that used before.

To develop muscular endurance, the overload principle dictates increasing the number of repetitions, increasing the length (time) of the repetition, decreasing the rest interval between activities or a combination of two or three methods.

The amount of increase must be appropriate for the age and fitness level of the participants (Fox *et al.*, 1989; American College of Sports Medicine, 2006).

As the participants training together did not have homogeneous fitness levels, it was very difficult to apply the principle of overload, and thus the PT Programme designed included the use of maximal repetitions. This was advantageous as it allowed each participant to perform to the best of his/ her ability, however the risk was that the participant did not work to his/ her maximum, but did just enough to keep up with the group.

The principle of progression refers to incorporating a systematic approach to increasing frequency of exercise, the volume of repetitions and/or the intensity of the activity. To avoid injuries, appropriate progression and appropriate goal setting is essential. This Programme followed an average of 10% weekly progression, as advocated in the literature to be a safe yet effective progression rate (Heyward, 2002). The FITT principle was applied and Table 3.1 summarizes how to apply the FITT (Frequency, Intensity, Time and Type) principle, based on fitness level goals (Heyward, 2002).

As military combat performance can be viewed as an athletic performance, the frequency, as well as the duration of the PT training was dictated by the PT policy (DOD policy on Physical Training, DOD Instruction: SG no 00006/2000) which stipulated that PT would take place 5 times per week for a period of 40 minutes. The only variables that could then be manipulated were the intensity and the type of physical activity followed.

Table 3.1: Application of training principles to develop muscular strength and muscular endurance based on fitness goals

Training principles applied to muscular strength and muscular endurance, based on fitness goals			
	Base health-related fitness	**Intermediate health-related fitness**	**Athletic performance fitness**
Frequency	2-3 times per week; allow for minimum one-day rest between training sessions	3-4 times per week; alternating upper - and lower - body segments will allow for consecutive training days	4-5 times per week; training activities are specific to sport participation
Intensity	Very light, less than 40% of a "projected" maximal effort	Light to moderate, 50%-70% of "projected" maximal effort	Specific load adaptation required for sport participation
Time	2-3 sets of 6-8 (strength) / 10-12 (endurance) repetitions	2-3 sets of 6-8 (strength) / 10-12 (endurance) repetitions	2-3 sets of 6-8 (strength) / 10-12 (endurance) repetitions
Type	Body weight, single and multijoint activities involving major muscle groups	Resistance exercise such as leg press, bench press, pull-ups additional presses and pulls	Advanced sport-specific, multi-joint lofts (clean pulls, power presses, Olympic style lifts)
Overload	Not necessary to bring components to overload during base level	Introduce one of the components of overload; 1-2 times per week	Programme design should stress variable intensities and durations to bring student into overload; 2-3 times per week
Progression and specificity	Let student get the idea of correct movement. Progression is minimal	Introduce programme design and incorporate variation	Specific sets, repetitions, and exercises to meet desired outcomes

The intensity of training can be calculated either indirectly by monitoring heart rate, or directly, by determining the workload intensity at the anaerobic threshold. However, as 185 BT recruits had to train together in large groups and no funds were available to provide each participant with his/her own heart rate monitor, the intensity of training was difficult to control and manipulate.

The type of physical activity used in the programme design was determined by the resources available, as well as by what the researcher deemed to be the most appropriate for the development of the participants' physical fitness. This saw the introduction of using wooden poles, as a means of increasing resistance in a synchronised and organised manner.

3.4.3 Quantification (Energy Expenditure) of BT and PT Programme

The Energy Expenditure for the BT programme followed in this study was derived by calculating the Basal Metabolic Rate (BMR) – the energy that is necessary to maintain life or organ function in the body (Stedman's Medical Dictionary, 2000). This was determined by taking weight, age and sex into consideration. The daily kilojoules used for men and women were calculated as 6832.5 kJ/day and 5910 kJ/day respectively. Therefore, the average BMR was 6371.25 ~ 6371.3 kJ/day. The average activity levels were expressed as multiples of BMR (meaning regular daily movements and activity), excluding the PT Programme.

All the BT activities could be classified as light levels of activity, thus a BMR of 1.5 was used for males and females for calculation purposes. The average total minutes on the training program with basic exercises was 45 minutes, four times per week. Thus 1350 kJ was used for PT four times per week. The average kJ used for BT per day was calculated by averaging three hours of exercise per day, resulting in 8485.7 kJ used per day.

3.5 METHODS

As the study was conducted on military personnel, during military training and military time, the rules and habits of the military had to be abided by. This influenced the methodology employed and the study design chosen. The aim of BT is to create a combat ready soldier, therefore, it was not possible to have a true control group, with regard to the PT Programme, as all the participants had to follow the same programme (Casez *et al.*, 1995).

In order to evaluate the effect of the PT Programme on physical fitness, Pre-test and Post-test measures were taken for the EG (who were subjected to a new PT Programme). These measures were taken on fitness test results, and then were also compared to the fitness test results of a CG, who had undergone BT in the year prior to the EG.

Additionally, the participants acted as their own controls, as those that developed stress fractures were compared to their matched counterparts, who did not develop stress fractures. Pre-test and Post-test biokinetic-, bone density-, as well as fitness test parameters were measured. This same method has been followed by other researchers successfully (Taimela *et al.*, 1990; Milgrom *et al.*, 1994; Rosendal *et al.*, 2003; Armstrong *et al.*, 2004; Välimäki *et al.*, 2005; Lappe *et al.*, 2005; Rauh *et al.*, 2006; Shaffer *et al.*, 2006).

The risk of this was that should the incidence of stress fractures be statistically insufficient or non-existent, the interpretation of results would then become difficult.

The methodological approaches employed were as follows:

3.5.1 Participant selection

A high incidence of shin splints and stress fractures was observed in female participants, in the South African National Defence Force, during BT in the beginning of 2005 (Wood & Krüger, 2007). It was for this reason that this study was conducted specifically on BT participants. The Arm of Service used was decided upon, based on logistical and financial constraints.

Participants utilised were volunteers from the South African Health and Medical Service intake, who started their BT on 03 July 2006 and completed it on 05 October 2006. This particular group of Basic trainees was selected for the following logistical reasons:

- This BT group reported and cleared in at the Military Health Training Formation in Pretoria. The procedures followed in the Pre-testing of these participants required specialised equipment, which was only available to military participants at 1 Military Hospital, located in Pretoria.
- This BT group also returned to the Military Health Training Formation in Pretoria at the end of their BT, thus then logistically, ideally located near 1 Military Hospital for the Post-testing.
- Since the researcher was also located in Pretoria the management and control of the execution of the study was ideal.

3.5.2 Sample

A sample can be defined as a subset of a population and sampling plan, as a design, scheme of action or procedure that specifies how the participants are to be selected in a survey study (Rosnow & Rosenthal, 1996). A distinction is made between probability and non-probability sampling. In this study, use was made of a non-probability sampling method. This type of sampling method can be described as the selection of a population element to be part of the sample, based in some part, on the judgment of the researcher (Kinnear & Taylor, 1996).

There is a number of sampling procedures that fall into this category. A sample of convenience was used in this study and consisted of 185 BT candidates who underwent 12 weeks of BT. Additionally, 198 participants from the previous year's BT fitness results, were used as controls to compare fitness changes.

The study started with 185 participants - 100 male and 85 female. After 12 weeks of BT, two participants dropped out of the study, both female, having resigned from the South African National Defence Force.

3.5.3 Informed consent

All participants that reported for BT at the Military Health Training Formation in July 2006, were addressed by the researcher and informed of the aim of the study, the reasons for the study and the procedures of the study. Any questions that arose were answered by the researcher. The participants were then asked to volunteer and once the volunteers had been identified, each volunteer completed and signed an informed consent form prior to participating in the study (Appendix A).

3.6 PROCEDURES

The procedures that were followed are outlined in chronological order below:

3.6.1 Ethical approval from the South African Defence Force Ethics Committee

Ethical approval was obtained from the South African Defence Force Ethics Committee (Ethical clearance number SG/R&D/2-Jun-06/ 083) to conduct the study. As ethical approval was not obtained for blood turnover markers, this could not be done. The medical personnel at 1 Military Hospital, staff of the Military Health Training Formation in Pretoria, as well as in Lohatla, were marked to assist in the project. Relevant documentation and letters were written by the researcher to obtain their support.

3.6.2 Ethical approval from the Medical Faculty of the University of Pretoria

Ethical approval was obtained from the Medical Faculty of the University of Pretoria (Project number 57/2006) to conduct the study. Ethical approval was obtained for blood turnover markers; however, as the South African Defence Force Ethics Committee did not grant approval for this, it had to be excluded.

3.6.3 Financial approval for Bone Density tests

Financial approval was obtained to conduct 70 Bone Density tests on the female participants. This was based on the recent history of a high incidence of stress fractures in female participants (Wood & Krüger*,* 2007). Due to the high cost factor involved, only 70 randomly selected female participants underwent full Bone Density scans.

3.6.4 Logistical planning details for Pre-testing procedures

Prior to departing for their 12 weeks of BT in Lohatla, the participants were in Pretoria for a period of five days. Careful planning took place to ensure that all participants completed all the necessary physical tests. Table 3.2 outlines the practical programme followed, in order for the participants to complete all their testing in the allocated time. An information session was held on the day of arrival and the procedure detailed in 3.5.3 was followed.

Table 3.2: Detailed outline of practical programme followed to complete testing of all variables

STRESS FRACTURE RESEARCH PROGRAMME: 03/07-08/07/2006							
Day	**Time slots**	**Group 1**	**Group 2**	**Group 3**	**Group 4**	**Group 5**	**Group 6**
Monday	**07H00-17H30**	**Clearing in, information session, informed consent, activity questionnaires.**					
Tuesday 1	**07H00-11H00**	**DEXA**	**KIT**	**ECG**		**Fitness**	**IT & Bio**
Tuesday 2	**11H00-13H00**				**ECG**		
Tuesday 3	**14H30-17H30**			**Fitness**	**Fitness**		
Wednesday 1	**07H00-11H00**	**IT & Bio**				**ECG**	**KIT**
Wednesday 2	**11H00-13H00**		**ECG**	**IT & Bio**		**KIT**	
Wednesday 3	**14H30-17H30**	**Kit**	**IT & Bio**				**Fitness**
Thursday 1	**07H00-11H00**						
Thursday 2	**11H00-13H00**	**Fitness**	**Fitness**	**KIT**		**IT & Bio**	**ECG**
Thursday 3	**14H30-17H30**						
Friday 1	**07H00-11H00**				**IT & Bio**		
Friday 2	**11H00-13H00**	**ECG**				**IT & Bio**	
Friday 3	**14H30-17H30**						
Saturday	**07H00-17H00**	**Catch up**	**DEXA**	**Catch up**			

Key:

ECG- *Electrocardiogram, resting blood pressure and heart rate variability (the results of the resting blood pressure were included in this study, however, the other parameters were outside the scope of this study and were done to reach the objectives of a different study)*
Fitness- *Standardised Military Fitness tests*
IT- *Isokinetic testing on the Cybex 340*
Bio- *Biokinetic evaluation which included resting blood pressure, resting heart rate, anthropometry (height, body mass, skinfolds, somatotyping, waist-hip), skeletal alignment (leg length, Q angle and foot type) and flexibility (hip external rotation, ankle dorsiflexion & ankle plantarflexion)*
DEXA- *Full bone scan done on a dual energy absorptometry on the Lunar Prodigy*
KIT- *Issue of army kit at the Logistical stores.*

For practical execution of the testing the all the female participants were randomly divided into groups one and two (35 participants in each) according to the table of random numbers, and the remaining female participants were placed into group three (Thomas & Nelson, 2001).The male participants were also randomly divided into groups three to six with 30 participants per group, according to the table of random numbers (Thomas & Nelson, 2001). Each group started at a station and rotated to the next ie A to B, B to C etc. Care was taken that the isokinetic and biokinetic evaluations were not completed on the same day as the fitness tests, to provide sufficient recovery time.

3.6 TESTING PROTOCOL

A similar testing protocol was adopted for both Pre- and Post-testing procedures. The only difference was that the physical activity questionnaire was only completed at the start of the study.

3.7.1 Health and Physical Activity Questionnaire

Once the informed consent had been obtained, participants completed a questionnaire which provided a detailed history of sport participation, as well as health and medical history information (Appendix B) (Lee & Nieman, 2007).

3.7.2 Biokinetic evaluation

The participants underwent a biokinetic evaluation which included the following:

3.7.2.1 Anthropometric evaluation

3.7.2.1.1 Height (standing)

Equipment: Stadiometer

Procedure: Height was calculated to the nearest 0, 1 centimeter (cm) with a statiometer. Height, defined as the distance between the soles of the feet and the vertex, was taken whilst the participant stood up straight, barefoot, with heels, gluteus maximus, upper-back and back of head against the anthropometer. The ears, acromion, greater trochanter, back of patella and front of calcaneus were in the same vertical line. The angle of the eye and the upper hole of the ear were on the same horizontal level. Measurement was taken at the end of a deep inhalation. No asymmetry was allowed (Smit, 1979; Eston & Reilly, 2001).

3.7.2.1.2 Body mass

Equipment: Detecto standing scale

Procedure: Participants were weighed, in kilograms (kg), on a calibrated medical scale wearing only underwear, running shorts and a t-shirt. Each participants' mass was calculated to the nearest 0, 1 kg (Eston & Reilly, 2001).

3.7.2.1.3 Body Mass Index

The Body Mass Index (BMI) is a measure of the lean mass and fat mass components. It is used in epidemiologic research and has a moderately high correlation (r_{xy}= 0.69) with body density. It was calculated using the following formula:

$$BMI = \frac{mass}{height^2}$$

Where Mass is measured in kilograms and height in meters (Morrow *et al.*, 2000).

The following ratings have been applied to the BMI ($kg.m^{-2}$) (American College of Sport Medicine, 2006:58):

- Underweight: <18.5
- Normal: 18.5-24.9
- Overweight: 25.5-29.9
- Obesity, class:
    - I: 30.0-34.9
    - II: 35.0-39.9
    - III: ≥40

3.7.2.1.4 Skinfolds

Equipment: Skinfold caliper (Harpenden John Bull)

Procedure: A manual skinfold caliper was used to determine the participant's percentage body fat and somatotype. The Harpenden John Bull skinfold calliper has an accuracy of 99.00% and a repeatability measurement of 0.20 mm (Irazusta *et al.,* 2006). The 'six skinfold method" was used (Yuhasz, 1974). All skinfold measurements were measured on the right side in millimeters (mm). The researcher pinched the skin at the appropriate site to raise a double layer of skin and the underlying adipose tissue, but not the muscle. The calipers were applied 1 cm below and at right angles to the pinch, and a reading was recorded two seconds later. The mean of the two measurements was taken. If the two measurements differed greatly, a third was done and the median value was taken (International Standards for Anthropometric Assessment, 2001).

Triceps

The participant assumed a relaxed standing position with the left arm hanging by its side. The right arm was relaxed, with the shoulder joint slightly externally rotated and elbow extended by the side of the body. The skinfold was taken vertically, parallel to the long axis of the arm, on the landmark (which was at the level of the mid-point between the acromion and the olecron processes), on the mid-line of the posterior surface of the arm and over the triceps muscle (International Standards for Anthropometric Assessment, 2001).

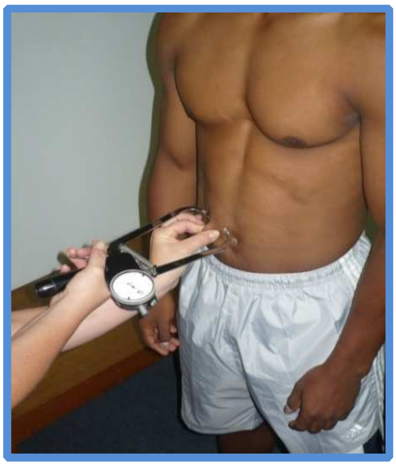
Subscapular

The participant assumed a relaxed standing position with the arms hanging by its sides. The line of the skinfold was determined by the natural fold lines of the skin (International Standards for Anthropometric Assessment, 2001).

Supraspinale

The participant assumed a relaxed standing position with arms hanging by its sides.The fold runs medially downward at about a 45º angle as determined by the natural fold of the skin (International Standards for Anthropometric Assessment, 2001).

Abdominal



The participant assumed a relaxed standing position with the arms hanging by its sides. The vertical skinfold was taken 5cm adjacent to the umbilicus to the right side (International Standards for Anthropometric Assessment, 2001).

Front thigh

The participant assumed a seated position on the front edge of the box with the torso erect and the arms hanging by its sides. The knee of the right leg was bent at a right angle. The researcher stood facing the right side of the seated participant on the lateral side of the thigh. The site was marked parallel to the long axis of the thigh, at the mid-point of the distance between the inguinal fold and the superior margin of the anterior surface of the patella (while the leg was bent). The skinfold measurement was taken with the knee bent at the marked site (International Standards for Anthropometric Assessment, 2001).

Medial calf

The participant assumed a relaxed standing position with the arms hanging by its sides and the right foot placed on a box. The right knee was bent at 90º. The fold taken was parallel to the long axis of the leg (International Standards for Anthropometric Assessment, 2001).

3.7.2.1.5 Breadths

Equipment: Small sliding calliper

Procedure: Breadths are widths measured at standard anatomical sites and were measured to the nearest 0,1 cm. The sites were first marked and care was taken that the calliper was not too tight or too loose, and lying flat against the skin (Carter, 2002).

Biepicondylar humerus

The participant assumed a relaxed seated position. The right arm was raised anteriorly to the horizontal and the forearm was flexed at right angles to the arm. The distance between the medial and lateral epicondyles of the humerus was measured. This was done by gripping the small sliding caliper correctly, using the middle fingers to palpate the epicondyles of the humerus, starting proximal to the sides. Firm pressure was placed on the crossbars to compress the subcutaneous tissue (International Standards for Anthropometric Assessment, 2001).

Biepicondylar femur

The participant assumed a relaxed position with the hand clear of the knee region. The right leg was flexed at the knee to form a right angle with the thigh. The greatest distance between the lateral and medial epicondyles of the femur was measured. With the caliper in place, the author used her middle fingers to palpate the epicondyles of the femur beginning proximal to the sites. Firm pressure was applied on the crossbars in order to compress the subcutaneous tissue (International Standards for Anthropometric Assessment, 2001).

3.7.2.1.6 Girths

<u>Equipment</u>: Flexible steel tape measure

<u>Procedure</u>: Girths are circumferences measured at standard anatomical sites and were measured to the nearest 0,1 cm. The sites were first marked and care was taken that the tape was not too tight or too loose, and lying flat on the skin (Carter, 2002).

Biceps

The participant assumed a relaxed standing position with the left arm hanging by its side. The participant's right arm was raised anteriorly to the forearm supinated and flexed at 45-90˚to the arm. The researcher stood to the side of the participant and asked the participant to tense the elbow flexors and the participant was then encouraged to contract the arm muscles, as strongly as possible, while the author took the measurement at the peak of the Biceps. The greatest girth of the arm was measured and recorded (International Standards for Anthropometric Assessment, 2001).

Calf

The participant assumed a relaxed standing position with arms hanging by its sides. The feet were separated and the weight evenly distributed. The participant stood in an elevated position and the author placed the tape around the calf where the maximum girth of the calf was measured and recorded (International Standards for Anthropometric Assessment, 2001).

3.7.2.1.7 Anthropometric derivates

From the above measurements, the following was derived:

- The sum of the 6 skinfolds,
- Lean body mass,

- Fat mass,
- Somatotype and
- Percentage body fat (%).
    - The % body fat was calculated using Yuhasz equation for males and females (Yuhasz, 1974):

$$\boldsymbol{Males}\ \%\ \boldsymbol{body\ fat} = (0.1051\ x\ sum\ of\ triceps, sub\ scapular, supraspinale, abdominal, front\ thigh, calf) + 2.585$$

$$\boldsymbol{Females}\ \%\ \boldsymbol{body\ fat} = (0.1548\ x\ sum\ of\ triceps, sub\ scapular, supraspinale, abdominal, front\ thigh, calf\ ) + 3.580$$

3.7.2.1.8 Waist

Equipment: Flexible steel tape measure

Procedure: The waist measurement was taken at the narrowest waist level, or if this was not apparent, at the mid point between the lowest rib and the top of the hip bone (illiac crest) with the tape lying horizontal, and flat against the skin (Welborn *et al.,* 2003).

3.7.2.1.9 Hip

Equipment: Flexible steel tape measure

Procedure: The hip girth measurement was taken over minimal clothing, at the level of the greatest protrusion of the gluteal muscles with the tape lying horizontal and flat. The participant stood erect with his/her weight evenly distributed on both feet and legs slightly parted (Welborn *et al.,* 2003).

3.7.2.1.10 Waist/hip ratio

The waist to hip ratio was calculated using the following formula (Welborn *et al.*, 2003):

$$\boldsymbol{WHR} = \frac{\boldsymbol{Gw}}{\boldsymbol{Gh}}$$

Where:

$WHR = Waist\ to\ Hip\ Ratio\ (WHR)$

$Gw\ =\ waist\ girth\ and$"

$Gh\ =\ hip\ girth$"

Table 3.3 gives general guidelines for acceptable levels for hip to waist ratio (Welborn *et al.*, 2003).

Table 3.3: Acceptable levels for hip to waist ratio

	Acceptable		**Unacceptable**		
	Excellent	**Good**	**Average**	**High**	**Extreme**
Male	< 0.85	0.85 - 0.90	0.90 - 0.95	0.95 - 1.00	> 1.00
Female	< 0.75	0.75 - 0.80	0.80 - 0.85	0.85 - 0.90	> 0.90

3.7.2.2 Blood pressure

Equipment: Mercury sphygmomanometer, cuff and stethoscope

Procedure: The sphygmomanometer was placed on a bench where the participant could not see the mercury column. Blood pressure was recorded after the participant had rested quietly for 5 minutes, and this measure preceded all the other measures in the session. The participant was seated with the arm resting on the bench, the elbow approximately at the level of the heart. A medical officer placed the cuff and attached it over the upper arm and then increased the pressure to approximately 180 mmHg.

The stethoscope was placed over the brachial artery in the cubital fossa. The pressure was released at a rate of approximately 2 mm per second. The pressure at which the first sounds were heard (systolic pressure) and the pressure when all sounds disappeared (diastolic pressure) was recorded (American College of Sports Medicine, 2006).

3.7.2.3 Resting heart rate

Equipment: Stopwatch

Procedure: Upon completion of the blood pressure test, the medical officer then took the resting heart rate at the wrist of each participant. He placed his index and middle fingers together on the left wrist, about 1cm on the inside of the joint, in line with the index finger. On feeling the pulse, the number of beats the medical officer felt within a one minute period was recorded (American College of Sports Medicine, 2006).

3.7.2.4 Flexibility evaluation

The following static flexibility tests, that directly measured the amount of joint rotation in degrees, were selected: ankle plantarflexion, ankle dorsiflexion and hip external rotation. They were selected based on their role as potential stress fracture risk factors (Hughes, 1985; Giladi *et al.*, 1987; Giladi *et al.,* 1991; Milgrom *et al.,* 1994).

3.7.2.4.1 Hip external rotation

Equipment: Goniometer

Procedure The participant assumed a sitting position. The goniometer was centered over the anterior part of the patella with the fixed arm positioned perpendicular to the floor and the moving arm placed over the anterior midline of the lower leg, using the crest of the tibia and point midway between the malleoli for reference. The participant sat with knees flexed 90˚, with a rolled towel placed under the femur. The measurement was taken as the amount of rotation, in degrees, completed in external hip rotation with the diastal end of the femur acting as the stabilizer. Participants were instructed not to rotate and laterally tilt the pelvis when executing the movement (Heyward, 2002).

3.7.2.4.2 Ankle dorsiflexion and plantarflexion

Equipment: Goniometer

Procedure: The participant assumed a sitting position. The goniometer was positioned over the lateral aspect of the lateral malleolus with the stationary arm being the midline of the fibula, using the head of the fibula as reference, and the moving arm was placed parallel to lateral aspect of the fifth metatarsal, with the tibia and fibula providing the stabilization. The participant sat on the end of the table with knees flexed and ankles positioned at 90˚. The measurement was taken as the amount of rotation, in degrees, completed in dorsiflexion and in plantarflexion (Heyward, 2002).

3.7.2.5 Biomechanical parameters

3.7.2.5.1 Leg length

Equipment: Flexible steel tape measure

Procedure: The participant assumed a supine position. The distance from the superior iliac crest to the medial malleolus was measured on the left and right leg and recorded, by the medical officer, to the nearest 0,1cm (Heyward, 2002).

3.7.2.5.2 Q angle

Equipment: Goniometer

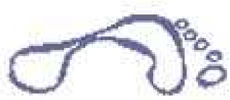
Procedure: The participant assumed a standing position. The Q - angle was measured as the acute angle (Q) formed by a line from the tibial tuberosity through the midpoint of the patella, and a line from the anterior superior iliac spine through the midpoint of the patella (Brody, 1980; Clement & Taunton, 1981). This angle represents the degree of deviation of the patellar tendon from the line of pull by the quadriceps muscles on the patella (Cowan *et al.*, 1996). The Q - angle for each knee was measured, by the same technician, in degrees and recorded.

3.7.2.5.3 Foot type

Equipment: Power chalk, black board

Procedure: The participant assumed a standing position. The participants placed their feet in white chalk and were then asked to stand, with their weight evenly distributed on both legs, onto a blackboard, leaving a visible footprint. The medical officer then categorised each foot as being flat, normal or high arched, based on his observation of the imprint formed (Table 3.4).

Table 3.4: Foot type categorisation based on footprint

Foot type		
Flat foot	**Normal foot**	**High Arched Foot**
		

3.7.2.6 Isokinetic testing

Equipment: Cybex 340 System (Cybex, Division of Lumex, Inc., 2100 Smithtown Avenue, Ronkonkoma, New York, 11779).

Method: Isokinetic testing involves the assessment of maximl muscle tension throughout a range of joint motion set at a constant angular velocity (American College of Sports Medicine, 2006). All isokinetic testing was performed at 1 Military Hospital, on a computerised isokinetic dynamometer. All testing was done as outlined in the Cybex 340: Extremity Testing and Rehabilitation System User's Manual, 1988. All study participants underwent isokinetic testing to determine upper and lower leg isokinetic strength.

3.7.2.6.1 Knee extension / flexion

The following positioning, stabilisaton and set-up procedure was followed for the knee extension/ flexion test:

- Warm-up for 7 minutes on a stationary bicycle
- The dynamometer was rotated to the right side,
- The long input adapter was attached and the adjustable arm was installed,
- The participant was positioned in a seated position at a 0˚ tilt,
- The seat, dynamometer axis and dynamometer height was adjusted to align with the axis of rotation,
- The shin pad was positioned just above the medial malleolus and was strapped tightly to the participant's leg with a Velcro belt,
- The participant's pelvis and torso was stabilized by tightly securing the 3-point safety belt and lap belts,
- Verbal introduction on the isokinetic concept of exercise was given,
- Warm-up (3 submaximal, 3 maximal repetitions) with a 30 seconds rest,
- Maximal test at slow velocity (60 º/s), 5 repetitions,

- The patient was instructed to begin the test in full flexion with the heel touching the kick pad, and keep arms crossed over chest throughout all test bouts;
- This was then repeated on the left leg.

After the test the peak isokinetic knee extension and knee flexion torque was recorded as well as the quadriceps to hamstring ratio.

3.7.2.6.2 Ankle plantar/dorsiflexion

All participants were instructed to wear flat tennis-style shoes. The following positioning, stabilisaton and set-up procedure was followed for the ankle plantar/dorsiflexion test:

- Warm-up for 7 minutes on a stationary bicycle,
- The '340 position chair method' was chosen,
- The dynamometer was rotated and positioned to the right side for the reclined 340 chair,
- The back height was adjusted to the lowest position,
- The short input adapter was attached and the plantar / dorsiflexion footplate was installed,
- The patient was instructed to lie prone with the foot flat on the footplate, with ankle neither inverted nor everted,
- The participant was instructed to slide so that the ankle was lined up with the dynamometer input shaft and to keep the knee of the test limb (right) locked in full extension throughout the movement,
- The ankle was secured with the footplate belts as well as with the 340 thigh stabilization belts,
- Verbal introduction to the isokinetic concept of exercise was given,
- Warm-up (3 submaximal, 3 maximal repetitions) with a 30 seconds rest,

- Maximal test at slow velocity (30 º/s), 5 repetitions,
- The participant was instructed to begin the test in full dorsiflexion;
- This was then repeated on the left ankle.

After the test, the peak isokinetic ankle dorsiflexion and ankle plantarflexion was recorded.

3.7.2.7 Isometric handgrip test

3.7.2.7.1 Handgrip strength test

The purpose of this test was to measure grip or forearm muscle strength. Handgrip strength is important for military training, as the hands are used for weapon handling and lifting equipment. Additionally, hand strength is often a good indicator of general body strength (Heyward, 2002).

Equipment: Handgrip dynamometer (Jamar hydraulic hand dynamometer).

Procedure: The participant first held the dynamometer in the dominant hand in line with the forearm, hanging by the thigh. Maximum grip strength was then determined without swinging the arm. The better of two trials for each hand was recorded according to the prescribed protocol. The values listed below (in kilograms) give a guide to expected scores for adults (Heyward, 2002).

Table 3.5: Ratings for Handgrip strength test (Heyward, 2002).

Rating	Males (kg)	Females (kg)
Excellent	> 64	> 38
Very good	56-64	34-38
Above average	52-56	30-34
Average	48-52	26-30
Below average	44-48	22-26
Poor	40-44	20-22
Very poor	< 40	< 20

3.7.3 Bone density

Seventy randomly selected female participants underwent Bone Densiometry analysis at the Pretoria Heart Hospital.

Equipment: Dual-Energy X-ray Absorptiometry (DEXA) scanner (Prodigy; GE/Lunar Corporation, Madison, WI).

Procedure: The participant assumed a supine position. The DEXA was used to measure BMD (g), BMC (g) and body composition with lean mass (g) and fat mass (g). DEXA can distinguish regional as well as whole body parameters of BMD, BMC and body composition. As such, it is considered a reference standard, and the latest body composition research uses this method. BMD, BMC and body composition was determined at various body regions (total body, arms, legs and trunk), the lumbar vertebrae, and hip regions (total hip, femoral neck, trochanter and femoral shaft) (Mazess *et al.*, 1990; Heyward, 2002).

Prior to the start of the test, each participant was fully briefed on what the test would entail. The Bone Density Test is a simple, painless non-invasive procedure. The participants were also asked to wear comfortable clothing. Clothing that had zippers, underwires or metal buttons was removed prior to the test.

The participant lay on the whole-body DEXA scanner, with the X-ray sources mounted beneath the table and the detector overhead. The participant was asked to lie still whilst the DEXA scanned with photons that were generated by two low-dose X-rays at different energy levels. The body's absorption of the photons at the two levels was measured. The ratios were then used to predict BMC, BMD, total body fat and fat-free mass. Each test took 20 minutes to complete (Mazess *et al.*, 1990).

Additionally, to minimise variability (diagnostic and monitoring) measurements were made on the same DEXA instrument, namely the LUNAR DPX, at the Pretoria Heart Hospital, with the same two radiographers completing both the Pre and Post tests on their respective participants (Beshgetoor *et al.,* 2000; Phillipov *et al.,* 2001; Bemben *et al.,* 2004). A high resolution, computer-generated image of the skeleton, allowed for correction of possible position errors (Beshgetoor *et al.,* 2000).

The results for BMD were given in g/cm^2 and expressed in the form of two scores:

- ***T-score*** — reflects the amount of bone the participant has compared with a young adult of the same sexr with peak bone mass. A score above -1 is considered normal. A score between -1 and -2.5 is classified as osteopenia, the first stage of bone loss. A score below -2.5 is defined as osteoporosis. The T-score is used to estimate the individual's risk of developing a fracture.
- ***Z-score*** — reflects the amount of bone the participant has compared with other people in the same age group and of the same size and sex.

Measurements were also given for body composition from the total body scan with lean mass (g) and fat mass (g). The reproducibility for total body measurements was 0.7% (Heyward, 2002).

3.7.4 Standard fitness test

The standard fitness test, consisting of five components was executed in the following sequence, as prescribed by the DOD policy on PT 2000. The 2.4km running test was executed as the first component of the battery test. Participants then had a maximum rest period of 15 minutes, but not less than 10 minutes, after the 2.4km running test. This was followed by the sit-up test, the push-up test and the shuttle run test. The last component of the battery test was the 4km walk test. A rest period of 2 minutes was given between these components. The component description and execution was as follows:

3.7.4.1 Sit-ups

Equipment: Stopwatch

Procedure: The sit-ups were executed with the knees bent at a 90˚ angle, the feet fixed, the hands were kept on the ears, and the elbows pointing forwards, touching the knees with every sit-up. The arms were bent and pressed against the ears throughout the exercise. This position prevented the bent arms from shooting upward and facilitating the upward movements. The exercise had to be repeated, without a rest or a break in rhythm. A pause was allowed only when the body was in the active rest position (on top). The total number of sit-ups performed in 2 minutes was recorded.

3.7.4.2 Push-ups

Equipment: Stopwatch

Procedure: The push-ups were executed from a prone position with a stretched body and bent arms (women executed the push-up with their knees on the ground). The exercise consisted of raising and lowering the body without bending it, by using the knees or the toes as a fulcrum. When the arms were bent, the chest had to touch the partner's fist, which was placed underneath the participant's chest in line with the palms of his/her hand. A uniform rhythm had to be maintained throughout, otherwise the test was stopped. A pause was allowed only when the body was in the active rest position (on top). The total number of push-ups performed in 2 minutes was recorded.

3.7.4.3 10 x 22 m Shuttle Runs

Equipment: Stopwatch

Procedure: A distance of 22 m was run, 10 times without any breaks. The participant started behind the starting line, ran to the 22 m mark and turned around on or over the mark. When the participant reached the starting line for the first time, he had completed two laps. The time taken to complete 10 laps was timed and recorded.

3.7.4.4 2.4 km Run

Equipment: Stopwatch

Procedure: The test was conducted over a distance of 2.4 km on a flat surface. The first half of the distance (1,2 km) was run to a turning point, and the second half was run over the same route, back to the starting point. The time taken to complete the distance was timed and recorded.

3.7.4.5 4km Walk

Equipment: Stopwatch

Procedure**:** The test was executed on a flat, circular route of 4 km. No running or jogging was allowed. The time taken to complete the distance was recorded.

3.8 TWELVE WEEK BT PERIOD

The participants then travelled to Lohatla on Sunday, 9 July 2006, and commenced their 12-week BT.

3.8.1 BT programme

A standardised BT programme was followed (Appendix Copy Disk- A). The main aim of this Programme was to ensure a combat ready soldier at the end of the 12-week period. Activities included drill, regimental aspects, compliments and saluting, CHATSEC course, general military aspects, musketry, shooting, signal training, mine awareness, map reading, buddy aid, field craft, water orientation, parade rehearsal and PT. It is difficult to quantify the BT programme, however, since the same standardised programme was followed by all the study participants, it acted as its own control. Additionally, the same BT programme was followed by the previous year, except for a different PT programme.

3.8.2 Menstrual history questionnaire

In the fifth week of BT all 83 female participants were requested to complete a questionnaire which provided detailed insight into their menstrual history, prior to BT, as well as into changes which may have occurred during the initial part of BT. This questionnaire was repeated at the end of the 12-week period (Appendix C).

3.8 STATISTICAL ANALYSIS

The information obtained from the sample was captured onto computer and analysed by means of the Statistical Product and Service Solutions package. Data were only analysed for cases where complete information was available. Thus, the base size differs for the different types of tests done by the BT candidates. The following statistical procedures were used to analyse the data:

3.9.1 Descriptive statistics.

Descriptive statistics are primarily aimed at describing the data and were used to describe the sample, as well as to give insight into the candidate's responses to the Health and Physical Activity questionnaires. The mean, range and standard deviations were used to describe the results of all biokinetic, bone density and fitness tests. The following descriptive statistics were used: frequencies, mean, range and standard deviations. A brief definition of the latter three follows:

3.9.1.1 Mean

Mean is generally what is meant by the word 'average'. The mean is the total of the scores divided by the number of scores (Howell, 1992). Certain disadvantages are associated with the mean: "*It is influenced by extreme scores, its value may not actually exist in the data, and its interpretation, in terms of the underlying variable being measured, requires at least some faith in the interval properties of the data"* (Howell, 1992: 33).

3.9.1.2 Range

The range is a measure of distance – the distance from the lowest to the highest score. It has the undesired property of being dependent on the sample size because the more values that you have, the farther apart the largest and the smallest of those values are likely to be (Howell, 1992).

3.9.1.3 Standard deviation

The standard deviation is the positive square root of the variance, which can be defined as the sums of squared differences between scores and their means (Tabachnick & Fidell, 1996). The more variability there is in a group of responses, the higher the value of the variance and subsequently the standard deviation, the more homogeneous the group responses, are the lower the value (Kranzler & Moursund, 1995).

3.9.2 Inferential statistics

Inferential statistics can be defined as follows: "*Test hypotheses about differences in populations on the basis of measurements made on samples of participants*" (Tabachnick & Fidell, 1996 : 9).

3.9.2.1 Chi-square analysis

Chi-square analysis was used to determine whether statistically significant relationships existed between the group membership (experimental vs. control), and the pass or fail rates of the groups on all fitness tests. Chi-square tests are used when there are two nominal variables and determination of whether these variables are independent of one another is needed. The data are cast in what is commonly referred to as a contingency table (Howell, 1992).

This technique gives an indication of whether there is a statistically significant relationship between two variables. The coefficient does not, however, give an indication of the strength or direction of the relationship.

3.9.2.2 T-tests for Dependant samples

This test is used when there are two matched samples, often called repeated measures, where the same participant responds on two occasions, and a test on the difference between their two means is performed (Howell, 1992).

This test was used to determine whether statistically significant differences existed between the Pre- and Post-test measurements of the EG on biokinetic and bone density data. This analysis was repeated for males and females.

3.9.2.3 T-tests for Independent samples

The results of fitness tests were analysed by means of this procedure, in order to test for statistically significant differences between the EG and CG on all measurements taken. The T-test assesses the statistical significance of the difference between two independent sample means (Hair *et al.,* 1998). Statistical significance will be reported at the 5% level of significance.

3.9.2.4 Friedman's rank test for k correlated samples

This test is the distribution free analogue of the one-way, repeated measures analysis of variance. "*It is a test on the null hypothesis that the scores of each treatment were drawn from identical populations, and it is especially sensitive to population differences in central tendency*" (Howell, 1992: 624). This test was used to determine whether statistically significant differences existed between measurements obtained during the Pre-test and two consecutive Post-tests during the fitness tests.

The methodlogy used and procedures followed were outlined in this chapter. The cohort comprised of 183 South African BT trainees where prospectively followed over a 12-week BT period and tested at the beginning and end of the 12 weeks. A mid-course fitness evaluation was also included in the results and only 68 female participants underwent Dexa testing due to financial constraints. The following chapter provides the results measured and attempts to explain and discuss these results.

CHAPTER 4

RESULTS AND DISCUSSION

The primary goal of this study, set before the study commenced, was to determine the incidence of stress fractures, during 12 weeks of BT. This was done by analysing and monitoring the changes in the military recruits' intrinsic risk factors, if any, from when they reported, to when they completed their training. The study aimed to achieve this goal through the following objectives:

4.1 PRIMARY OBJECTIVES

The objectives of this investigation are:

- To determine the incidence of stress fractures during 12 weeks of BT;
- To compare the results of risk indicators obtained from the group of participants who suffered stress fractures during their 12 weeks of BT, with the rest of the original group (controls) who didn't suffer from any stress fractures.

4.2 SECONDARY OBJECTIVE

- To determine whether 12 weeks of BT results in any changes in physical markers, whilst following a progressive, scientifically designed PT programme.

Due to the uniqueness of both military recruits and military training, generalisation of this investigation's findings to other population groups, should only be done with the utmost caution. The results are based on data collected. The sample sizes changed according to the number of participants who were tested with a particular test. All analyses are based on participants where all the data was available.

The Bone Density measurements were only taken for 70 randomly selected female participants from the cohort therefore the results of these variables reflects this sample. For the physical fitness results and discussion, the cohort is referred to as the EG and their results were compared to the CG. The CG consisted of 198 participants, who had undergone BT in the SAMHS, in Lohatla, in the year prior to the cohort’s BT. Analysis for this group (CG) also only included the number of cases with complete data.

All results that showed statistically significant tendencies were significant at the 95% level of confidance, unless otherwise specified. One must remember that all statistically significant differences necessarily imply clinical differences in results.

4.3 STRESS FRACTURES INCIDENCE DURING BT

All participants were followed, for the occurrence of stress fractures, from the first day of BT until the last day of training or separation from BT. Upon the completion of the training or separation, the participant's medical records were reviewed in order to collect information on the number of visits to the sickbay, injury occurrence, site, onset, diagnosis, treatment and the number of light duty days given (if any).

The diagnosis of stress fractures was based on criteria used on the clinical presentation of localised pain of gradual and harmful onset, without prior acute trauma, aggravated by repetitive weight-bearing activities and relieved with rest; and then followed by a radiograph and/or Bone Scan, at a site consistent with the clinical presentation, which confirmed the presence of a stress fracture (Bennell & Brukner, 1997; Rauh *et al.,* 2006). This was diagnosed by the medical officer of the sickbay and recorded in the recruit's medical record.

Upon reviewing the medical records it was found that after following the cohort prospectively for the duration of 12 weeks of BT, not one recruit was diagnosed with a stress fracture (although a total of 719 visits to the sickbay were recorded over this period). Furthermore, the researcher reviewed the medical records of all participants for a six month period after the completion of BT, to ensure that the delayed confirmation of stress fracture diagnosis was controlled for (Jones *et al.,* 2002). This review also found no incidence of stress fractures.

This is in contrast to several other studies that specifically looked at the stress fracture incidence during a recruits' initial-entry, which starts with BT. Researchers showed that the stress fracture incidence reported was sex specific, with the incidence rate, during BT, ranging from 0.9% to 5.2% in males, and 3.4% to 21.0% in females (Reinker & Ozbourne, 1979; Kowal, 1980; Brudvig *et al.,* 1983; Jones *et al.,* 1993a; Jones *et al.,* 1999).

Possible reasons for this lack of stress fracture occurrence include, insufficient cohort size, lack of risk factors within the cohort and the new, gradually progressive, scientifically designed PT Programme used during BT.

4.3.1 Cohort size

Although a prospective cohort is the preferred design as it permits the ongoing collection of predetermined data sets over a specific period of time, it has the risk of no incidences occurring in the specific period of time (Snyder *et al.,* 2006). The study started with 185 participants, 100 male and 85 female. After the 12 weeks of BT, 2 female participants dropped out of the study, having resigned from the South African National Defence Force. In 2 local studies, Gordon *et al.* (1986c) reported a stress fracture incidence of 4.12% amongst the 947 recruits studied whilst Jordaan and Swellnus (1994) reported a 1.2% incidence rate amongst 1151 recruits during the nine weeks of BT in 1989. A case series study done on 250 female cohort of Infantry BT participants, in the South African context, found 19 stress fractures had developed in the 12-week period (Wood & Krüger, 2007).

The method used in the diagnosis of a stress fracture plays a vital role in the final incidence rate of the various studies. When Bone Scans are used to classify stress fractures, the incidence rate appears to be over inflated, as opposed to a radiographic diagnosis, where a lower incidence rate is reported. This is due to its poor sensitivity (Milgrom *et al.,* 1994, Berger *et al.,* 2007). In the current study, despite the use of Bone Scans as a diagnosis tool, no incidences of stress fractures were reported. The different sensitivity and specificity of Bone Scans and radiographs, in detecting stress fractures, is relevant to both clinicians as well as to researchers. In addition, the delayed confirmation of stress fracture diagnoses by radiographs, must be factored into both clinical and research protocols (Jones *et al.,* 2002). Regardless of the diagnosis method used, it is clear that stress fractures are a common problem within the military environment (Lappe *et al.,* 2001; Jones *et al.,* 2002; Rosental *et al.,* 2003; Välimäki *et al.,* 2005; Rauh *et al.,* 2006; Shaffer *et al.,* 2006).

4.3.2 Risk

To begin with, the cohort used may not have possessed the intrinsic risk factors as highlighted in the literature, or may not have been exposed to the extrinsic risk factors identified in previous studies, thus reducing the risk for developing stress fractures (Brukner *et al.,* 1999; Jones *et al.,* 2002; Rosental *et al.,* 2003; Välimäki *et al.,* 2005; Rauh *et al.,* 2006; Shaffer *et al.,* 2006). This will be investigated in detail under 4.4 and 4.5.

4.3.3 Scientifically designed progressive PT Programme

The gradually progressive, scientifically designed PT Programme used during BT (Appendix: Copy Disk- B), may have contributed to no stress fractures being developed. As all training exercises involve the maintenance of a balance between the risk of fracture, inherent in exposure to loading, and the beneficial effect that loading has (stimulating bone cells to produce a more robust architecture)(Brukner *et al.,* 1999; Ducher *et al.,* 2006), the PT Programme designed was, possibly, a safer exercise regime for the BT population.

4.4 RISK FACTORS RESULTS

4.4.1 Intrinsic risk factors

Intrinsic risk factors are characteristics of the individual sport or exercise participant. This includes demographic characteristics, anatomic factors, bone characteristics, physical fitness and health risk behaviors (Jones *et al.,* 2002).

4.4.1.1 Demographic characteristics

Demographic characteristics that have been reported in the literature include age, sex and race (Proztman & Griffis, 1977; Reinker & Ozbourne, 1979; Kowal, 1980; Brudvig *et al.,* 1983; Lloyd *et al.,* 1986; Barrow & Saha, 1988; Gardner *et al.*, 1988; Zahger *et al.,* 1988; Brunet *et al.,* 1990; Myburgh *et al.,* 1990; Friedl *et al.,* 1992; Jones *et al.,* 1993b; Goldberg & Pecora, 1994; Bennell *et al.,* 1996; Bijur *et al.,* 1997; MacLeod *et al.,* 1999; Shaffer *et al.,* 1999b; Beck *et al.,* 2000; Bell *et al.,* 2000; Kelly *et al.;* 2000; Lappe *et al.*, 2001; Jones *et al.,* 2002; Shaffer *et al.,* 2006).

4.4.1.1.1 Chronological Age

The ages of the cohort used in this study ranged from 18 to 22 years (see Table 4.1), with 74.3% of the participants, falling in the category between 19 and 21 years of age.

Table 4.1: Chronological age of the participants in years

		Frequency	Percent	Valid Percent	Cumulative Percent
Age	18	17	9.2	9.2	9.8
	19	40	21.9	21.9	31.1
	20	57	31.1	31.1	62.3
	21	39	21.3	21.3	83.6
	22	30	16.4	16.4	100.0
	Total	183	100.0	100.0	

Studies in military recruits have had conflicting results as to whether recruits in their late twenties and early thirties are at an increased risk for stress fractures compared to their younger counterparts (Brudvig *et al.,* 1983; Gardner *et al.*, 1988; Milgrom *et al.*, 1994). The military studies reviewed indicated that older age, specifically men over the age of 21 years, may heighten the risk of stress fractures (Brudvig *et al.,* 1983; Gardner *et al.,* 1988; Milgrom *et al.*, 1994).
Based on the above, it appears that the age of this cohort was not a factor that would have placed them at an increased risk for the development of stress fractures.

4.4.1.1.2 Sex

The cohort studied, consisted of 54.6% male participants and 45.4% female participants as indicated in Table 4.2.

Table 4.2: Sex of the participants

		Frequency	Percent	Valid Percent	Cumulative Percent
Sex	Male	100	54.6	54.6	54.6
	Female	83	45.4	45.4	100.0
	Total	183	100.0	100.0	

Amongst demographic factors, female sex is the most commonly identified intrinsic risk factor for stress fractures (Proztman & Griffis, 1977; Reinker & Ozbourne, 1979; Kowal, 1980; Brudvig *et al.,* 1983; Lloyd *et al.*, 1986; Barrow & Saha, 1988; Zahger *et al.*, 1988; Brunet *et al.*, 1990; Myburgh *et al.*, 1990; Friedl *et al.*, 1992; Jones *et al.,* 1993a; Goldberg & Pecora, 1994; Bennell *et al.*, 1996; Bijur *et al.*, 1997; MacLeod *et al.*, 1999; Beck *et al.,* 2000; Bell *et al.,* 2000; Jones *et al.*, 2002; Shaffer *et al.*, 2006).

Contrary to studies that have shown that women, performing the same, prescribed physical activities as men during BT, incur stress fractures at incidences 2–10 times higher than those for men (Proztman & Griffis, 1977; Reinker & Ozbourne, 1979; Kowal, 1980; Brudvig *et al.,* 1983; Jones *et al.*, 1993a; Bijur *et al.*, 1997; MacLeod *et al.*, 1999; Armstrong *et al.*, 2004), this cohort did not experience any stress fractures, even though 45.4% of the cohort were females who trained with their male counterparts.

This study possibly reinforces the findings by Bell *et al.*(2000) who reported that although the crude injury rates indicated that women were at a higher risk of injury than men, when the injury rates were adjusted for fitness, no significant sex difference existed. Thus, much of the sex related injury relationship appears to be explained by physical fitness, in particular, aerobic fitness, as opposed to the sex *per se*. There appears to be no significant difference between the fitness levels of the female and male counterparts (see section 4.4.1.4).

Additionally, other studies examining risk factors have suggested that this higher incidence of stress fractures in young women may be secondary to decreased BMD associated with eating disorders and irregular menses (Black, 1982; Myburgh *et al.;* 1990; Milgrom *et al.,* 1991). The female participants of this cohort who had BMD tested, showed that their BMD was within the limits as prescribed by the World Health Organisation (WHO) (1994). It therefore appears that this cohort sex did not place this cohort at risk for stress fractures.

4.4.1.1.3 Race

Several military studies have examined race as a potential risk factor for stress fractures (Brudvig *et al.,* 1983; Barrow & Saha, 1988; Gardner *et al.,* 1988; Jones *et al.,* 1989; Friedl *et al.*, 1992; Milgrom *et al.,* 1994; Shaffer *et al.*, 1999b; Kelly *et al.,* 2000; Lappe *et al.,* 2001; Shaffer *et al.*, 2006). This cohort was predominantly African (93.5%) as shown in Table 4.3.

Table 4.3: Race of the participants

		Male	Female	Total	Cumulative %
Race	African	94	77	171	93,5%
	Mixed	1	4	5	2.7%
	Indian	1	1	2	1.1%
	Caucasian	4	1	5	2.7%
	Total	100	83	183	100

These military studies suggest that the risk for stress fractures is greater for both male and female Caucasians than for other racial groups, including Afro-Americans, Hispanics and Ethiopians (Brukner *et al.,* 1999). Although the latter are officially classified as Caucasian. The literature strongly suggests that Africans and Hispanics are less likely to develop stress fractures and it has been surmised that higher bone density, larger bones as well as different biomechanical features, such as foot type and lower limb alignment, or anthropometrical features, such as the amount of lean body mass may have a protective effect (Giladi *et al.,* 1991; Bennell & Brukner, 1999; Kelly *et al.,* 2000; Shaffer *et al.,* 2006).

The current study cannot support findings on higher or lower stress fracture incidence regarding race as there were no stress fractures reported. However, with this cohort being 93.5% African, the above-mentioned studies possibly explain why no stress fractures developed and the racial composition of the cohort providing protection against stress fracture development.

4.4.1.2 Anatomical factors

This study evaluated three biomechanical parameters: foot morphology, the Q angle and leg length. These biomechanical factors are surmised to alter the biomechanics of a movement and in this way, create stress-concentration areas in bone or promote muscle fatigue, possibly predisposing the individual to the development of a stress fracture (Hall, 2003). The complete descriptive analysis is presented in Appendix Copy Disk- D as complete statistical output.

4.4.1.2.1 Foot morphology

The medical officer categorised each foot as being flat, normal or high arched based on his observation of the imprint formed. The results in Table 4.4 and 4.5 indicate that the male participants, mostly, had neutral left and right foot types (75%). This tendency was echoed in the female participants where 77.1% had neutral left and right foot types.

Studies have shown that the risk for stress fractures is greater for military recruits who have a high foot arch than for those with a low foot arch (Giladi *et al.,* 1985; Simkin *et al.,* 1989; Brosh & Arcan, 1994; Kaufmann *et al.,* 1999).

Table 4.4: Classification of foot type (left)

Sex			Frequency	%	Valid %	Cumulative %
Male	Valid	Flat	22	22.0	22.0	22.0
		Neutral	75	75.0	75.0	97.0
		High	3	3.0	3.0	100.0
		Total	100	100.0	100.0	
Female	Valid	Flat	18	21.7	21.7	21.7
		Neutral	64	77.1	77.1	98.8
		High	1	1.2	1.2	100.0
		Total	83	100.0	100.0	

Table 4.5: Classification of foot type (right)

Sex			Frequency	%	Valid %	Cumulative %
Male	Valid	Flat	20	20.0	20.0	20.0
		Neutral	75	75.0	75.0	95.0
		High	5	5.0	5.0	100.0
		Total	100	100.0	100.0	
Female	Valid	Flat	18	21.7	21.7	21.7
		Neutral	64	77.1	77.1	98.8
		High	1	1.2	1.2	100.0
		Total	83	100.0	100.0	

The current study found that only 4% of male recruits and 1.2% of female recruits had high-arched feet. With the majority having neutral to flat feet. This is in line with the cohort been 93.5% African as this racial group typically have neutral to flat feet compared to other racial counterparts (Wunderlich & Cavanagh, 2001). it can be concluded that foot morphology was not a risk factor for this cohort due to the high incidence of a neutral foot.

4.4.1.2.2 Quadriceps angle (Q angle) and leg-length

The mean range for both the male and female Q angle was 9.76° to 11.9°. Additionally, no statistically significant differences were found in the male and female participants' Q angle of both the right and left leg between Pre and Post test measurements (see Figure 4.1). A relationship has been found to exist between the Q angle, a measure of knee alignment, and the incidence of stress fractures. Cowan *et al.* (1996) showed a cumulative incidence of stress fractures 4.3 times higher in recruits whose Q angle was greater than 15° compared to that of male recruits with Q angles of 10° or less. It therefore appears that if the Q angle is a risk factor for stress fracture development it has to be greater than 15°. This cohort was thus not at risk as their mean Q angles were not greater than 15°.

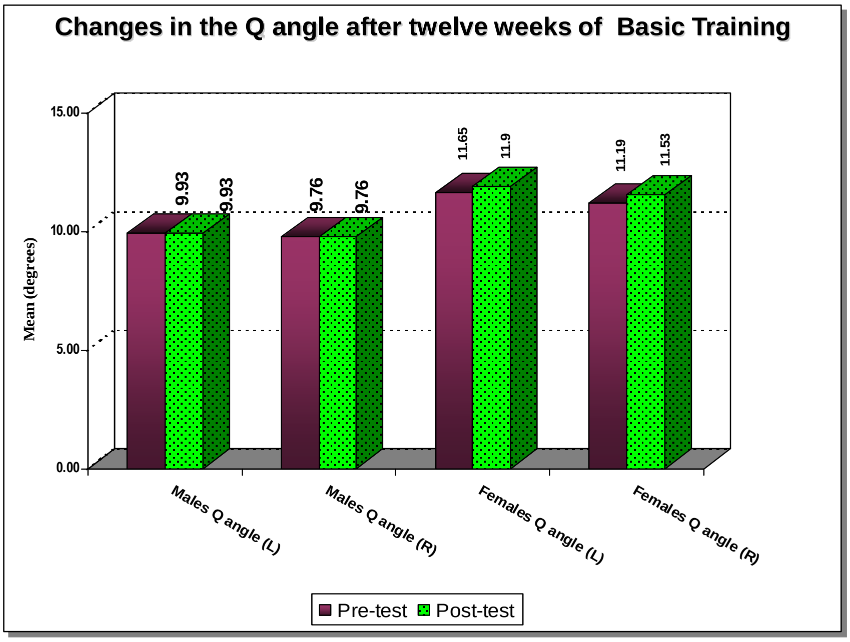


Figure 4.1: Changes in the Q angle after 12 weeks of BT.

The mean leg-length of the participants in the current study is shown in Figure 4.2.

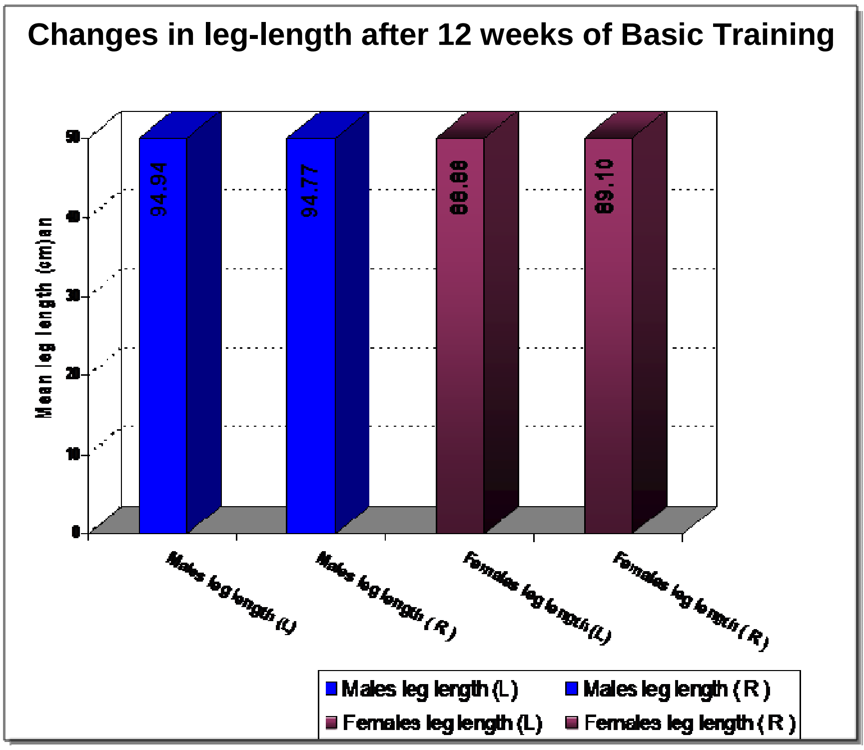


Figure 4.2: Changes in leg-length after 12 weeks of BT

A leg-length discrepancy has theoretically, been postulated as being a potential risk factor for stress fractures because of the resulting skeletal realignment and asymmetries in loading, body tortion and muscle contraction (Ammann & Rizzoli, 2003).The majority of studies assessing the association between differences in right and left leg-length and the risk of stress fractures do suggest an association with a leg-length difference of more than 0.5 cm (Friberg, 1982; Brunet *et al.,* 1990; Bennell *et al.,* 1996).

The current study found that although only 24% of males and 12.04% of the females had a leg-length discrepancy of less than 0.5 cm, there were no incidences of stress fractures reported. The incidence of leg-length discrepancy is reported in percentage of occurrence in Table 4.6. The findings in this study concur with those reported by Cowan *et al.* (1996) who found no difference in stress fracture incidence amongst 294 Army trainees with measured leg-length discrepancies and trainees without them.

Table 4.6: Leg-length discrepancy expressed in percentage of occurrence

Sex	Discrepancy(%) >2.00cm	Discrepancy(%) 1.01-2.00cm	Discrepancy(%) 0.5-1.00cm	Discrepancy(%) 0.00-0.49cm
Male (n=100)	3.00	20.00	53.00	24.00
Female (n= 83)	0.12	20.48	66.27	12.04

4.4.1.3 Bone characteristics

Bone strength is related to both bone density as well as bone geometry (Brukner *et al.*, 1999; Ducher *et al.*, 2006). A number of researchers have examined military and civilian bone characteristics (geometry or density) and the occurrence of stress fractures (Margulies *et al.*, 1986; Milgrom *et al.*, 1988; Milgrom *et al.*, 1989; Pouilles *et al.*, 1989; Carbon *et al.*, 1990; Giladi *et al.*, 1991; Grimston *et al.*, 1991; Beck *et al.*, 1996; Beck *et al.*, 2000; Jones *et al.*, 2002).

Due to the high cost factor and the high incidence of stress fractures amongst South African female military BT trainees, reported by Wood and Krüger (2007), only female participants underwent DEXA scans. The results therefore only reflect these results.

The current study investigated the bone density of 70 randomly selected female participants from the 83 female participants in the sample. One of the 70 participants terminated her employment before any bone density tests could be completed, thus Pre-test measurements were completed on 69 female participants. Furthermore, another member terminated her employment before the end of BT. Complete bone density data are thus available for 68 female participants.

The complete descriptive analysis is presented in Appendix Copy Disk-E as complete statistical output. Mean scores on all relevant measurements were transferred to the figures and tables in the following sections for easier interpretation.

4.4.1.3.1 Bone density

BMD measurements are used to diagnose osteoporosis, assess future fracture risks, and monitor treatment. DEXA is a planar measurement where BMC is measured (g) and then related to the scanned region area (cm^2) to provide the BMD (g/cm^2). BMD is calculated as follows (Phillips & Phillipov, 2006):

$$BMD = \frac{BMC\ (g)}{Area\ (cm^2)}$$

The measurements taken in this study were compared to the reference data for the LUNAR DPX (Lunar Corporation, 1993).

The following measurements were taken and reported:

- **Absolute BMD** (g/cm^2): was calculated by comparing the X-ray attenuation measurements for the participants, to measurements of the LUNAR DPX calibration standard. This allowed a comparison between the Pre-test and Post-test measurements to be made (Nielsen, 2000).
- **T-score**: represented the number of Standard Deviations (SD) that the absolute BMD found to be above or below the mean value for a healthy, same sex, young adult counterpart (20–35 years-when peak bone mass occurs). This score assisted in defining bone status as being normal (≥–1 and ≤+1), osteopaenia (between –1.0 and –2.5) or osteoporosis (<–2.5) as outlined according to the World Health Organisation (WHO) (1994) represented in Figure 4.3. One SD approximates to 10% of total BMD,

thus a T-score of –1 implies that BMD was about 10% less than the mean of a young, healthy, same sex counterpart (Kanis *et al.,* 2000).

- **Z-score**: this represented the number of SDs the absolute BMD found to be above or below the mean value for a healthy, age and sex matched counterpart (Kanis *et al.,* 2000), in other words, the relative BMD status with respect to an age and sex matched counterpart. This measurement assesses whether there was an underlining cause of an abnormal BMD measurement (over and above the effects of aging and sex) (Kanis *et al.,* 2000). The Z-score is not used to confirm a diagnosis of osteoporosis because a favorable BMD measurement (compared to the average BMD measurement for the patient's age group) does not mean the individual is not at risk for osteoporosis (Nielsen, 2000).

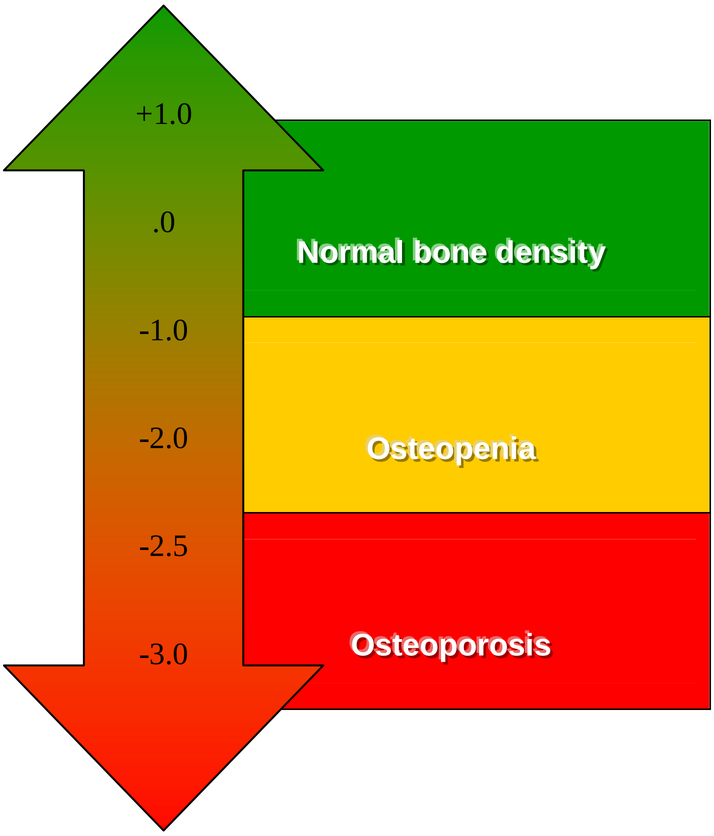


Figure 4.3: Bone density classification according to the WHO guidelines (World Health Organisation, 1994, Kanis *et al.,* 2000).

A complete bone density test was done which included assessing the BMD at the following measurement sites:

- **Total body:** value represented the mean of all the body regions combined, namely: the head, arms, legs, trunk, ribs, pelvis and spine (Bemben *et al.,* 2004).
- **Anterior-Posterior (AP) Spine**: value represented the average of vertebrae L1–L4 (Casez *et al.,* 1995; Cline *et al.,* 1998; Bemben *et al.,* 2004; Välimäki *et al.,* 2005).
- **Left femur**: These measurements include those for the neck, trochanter and Ward's triangle (Cline *et al.,* 1998; Beck *et al.,* 2000; Bemben *et al.,* 2004). The latter is defined as an area of diminished density in the trabecular pattern of the neck of the femur evident by X-ray as well as by direct inspection of the area (Stedman's Medical Dictionary, 2000).

BMD predicts future risk of fractures however; this is complicated by the effects of individuals' sex, age and previous facture history (Kanis *et al.,* 2000, Phillipov *et al.*, 2001). For each SD decrease in femur and neck BMD, the relative risk of hip and vertebral fracture increases by 2.6 and 1.8 respectively. Additionally, the relative risk of vertebral and hip fracture increases 2.3 and 1.6 times respectively for each SD decrease in spine BMD. The best estimate of fracture risk, at any particular site, is given by a BMD measurement of the site measured (Phillipov *et al.*, 2001).

In general, the risk for bone fracture doubles with every SD below normal. Thus, a person with a BMD of 1 SD below normal (T-score of -1) has twice the risk for bone fracture than a person with a normal BMD. A person with a T-score of -2 has four times the risk for bone fracture than a person with a normal BMD (Kanis *et al.,* 2000, Phillips & Phillipov, 2006).

Table 4.7 shows that for all measurement sites, at least 80% of all participants had normal bone density measurements for both the Pre-test and Post-test. It was only in the Pre-test and Post-test measurements for L2, where 79.71% and 77.61% of the participants were respectively classified as having normal bone density, while 76.12% of the participants were classified as having normal bone density L1 measurements. These findings are similar to those observed by Casez *et al.* (1995) and Välimäki *et al.* (2005).

Table 4.7: Bone status of participant T-scores according to the WHO guidelines

Measurement site	Normal (≥–1 and ≤+1)		Osteopaenia (–1.01 and –2.49)		Osteoporosis (<–2.5)	
	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
	%	%	%	%	%	%
T-score total body	94.20	95.52	2.90	4.48	2.90	0.00
T-score: total hip	97.10	97.01	2.90	2.99	0.00	0.00
Neck	89.86	92.54	10.14	7.46	0.00	0.00
Ward's	92.75	92.54	7.25	7.46	0.00	0.00
Trochanter	84.06	85.07	14.49	13.43	1.45	1.49
T-score: L1	81.16	76.12	17.39	19.40	1.45	4.48
T-score: L2	79.71	77.61	17.39	20.90	2.90	1.49
T-score: L3	88.41	89.55	11.59	8.96	0.00	1.49
T-score: L4	82.61	82.09	14.49	13.43	2.90	4.48
T-score: L1-L2	84.06	82.09	15.94	16.42	0.00	1.49
T-score: L1-L3	88.41	85.07	11.59	13.43	0.00	1.49

Measurement site	Normal (≥–1 and ≤+1)		Osteopaenia (–1.01 and –2.49)		Osteoporosis (<–2.5)	
	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
	%	%	%	%	%	%
T-score: L1-L4	86.96	86.57	13.04	11.94	0.00	1.49
T-score: L2-L3	88.41	86.57	11.59	11.94	0.00	1.49
T-score: L2-L4	86.96	85.07	10.14	11.94	2.90	2.99
T-score: L3-L4	85.51	85.07	11.59	11.94	2.90	2.99

Additionally, the cohort was 92.8% African with only 1.2% Caucasian. According to Shaffer *et al.* (2006: 111)"…*lower rates or apparent protective factors against stress fractures among black women, may be related to their higher bone density."* This is supported by work by Bennell & Brukner (1997) and Kelly *et al.* (2000).

The above studies support the findings that only two participants having a total body density T-score measurement of >-2.5. This is a very small number to classify the group as a risk for fracture development based on BMD measurements.

An increased fracture risk is not only associated with low bone density, but also with a previous history of fracture (Phillips & Phillipov, 2006). In the fifth week of BT, all 83 female participants were requested to complete a questionnaire regarding previous history of fractures. The complete, descriptive analysis is presented in Appendix Copy Disk – F (Tables 1 to 6) as complete statistical output. A small percentage (3.6%) of the female sample indicated that they had a history of osteoporosis in their family. Therefore, 96.4% of the female cohort reported no history of osteoporosis. None have been treated for low BMD.

The results in Table 4.8 indicate that 7.3% of these female participants had suffered a fracture in their past.

Table 4.8: History of fracture

		Frequency	%	Valid %	Cumulative %
Valid	Yes	6	7.2	7.3	7.3
	No	76	91.6	92.7	100.0
	Total	82	98.8	100.0	
Missing	System	1	1.2		
Total		83	100.0		

Additionally, in order to minimise variability (diagnostic and monitoring), measurements were made on the same DEXA instrument, namely the LUNAR DPX at the Pretoria Heart Hospital, with the same 2 radiographers completing both the Pre and Post tests on their respective participants (Beshgetoor *et al.,* 2000; Phillipov *et al.*, 2001; Bemben *et al.,* 2004)**.** A high resolution computer-generated image of the skeleton allowed for correction of possible position errors (Beshgetoor *et al.,* 2000).

Other factors affecting DEXA BMD values include significant weight change and absolute body size (Nielsen, 2000; Tothill, 2005). The BMD was thus analysed with statistically controlling for body weight (Pouilles *et al.,* 1989). Additionally, the absolute, as well as the relative measurements, were analysed for changes between Pre and Post test measurements.

According to Phillopov *et al.,* (2001) significant changes in serial BMD values are associated with changes greater than 0.055 and 0.045 g/cm^2 at the spine and hip respectively (ie 4–7% depending on the baseline BMD value) (Phillips & Phillipov, 2006).

4.4.1.3.2 Changes in BMD after 12 weeks of BT

BMD may be measured within a volume of bone (g/cm^3), termed volumetric density, or within a known area of bone (g/cm^2), termed areal density (Chinappen-Horsley *et al.,* 2007). The LUNAR DPX used in this study, measured areal density thus, when interpreting the BMD results, it is important that the site area be considered (Phillopov *et al.,* 2001, Phillips & Phillipov, 2006).

The changes in total BMD were only clinically and statistically significant at the head site, with a mean increase of $0.067 g/cm^2$. Increases in BMD and area at this site may be attributed to consumption of both calcium (800-1200 mg) (Välimäki *et al.,* 1994; Lappe *et al.,* 2008) and Vitamin D daily as most of their BT occurred outdoors under the African sun (Chapuy *et al.,* 1992; Dawson-Hughes *et al.,* 1997; Lappe *et al.,* 2008). However, this is speculation as these two markers where not tested for and could possibly be an area for future research.

The pelvis site total BMD measurement showed a clinically significant mean increase of $0.141 g/cm^2$ whilst the pelvis area, showed a significant decrease of $5.44 cm^2$. Both the head and the pelvic site BMD measurement changes were larger than that prescribed by Phillopov *et al.* (2001).

A reason for the BMD change in the pelvis was not being statistically significant ($p= 0.311$), may be attributed to the small base size and the SD (1.12 for the pelvis measurement), which was far greater than the other sites. The increase in BMD and the simultaneous decrease in area, may be explained by the timing of the bone remodeling process. Remodelling refers to the process via which fatigue, damaged bone is replaced by new bone. Remodelling occurs in cycles, which involve breakdown of bone by osteoclasts and the laying down of new bone matrix by osteoblasts. Through a coupled process, over time, filling in of the resorped areas may be incomplete. It occurs at many simultaneous sites, throughout the body, where bone is experiencing growth, mechanical stress, micro fractures or breaks. Remodelling occurs on the surface of trabeculae bone of the pelvis (Martini *et al.,* 2001).

The total remodelling process takes about four to eight months. As the participants were subjected to intense, weight-bearing exercise and the Post-test was carried out only three months after the based-line values were measured, the participants may have been going through the reabsorption phase of the remodelling process, characterised by the osteoclasts digging out a cavity, called a resorption pit, in spongy bone, or burrowing a tunnel in compact bone, which may have affected the area (Martini *et al.,* 2001).

What is vital to understand is that the positioning of the participant for the Post-test DEXA scan needed to be identical to the Pre-test. Failure of this may have resulted in the area measured been different to the Pre-test and thus influencing both the BMD and the area measurements. Although great care was taken to replicate the testing by utilising the same radiographers and the same DEXA machine, the chance of error still exists (Phillopov *et al.,* 2001, Phillips & Phillipov, 2006). Therefore, T-scores and Z-scores are a more reliable measure as they are calculated independent of area (Phillips & Phillipov, 2006).

Additionally, the leg area also showed statistically significant increases in the mean scores measured, without a statistically significant change in BMD. This may be attributed to the intense weight-bearing exercises followed by the participants during the 12 weeks of BT - which may have stimulated modelling in the overload zone, in this case the legs, resulting in the accretion of bone (Duncan & Turner, 1995; Martini *et al.,* 2001). Exercise has been recognised as, usually, having a beneficial effect on bone density because of the mechanical loading forces on the skeleton (Snow, 1996; Stewart *et al.,* 2005). Figure 4.4 reflects the changes in the total body area measurements that occurred during BT.

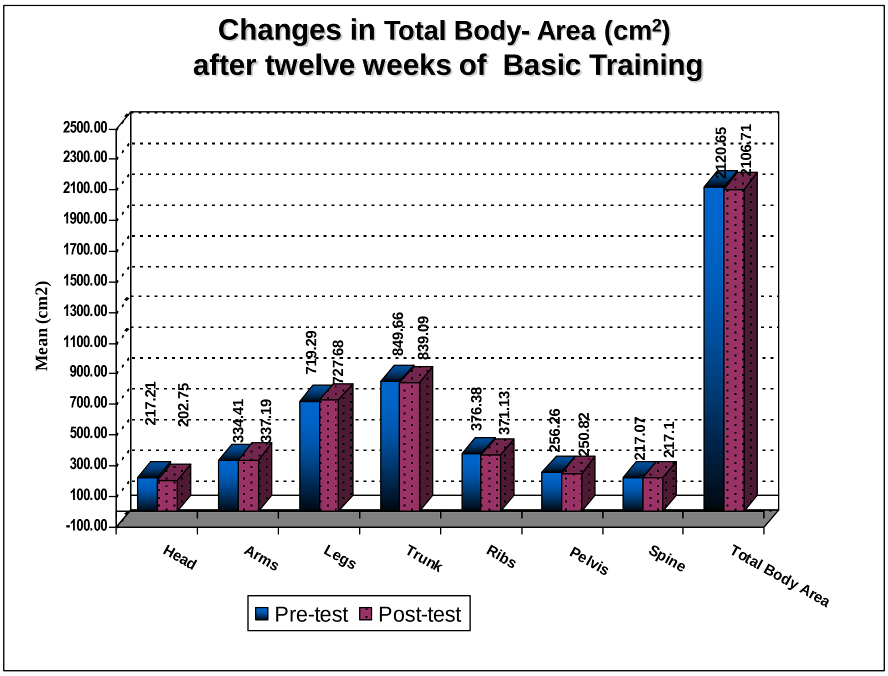


Figure 4.4: Changes in Total Body - Area (cm^2) after 12 weeks of BT in female participants

The changes in AP Spine BMD were only clinically significant at the T12 site, showing a mean increase of 0.4.46g/cm^2 and a clinical and statistical decrease in T12 site area measurement (Phillopov *et al.,*2001). Statistically significant differences were found on all but two of the AP Spine Area (cm^2) measurements. No significant differences were found at L1 and L1-L2 measurements. All the other measurements showed a statistically significant increase from Pre- to Post-test measurements as shown in Figure 4.5. These changes may also be attributed to the reasons cited above.

The changes in left femur BMD were also only clinically significant at one site, with the femur neck showing a mean increase of 0.147g/cm^2 (Phillopov *et al.,* 2001). The Ward's triangle and Trochanter areas showed statistically significant differences in area measurements of the Left Femur (see Figure 4.6).

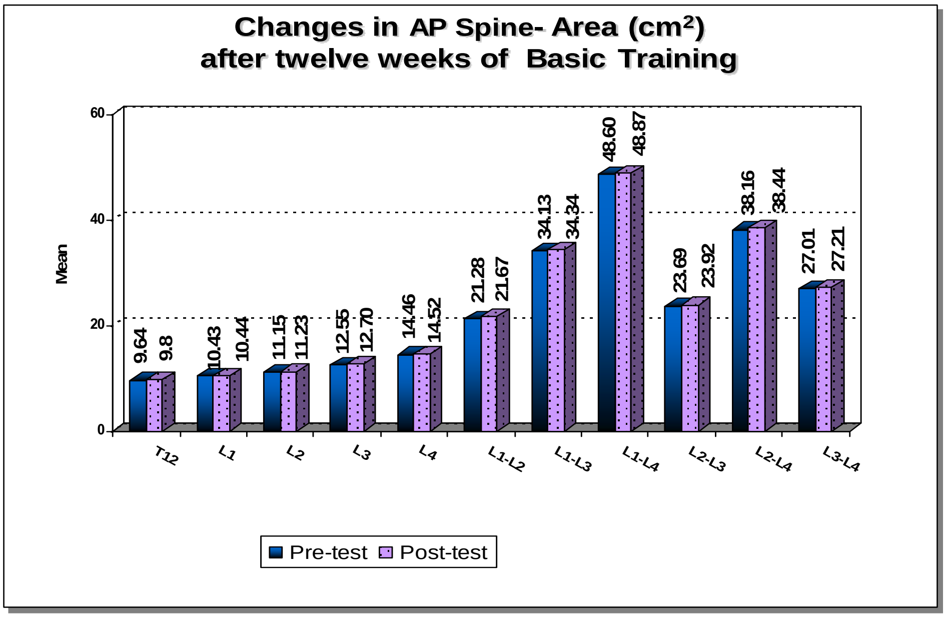


Figure 4.5: Changes in AP Spine - Area (cm^2) after 12 weeks of BT in female participants

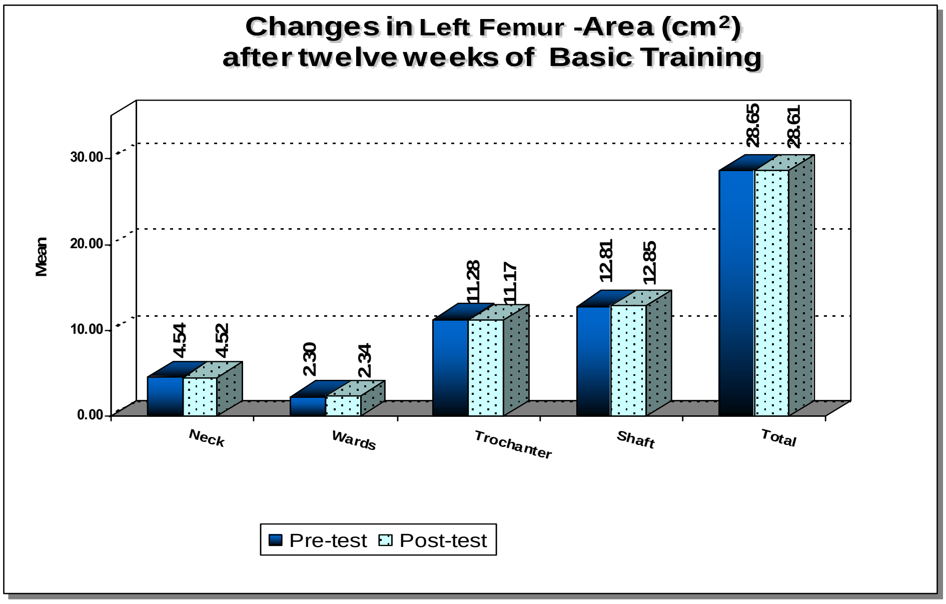


Figure 4.6: Changes in Left Femur - Area (cm^2) after 12 weeks of BT in female participants

The Ward's area measurement of the Pre-test (x=2.30) was significantly lower than the Post-test (x=2.34). The Pre-test of the Trochanter area showed a significantly higher score (x=11.28) than the Post-test (x=11.17). The same reasons sited for the increase in BMD and area for the total body and AP Spine, can be used to explain the increases observed in the femur, neck and Ward's triangle, whilst the decrease could be attributed to the timing involved in the bone remodeling process (Martini *et al.,* 2001).

4.4.1.3.3 Changes in BD T-scores and Z-scores after 12 weeks of BT

The results in Figure 4.7 indicate that no statistically significant difference was found in both the Total Body T-score and Z-score measurements as the changes were smaller than that prescribed by Phillopov *et al.* (2001).

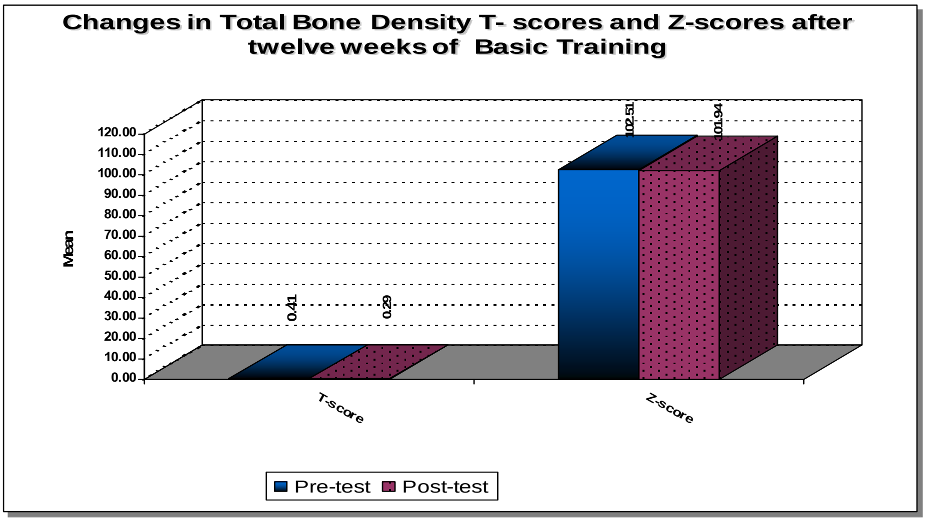


Figure 4.7: Changes in Total Bone Density T-scores and Z-scores after 12 weeks of BT in female participants

The Pre- and Post-test measurements did not change significantly. These findings echo those found by Bemben *et al.* (2004) who compared total body BMD changes in gymnasts and cross-country athletes following six months of training and competition. Only one statistically significant difference was found on the AP Spine T-scores (see Figure 4.8). A statistically significant decline in the L1 scores was observed. None of the other scores showed statistically significant changes.

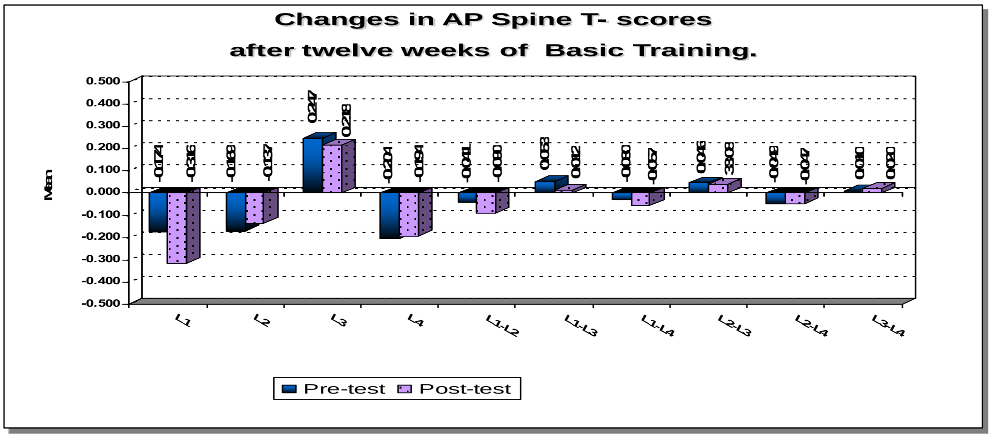


Figure 4.8: Changes in AP Spine T-scores after 12 weeks of BT in female participants

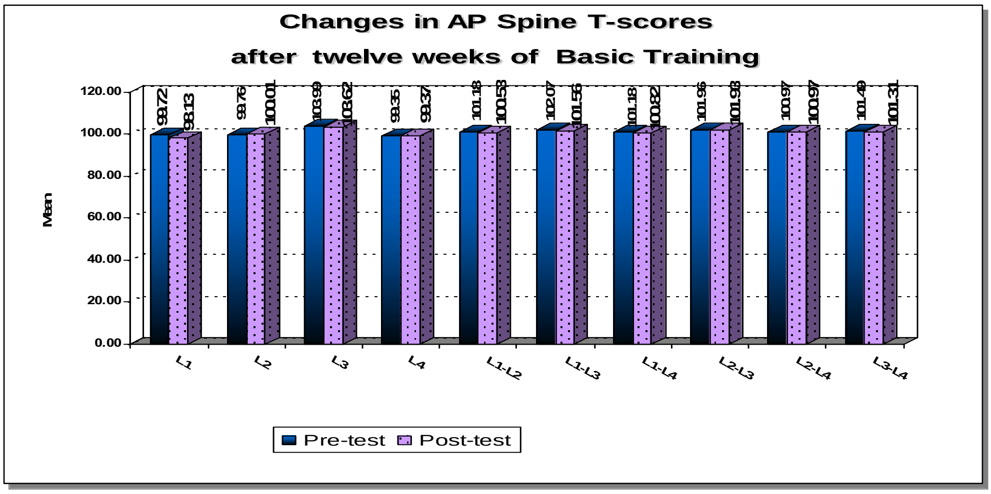


Figure 4.9: Changes in AP Spine Z - scores after 12 weeks of BT in female participants

Only one statistically significant difference was found in the AP-Spine Z-scores as shown in Figure 4.9. Once again, the significant change occurred in the L1 measurement, with Pre-test scores (x=99.72) significantly higher than Post-test scores (x=98.13).

Figure 4.10 reflects the results of the Left-Femur T-scores. Only one statistically significant difference was found at the 5% level of significance. The Left-Femur T-score showed a significant increase from Pre-test (x=0.674) to Post-test (x=0.718).

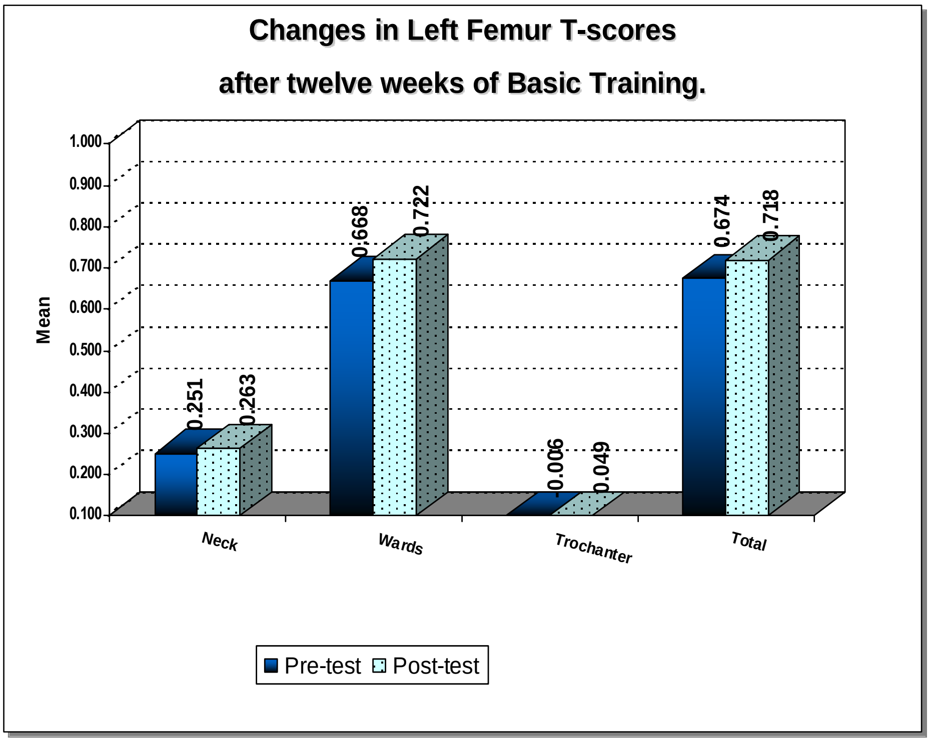


Figure 4.10: Changes in Left Femur T - scores after 12 weeks of BT in female participants.

Only one statistically significant difference was found in the Left-Femur Z-scores, namely in the total Z-score (See Figure 4.11). The Post-test score (x=109.15) was significantly higher than the Pre-test score (x=108.43) as shown in Figure 4.11. This difference was significant at the 5% level of significance.

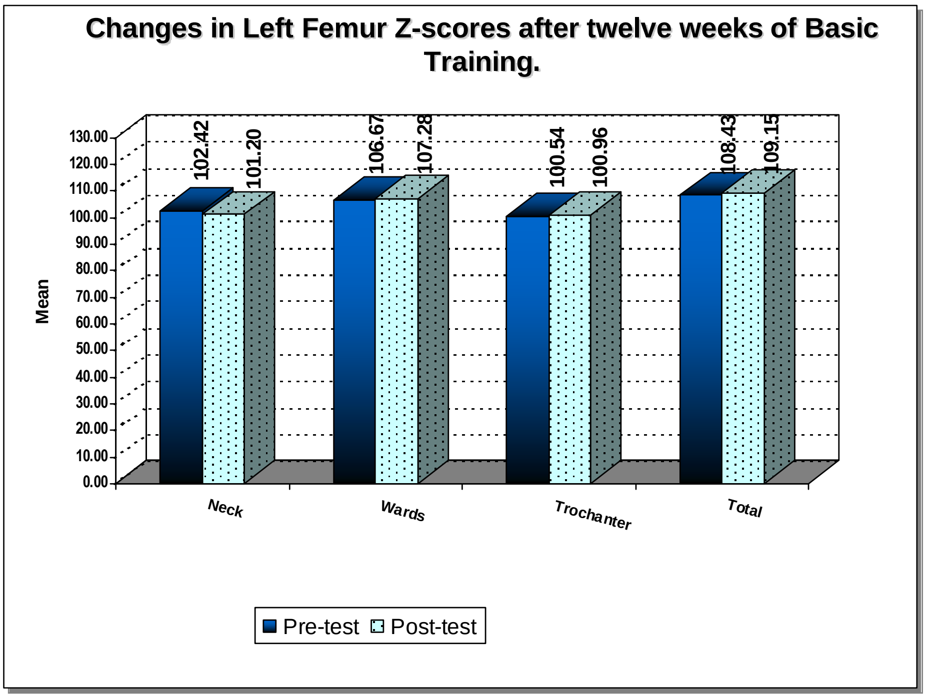


Figure 4.11: Changes in Left Femur Z - scores after 12 weeks of BT in female participants

4.4.1.3.4 Changes in BMC after 12 weeks of BT

The total BMC measurements showed a significant decrease. Figure 4.12 shows the 12 statistically significant changes, on the 5% level of significance, which occurred in the BMC measurements taken. The left arm, left trunk, left total bone, total trunk as well as the left femur's Ward's' triangle, neck and total femur mineral content mean scores showed a statistically significant decrease from Pre-test to Post-test. This supports other studies that also showed significant decreases in BMC, at some of these sites, after BT (Casez *et al.,* 1995; Armstrong *et al.,* 2004).

The head, left leg, right leg, total legs and L1's BMC mean scores showed a statistically significant increase from Pre- to Post-test. These findings support studies by Pouilles *et al.* (1989) and Marguiles *et al.* (1986). The former study reported that BMD was significantly lower amongst 41 stress fracture participants than amongst 48 recruits from the same units, matched for chronological age, height, and weight and that mean BMC increased significantly during 12 weeks of military training amongst 35 uninjured recruits (Pouilles *et al.,* 1989). Marguiles *et al.* (1986) found that mean BMC increased significantly during fourteen weeks of BT for both the 105 persons, whose training was interrupted by stress fractures and other conditions, and the 144 persons who completed training. Tibial bone width did, however, not increase.

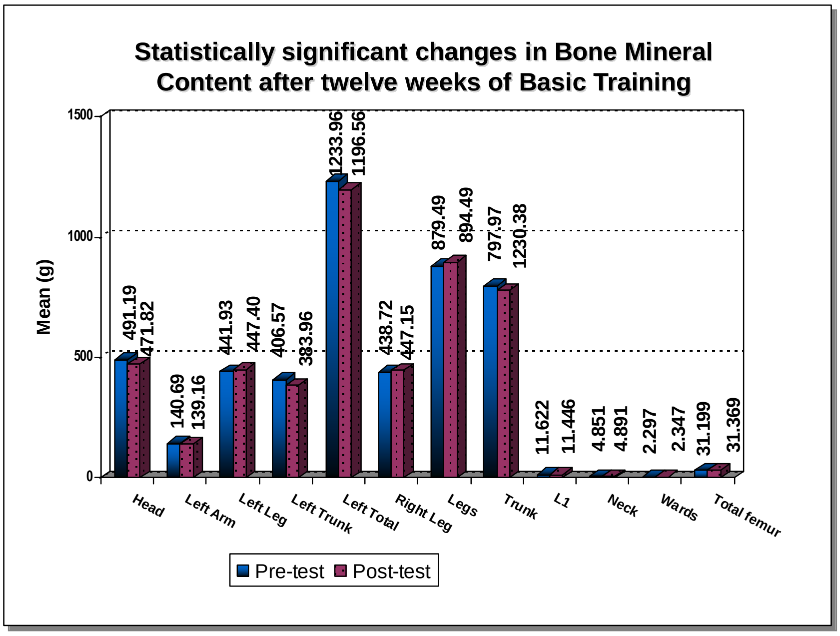


Figure 4.12: Statistically significant changes in BMC after 12 weeks of BT in female participants

The mean BMC of participants in these studies with stress fractures was lower before training than that of persons who completed the training, but not significantly so.

4.4.1.3.5 Bone geometry

This study did not measure skeletal ratios, cross-sectional bone area or cross-sectional moments of inertia, thus, no conclusions can be made regarding the risk of the female participants to stress fracture development, based on results from this study. However, what must be noted is that this is definitely an area for future research, especially as new technology emerges and one can now accurately and precisely calculate skeletal ratios from DEXA total body scan images:

> "…*the LPC method is easy to use and relatively rapid. This new phenotype will be useful for osteoporosis research for individuals or large-scale epidemiological or genetic studies*" (Chinappen-Horsley *et al.,* 2007: 113).

A bone's strength is greatly determined by its geometry and is directly proportional to the bone's cross-sectional area, when either tension or compression loads are applied to it. This implies that a larger bone is more resistant to fracture, as the internal forces are distributed over a larger surface area therefore resulting in lower stresses (Hayes & Gerhart, 1985; Ammann & Rizzoli, 2003).

The amount of load the bone can withstand before failing, is directly proportional to the cross-sectional area of the bone (Brukner *et al.,* 1999). Bones that have a larger cross-sectional area, and in which bone tissue is distributed further away from the neural axis, will be stronger when subjected to a load and will be less likely to fracture (Buckwalter *et al.,* 1995; Hall, 2003; Greene *et al.,* 2005). The strength in bending of the long bone shaft, to bending and torsional stresses should be proportional to its section modulus and inversely related to its length.

> "*In military recruits who are subjected to intense, unaccustomed physical activity, the presence of smaller and weaker bones may lead to a higher rate of bone microdamage. If there is inadequate time for adaptive cortical remodeling to occur, a stress fracture could result*" (Brukner *et al.,* 1999:53-54).

4.4.1.4 Physical fitness

Two methodologies were utilised to assess the relationships between lack of prior physical activity and/or poor physical conditioning, with the incidence of stress fractures. The first was through the use of questionnaires where the participants reported on past and current levels of activity (Gardner *et al.*, 1988; Montgomery *et al.*, 1989; Cline *et al.,* 1998). The second method was comprised of various aerobic fitness tests which, indirectly measured the fitness component (Jones *et al.,* 1993a; Bijur *et al.,* 1997; Beck *et al.,* 2000; Bell *et al.*, 2000; Knapik *et al.*, 2001; Jones *et al.*, 2002; Rauh *et al.*, 2005; Rauh *et al.,* 2006; Shaffer *et al.*, 2006).

This study utilized both methods. All participants completed a Health and Physical Activity questionnaire, which provided a detailed history of sport participation as well as health and medical history information (Appendix B) (Lee & Nieman, 2007). Additionally, the participants' physical fitness was assessed through a standardised physical fitness test.

The physical fitness tests, used by militaries around the world, differ from country to country and between service corps; however, they are all comprised of a combination of muscle endurance and aerobic fitness tests, such as 2.4 km run, maximal amount of push-ups and sit-ups in two minutes, shuttle runs and a 4 km walk (Gordon *et al.*, 1986a; Gordon *et al.*, 1986b; Shaffer *et al.*, 1999a; Beck *et al.*, 2000; Bell *et al.*, 2000; Rosendal *et al.*, 2003; Knapik *et al.*, 2005; Dyrstad *et al.,* 2006).

Results of the standard fitness test were analysed. This was done to determine whether statistically significant differences occurred, over time for all fitness components done within the EG that was tested during this study, as well as in the CG which consisted of participants who completed their BT a year prior to the EG, at the same unit as the EG. The CG utilised the same BT programme, but did not follow the new PT Programme, as did the EG, instead, they utilised the pre-existing PT Programme.

The results were split for male and female participants, due to different norms used for the two sexes. Complete statistical results are presented in Appendix Copy Disk - G.

Questions regarding level of physical activity prior to entering the service and the frequency of the activity, have provided important clues about the effect of past activity on current risk of PT related injuries and stress fractures (Jones *et al.,* 1999). The majority of recent studies tend to suggest that physical fitness or prior physical activity, may be a predictor of stress fracture risk in individuals undergoing BT (Jones *et al.,* 1993a; Bijur *et al.,* 1997; Windfield *et al.,* 1997; Bell *et al.,* 2000; Välimäki *et al.,* 2005; Shaffer *et al.,* 2006).

4.4.1.4.1 Physical activity levels based on the Health and Physical Activity questionnaire

Participants completed a questionnaire which provided a detailed history of sport participation as well as health and medical history information (Appendix B). As shown by Table 4.9, the majority of participants (74.3%) indicated that they were active in sports. Several military studies have examined the association between previous levels of physical activity and risk of stress fracture during military training (Gardner *et al.,* 1988; Montgomery *et al.,* 1989; Jones *et al.,* 1999; Shaffer *et al.,* 1999a).

Table 4.9: Activity levels of the participants

		Frequency	%	Valid %	Cumulative %
Valid	Yes	136	74.3	74.3	74.3
	No	47	25.7	25.7	100.0
	Total	183	100.0	100.0	

The complete results of this analysis are presented in Appendix Copy Disk,- H, tables 19-22. The majority of participants (84%) indicated that they did participate in sport. The types of sports are listed in Table 4.10 and include soccer (49.3%), followed by netball (15.1%) and running (13.2%).

Table 4.10: Kind of sport the participants participated in

Sport type	Frequency	%	Valid %	Cumulative %
Soccer	75	40.8	49.3	49.3
Rugby	4	2.2	2.6	52.0
Running	20	10.9	13.2	65.1
Netball	23	12.5	15.1	80.3
Karate	6	3.3	3.9	84.2
Cricket	2	1.1	1.3	85.5
Boxing	1	.5	.7	86.2
Tennis	1	.5	.7	86.8
Basketball	3	1.6	2.0	88.8
Volleyball	5	2.7	3.3	92.1
Softball	2	1.1	1.3	93.4
Walking	1	.5	.7	94.1
Dance	1	.5	.7	94.7
Javelin	1	.5	.7	95.4
Gym	2	1.1	1.3	96.7
Hockey	2	1.1	1.3	98.0
Body building	2	1.1	1.3	99.3
Snooker	1	.5	.7	100.0
Total	152	82.6	100.0	
Missing from system	32	17.4		
Total	184	100.0		

The level of participation was mostly recorded at a social level (66.9%) with the remaining third, competing at club, provincial or national level. Participants were divided in their opinion regarding the intensity of participation with 39.2% indicating low intensity, 29.1% reporting medium intensity and 31.8%, reporting high intensity of participation.

Some military studies have reported a relationship between self-reported, previous physical activity levels and a rate of stress fracture development during BT, while others have failed to corroborate a relationship (Gardner *et al.*, 1988; Montgomery *et al,* 1989; Winfield *et al.*, 1997; Cline *et al.,* 1998; Shaffer *et al.*, 1999a). The aim was thus to compare the self-reported, previous physical activities to the rate of stress fractures in this study's cohort, but, due to no stress fractures being reported, this was not possible.

Several prospective studies of US Army recruits and US Marine Corps recruits, have reported that a sedentary lifestyle behaviour prior to entering the military, is associated with higher risk of injury during the initial BT (Gardner *et al.,* 1988; Jones *et al.,* 1993a; Jones *et al.,* 1993b). Before the start of training, 3010 Marine recruits completed a survey on past health and health behaviours, rating their previous physical activity level in five categories from inactive to very active. The study documented a significant trend of higher cumulative incidence of radiographically confirmed stress fractures amongst those recruits with successively lower levels of previous activity (Gardner *et al.,* 1988).

Another study of Marine recruits also showed higher rates of stress fractures among those least physically activity prior to BT (Shaffer *et al.,* 1999b). Marine recruits who reported never or only occasionally sweating, experienced significantly more stress fractures, along with those with fewer months of running before entering BT. A survey of 449 Navy Special Warfare trainees (Montgomery *et al.,* 1989) and a study of Finnish Army recruits reported similar findings (Taimela *et al.,* 1990).

Conversely, a military study found no relation between the duration of training or the amount of running prior to BT, and stress fracture risk (Swissa *et al.,* 1989). The level of previous physical activity should be investigated further in a cohort, where the level of physical activity prior to the start of BT is compared in stress fracture cases versus that of the non-stress fracture cases.

4.4.1.4.2 Aerobic physical fitness

The aerobic physical fitness of this cohort was indirectly measured by the 2.4 km run and 4 km walk in the standard fitness test (DOD policy on Physical Training, DOD Instruction: SG no 00006/2000). The most consistently documented risk factor for injuries in US Army studies is low cardio-respiratory endurance, measured by running performance. Both men and women indicated trends of increasing risk of injury for groups with increasingly low running times (Jones *et al.,* 1993a; Bijur *et al.,* 1997; Shaffer *et al.*, 1999b; Beck *et al.*, 2000; Bell *et al.*, 2000; Jones *et al.*, 2002; Rosendal *et al.*, 2003; Knapik *et al.*, 2005; Rauh *et al.*, 2005; Rauh *et al.,* 2006; Shaffer *et al.,* 2006). Stress fractures were included amongst the injuries documented, however, the link between poor aerobic fitness and stress fracture development, was unclear, as the above-mentioned studies showed a clear association whilst others did not (Swissa *et al.,* 1989; Giladi *et al.,* 1991; Hoffman *et al.,* 1999; Brukner *et al.,* 1999).

Although data are conflicting, low levels of aerobic fitness, before BT, have been consistently identified as a risk factor amongst women (Jones *et al.,* 1993a; Winfield *et al.,* 1997; Bell *et al.,* 2000; Shaffer *et al.,* 2006). As the baseline fitness is a modifiable factor, this is an area in which much attention should be paid. Shaffer *et al.* (2006) suggest that objective measures such as run time, previous aerobic or high activity levels, are consistent in predicting stress fractures during military training for both male and female soldiers.

As this cohort did not suffer any stress fractures, the contribution of aerobic fitness to the development of stress fractures cannot be made. Additionally, the SANDF's standard fitness test utilizes the 2.4 km run and the 4 km walk as its test for aerobic fitness, but Army's around the world utilize different measures, making comparisons difficult. The American Physical Fitness Test (APFT) executed by the American Military utilises a 1- and 2- mile run as the test of aerobic fitness (Popovich *et al.*, 2000; Sonna *et al.,* 2001; Knapik *et al.,* 2002; Armstrong *et al.,* 2004; Knapik *et al.,* 2005; Rauh *et al.*, 2005; Knapik *et al.,* 2006; Rauh *et al.,* 2006; Smith & Petersen, 2007), whilst the Norwegian Military makes use of a 3 km run (Heir & Eide, 1997; Dyrstad *et al.,* 2006). The only armies found to use the 2.4 km run are the British and New Zealand Armies (Daniels *et al.,* 1979; Daniels *et al.,* 1982; Stacey *et al.,* 1982; Harwood *et al.,* 1999). What makes using the latter difficult for comparisons, is that BT in the British Army is six weeks in duration, whilst recruits in New Zealand follow a 10 week BT Programme, compared to the 12-week programme followed by the SANDF. Additionally, none of these studies documented the incidence of stress fractures or related them to aerobic fitness as a risk factor.

Regardless of the measurement used to assess aerobic fitness, the changes, if any, in aerobic fitness could be assessed, and the effect of the new PT programme was ascertained, by comparing the results of the EG to those of the CG.

The 2.4 km running test was executed as the first component of the battery test, whilst the last component of the battery test was the 4 km walk test. Both these tests measured the time taken to complete the specified distance and were a measure of cardiorespiratory fitness (Daniels *et al.,* 1982; Stacey *et al.,* 1982; Harwood *et al.,* 1999). The standardised fitness test was done in the first week of BT (measurement A), the mid-evaluation took place in the 5th week (measurement B) whilst the last fitness test, was done in the last week of BT (measurement C).

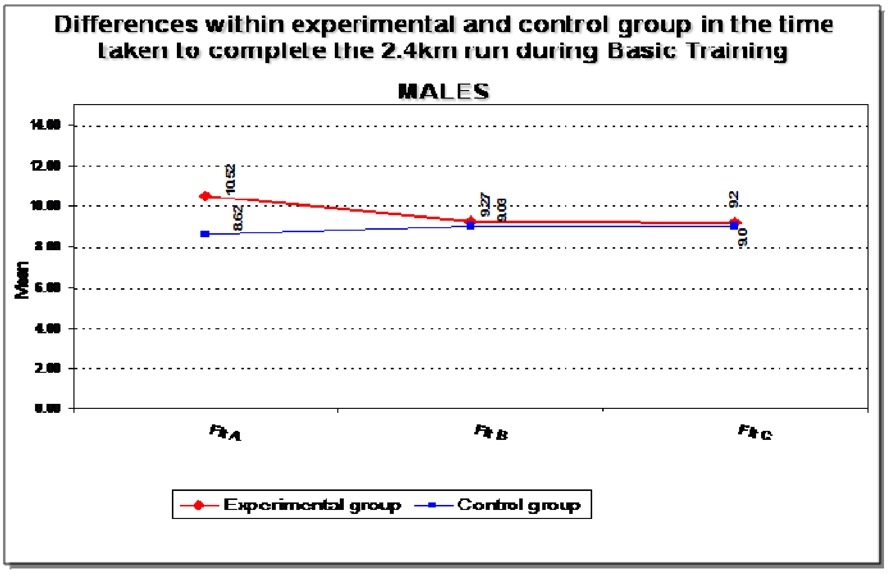


Figure 4.13: Differences (within males) in the EG and CGs in the time taken to complete the 2.4 km run

Figure 4.13 reflects the results for males on the total time taken to complete the 2.4 km run over the 3 measurements taken, i.e., measurements A, B and C. The results show that there were statistically significant differences between the Pre- and (two) Post-test measurements for the male participants in the EG and CG. The EG showed a statistically significant decline in total time taken to complete the 2.4 km run from the Pre- to the Post-tests. Even though the CG showed a significant difference in total time taken to complete the 2.4 km run, it did not show a significant decline, but rather an increase over time. The EG also had a much higher time at the first measurement (A), but at the last Post-test measurement (C), the two groups' times were similar. Thus, the male participants in the EG were not as fit as those in the CG at the start of BT. However the EG improved sufficiently to be as fit as the CG by the end of 12 weeks of BT.

The results of the total time taken by the female participants to complete the 2.4km run are reflected in Figure 4.14. There were statistically significant differences between the Pre- and (two) Post-test measurements for both the EG and CG also exhibited in the males groups. The EG showed a statistically significant decline in total time taken from the Pre- to the Post-tests.

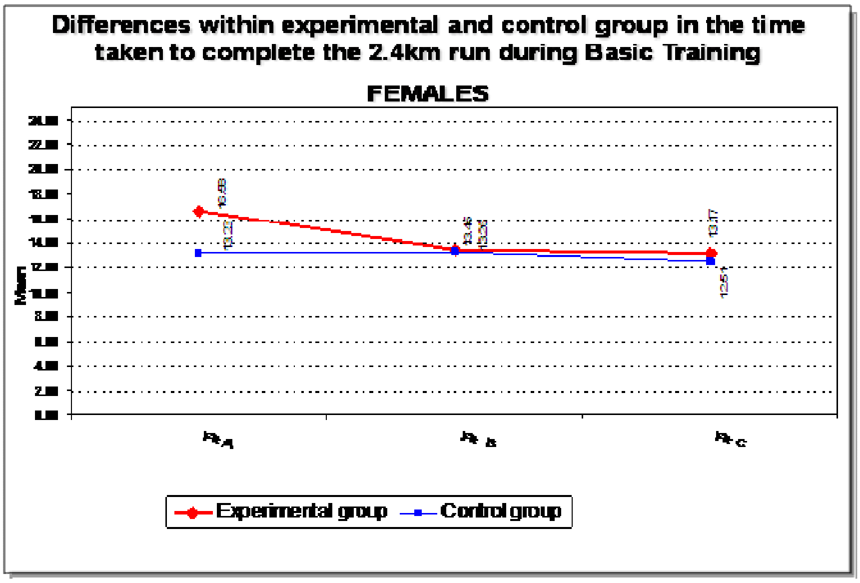


Figure 4.14: Differences (within females) in the EG and CG in the time taken to complete the 2.4 km run

Even though the CG showed a significant difference in scores, it did not show a steady decline in the total time measured, but rather, an initial increase in time in the first Post-test (B) with another decline, during the last Post-test (C). The EG also had a much higher score at the first measurement (A), but at the last Post-test measurement (C), the two groups' times on the 2.4 km run, were not significantly different. This response is then very similar to the profile of the males.

The results in Figures 4.15 and 4.16 reflect the results for the time taken to complete the 4 km walk by sex. Statistically significant differences were found in mean time scores for both the EG and CG's. In both the male and female groups, the time taken to complete the 4 km walk decreased significantly over time, reflecting an improvement in cardiovascular fitness (Heyward, 2002). The EG did, however, have the biggest decrease and thus showed a greater improvement than the CG. This supports the findings in the 2.4 km run and appears as if the PT Programme followed by this study's cohort, was a better training stimulus that yielded greater improvements in aerobic fitness, than did the PT programme followed by the CG.

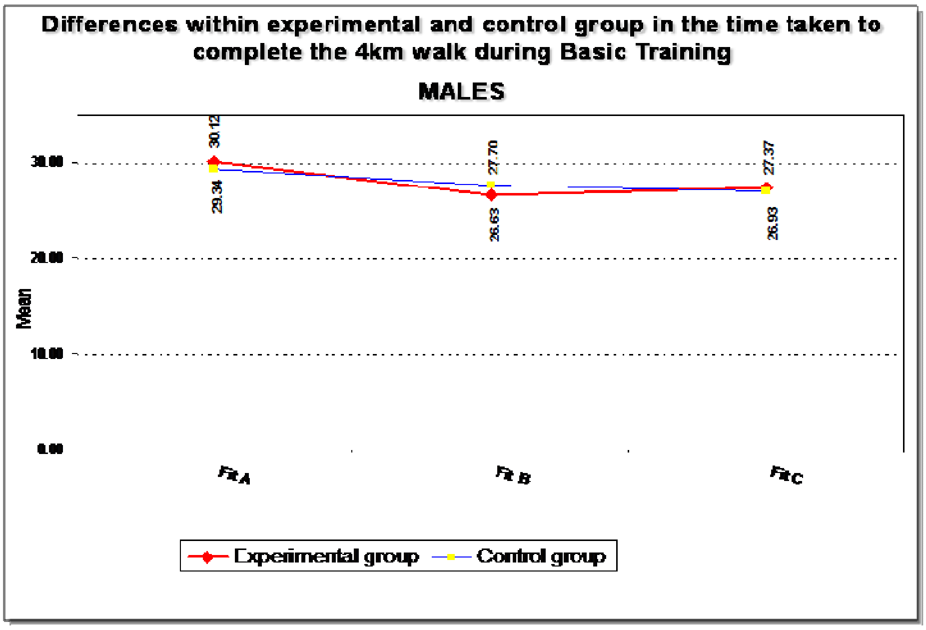


Figure 4.15 Differences (within males) in the EG and CG in the time taken to complete the 4km walk

In order to determine whether statistically significant differences existed between the EG and CG, at each of the 2.4 km run and 4 km walk, measurements at each of the testing phases (Pre-test A, Post-test B and Post-test C), t-tests for independent samples were used.

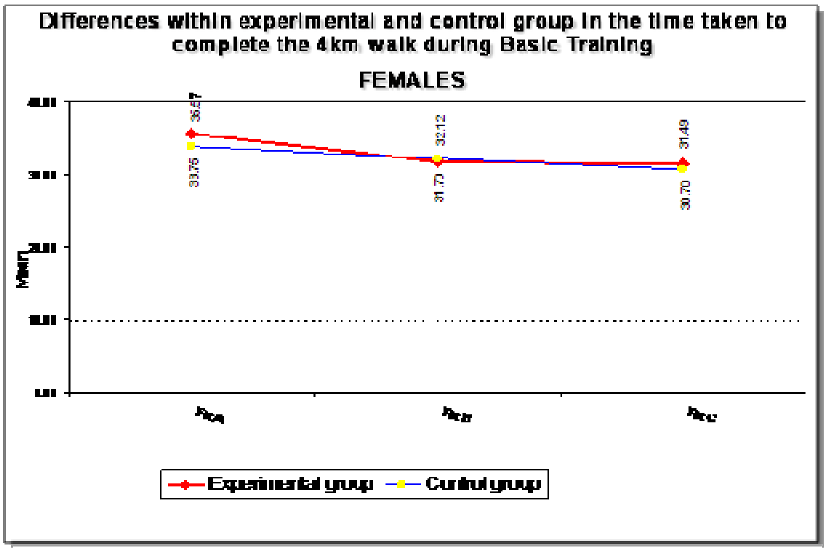


Figure 4.16: Differences (within females) in the EG and CG in the time taken to complete the 4 km walk

The results in Figure 4.17 reflect the differences between the male EG and CG for the time taken to complete the 2.4 km run and 4 km walk at the three measurement dates.

Statistically significant differences, between the mean scores of the male participants in the EG and CG, were found in the time taken to complete the 2.4 km, run during the first fitness test (measurement A). The time taken to complete the 4 km walk showed no significant difference. The EG took significantly longer to complete the 2.4 km run than the CG, thus indicating that the male participants in the CG were more fit cardiovascularly than those in the EG (Heyward, 2002).

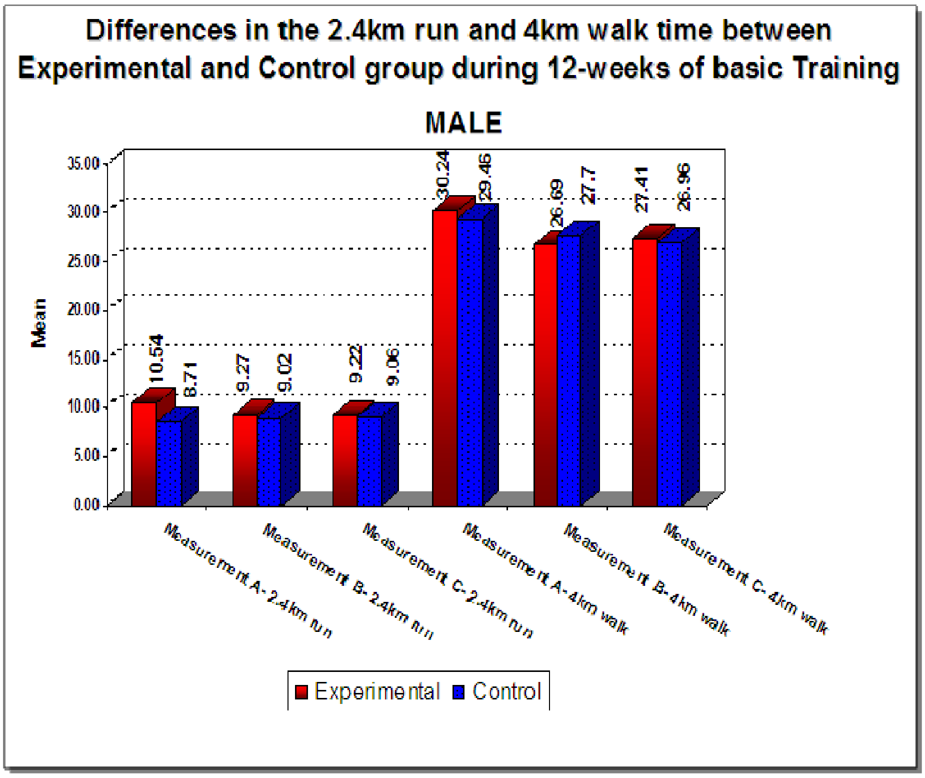


Figure 4.17: Differences in the time taken to complete the 2.4 km run and the 4 km walk between male participants of the EG and CG

During the Post-test (measurement B) the EG still had significantly higher 2.4 km run times than the CG. The differences in mean scores were, however, slightly less than during the Pre-test.

The 4km walk time of the EG was significantly better than that of the CG at the first Post-test. These results imply that the EG's performance improved to such an extent, that they were performing better than the CG at the first Post-test.

The differences between the male EG and CG during the second Post-test (C), found no statistically significant difference in the 2.4km run time and the 4km walk time. The EG thus caught up with the CG during the first Post-test (B) and their performance, on these two tests, remained similar thereafter during Post-test (C).

This reflects a 12.5% improvement in running time for the 2.4 km test for the male participants in the EG, compared to the slight decrease shown by the CG (-0.4%) during the 12 weeks of BT. The changes in aerobic fitness were not as marked in the 4 km walk, however, the 9.4% improvement observed in the EG was still greater than the 8.5% shown in the CG. It could, therefore, be deduced that the PT Programme followed by the EG, elicited a better aerobic fitness change in the male participants, compared to the PT programme followed by the CG, as both groups followed the same BT programme. Alternatively, various studies have indicated that greater improvements in aerobic fitness would be expected of groups with lower initial aerobic fitness. As the EG had a lower initial aerobic fitness, this could explain the findings (Pollack *et al.;* 1969; Daniels *et al.,* 1979; Shvartz & Reibold, 1990; Legg & Duggan, 1996; Dyrstad *et al.,* 2006).

The results in Figure 4.18 reflect the differences between the female participants in the EG and CG for the time taken to complete the 2.4 km run and 4 km walk at the three measurement dates.

The EG took significantly longer to complete the 2.4 km run than the CG did at the Pre-test (measurement A). In measurement C, the 2.4 km run time of the EG was significantly poorer than that of the CGs. Since there was no difference in performance during the first Post-test (B), there seems to have been a slight decline in the EG's performance during the last Post-test (C). On the 4km walk, the EG still performed poorer than the CG during the last Post-test, even though within the group itself, there was improvement on this test.

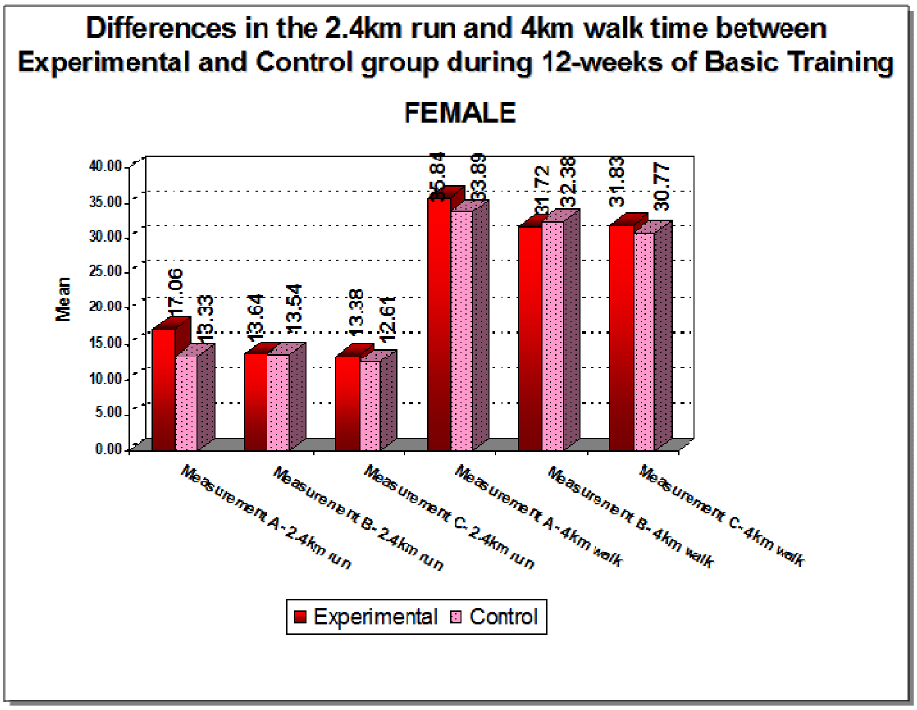


Figure 4.18: Differences between females in the EG and CG in the time taken to complete the 2.4 km run and the 4 km walk

This reflects that the female participants in the EG, although having started off with a poorer cardiovascular fitness level than that of the the CG, showed a 21.6% improvement in running time for the 2.4 km test, compared to the 5.4% improvement shown by the CG. The EG experienced a 20.0% improvement within the first five weeks of BT. The slight decline in the EG's performance, during the last Post-test, in the time taken to complete the 2.4km run, may be due to lack of motivation, as the participants were completing this test purely for research purposes and they were cognisant of the fact that their performance would not influence their results in BT. This was not the case for the CG, whose last Post-test contributed to their final mark for BT.

As with the 2.4 km run, the changes in aerobic fitness were marked in the 4 km walk, especially by the female participants in the EG, within the first five weeks of

BT. Although the EG still performed poorer than the CG did during the last Post-test on the 4 km walk, the EG showed an 11.2% improvement on this test within the group itself, compared to the 9.2% shown by the CG.

Once again, the improvements seen could be attributed to the new PT Programme, as suggested improvements were greater in the EG, because they had a lower initial aerobic fitness (Pollack *et al.;* 1969; Daniels *et al.,* 1979; Shvartz & Reibold, 1990; Legg & Duggan, 1996; Dyrstad *et al.,* 2006).

The initial fitness aerobic level of the male participants in both the EG and CG, (10.54 ± 1.06min and 8.71 ± 1.25 min, respectively) is slightly lower than that reported by Harwood *et al.* (1999) - 9.4 ± 0.94 min. Harwood *et al.* (1999) reported a 9% improvement after 13 weeks of military training compared to the 12.5% and -0.4% found in the EG and CG respectively, after 12 weeks. The female participants' initial fitness aerobic level in both the EG and CG, 17.07 ± 2.01 min and 13.33 ± 2.26 min respectively, is far lower than that reported by Harwood *et al.* (1999) - 11.8 ± 1.10 min. The female participants, in this British cohort, showed an 11% improvement after 13 weeks of military training compared to the 21.6% and 5.4% found after 12 weeks in the EG and CG respectively. Once again these changes may be attributed to the new PT Programme or/and the lower initial level of aerobic fitness (Pollack *et al.;* 1969; Daniels *et al.,* 1979; Shvartz & Reibold, 1990; Legg & Duggan, 1996; Dyrstad *et al.,* 2006).

4.4.1.4.3 Muscular strength and endurance

The participant's muscle strength and muscle endurance was indirectly measured by sit-up and push-up tests in the standard fitness test (DOD policy on Physical Training, DOD Instruction: SG no 00006/2000). Isometric strength was determined by the handgrip strength test and isokinetic strength was measured by knee extension/flexion and ankle plantar/dorsiflexion isokinetic testing (Cybex

340: Extremity Testing and Rehabilitation System User's Manual, 1988; Heyward, 2002).

The effect of muscle strength and endurance on injury rates and risks has been well documented. However, the effect of muscle strength and endurance on injury rates and stress fracture risk in military and athletic populations has not been the participant of intensive study (Jones & Knapik, 1999; Jones *et al.,* 2002).

Lower muscle strength and endurance have been documented as likely contributors to stress fractures in military recruits (Giladi *et al.,* 1991; Grimston *et al.,* 1991; Almeida *et al.,* 1997; Burr, 1997; Beck *et al.,* 2000; Jones *et al.,* 2002; Armstrong *et al.,* 2004). Muscle fatigue, with the resulting increased bone strain, may contribute to stress fracture injury after daily strenuous exercise (Beck *et al.,* 2000; Jones *et al.,* 2002; Armstrong *et al.,* 2004).

Sit-up and push-up test

As this cohort did not suffer any stress fractures, the contribution of muscle strength and endurance to the development of stress fractures cannot be fully assessed. However, the effect of the new PT Programme can be assessed by comparing the results of the EG to those of the CG.

Figure 4.19 reflects the amount of push-ups that males completed in the allocated 2 minutes. The initial amounts performed by the EG (31.45 ± 8.87 push-ups) and the CG (39.16 ± 12.81 push-ups) are in line with findings reported by Bell *et al.* (2000) - who performed a mean 32.4 ± 12.4 push-ups, Popovich *et al.* (2000) - who completed 36.9 ± 13.6 push-ups and Jones *et al.* (1993a) who performed 31.0 ± 9.3 push-ups. Popovich *et al.* (2000) reportedly had a 3.1% stress fracture rate in a cohort of 1357 male participants, whilst Jones *et al.* (1993a) had a 2.4% stress fracture incidence in their 124 strong cohort. This study suggests that muscle strength and endurance, as measured by push-ups, is not a risk factor for the development of stress fractures in male participants, however this would have to be investigated further in a study where stress fracture incidences are reported

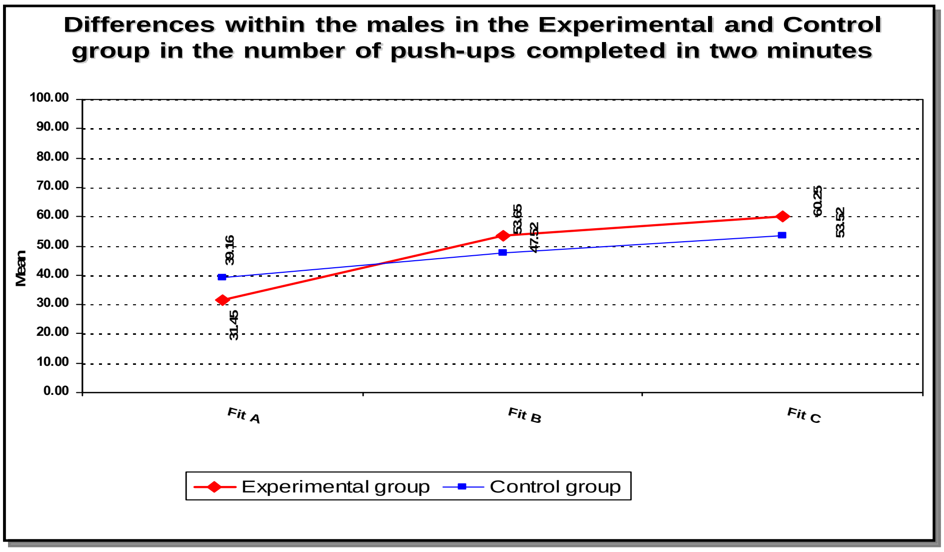


Figure 4.19: Differences (within males) in the EG and CG in the number of push-ups completed in two minutes

The results reflect that both the groups showed statistically significant increases in the amount of push-ups they could do over time. The EG had a lower score than the CG at the Pre-test measurement, but the EG (60.06 ± 11.07 push-ups) could do more push-ups than the CG (53.56 ± 11.33 push-ups) by the third measurement (C) at the end of the 12 weeks of BT.

The initial number of push-ups performed by the female participants (see Figure 4.20) in the EG (31.30 ± 10.34 push-ups) and the CG (41.58 ± 13.01 push-ups) is far greater than that reported by Bell *et al.* (2000), with a mean 10.9 ± 7.4 push-ups and Jones *et al.* (1993a) who only performed 12.4 ± 9.9 push-ups. Jones *et al.* (1993a) reported a 12.3% stress fracture rate. However the findings were similar to the 28.8 ± 9.5 push-ups and 33.7 ± 11.6 push-ups reported by Knapik *et al.* (2004).

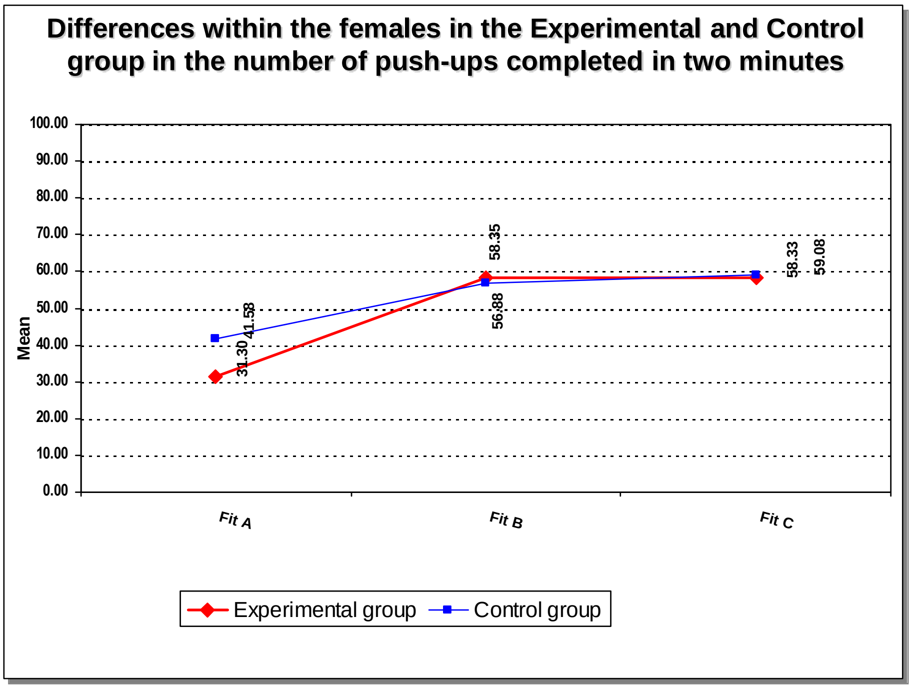


Figure 4.20: Differences (within females) in the EG and CG in the number of push-ups completed in two minutes

Unfortunately, they did not indicate if any stress fractures occurred. From the above, it would appear that the female participants of this cohort may have had a much lower risk for the development of stress fractures, due to their initial muscle strength and endurance as measured by the push-up test. This is in line with Bell *et al.* (2000: 144) who argued that "…*gender, after controlling for fitness, is not significantly associated with training-related injury, while fitness, a covariate of gender, is.* "

When observing the changes that took place over the 12 weeks of BT, the trend for the female participants was similar to the males participants, where both the EG and CG showed statistically significant increases in the amount of push-ups they could do over time (see Figure 4.21). The EG had a lower score than the CG at the Pre-test measurement, but the EG (56.32 ± 13.69 push-ups) caught up to the CG (59.47 ± 14.05 push-ups) by the end of BT.

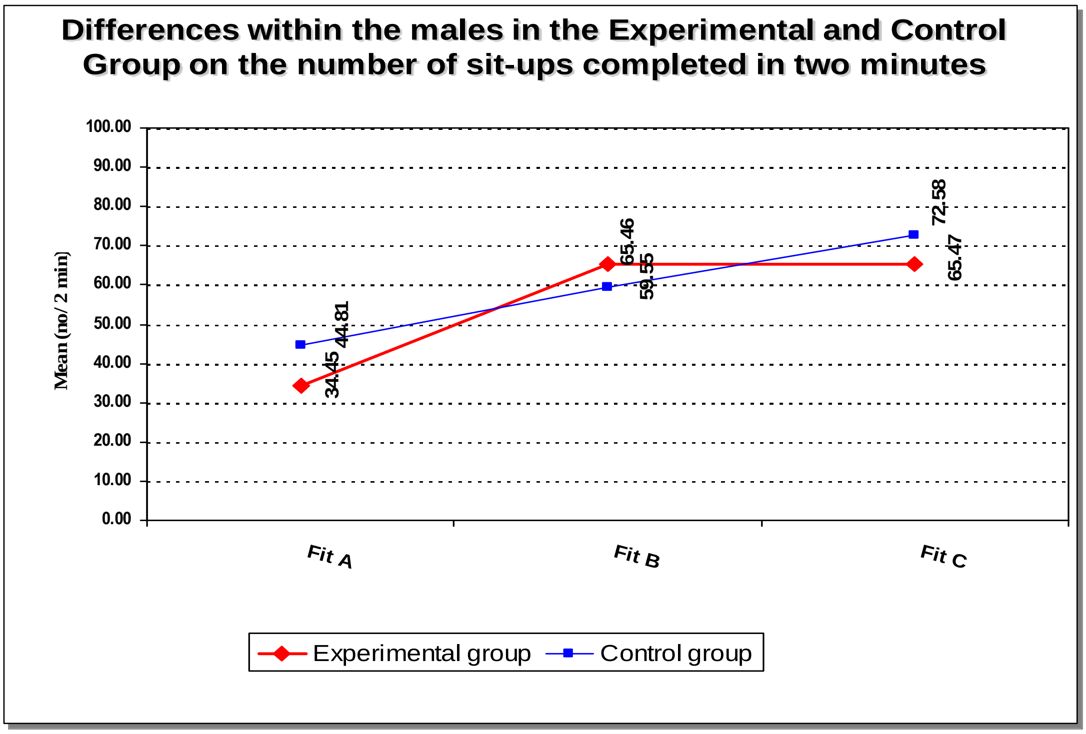


Figure 4.21: Differences (within males) in the EG and CG on the number of sit-ups completed in 2 minutes

The results in Figure 4.21 reflect the number of sit-ups the males completed in the allocated 2 minutes. At the Pre-test the male participants of this study's cohort completed 34.45 ± 10.07 sit-ups, which is lower than that of male participants from the American Army who performed 43.7 ± 11.6 sit-ups (Bell *et al.,* 2000). Beck *et al.* (2000) reported a 6.4% stress fracture incidence in their male cohort. Those that developed stress fractures, completed 51.8 ±10.8 sit-ups on entry into BT and those that did not develop any stress fractures having completed significantly more (57.2 ± 13.3 sit-ups). Additionally, Jones *et al.* (1993a) reported a 2.4% stress fracture incidence and they too completed more sit-ups (54.5 ± 13.8 sit-ups) than the present cohort. The findings in this study do not support that muscle strength and endurance, as measured by the sit-up test, are a risk factor for the development of stress fractures in male participants as no stress fracture incidence was reported amongst the male participants in the EG.

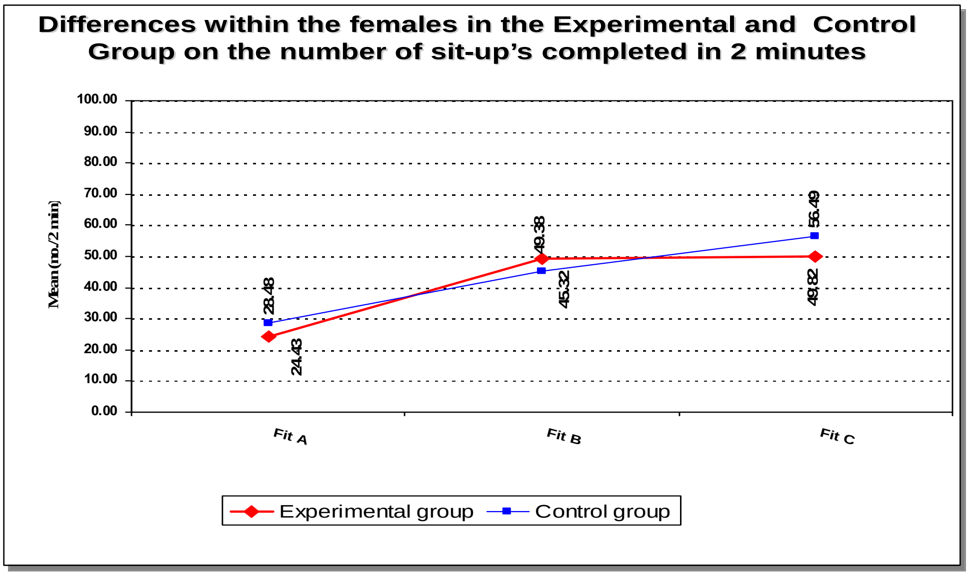


Figure 4.22: Differences (within females) in the EG and CG on the number of sit-ups completed in 2 minutes

Male participants in both the EG and the CG showed statistically significant increases in the number of sit-ups that they could do, when comparing the Pre-test with the consecutive 2 Post-tests. The CG, however, showed a steady increase, while the EG seemed to reach their peak sooner, with Post-test (B) and (C) having similar scores.

The results of the female participants are presented in Figure 4.22. At the Pre-test, this study's female cohort completed 24.43 ± 10.09 sit-ups, which is lower than those completed by the female participants from the American Army - 30.9 ± 13.9 sit-ups (Bell *et al.,* 2000). Beck *et al.* (2000) reported a 5.3% stress fracture incidence in their female cohort. Those that developed stress fractures, completed 32.7 ± 6.64 sit-ups on entry into BT and those that did not develop any stress fractures, completed slightly more (35.0 ± 6.45 sit-ups). Additionally, Jones *et al.* (1993a) reported a staggering 12.3% stress fracture incidence and they too completed more sit-ups (37.9 ± 11.9 sit-ups) than the present cohort. Similarly to the male participants, the findings do not support that muscle strength and endurance, as measured by the sit-up test, are a risk factor for the development of stress fractures in female participants.

The female participants in both groups showed a statistically significant increase in the number of sit-ups they could complete over time. This increase was greatest between Post-tests (A) and (B) whist the CG showed a steady increase peaking at Post-test (C).

The improvements in muscle endurance and muscle strength as measured by sit-up and push-up tests, are similar to the findings of other researchers who documented similar changes in these two parameters during BT (Bell *et al.,* 2000; Popovich *et al.,* 2000; Sonna *et al.,* 2001; Knapik *et al.,* 2002; Armstrong *et al.,* 2004; Evans *et al.,* 2005; Knapik *et al.,* 2005; Dyrstad *et al.,* 2006; Knapik *et al.,* 2006).

T-tests for independent samples were used to determine whether statistically significant differences existed between the EG and CG, for sit-up and push-up measurements, at each of the testing phases (Pre-test A, Post-test B and Post-test C). The complete statistical results can be found in Appendix Copy Disk - G.

The results in Figure 4.23 reflect the changes in sit-ups and push-ups performed by the male participants. The EG completed significantly less push-ups than the CG with the same tendency found for sit-ups - the EG performed significantly poorer than the CG at the Pre-test. Statistically significant differences between the mean scores of the EG and CG were found in both the push-up and sit-up test during the first Post-test. Since there were significant differences during the Pre-test (A), these results imply that the EG's performance improved to such an extent that they were performing better than the CG at the first Post-test.

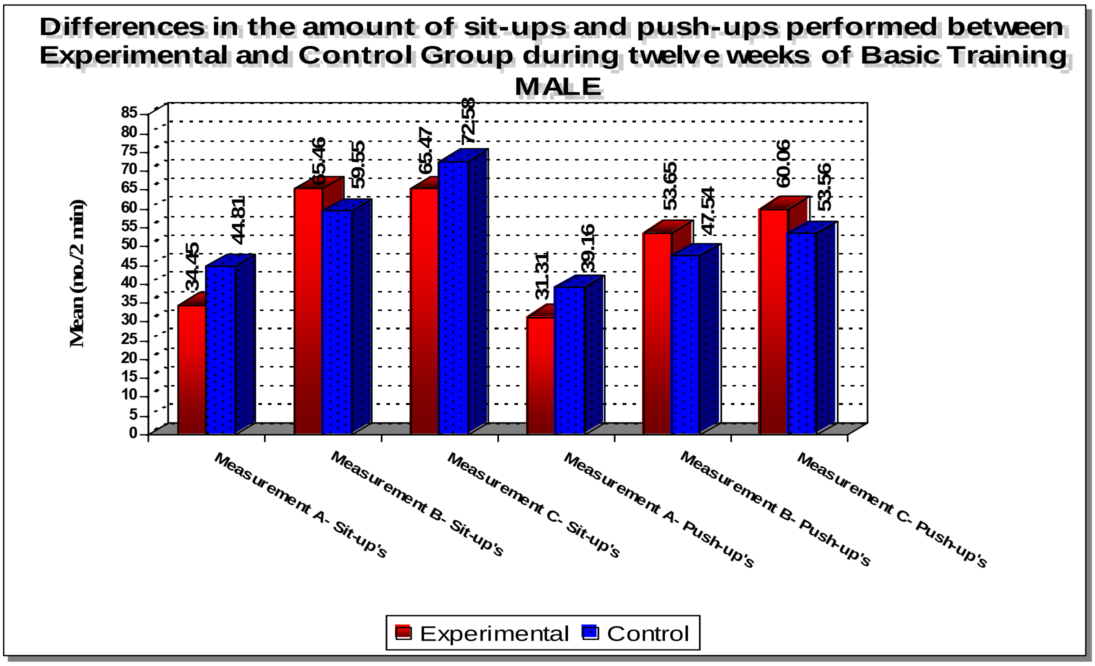


Figure 4.23: Differences in the amount of sit-ups and push-ups performed by male participants in the EG and CG

During the last measurement (C), statistically significant differences between the mean scores of the EG and CG were found for both the sit-up and push-up tests. In both cases, the EG performed better than the CG.

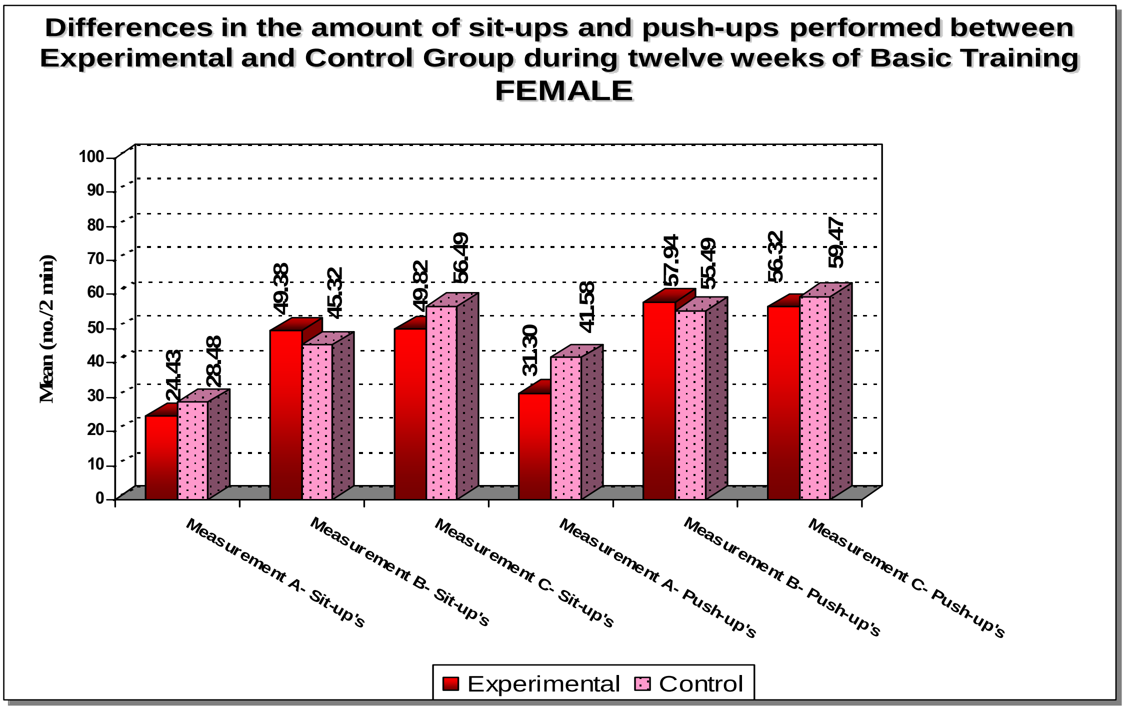


Figure 4.24: Differences in the amount of sit-ups and push-ups performed by female participants in the EG and CG

The results in Figure 4.24 reflect that, similar to the male results, the EG also did significantly less push-ups and sit-ups than the CG at the Pre-test scoring. During Post-test B, no statistically significant differences between the mean scores of the EG and CG were found. The results imply that the EG improved their performance on this test to such an extent, that their mean scores moved from being below the CGs to being above them during the first Post-test. The CG performed significantly more sit-ups than the EG during the last Post-test (C). This showed that although the EG showed a sharp increase in sit-up performed after five weeks of BT, the group then reached a plateau and did not improve further whereas the CG, showed a steady and significant increase throughout the 12 weeks. The number of push-ups performed did, however, not differ significantly. The performance of the two groups, in terms of push-ups, thus remained the same from the previous Post-test. The EG's performance improved to reach the same level as the CG's, and then remained the same.

Handgrip strength test

Both male and female participants showed a statistically significant decrease in their isometric left handgrip strength as measured with the handgrip dynamometer (see Figure 4.25 and 4.26). The complete statistical results can be found in Appendix Copy Disk - D.

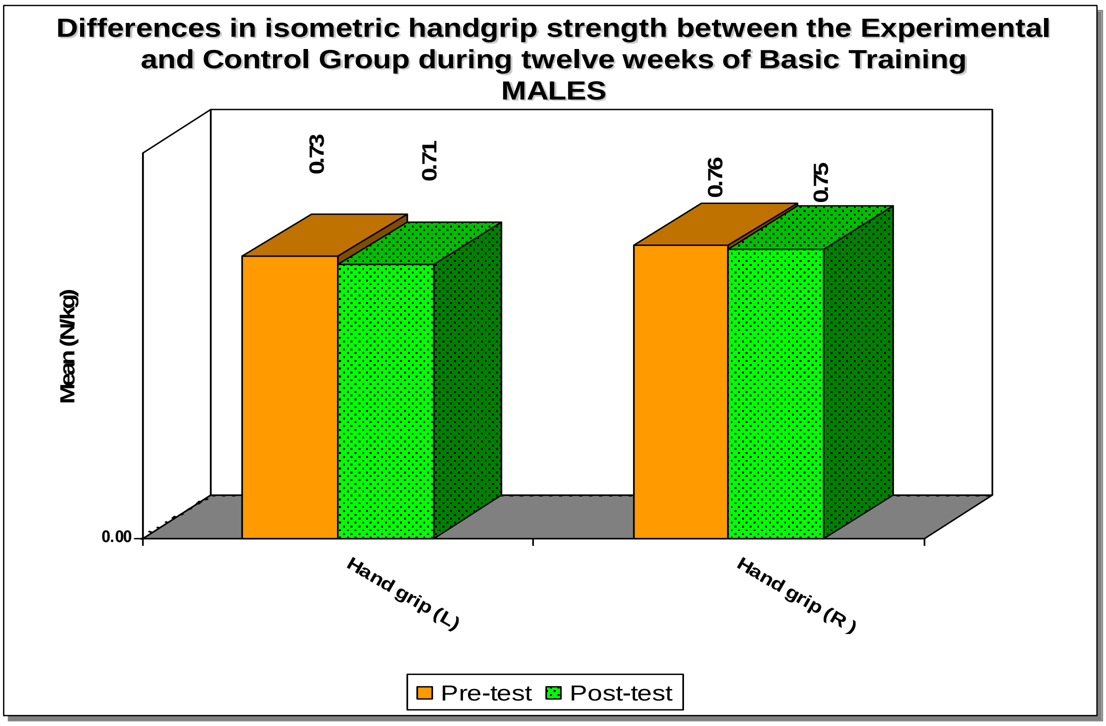


Figure 4.25: Differences in isometric handgrip strength between the EG and CG in male participants during 12 weeks of BT

There was no significant increase or decrease in the isometric right handgrip strength. These findings are in contrast to those reported by Brock & Legg (1997) and Teves *et al.* (1985) who showed a 10.5% and 15.8% increase in handgrip strength respectively. The findings are, however, similar to those found by Marcinik *et al.* (1985) and Legg & Duggan (1996) who also reported decreases in isometric handgrip strength. Both authors attributed these changes to insufficient emphasis being placed on muscle strength and endurance training, and that the emphasis was rather placed on running exercises during BT.

In this study, much of the military training centered on weight bearing PT, such as marching or running, which are lower limb exercises. Upper body strength and endurance formed part of the PT Programme but very little isolated, lower arm training was done.

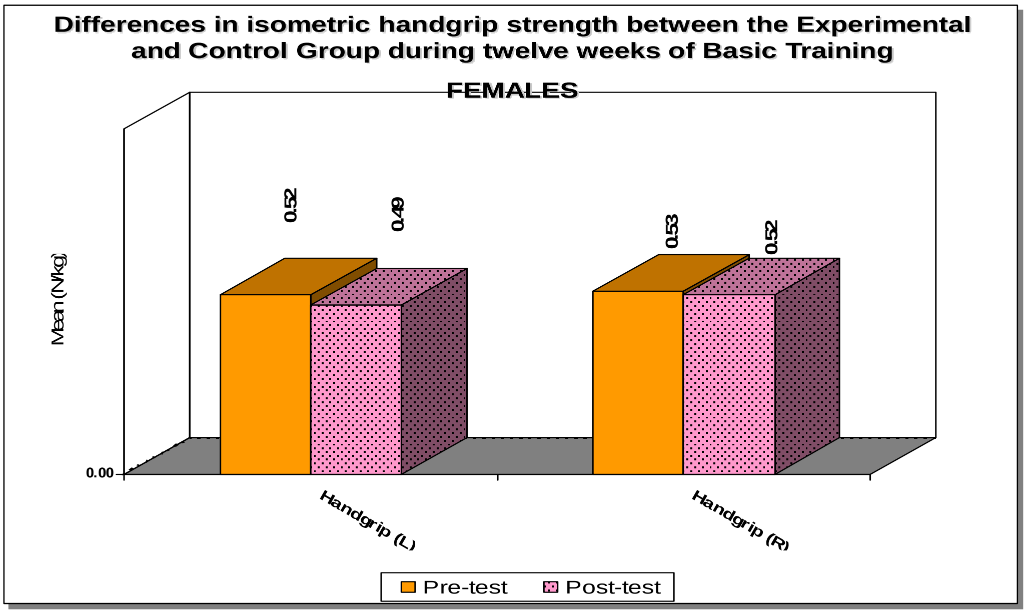


Figure 4.26: Differences in isometric handgrip strength of female participants between the EG and CG during 12 weeks of BT

The only exception may have been the weapon training, which demands high rates of manual handling of ammunition equipment and involves a fair amount of lower arm exercise (Legg & Patton, 1987). As only 5% (n=5) and 1.67% (n=2) of the male and female cohorts, respectively, were right handed, this may explain why the strength in their right hands did not show as much of a decrease as in their left, as their right hands were used for the weapon handling activities.

Isokinetic strength

The concept of isokinetic exercise was developed by James Perrine and introduced in the scientific literature in 1976 by Hislop and Perrine (1967) and Thistle *et al.* (1976) (Perrin, 1993). Isokinetic testing is performed on devices at a fixed speed with variable resistance that is totally accommodative to the individual throughout the range of motion (Brukner & Khan, 1996).

Participants in this cohort underwent both knee extension and flexion isokinetic testing at 60º, and ankle plantar and ankle dorsiflexion testing at 30º. The cohort mean results can be compared to the recommended norms available in the literature, and the results can then be analysed to determine if the participants' isokinetic strength was below the recommended norm thus, possibly, placing the participants at risk for the development of stress fractures (Perrin, 1993).

Figures 4.27 and 4.28 reflect the male participants' results for both their knee and ankle isokinetic evaluation. As the male participants had a 1.4 kg increase in their mean body mass, both the relative, as well as the absolute values, were considered. The values represent the results of their mean relative and absolute peak torque obtained at 60˚/s over five repetitions. The complete statistical results can be found in Appendix Copy Disk - D.

As outlined in Table 4.11, the male participants' initial absolute and relative isokinetic quadriceps and hamstring strength was below that prescribed for college track athletes by Appen and Duncan (1986) and Worrel *et al.* (1991).

Table 4.11: Isokinetic strength changes that occurred in the male participants during 12 weeks of BT

Isokinetic movement	Pre-test			Pre-test	Post-test			Post-test
	Males			Norms	Males			Norms
	n	Mean (SD)			*n*	Mean (SD)		
Knee extension (abs)(60º/sec)(Nm)	*100*	L	170.07 (34.82)	202.64 *(Appen & Duncan, 1986)*	*100*	L	173.77 (32.12)	202.64
		R	164.28 (38.73)			R	169.09 (30.88)	
Knee flexion (abs)(60º/sec) (Nm)	*100*	L	106.34 (24.09) *	129.2	*100*	L	120.31 (23.25) *	129.2
		R	103.51 (25.70)			R	123.72 (24.29) *	
Knee extension (rel)(60º/sec) (Nm)	*100*	L	2.75 (0.46)	2.95 *(Worrell et al., 1991)*	*100*	L	2.75 (0.40)	2.95
		R	2.66 (0.53)			R	2.68 (0.43)	
Knee flexion (rel)(60º/sec) (Nm)	*100*	L	1.72 (0.33)	1.83	*100*	L	1.90 (0.33) *	1.83
		R	1.68 (0.37)			R	1.96 (0.379) *	
Knee flexor/extensor ratio (60º/sec)(%)	*100*	L	64.27 (15.73)	60% (Perrin, 1993)	*100*	L	69.90 (10.22) *	60%
		R	64.72 (14.71)			R	73.84 (11.29) *	
Ankle plantarflexion (abs)(60º/sec) (Nm)	*100*	L	68.47 (17.28)	79.29 *(Berg et al., 1985)*	*100*	L	72.51 (17.40)	79.29
		R	68.21 (17.86)			R	77.92 (18.28)	
Ankle dorsiflexion (abs)(60º/sec) (Nm)	*100*	L	28.63 (5.02)	22.8	*100*	L	27.45 (5.14)	22.8
		R	28.52 (5.07)			R	28.27 (5.58)	
Ankle plantarflexion (rel)(60º/sec) (Nm)	*100*	L	1.11 (0.27)	No norms	*100*	L	1.13 (0.31)	No norm
		R	1.11 (0.29)			R	1.22 (0.35)	
Ankle dorsiflexion (rel)(60º/sec) (Nm)	*100*	L	0.46 (0.06)	No norms	*100*	L	0.44 (0.08)	No norm
		R	0.46 (0.07)			R	0.45 (0.08)	

Values are mean differences between Pre-test and Post-test and prescribed isokinetic norms

* Significant change from the Pre-test to the Post-test at the end of 12 weeks of BT $p \leq 0.05$.

When compared to the isokinetic knee extension (221± 40 – right / 208 ±40 -left) and flexion (119 ± 29 – right / 114 ± 27 -left) absolute findings reported by Gordon *et al.* (1986b) on 93 BT recruits, these participants have weaker quadricep strength and similar hamstring strength. Even when measured up to a more recent (2006) study, comparing 2 different units of 'elite' soldiers extensor strength (211± 35/ 241±55 – right / 212 ±24/ 212 ±37 -left) and flexor isokinetic strength (105± 24/ 124 ±31 – right /107 ± 20/ 114 ± 29 - left) in the British military the male participants of this cohort have relatively weaker quadriceps and hamstring strength (Simpson *et al.,* 2006).

During the 12 weeks of BT the male participants' relative and absolute knee extensors peak torque showed no statistically significant changes from Pre-test to Post-test. This supports the findings by Gordon *et al.* (1986b). However, the male participants did show a relative and absolute statistically significant increase in knee flexor peak torque. This is in contrast to Gordon *et al.* (1986b), who showed no significant change with BT. This change may be attributed to the PT Programme eliciting adequate training stimulus as well as to the relatively low initial isokinetic strength (Daniels *et al.,* 1979; Perrin, 1993).

The hamstring muscle group has been shown to produce about 60% of torque values generated by the quadriceps muscle, at 60º/sec isokinetic test velocity, and this is accepted to be the ideal ratio (Perrin, 1993). The males in this study had statistically significant increases, from the Pre-test to the Post-test, in their knee flexor-extensor ratios. This was true for both left and right sides.

Upon entering into BT, male participants' isokinetic dorsiflexion strength was greater than that reported by 69 male Cadet officer trainees entering the Belgian Royal Military Academy, for six weeks of BT (21.24 ± 4.72 – right / 21.44 ± 5.29 - left). However, the Belgian cadets had a far greater plantar flexor isokinetic strength (83.42 ± 25.05 – right / 87.56 ± 26.19 - left) (Mahieu *et al.,* 2006).

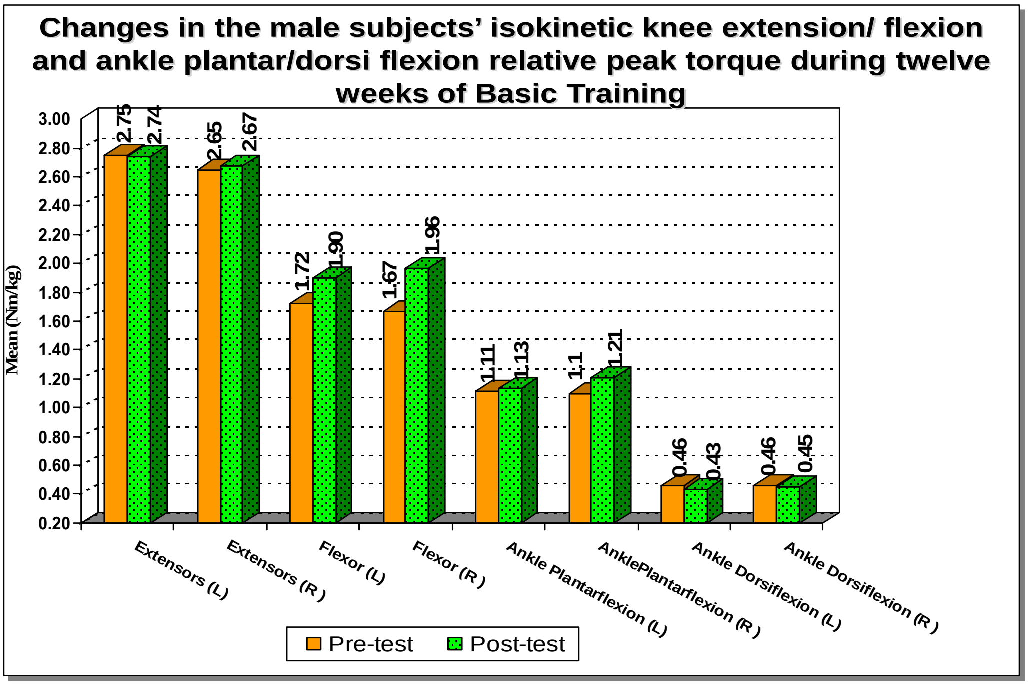


Figure 4.27: Changes in male participants' isokinetic knee extension/ flexion and ankle plantar/dorsi flexion relative peak torque during 12 weeks of BT

The ankle isokinetic evaluation found that the male participants showed a statistically significant increase in relative and absolute right plantarflexion, whilst a statistically significant decrease from Pre-test to Post-test was observed in their left relative and absolute ankle dorsiflexion values.

These changes may be attributed to the high amount of running activities and calf strengthening exercises included in the PT Programme, however, little emphasis was placed on specific exercises to develop tibialis anterior, extensor ditorum longus, and peroneous tertius muscle strength. This should be considered when revising the PT Programme.

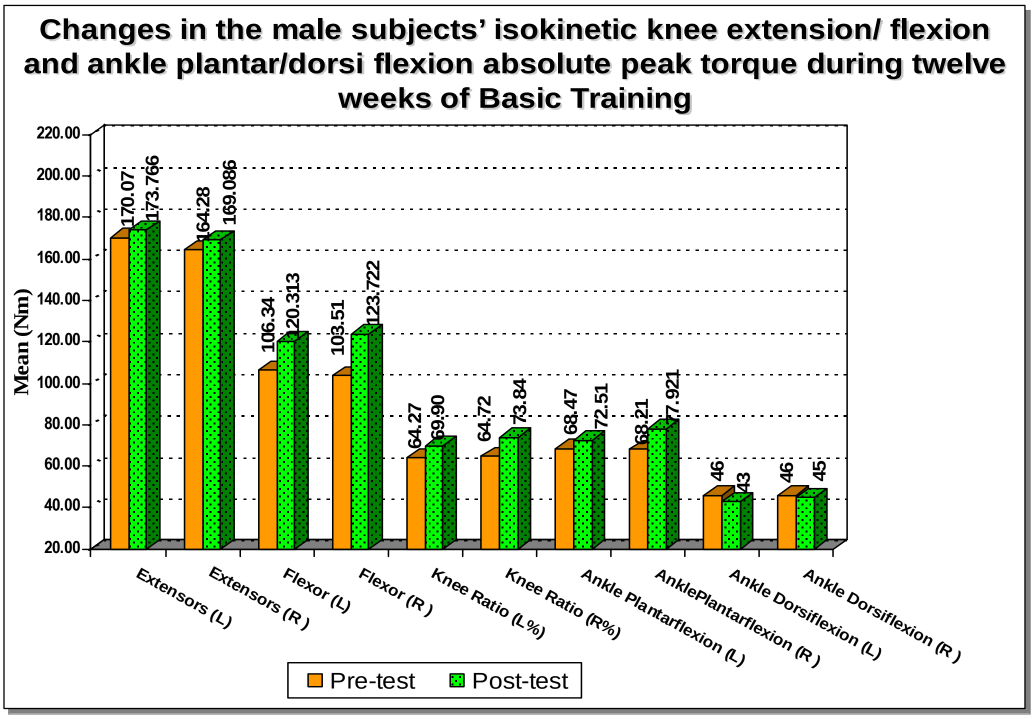


Figure 4.28: Changes in male participants' isokinetic knee extension/ flexion and ankle plantar/dorsi flexion absolute peak torque during 12 weeks of BT

Considerably less literature is available on the isokinetic strength of female military recruits, thereby rendering it difficult to compare the female participants in this cohort's initial isokinetic strength. Table 4.11 and Figures 4.29 and 4.30 reflect the female participants' results for both their knee and ankle isokinetic evaluations. Unlike the male participants, the female participants did not have a significant change in body mass during the 12 weeks of BT. Therefore, relative isokinetic changes will be reflected in the absolute values.

As outlined in Table 4.12, the female participants' initial absolute isokinetic quadriceps and hamstring strength was slightly below that reported by Fillyaw *et al.* (1986) for female university soccer players. However, this cohort's female absolute flexor strength was greater than the Fillyaw *et al.* (1986) group. When their relative extensor and flexor isokinetic strength was compared to females ages 15 to 34 years, this cohort favoured well (Highgenboten *et al.,* 1988).

Table 4.12: Isokinetic strength changes that occurred in female participants during 12 weeks of BT

Isokinetic movement	Pre-test				Post-test			
	Females			Norms	Females			Norms
	N		Mean (SD)		*n*		Mean (SD)	
Knee extension (abs)(60º/sec)(Nm)	*83*	L	111.61 (22.72)	118.32 (Fillyaw *et al.* , 1986)	*83*	L	105.88 (26.72)	118.32
		R	106.20 (23.66)			R	107.95 (19.96)	
Knee flexion (abs)(60º/sec) (Nm)	*83*	L	67.39 (12.82)	63.51	*83*	L	71.05 (14.13)*	63.51
		R	66.23 (17.01)			R	73.76 (13.01)*	
Knee extension (rel)(60º/sec) (Nm)	*83*	L	1.87 (0.36)	1.26 (Highgenboten *et al.*, 1988)	*83*	L	1.78 (0.44)*	2.19
		R	1.79 (0.39)			R	1.81 (0.30)	
Knee flexion (rel)(60º/sec) (Nm)	*83*	L	1.14 (0.24)	0.87	*83*	L	1.19 (0.22)*	0.87
		R	1.12 (0.28)			R	1.24 (0.22)*	
Knee flexor/extensor ratio (60º/sec)(%)	*83*	L	61.34 (10.64)	60% (Perrin, 1993)	*83*	L	68.16 (14.57)*	60%
		R	63.13 (11.81)			R	69.87 (14.75)*	
Ankle plantarflexion (abs)(60º/sec) (Nm)	*83*	L	47.45(12.88)	*79.29 (Berg et al., 1985)*	*83*	L	49.66 (12.12)	79.29
		R	44.28 (11.31)			R	52.92 (12.92)	
Ankle dorsiflexion (abs)(60º/sec) (Nm)	*83*	L	19.96 (4.17)	31.01	*83*	L	19.65 (5.44)	31.01
		R	19.11 (3.71)			R	20.23 (5.26)*	
Ankle plantarflexion (rel)(60º/sec) (Nm)	*83*	L	0.80 (0.22)	No norms	*83*	L	0.83 (0.21)	No norms
		R	0.75 (0.20)			R	0.89 (0.21)*	
Ankle dorsiflexion (rel)(60º/sec) (Nm)	*83*	L	0.34 (0.08)	No norms	*83*	L	0.33 (0.08)	No norms
		R	0.32 (0.07)			R	0.34 (0.08)*	

Values are mean differences between Pre-test and Post-test and prescribed isokinetic norms

* Significant change from the Pre-test to the Post-test at the end of 12 weeks of BT. p≤0.05.

The female participants showed more statistically significant changes than the male participants during 12 weeks of BT. Left leg mean relative knee extensor peak torques showed a statistically significant decrease from Pre-test to Post-test, whilst knee flexor values, on both legs, showed statistically significant increases from the Pre-test to the Post-test. The decrease in left extensor strength is difficult to explain and should be researched further, by including a lower limb strength test in the Standardised PT test as, currently, only upper body and trunk muscular endurance is assessed with the push-up and sit-up tests (DOD Policy on Physical Training, 2000).

The knee flexor-extensor ratio showed statistically significant increases. This difference was statistically significant for the left and right sides.

The results of the knee flexor-extensor ratio are, however, similar to those observed in the male participants. One possible area of concern is that the female cohort showed a large increase in flexor strength accompanied by no or a slight decrease in knee extensor strength. This resulted in the knee flexor-extensor ratio going from around the desired 60% to almost 70%, possibly predisposing the cohort to thigh injuries (Perrin, 1993). It therefore appears that the PT Programme produced an insufficient training stimulus for knee extensor strength development in the female cohort and should be revised by including more strength training knee extensor exercises.

Upon entering into BT the female participants' isokinetic dorsiflexion and plantarflexion strength was far less than that reported on twenty-year old female college basketball players (Berg *et al.,* 1985). Additionally, it was also less than the plantarflexion (59.5 ± 12.7-left / 64.8 ± 11.7- right) and dorsiflexion (30.2 ± 5.6- left / 32.4 ± 4.7- right) in another study of female college basketball players (Payne *et al.,* 1997).

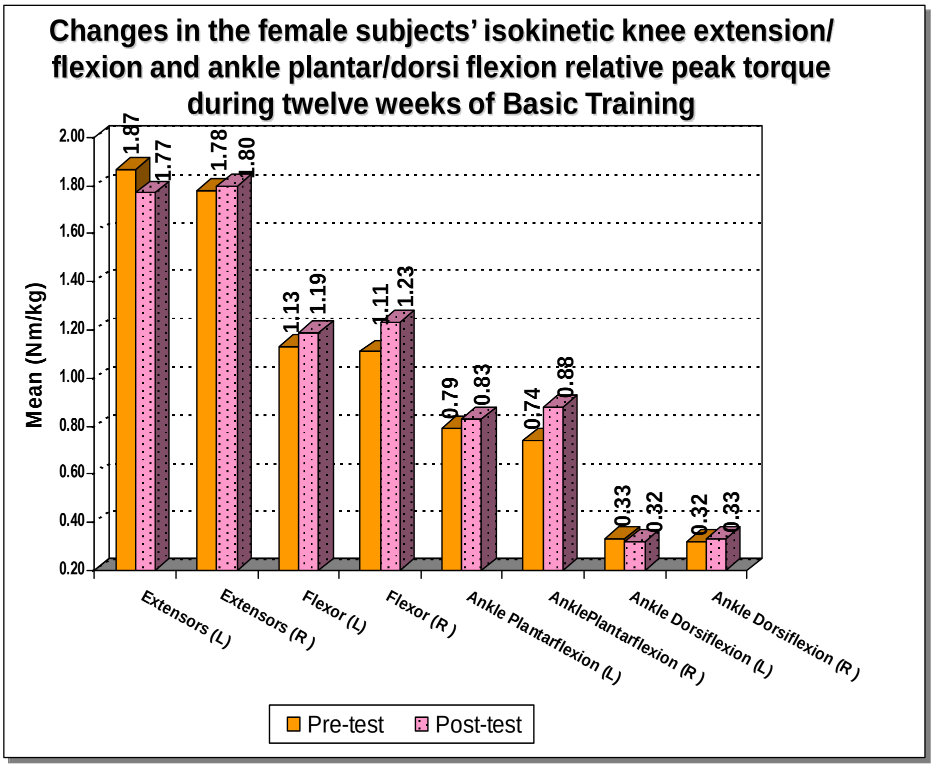


Figure 4.29: Changes in female participants' isokinetic knee extension/ flexion and ankle plantar/dorsi flexion relative peak torque during 12 weeks of BT

The ankle isokinetic evaluation found that the female participants showed a statistically significant increase in relative right plantarflexion, (the same as the male participants), however, the female participants experienced a statistically significant increase in the mean peak torque of their right limb with ankle dorsiflexion from Pre-test to Post-test.

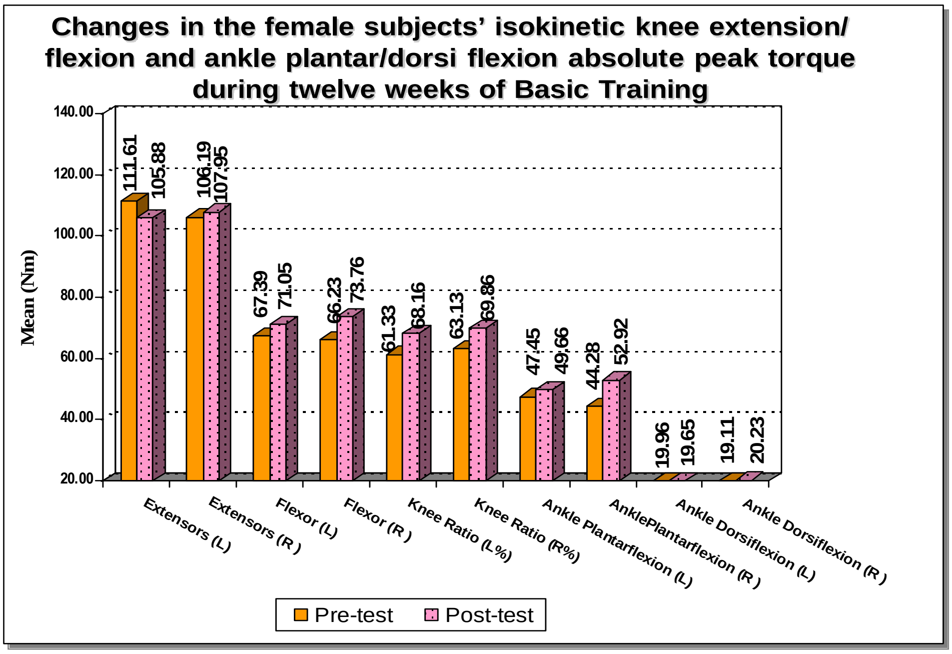


Figure 4.30: Changes in female participants' isokinetic knee extension/ flexion and ankle plantar/dorsi flexion absolute peak torque during 12 weeks of BT

The PT Programme included exercises designed to improve muscle strength (Appendix Copy Disk - B). The PT programme was progressive in nature, thus the strength training stimulus continued to increase over the 12 weeks of BT. This was achieved by including exercises from week five using wooden poles. In a military set-up, strength training is often difficult to execute as the strength training facilities are limited and the number of training recruits, to undergo the strength training simultaneously are large (Jones *et al.,* 1993b; Knapik *et al.,* 2005). The pole used in PT provided a cost-effective method of strength training which elicited a sufficient strength training response. It was based on the free-weight principle and may have contributed to the increase in strength (Daniels *et al.,* 1979; Fleck & Kramer, 1997; Heyward, 2002).

4.4.1.4.4 Anaerobic physical fitness

Anaerobic capacity refers to the total amount of energy that can be released by anaerobic pathways during intensive exercise to exhaustion; this is therefore applicable to a range of exercises that extend from about 60 seconds to 10 minutes (Hahn, 1992). Anaerobic fitness was measured by the 10 x 22m shuttle run test, a component of the SANDF standardized fitness test (DOD Policy on Physical Training, 2000).

10 x 22m Shuttle Run test

The results in Figure 4.31 reflect that there were statistically significant differences between Pre-test and Post-test shuttle run time scores, in males, in both the EG and CG. The CG, however, seemed to show a steady decline, while the EG, showed a slight increase toward the last Post-test score (C).

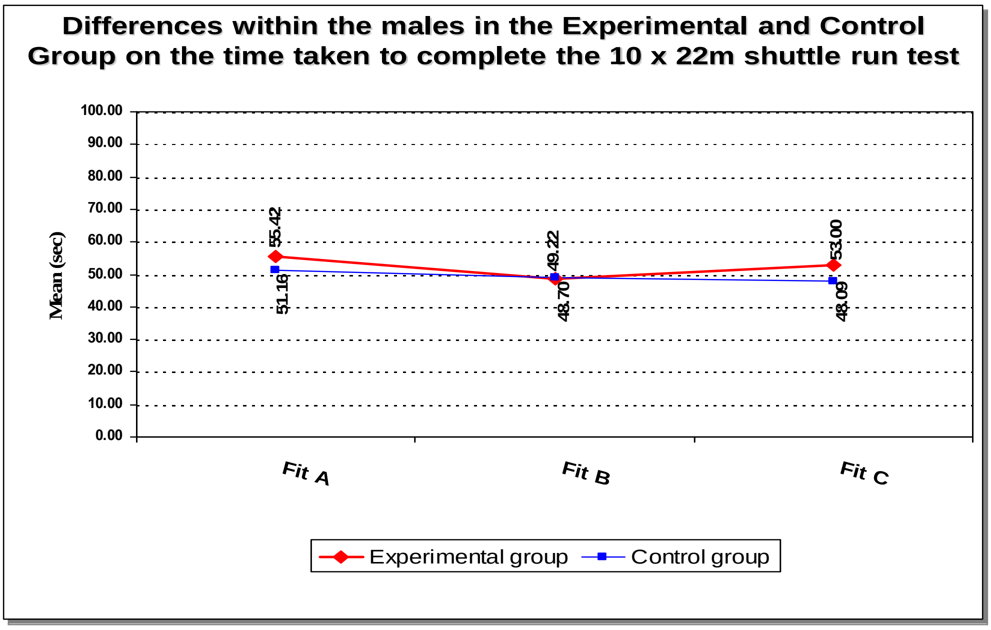


Figure 4.31: Differences (within males) in the EG and CG on the time taken to complete the 10 x 22m shuttle run test

The females showed a similar profile in their shuttle run times (see Figure 4.32). There were statistically significant differences between the times taken to complete the shuttle run test for the Pre-test and Post-test for both the EG and CG. The CG, however, seemed to show a steady decline, while the EG, showed a slight increase towards the last Post-test score (C).

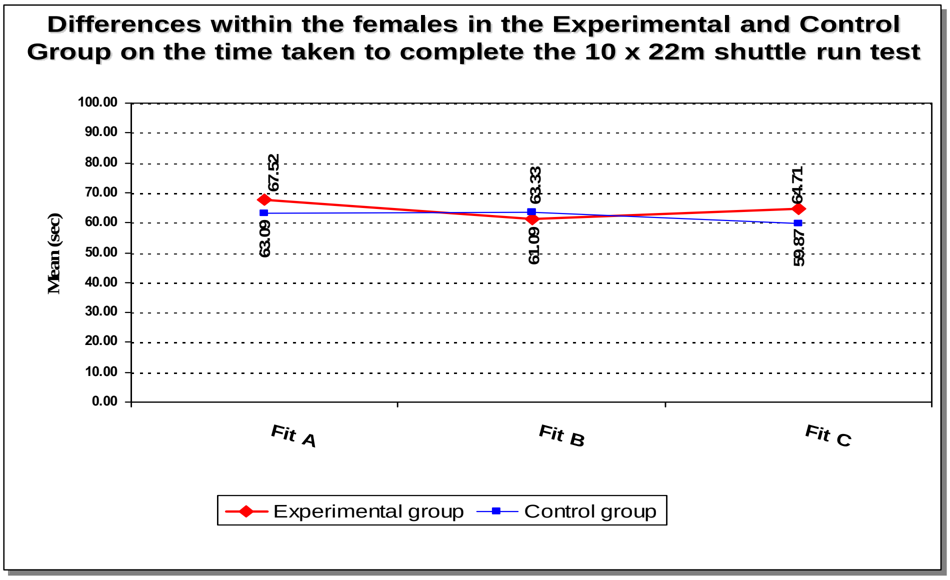


Figure 4.32: Differences (within females) in the EG and CG on the time taken to complete the 10 x 22m shuttle run test

The results in Figures 4.33 and 4.34 reflect the differences between the male and female EG and CGs, respectively, for the time taken to complete the 10 x 22m shuttle run test at the three measurement dates. Statistically significant differences between the mean scores of the EG and CG were found, with the CG performing better than the EG in the Pre-test. Although no statistically significant difference was shown by the male and female EG in the first Post-test (measurement B), the results imply that the EG improved its performance in the shuttle run test to such an extent, that its mean scores moved, from being below the CGs' to being above them during the first Pre-test. Both the male and female participants in the EG then showed a significant decrease in anaerobic fitness, with deterioration in time taken to complete the shuttle run test. This was not seen in the CG.

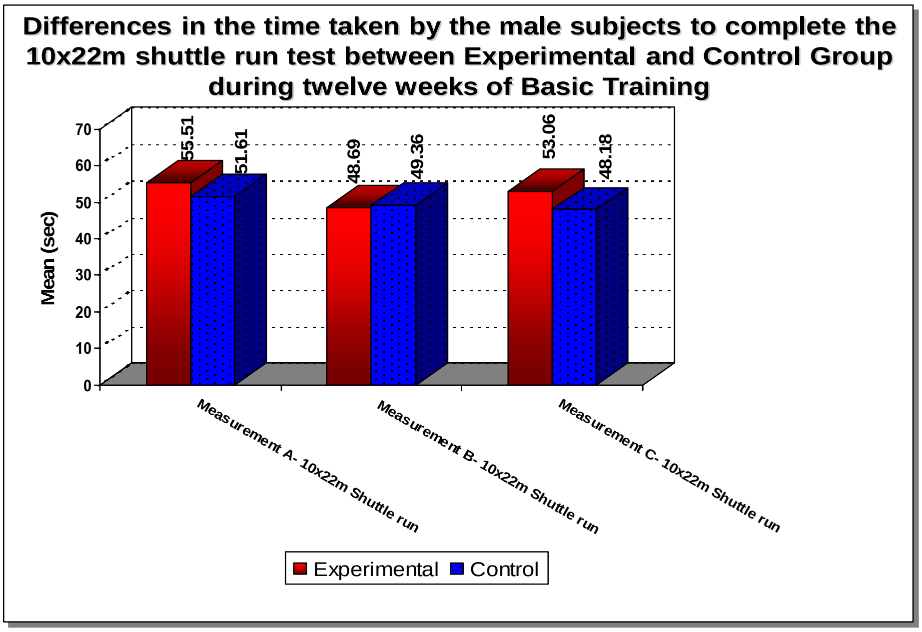


Figure 4.33: Differences in time taken by male participants to complete the 10 x 22m shuttle run test between the EG and CG 12 weeks of BT

The decline shown by the EG may be attributed to a lack of motivation, as the participants were completing this test purely for research purposes and they were cognisant of the fact that their performance would not influence their results in BT. This was not the case for the CG, whose last Post-test contributed to their final mark for BT. Additionally, the PT Programme followed by the EG may not have provided sufficient stimulus to elicit an improvement in the anaerobic component and should, therefore, be altered to include more anaerobic training.

The shuttle run test, as prescribed by the DOD Policy on PT (2000), is not a standardised test (as used by other studies) rendering comparison of results not possible. The majority of military studies utilising a shuttle run test use the multi-stage shuttle run test as prescribed by Léger *et al.*(1988) (Harwood *et al.,* 1999; Williams *et al.,* 1999; Rosendal *et al.,* 2003; Williams, 2005).

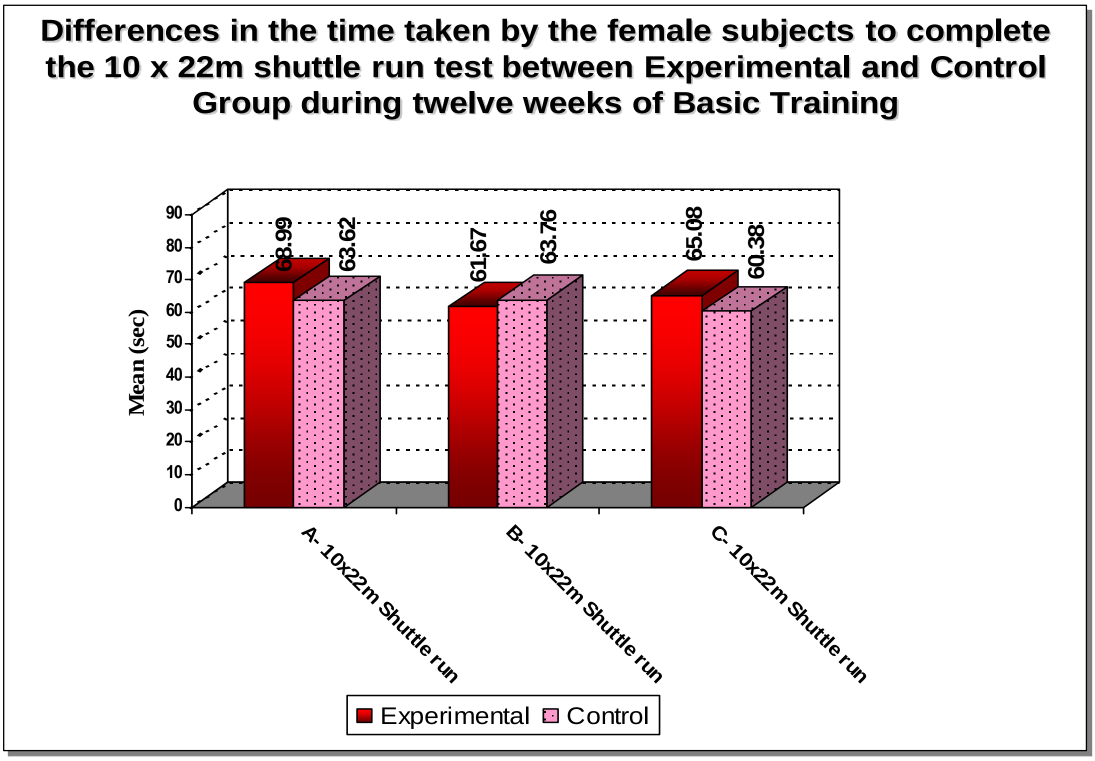


Figure 4.34: Differences in time taken by female participants to complete the 10 x 22m shuttle run test between EG and CG during 12 weeks of BT

4.4.1.4.5 Fitness test results

Points are allocated to each BT recruit according to their performance level (time achieved and number of repetitions achieved) per component. A BT recruit passes a component if 600 points are achieved. Recruits, under the age of 34 years, pass the battery test if they achieve a minimum of 3000 points the sum total of points achieved for all the components (DOD policy on Physical Training, DOD Instruction: SG no 00006/2000). A Chi-square analysis was used to determine whether there were statistically significant relationships between group membership (ie CG or EG) and pass or fail rates.

The complete statistical results for each fitness test are presented in Appendix Copy Disk - G. Only the results of the total tests were included in this analysis. The results of the Chi-square analysis indicated that there was a relationship between group membership and whether participants passed or failed the fitness test in total (see Table 4.13). However this relationhip was not strong enough to be statistically significant.

Table 4.13: Relationship between group membership and pass rate at the Pre-test (Measurement A)

Relationship between group membership and pass rate at the Pre-test (Measurement A)					
			Total Pass/Fail		Total
			Pass	Fail	
GROUP	Experimental	Count	37	146	183
		% within GROUP	20.2%	79.8%	100.0%
		% within fitness test A: Total Pass/Fail	24.2%	**68.5%**	50.0%
		% of Total	10.1%	39.9%	50.0%
	Control	Count	116	67	183
		% within GROUP	63.4%	36.6%	100.0%
		% within fitness test A: Total Pass/Fail	75.8%	**31.5%**	50.0%
		% of Total	31.7%	18.3%	50.0%
Total		Count	153	213	366
		% within GROUP	41.8%	58.2%	100.0%
		% within fitness test A: Total Pass/Fail	100.0%	100.0%	100.0%
		% of Total	41.8%	58.2%	100.0%

Relationship between group membership and pass rate at the Pre-test (Measurement A)

Chi-square Tests

	Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	**70.091(b)**	**1**	**0.000**		
Continuity Correction(a)	68.328	1	0.000		
Likelihood Ratio	72.842	1	0.000		
Fisher's Exact Test				0.000	0.000
Linear-by-Linear Association	69.900	1	0.000		
N of Valid Cases	366				

a. Computed only for a 2x2 table

b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 76.50.

The cross tabulation shows that the majority of participants who failed the total fitness tests during the Pre-test were in the EG (68.5%). This is supported in the previous sections, where the results of the EG are statistically poorer (p.0.005) than the CG in the Pre-test. The individual test results thus showed that the group who failed consisted mostly of participants in the EG.

Chi-square analyses of the first Post-test (measurement B) indicate that the majority of participants who failed were in the CG (73.3%) (Table 4.14). The same profile was found in the 2.4 km run, push-up and sit-up tests. However, on the shuttle run and 4 km walk tests, there were no significant relationships (Appendix Copy Disk - G).

Table 4.14: Relationship between group membership and pass rate at the first Post-test (Measurement B)

Relationship between group membership and pass rate at the first Post-test (Measurement B)

			Total Pass/Fail		
			Pass	Fail	Total
GROUP	Experimental	Count	151	8	159
		% within GROUP	95.0%	5.0%	100.0%
		% within fitness test B: Total Pass/Fail	50.0%	**26.7%**	47.9%
		% of Total	45.5%	2.4%	47.9%
	Control	Count	151	22	173
		% within GROUP	87.3%	12.7%	100.0%
		% within fitness test B: Total Pass/Fail	50.0%	**73.3%**	52.1%
		% of Total	45.5%	6.6%	52.1%
Total		Count	302	30	332
		% within GROUP	91.0%	9.0%	100.0%
		% within fitness test B: Total Pass/Fail	100.0%	100.0%	100.0%
		% of Total	91.0%	9.0%	100.0%

Chi-square tests

	Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	**5.954(b)**	**1**	**0.015**		
Continuity Correction(a)	5.055	1	0.025		
Likelihood Ratio	6.203	1	0.013		
Fisher's Exact Test				0.020	0.011
Linear-by-Linear Association	5.936	1	0.015		
N of Valid Cases	332				

a. Computed only for a 2x2 table

b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 14.37.

Table 4.15: Relationship between group membership and pass rate at the last Post-test (measurement C)

Relationship between group membership and pass rate at the last Post-test (Measurement C)					
			Total Pass/Fail		
			Pass	Fail	Total
GROUP	Experimental	Count	161	13	174
		% within GROUP	92.5%	7.5%	100.0%
		% within fitness test C: Total Pass/Fail	48.5%	68.4%	49.6%
		% of Total	45.9%	3.7%	49.6%
	Control	Count	171	6	177
		% within GROUP	96.6%	3.4%	100.0%
		% within fitness test C: Total Pass/Fail	51.5%	31.6%	50.4%
		% of Total	48.7%	1.7%	50.4%
Total		Count	332	19	351
		% within GROUP	94.6%	5.4%	100.0%
		% within fitness test C: Total Pass/Fail	100.0%	100.0%	100.0%
		% of Total	94.6%	5.4%	100.0%

Chi-square tests

	Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	**2.855(b)**	**1**	**0.091**		
Continuity Correction(a)	2.113	1	0.146		
Likelihood Ratio	2.916	1	0.088		
Fisher's Exact Test				0.103	0.072
Linear-by-Linear Association	2.847	1	0.092		
N of Valid Cases	351				

a. Computed only for a 2x2 table

b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 9.42.

The results of the Chi-square analysis in Table 4.15 shows that there was no statistically significant relationship between the total fitness scores at the last Post-test (measurement C) and the group membership of participants.

It appears that as participants grew fitter, their group membership seemed to not be a determinant in whether they would pass or fail anymore. The results of the individual tests indicated no significant relationships for the 2.4 km run, push-up and sit-ups tests. However, on the shuttle run and 4 km walk tests, there were significant relationships, with the EG, once again, making up the biggest part of the failing group.

4.4.1.4.6 Flexibility

Flexibility of muscles and joints may directly influence stress fracture risk by way of altering the forces applied to bone. Numerous variables have been assessed but the range of hip external rotation and of ankle dorsiflexion, have been associated, albeit inconsistently, with stress fracture development (Hughes, 1985; Giladi *et al.,* 1987; Giladi *et al.,* 1991; Milgrom *et al.,* 1994; Brukner *et al.,* 1999).

Recruits with external rotation of the hip greater than 65°, experienced an incidence of stress fracture 1.8 times higher than that of recruits with lower degrees of rotation (95% CI: 1.3, 2.5) (Giladi *et al.,* 1987; Giladi *et al.,* 1991). Conversely, Milgrom *et al.* (2004) failed to relate this measurement to stress fracture risk. The male and female participants of this cohort had a mean hip external rotation of 25.57º(L) / 23.40º(R) and 26.19º(L) / 24.78º(R) respectively-is below the recommended 45º-50º average ROM value for healthy adults (Heyward, 2002). The complete statistical results for each fitness test are presented in Appendix Copy Disk - D.

Limited hip external rotation has been linked to the risk of developing stress fractures; unfortunately, this could not be assessed in this study due to the lack of stress fracture incidence. It therefore appears that the hip external rotation of this cohort, was not an intrinsic risk factor, as it was below the documented risk of 65º (Giladi *et al.,* 1987; Giladi *et al.,* 1991). These findings thus support work done by Milgrom *et al.* (2004).

Hughes (1985) found that restricted ankle-joint dorsiflexion (ROM = ≈10º) was related to an increased risk of metatarsal stress fractures. The recruits who had a reduced range were 4.6 times more likely to develop a metatarsal stress fracture. The male and female participants of this cohort had a mean ankle dorsiflexion of 17.14º ± 3.65 (L)/18.25º ± 4.14 (R) and 15.21º ± 3.18(L)/ 16.40º ± 3.53(R), respectively.

According to Heyward (2002), the average ankle dorsiflexion ROM value for healthy adults is 20º. Therefore, the cohorts' mean values were slightly below the norm. Kaufman *et al.* (1999) reported that their 407 male Navy SEAL trainees had a mean ankle dorsiflexion of 20.5º ± 5.5, which was higher than the dorsiflexion results measured in the male participants of this study (17.14 ± (L) 18.25± (R)). Kaufman *et al.* (1999) classified >18.5° dorsiflexion as tight and 18.5°–23.0° dorsiflexion, with the knee bent at 90º , as a normal range. They did not suggest either ranges to be associated with a greater risk for the development of stress fractures (Kaufmann *et al.,* 1999).

The methodology used to assess the ankle dorsiflexion, with knee at 90º flexion meant that the gastrocnemius muscle was relaxed. DiGiovanni *et al.* (2002) found that isolated gastrocnemius contracture, as measured by dorsiflexion, with knee at 0º flexion, assisted in the development of forefoot and/or midfoot pathology in otherwise healthy people. These findings are, however, not supported by Kaufmann *et al.* (1999). As the did not have limited dorsiflexion this study cannot exclude limited ankle dorsiflexion as a possible risk factor in the development of stress fractures. The male cohort did, however, show a significant 43.40 %(L) and 38.52 %(R) improvement in their dosiflexion during the 12 weeks of BT possibly offering some form of protection. Further study by measuring ankle dorsiflexion, with the knee at 0º flexion, in the South African context is recommended.

All the flexibility measurements for male participants showed a statistically significant change from Pre-test to Post-test. The plantarflexion, both right and left, as well as the hip external rotation (right and left) showed statistically significant decreases in scores from the Pre-test to the Post-test. Both the right and left dorsiflexion scores showed a statistically significant increase in scores from the Pre-test to the Post-test (see Figure 4.35).

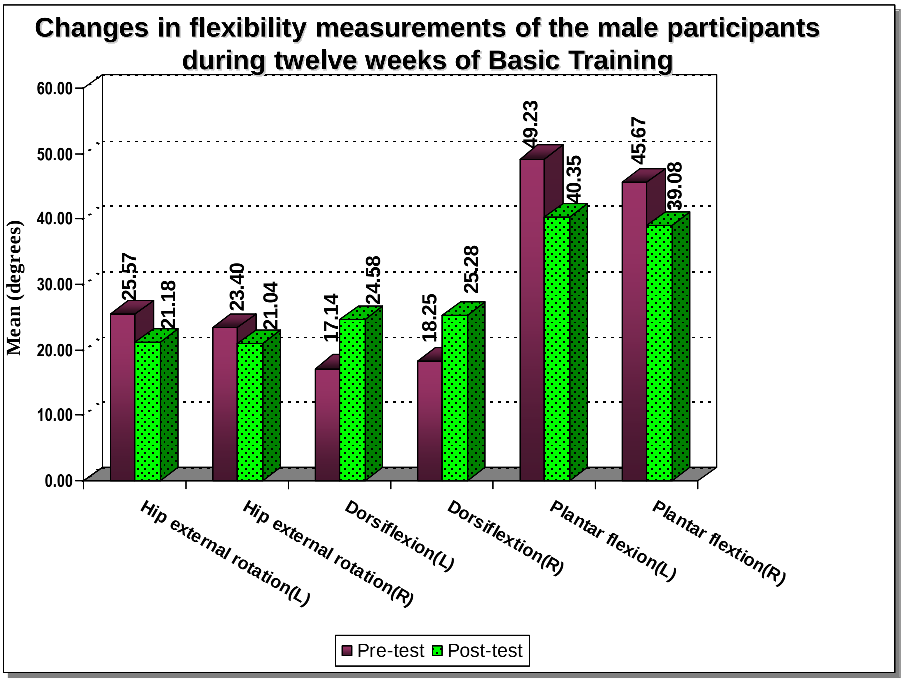


Figure 4.35: Changes in flexibility measurements of male participants during 12 weeks of BT (ankle plantarflexion, dorsiflexion and hip external rotation)

In female participants, not all flexibility measurements showed a statistically significant change in scores (see Figure 4.36). Hip external rotation scores on the right and left hand side, showed significant decreases, as was the case in the male participants. The ankle dorsiflexion of the right ankle showed no statistically significant changes, whilst the left decreased significantly. This is in contrast to the male findings which found ankle dorsiflexion increased significantly over the 12-week period. Where plantarflexion scores for males decreased significantly (see Figure 4.35), these scores seemed to have increased significantly for females both on the right and left hand side.

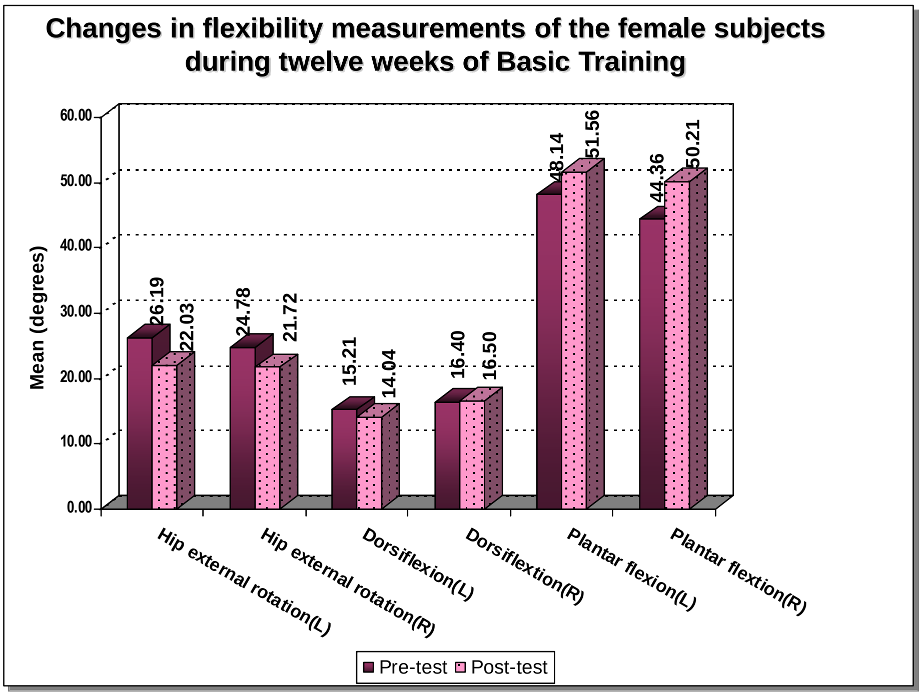


Figure 4.36: Changes in flexibility measurements of female participants during 12 weeks of BT (ankle plantarflexion, dorsiflexion and hip external rotation)

Although studies have reported prospective flexibility measures of toe touching ability to have increased during BT, there appears to be no clinical relevance

(Jones *et al.,* 1999; Kaufman *et al.,* 2000; Pope *et al.* 2000; Popovich *et al.,* 2000). Studies have found that lower extremity stretching before training does not offer a protective effect from stress fractures or reactions (Pope *et al.,* 2000; Shaffer & Uhl, 2006). Additionally, studies involving stretching concluded that pre-exercise stretching did not reduce the incidence of muscle soreness or lower extremity injuries, including stress fractures, in young active adults involved in running and marching (Yeung & Yeung, 2001; Herbert & Gabriel, 2002).

The PT Programme followed by this cohort, allowed for stretching at the end of each session. However, reasons for the difference in responses by the male and female participants, are not clear. Possibly, the vast improvement shown by the female participants in ankle plantarflexion may be attributed to the improvement in soleus strength, which assists in the plantarflexion, (see Figure 4.30). The male participants also had a smaller, but yet still significant, improvement in ankle plantarflexion strength (see Figure 4.28). Regardless of the reasons, this raises questions about the efficacy and the necessity of pre and post-exercise stretching for the prevention of lower extremity injuries, including stress fractures.

4.4.1.5 Body size and composition

Theoretically, body size and soft-tissue composition could affect stress fracture risk directly, by influencing the forces applied to the bones and, indirectly, by influencing bone density or menstrual function. Various potential risk factors related to body size and composition, have been investigated including: height, weight, skinfold thickness, Body-Mass Index (BMI), total and regional lean mass and fat mass, limb and segment lengths, body girths and widths (Brukner *et al.,* 1999).

Simple anthropometric techniques have usually been used as measurement tools, however, DEXA is being used with more frequency, despite its cost, due to its high accuracy rate dual-energy (Brukner *et al.,* 1999). In this study all participants were evaluated according to the Yuhasz (1974) method, with 70 female participants also underwent DEXA testing. The body composition results of the latter, will be discussed separately at the end of this section.

At the start of BT the anthropometric measurements showed the males participants to be taller and heavier than female participants (Table 4.16). This is similar to that reported by other military studies around the world (Jones *et al.,* 1993a; Legg & Duggan, 1996; Brock & Legg, 1997; Bell *et al.,* 2000; Lappe *et al.,* 2001; Knapik *et al.,* 2005).

Table 4.16: Means and standard deviations of selected anthropometric characteristics at the start of BT

Anthropometric Characteristics	Pre-test				Post-test			
	Males		Females		Males		Females	
	n	Mean (SD)	*N*	Mean (SD)	*N*	Mean (SD)	*n*	Mean (SD)
Height-cm	100	171.36 (5.86)	83	159.26(5.49)	100	171.36 (5.86)	83	159.26(5.49)
Mass-kg	100	61.78 (6.89)	83	60.22 (8.99)	100	63.18 (6.61)	83	60.04 (7.48)
Waist-Hip Ratio	100	0.78(0.04)	83	0.72(0.05)	100	0.76(0.08)	83	0.77(0.06)
Body Mass Index (kg.m^2)	100	21.43(2.16)	83	23.40(3.04)	100	22.42(2.47)	83	22.52(2.34)
Body Fat-%	100	8.72 (2.93)	83	17.33 (4.47)	100	8.15 (1.52)	83	14.92 (3.15)
Lean Mass-kg	100	56.29(5.52)	83	49.48 (5.46)	100	57.95 (6.00)	83	50.11 (5.37)
Fat Mass-kg	100	5.49 (2.39)	83	10.74 (4.27)	100	5.29 (2.29)	83	9.92 (4.76)
Endomorph component	100	2.79 (1.16)	83	5.87 (1.64)	100	2.60 (0.77)	83	5.37 (1.26)
Mesomorph component	100	3.95 (1.06)	83	3.65 (1.09)	100	4.76 (1.02)	83	4.73 (1.16)
Ectomorph component	100	3.42 (1.14)	83	1.48 (1.43)	100	3.15 (1.06)	83	1.46 (1.13)

The South African male participants were comparatively shorter (171.4 ± 5.9 cm) than research conducted on British male recruits (176.0 ± 0.08 cm), Norwegian male recruits (180.7 ± 6.4 cm) and American male recruits (175.2 ± 4.8 cm; 175.1 ± 7.3 cm) (Jones *et al.,* 1993b; Legg & Duggan, 1996; Bell *et al.,* 2000; Dyrstad *et al.,* 2006). Earlier studies conducted by Gordon *et al.* (1986a) and Jordaan and Schwellnus (1994), in the South African military, reported their recruits to be taller than the cohort studied here, documenting a mean height of 177.0 ± 6.5 cm and 178.6 ± 6.9 cm respectively. This difference may be attributed to the predominantly Caucasian sample used by Gordon *et al.,* (1986a) and Jordaan and Schwellnus (1994) compared to the current study, where the cohort was predominantly African (Steyn *et al.,* 2000).

The South African female participants were found to be of similar height and mass to other female recruits around the globe. Brock and Legg (1997) reported their British female recruits being 1.65m ± 7.1 cm tall and having a mass of 60.0 ± 7.9 kg, whilst the American female recruits were 163.3m ± 6.58 cm and 163.3m ± 6.7 cm tall and had a mass of 58.7 ± 5.76 kg and 57.8 ± 6.8 kg (Jones *et al.,* 1993a; Rauh *et al.,* 2006).

Jones *et al* (1993a) reported a stress fracture incidence of 2.3% (n=124) and 12.3% (n=186) in their male and female participants respectively, during BT. The male participants were a mean 4.14cm taller and 11.82kg heavier, whilst their female participants were 4cm taller and 1.5kg lighter than the participants of the current study. Rauh *et al.* (2006) had a 6.8% stress fracture incidence in their female recruits. Although both Jones *et al.* (1993a) and Beck *et al.* (1996) showed a risk association between stress fracture and shorter stature, this study supports the findings of studies that failed to conclude an association between stress fractures and various parameters of body size, due to the 0% incidence of stress fractures (Finestone *et al.,* 1991; Giladi *et al.,* 1991; Taimela *et al.,* 1990; Winfield *et al.,* 1997; Cline *et al.,* 1998; Shaffer *et al.,* 2006).

BMI9kg.m^2) has been both directly and inversely associated with stress fracture rates (Beck *et al.,* 1996; Zanker & Cooke, 2004). The male participants' BMI (21.43 ± 2.16) was similar to the 22.0 ± 2.1 reported by Williams (2005), the 24.3 ± 4.85 by Jones *et al.* (1993a) and the 24.8 ± 3.0 reported by Sonna *et al.* (2001). All the participants in these studies fell within the "normal" range of 18.5-24.9, as prescribed by the American College of Sport Medicine (2006). Due to the lack of stress fracture incidence in this study, it would appear that these finding do not support this inverse association as the male participants had a slightly lower BMI than Jones *at al*. (1993a) who reported a stress fracture incidence of 2.3%.

The female participants' BMI (23.40 ± 3.04) was also within the 'normal' range (American College of Sport Medicine, 2006) and similar to the 23.1 ± 3.1 reported by Sonna *et al.* (2001), the 21.7 ± 2.0 by, Rauh *et al.* (2006)and the 21.5 ± 1.9 reported by Shaffer *et al.* (2006). Rauh *et al.* (2006) reported a 6.8% stress fracture incidence and Shaffer *et al.* (2006), a 5.3% stress fracture incidence. Similar to the findings of Rauh *et al.* (2006), this study fails to support the inverse association of stress fracture incidence and BMI.

The percentage of body fat in the male (8.72 ± 2.93) and female participants (17.33 ± 4.47) was low in comparison to Irazusta *et al.* (2006), who reported 15.20 ± 5.02 and 22.50 ± 6.11 and also employed the Yuhasz's (1974) method. During the 12 weeks of BT, significant changes to most of the anthropometric measures occurred from Pre-test to Post-test (Figure 4.37). The male participants' mass (2.3%), biceps circumference (5.1%), calf circumference (2.3%) and lean body mass (2.9%) measurements showed significantly higher Post-test scores than Pre-test scores. All the changes were statistically significant at the 5% level of significance.

These findings are in support of the majority of research done on monitoring the changes in anthropometric measures during BT in militaries around the world. Adult artillery recruits, in the British Military, showed a 2.6% increase in body weight over a three month BT programme, compared to the 2.3% increase shown in the current study (Legg & Duggan, 1996). Williams (2005) also supported these findings by reporting a 1.3% and 2.9% increase in mass and a 2.7% and 4.1% increase in fat free mass in the British Army regular and Reserve Army personnel, respectively, after 12 weeks of BT. The current study showed a 2.9% increase in Lean Body Mass. Gordon *et al.* (1986a) reported a 0.7% increase in body weight and a 1.7% increase in lean body mass in the South African Defence Force after ten weeks of BT. Contrary to the above findings, Williams *et al.* (1999) reported a 1.6% loss in body mass over 10 weeks of BT with a 1.2% increase in Lean Body Mass, whilst Nindl *et al.* (2000) showed a decrease in body mass after a 62 day U.S. Army Ranger Course. BT recruits in the New Zealand military showed no change in body mass over a ten week period (Stacy *et al.,* 1982).

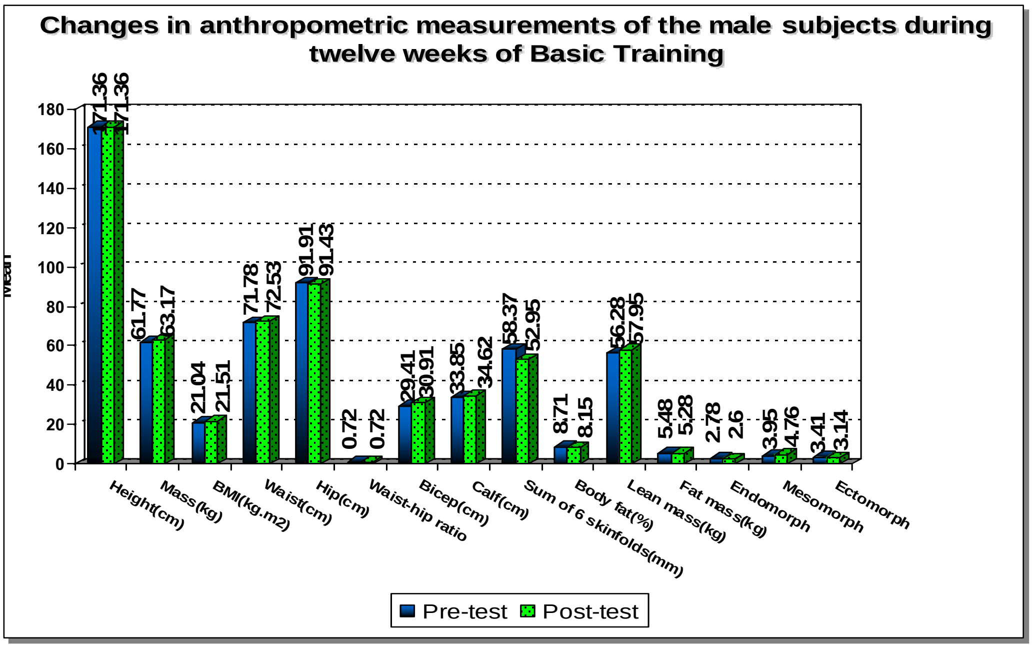


Figure 4.37: Changes in anthropometric measurements of male participants during 12 weeks of BT

The increase in FFM of 2.9% in the present study, is a positive training adaptation. This positive change may be attributed to the progressive resistance training that was included in the PT Programme. Increases in FFM of 4.1% and 1.2% for males have been reported by Sharp *et al.* (1993) and Williams *et al.* (1999), respectively, resulting from adaptations due to training programmes for BT.

The sum of skin folds (9.3) and %BF (6.5%)scores showed a statistically significant decrease in scores from Pre-test to Post-test.

These findings support work done by other researchers (Stacy *et al.,* 1982; Gordon *et al.,* 1986a; Williams *et al.,* 1999; Williams, 2005). Stacy *et al.* (1982) reported a 2.2% decrease in % BF, which is lower that the 6.5% reported by this study. This difference may be attributed to the shorter ten week BT programme followed by the New Zealand recruits or to the three-skinfold measurement technique used to measure %BF. This skinfold measurement technique may be responsible for the smaller difference observed by Gordon *et al.* (1986a), where a 4.4% decrease in %BF was observed over 12 weeks of BT with the sum of 4 skinfolds being used to calculate %BF. Williams *et al.* (1999) and Williams (2005) reported a staggering 21.7% and 10.2% decrease, respectively, after 12 weeks of BT. This sharp decrease may be attributed to the large scheduled PT time (71 periods of 40 minutes = 2,840 minutes in total; and 90 periods of 40 minutes = 3,600 minutes in total, respectively) compared to the lesser scheduled PT time for the current study (60 periods of 40 minutes = 2,400 minutes in total).

The reported percentage decrease in the sum of the 6 skinfolds is directly linked to the %BF, as this is used to calculate the %BF (MacDougall *et al.,* 1991). The male participants' fat mass, hip circumference and BMI did not change significantly from Pre- to Post-test. This supports the work by Williams (2005) who also found no significant change in BMI in regular British Army personnel (p 0.420).

Amongst the female participants, fewer statistically significant changes occurred. The mass, lean body mass, waist circumference, hip circumference and waist-hip ratio did not change significantly (Figure 4.38). This is in contrast to Brock and Legg (1997) who described a 1% increase in body mass after six weeks of BT in the British Army. Increased body mass was also observed in US female recruits after seven weeks of BT (Knapik *et al.,* 1980; Patton *et al.,* 1980).

Conversely, Williams *et al.* (1996) reported a 2.1% decrease in body mass and a 3.4% increase in Fat Free Mass (FFM) after 12 weeks of BT. The FFM increase compared favourably to the 2.3% reported by Brock and Legg (1997) and to the 1.3% increase experienced by this cohort. Surprisingly large increases in Fat Free Mass of 5.9% and 6.1% have been reported in US female BT recruits by Knapik *et al.* (1980) and Patton *et al.* (1980), respectively.

As with the male participants, significant increases in the bicep circumference (2.8%) and calf circumference (3.3%) were observed. The increases in these variables show a positive training adaptation, which may be attributed to the progressive resistance training that, was included in the PT Programme. It appears as if the training adaptation was not as successful as in the male participants, in resulting in the expected increase in lean body mass.

The sum of skin folds (16.3%) and % BF (13.9%) decreased significantly from Pre-test to Post-test. All these differences were significant at the 5% level of significance. These findings are similar to those in the male participants.

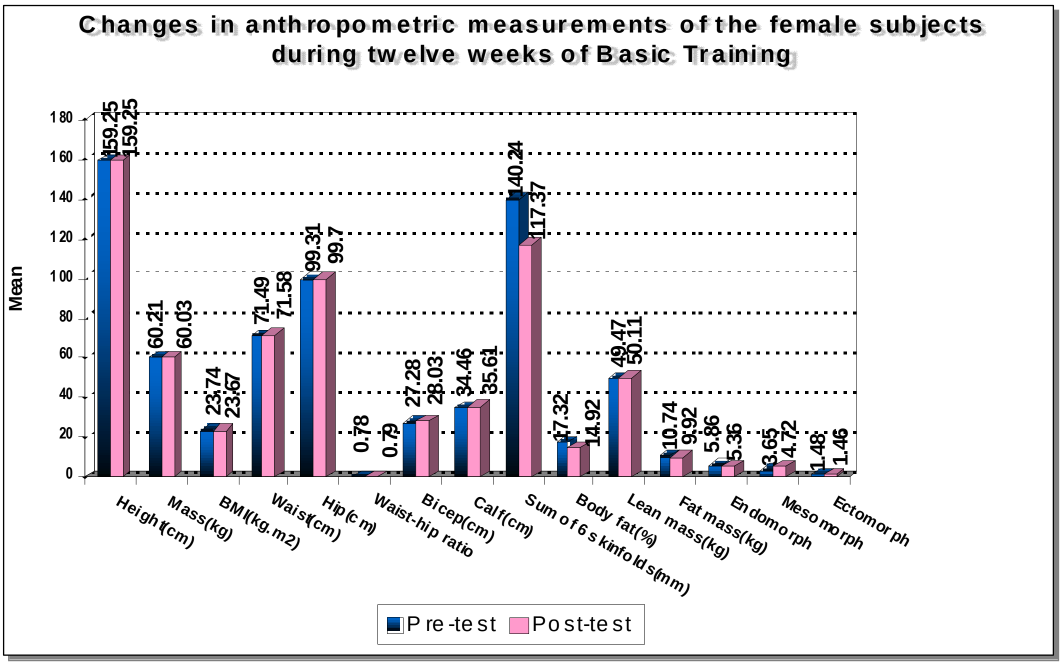


Figure 4.38: Changes in anthropometric measurements of female participants during 12 weeks of BT

The favourable change in %BF is less than the 16.8% decrease observed by Williams *et al.* (1996) in British female recruits over 12 weeks of BT, but compares well to the reported 3.3% decrease reported by Brock and Legg (1997).The comparatively small difference observed by Brock and Legg (1997) may be explained by the shorter six-week period of BT completed by these recruits. Decreased %BF was also observed for females after 7 weeks of US BT (Knapik *et al.* 1980 and Patton *et al.* 1980).

Acute weight loss was found to be a significant risk factor for stress fracture injuries in both male and female recruits (Armstrong *et al.,* 2004). In a study of 2591 Israeli soldiers, those with stress fractures weighed less than controls (Givon *et al.,* 2000). It, therefore, seems as if this cohorts' change in body mass over the 12 weeks of BT was not a risk factor for the development of stress fractures as no weight loss was observed. Contrarily, the male participants showed a significant increase in body mass, whilst the female participants remained constant throughout the BT period.

The male participants' pre-test somatotype was 2.8 - 4.0 - 3.4, following 12 weeks of BT the post-test somatotype was 2.6 – 4.8 – 3.1. This showed a favourable adaptation in all three categories with the endomorph component decreasing significantly ($p \leq 0.05$) by 6.8%, the mesomorph component increasing significantly ($p \leq 0.05$) by 20.5% and the ectomorph component decreasing significantly ($p \leq 0.05$) by 8.9%.

The somatotype changes in the male participants in the present study respresent a positive training adaptation which may be attributed to the progressive resistance and cardiorespriratory training components included in the PT Programme. Additionally, the decrease observed in the endomorph components may be attributed to the decrease observed in the %BF (MacDougall *et al.,* 1991). Whilst the decrease in the ectomorph components may be explained by the large increase in the mesomorph component and significant increases in bicep and calf circumferences (MacDougall *et al.,* 1991).

The female participants' pre-test somatotype was 5.9 – 3.7 – 1.5, whist the post-test revealed a 5.4 – 4.7 – 1.5 somatotype. This showed some favourable adaptation with the endomorph component decreasing significantly ($p \leq 0.05$) by 8.5%, the mesomorph component increasing significantly ($p \leq 0.05$) by 29.3% and the ectomorph component showing no change ($p=0.7$).

The changes observed in the female participants are similar to those in the male participants, however, no decrease was observed in the ectomorph component, which may be explained by the small increase in lean body mass and the small decrease observed in fat mass.

Figure 4.39 shows the changes that occurred in the cohorts' somatotype over the 12 weeks of BT. Both the male and female participants showed a statistically significant increase from Pre-test to Post-test in their Y-axis value, whilst the female participants showed a statistically significant decrease and the male participants experienced no significant changes in their X-axis value.

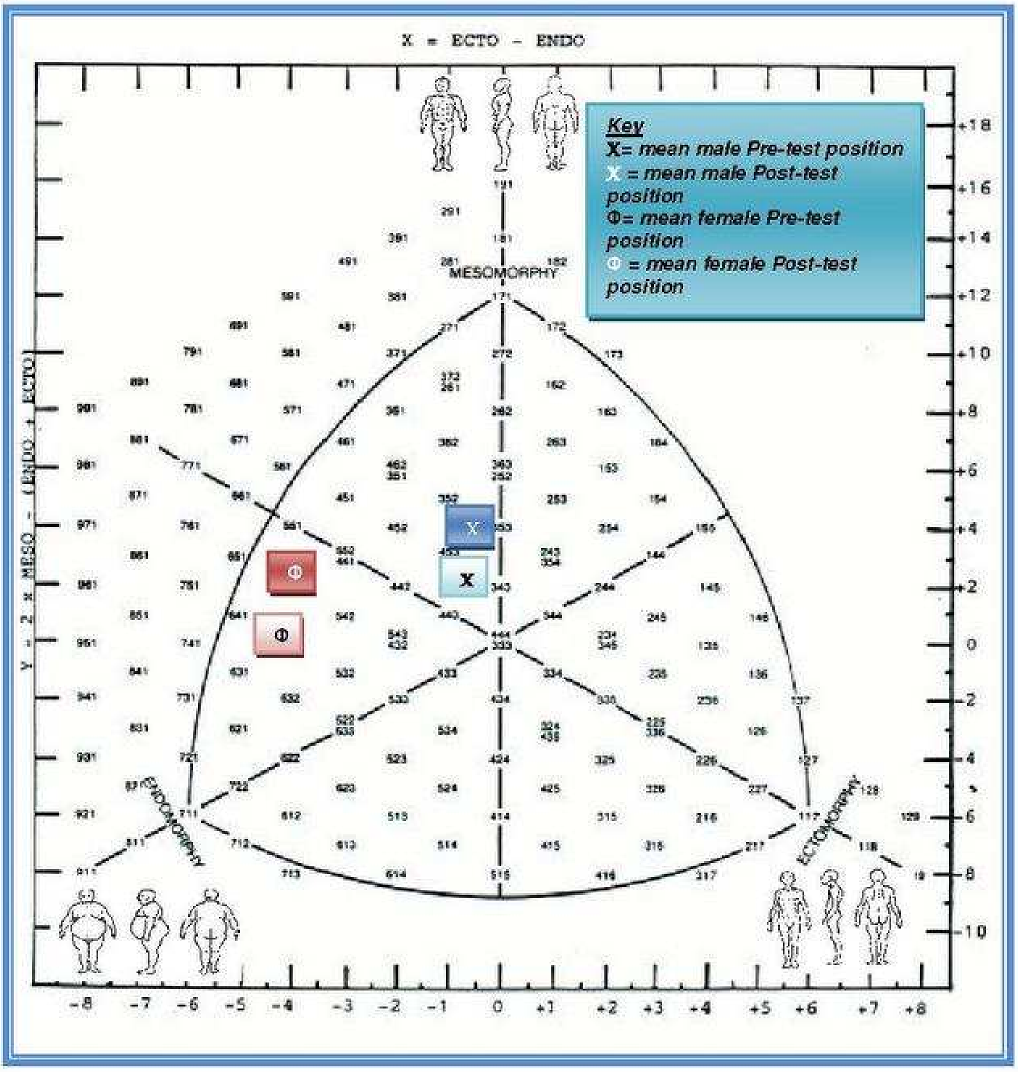


Figure 4.39: Dimensional representation of the somatotype changes in the male and female participants during 12 weeks of BT (Adapted from Carter, 2002)

In summary, the anthropometric changes during training were positive, although favourable changes were more prominent in the male recruits. Some changes, specifically in the female participants, although still positive, were of a lesser magnitude than has been shown to be possible during a training programme of similar length.

4.4.1.5.1 Dual-energy X-ray absorptometry assessed changes in body size and composition

DEXA has been shown to provide accurate estimates on BMC and BMD (Ellis & Shypailo, 1998). DEXA is highly precise and is used as a valid technique for body composition assessment in healthy young participants (Mazess *et al.,* 1990; Snead *et al.,* 1993; Kohrt, 1998; Pietrobelli *et al.,* 1998; Ellis & Shypailo, 1998; Prior *et al.,* 1997; Houtkooper *et al.,* 2000; Taylor *et al.,* 2002). Even though values may differ, based on the DEXA instrumentation, these differences are small (Tothill *et al.,* 1994; Kistorp & Svendsen, 1997; Ellis & Shypailo, 1998; Schoeller *et al.,* 2005).

In this study, DEXA measurements were done primarily to ascertain the BMD and BMC of the 70 female participants which were originaly selected, and the 68 who completed the BT, as discussed in Chapter 3. DEXA also provides a measure of total-body bone mineral mass, bone-free lean tissue, and fat mass thereby yielding a three-compartment model of body composition (Kohrt, 1998; Mattila *et al.,* 2007). Few studies have used DEXA to measure body composition on military recruits and only Knapik *et al.* (2001) included female recruits in their study (Knapik *et al.,* 2001; Lintsi *et al.,* 2004; Mattila *et al.,* 2007). The results are presented in kilograms for total body mass, grams for LBM and fat mass, and as percentage for BF. The DEXA assessed changes of regional body composition, of the female participants over 12 weeks of BT, are outlined in Table 4.17.

Table 4.17: Dual-energy X-ray absorptiometry assessed changes of regional body composition, of the female participants over 12 weeks of BT

Body Region	Total Soft Tissue Mass (g)		Percent Tissue Fat (%)		Fat Mass(g)		Lean Mass(g)	
	Difference	% △	Difference	% △	Difference	% △	Difference	% △
Total body	843.16	1.49	-4.11	-11.03*	-2224.58	-10.31*	3067.60	8.74*
Left side	153.75	0.54	-4.04	-10.85*	-1186.68	-10.93*	1340.46	7.59*
Right side	689.42	2.45*	-4.16	-11.17*	-1037.77	-9.68*	1727.24	9.90*
Trunk	-4.66	-0.02	-6.12	-16.53*	-1630.70	-17.02*	1626.08	10.38*
Left	-19.61	-0.16	-6.10	-16.49*	-816.12	-17.11*	796.54	10.20*
Right	23.60	0.19	-6.12	-16.53*	-814.72	-16.94*	829.48	10.55*
Legs	755.33	3.45*	-2.11	-4.99*	-222.81	-2.36	978.24	7.87
Left	302.29	2.73*	-2.09	-4.95*	254.92	5.34	440.46	7.00
Right	457.05	4.23*	-2.13	-5.04*	-36.55	-0.79	1335.06	21.76
Arms	156.08	2.76	-5.34	-17.44*	-290.53	-16.20*	446.67	11.56*
Left	6.36	0.22	-5.35	-17.48*	-168.44	-18.20*	175.05	8.83*
Right	149.67	5.45*	-5.35	-17.46*	-122.19	-14.07*	271.88	14.47*

Values are mean differences between Pre-test and Post-test and % change that was observed in 68 female participants.

* Significant change from the Pre-test to the Post-test at the end of 12 weeks of BT. p≤0.05.

The DEXA assessed total body mass, as reflected in Figure 4.40, did not increase significantly from Pre-test (59.14kg) to Post-test (59.96kg). Knapik *et al.* (2001) did not report changes in body mass as their major purpose of their investigation was to "…*examine associations between injuries and physical fitness with special attention to physiological measures of aerobic capacity, body composition, and muscle strength."* (Knapik *et al.,* 2001: 947). However, their female BT recruits were a mean 3.1kg heavier than those measured by DEXA in this study.

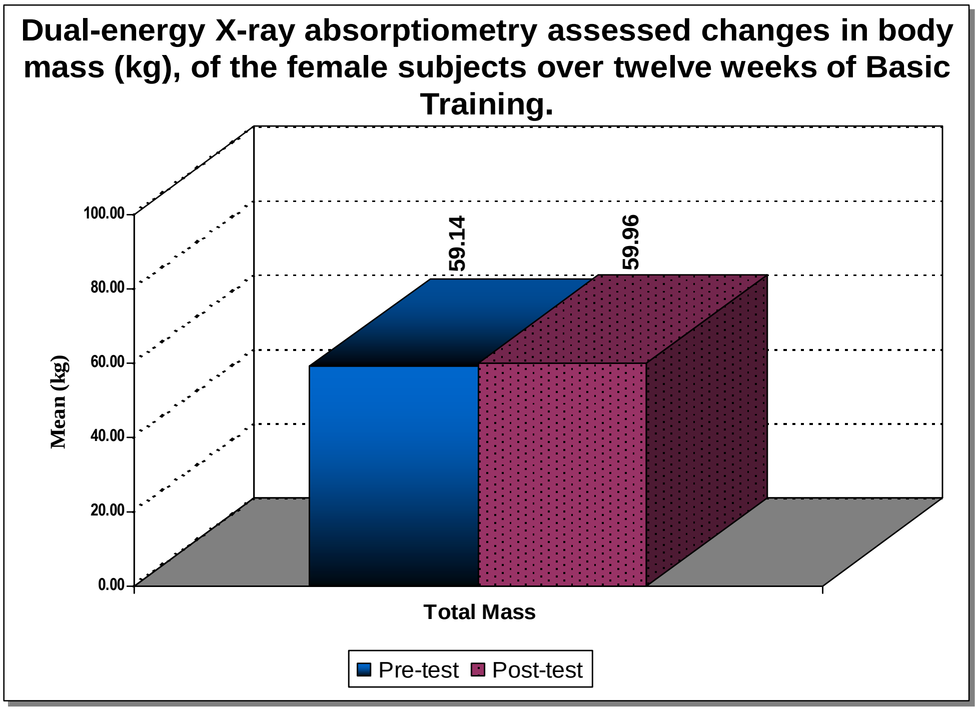


Figure 4.40: Dual-energy X-ray absorptiometry assessed changes in body mass (kg), of female participants over 12 weeks of BT.

The slight increase in total body mass supports findings by other researchers who used more traditional methods of assessing body mass and who also reported an increase in body mass (Knapik *et al.,* 1980; Patton *et al.,* 1980; Brock & Legg, 1997).

Changes in the whole body and regional total soft tissue mass over the 12 weeks of BT are given in Figure 4.41 and outlined in Table 4.16. Total soft tissue mass is the mass of the whole body's body tissue excluding the bone, teeth, nails, hair and cartilage mass (Stedman's Medical Dictionary, 2000).

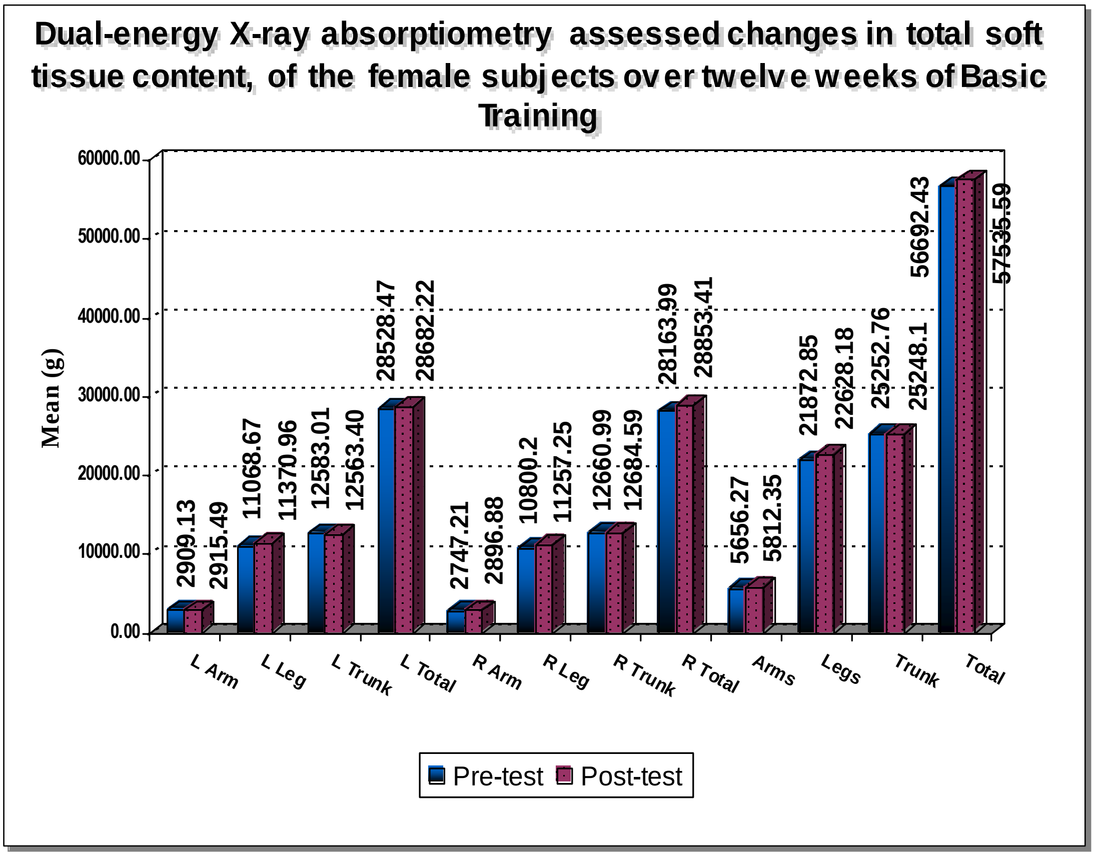


Figure 4.41: Dual-energy X-ray absorptiometry assessed changes in total soft tissue content, of female participants over 12 weeks of BT (arm, leg, trunk and total body region)

Significant increases, at the 5% level of significance, were observed in the left leg (302.29g: 2.73%), right leg (457.05g: 4.23%) and total leg (755.33g: 3.45%) measurements as well as in the right arm (149.67g: 5.45%) and total right tissue (689.42g: 2.45%), measurements. The total arm measurements (156.08g: 2.76%), as well as the total soft tissue measurements (843.16g: 1.49%) did not increase significantly. The increase observed in the leg area is similar to the significant increase (0.8g: 3.8%) reported by Nindl *et al.* (2000) in 31 civilian women after six months of periodised PT.

Soft-tissue composition of the total body and major sub-regions were measured with DEXA. Figure 4.41 reflects the changes that took place in the percent fat of the tissues in the different body regions. The results of the T-test indicate that statistically significant differences were found between Pre- and Post-test measurements for all measurements taken. All these differences were significant at the 5% level of significance. There was a favourable change in all the body regions in tissue percent fat, as the Post-test scores were significantly lower than Pre-test scores.

Due to conflicting data on associations between injuries and body composition as estimated by BMI or skinfolds, Knapik *et al.* (2001) tried to clarify the relationship by assessing body composition with DEXA (Macera *et al.,* 1989; Jones *et al.,* 1992; Jones *et al.,* 1993b; Heir & Eide, 1997). Unfortunately, Knapik *et al.* (2001) did not distinguish the type of injury and did not specify if the injuries reported included stress fractures, among their male and female BT cohort. They did, however, suggest that "…*body fat measured with DEXA demonstrated only a weak association with injury."* (Knapik *et al.,* 2001: 950).

According to Sonna *et al.* (2001), the mean percent body fat by DEXA (±SD) of 85 female Army recruits at the start of an eight-week BT course, was 27.9 ± 6.1, which was much lower than the 37.71 ± 7.39 measured in the 68 female recruits assessed by DEXA in this study. Unfortunately, Sonna *et al.* (2001) did not report the changes that occurred in percent body fat after their eight-week BT course. Although no studies have reported DEXA assessed changes in tissue percent fat in female military recruits, the findings support studies that have shown that intensive military training is effective in reducing total body fat as measured by two-compartment models, namely skinfold thickness measurement and bioimpedance (Knapik *et al.,* 1980; Patton *et al.,* 1980; Williams *et al.,* 1996; Brock & Legg, 1997).

Additionally, Nindl *et al.* (2000) reported a 2.7% decrease in total body adiposity compared to the 11.3% decrease observed in this study. This study showed that, before training, the legs had the greatest relative adiposity (11.51%), followed by the arms (11.40%) and trunk (10.09%) whilst in the Nindl *et al.* (2000) study, before training, the arms had the greatest relative adiposity (40.0%), followed by the legs (34.4%) and trunk (33.8%). After 12 weeks of BT, the female participants' difference was greater when comparing their relative leg adiposity (13.30%) to that of the trunk (10.24%) and the arms (8.38%).

Changes in % BF, fat tissue content and lean mass are shown in Figure 4.42, 4.43 and Figure 4.44. The left, right and total leg fat tissue content measurements where the only three measurements that did not show a statistically significant decrease from Pre-test to Post-test. The other regions experienced statistically significant soft tissue fat decreases during 12 weeks of BT. The trunk region experienced the largest decrease in fat tissue content showing a 17.02% decrease followed by the arm region with 16.20%. The leg region showed a non-significant increase in fat tissue content. These findings can be compared to the female, non-military, older participants in a Nindl *et al.* (2000) six month study that reported that their participants' arms exhibited the largest loss (30.8%), followed by the trunk (11.6%) and no changes in the leg region.

Nindl *et al.* (2000) highlighted the fact that few studies are available in the literature that document concomitant upper body, lower body and truncal changes in soft tissue fat and lean mass after longitudinal training. Their study thus shows the importance of considering regional body composition changes rather that whole body changes alone.

The progressive training programme followed by this cohort included both aerobic and resistance exercises, performed five days per week, that were efficacious in reducing the total body adiposity and regional adiposity of the truncal and arm regions – with the Nindl *et al.* (2000) training programme – however, very little mobilization of the fat stores was observed in the leg region.

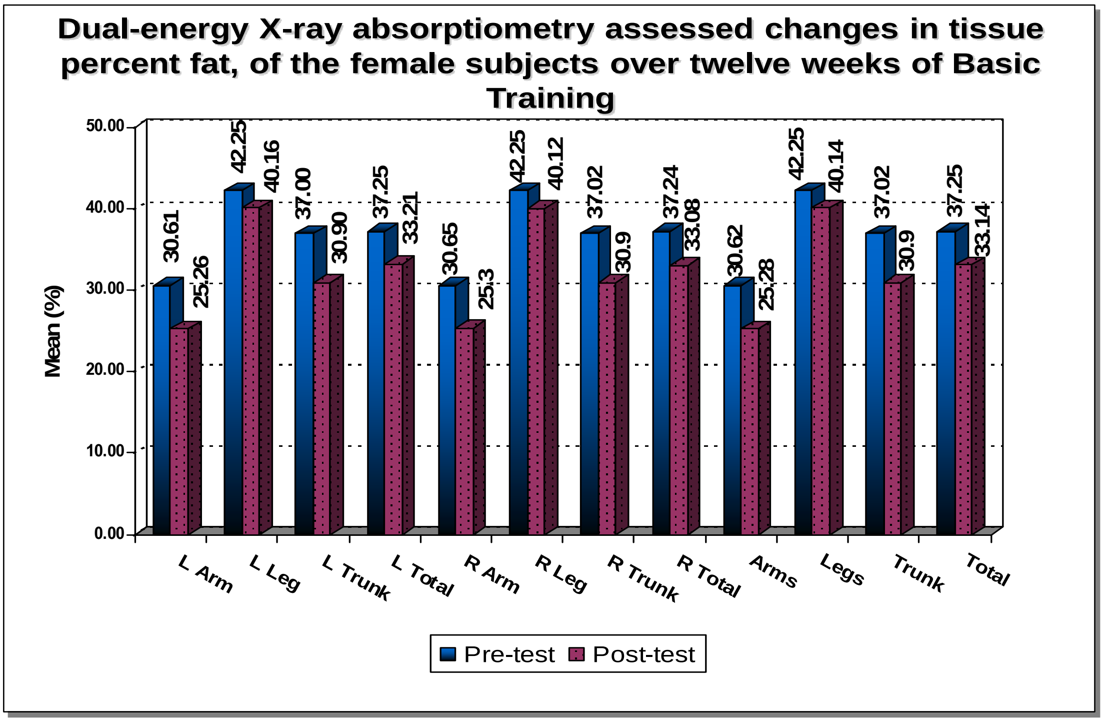


Figure 4.42: Dual-energy X-ray absorptiometry assessed changes in tissue percent fat, of female participants over 12 weeks of BT (arm, leg, trunk and total body region)

A prominent resistance of thigh fat to mobilization and utilization has been reported in the literature (Smith *et al.,* 1979; Rognum *et al.,* 1982; Nindl *et al.,* 2000). Reasons for this resistance have included lipoprotein lipase activity, local blood flow, receptor agonist-to-antagonist ratio, sympathetic nervous stimulation, tissue morphology and lipolytic responsiveness to endocrine stimuli (Smith *et al.,* 1979; Rognum *et al.,* 1982; Leibel *et al.*, 1989; Nindl *et al.,* 2000). The fat mobilization, for this study, was the same as Nindl *et al.* (2000): arm>trunk>legs compared to that documented for males: namely: trunk>arms>legs (Friedl *et al.,* 1993; Nindl *et al.,* 1996).

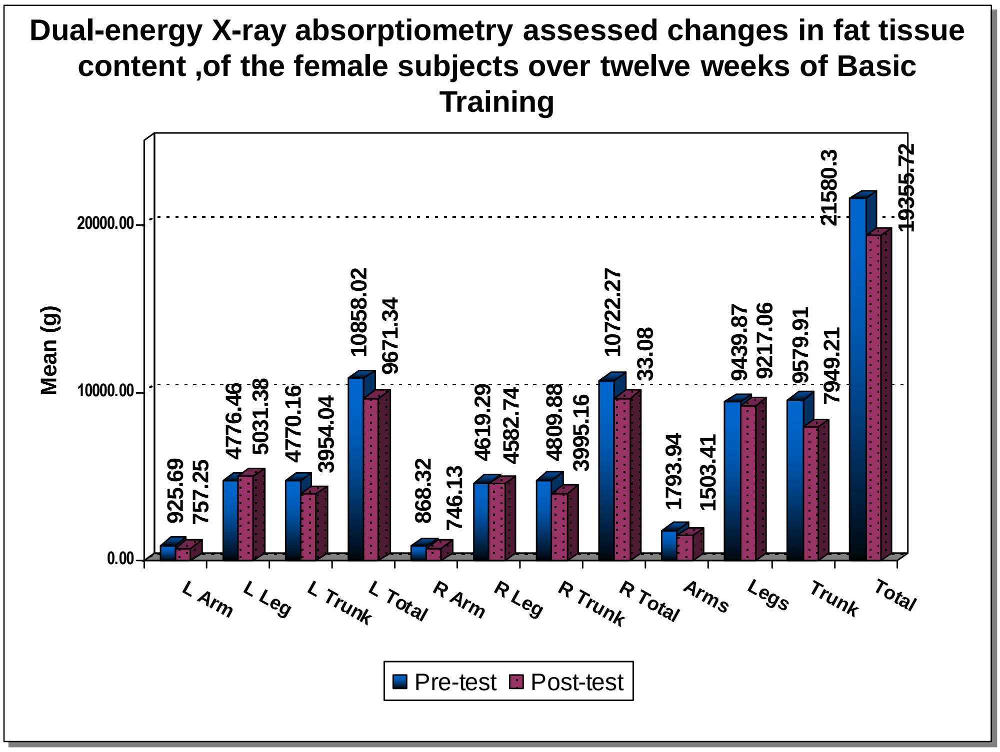


Figure 4.43: Dual-energy X-ray absorptiometry assessed changes in fat tissue content, of female participants over 12 weeks of BT (arm, leg, trunk and total body region)

An overall 8.74% increase in whole body soft tissue lean mass reflects the positive change that was evident in soft tissue lean mass of all the body regions. All but one of the soft tissue lean mass measurements showed statistically significant increases, which were significant at the 5% level of significance, whilst although the soft tissue lean mass of the right leg showed an increase, this change was not significant. Nindl *et al.* (2000) reported smaller, yet significant, gains in soft tissue lean mass - 3.8% between weeks 0 and 14, 1.8% between weeks 14 and 24, and an overall increase of 0.7kg or 5.5% after six months of periodised training.

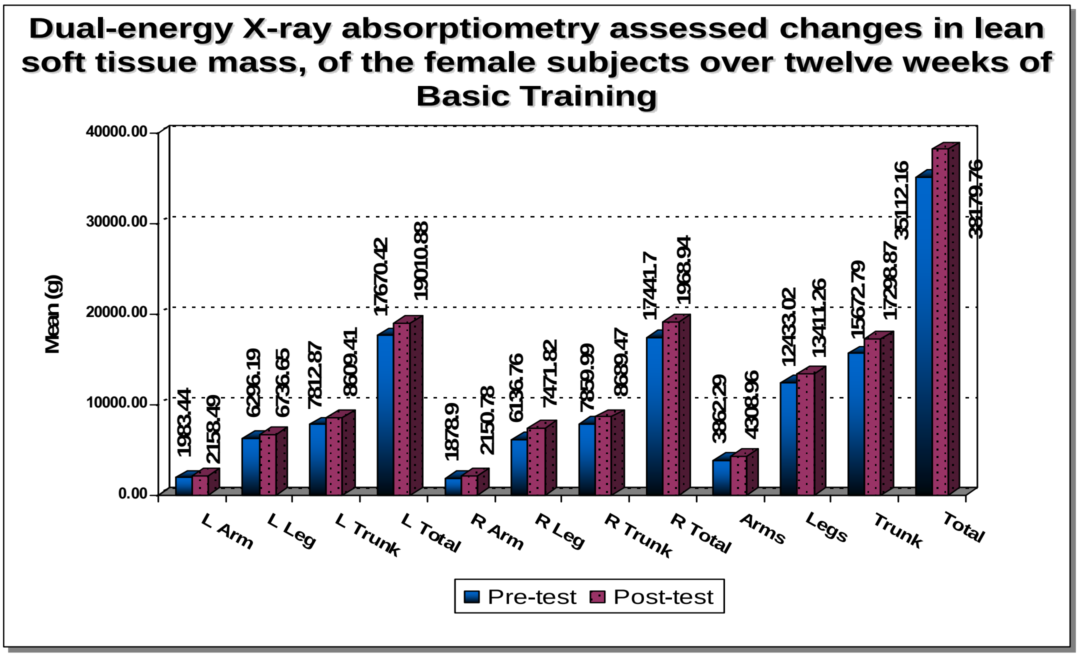


Figure 4.44: Dual-energy X-ray absorptiometry assessed changes in lean soft tissue mass, of female participants over 12 weeks of BT (arm, leg, trunk and total body region).

As the Knapik *et al.* (2001) study is the only known study to have assessed body composition by means of DEXA on military female recruits, it is not possible to directly compare the results. However, the gains shown in this study, support the increases reported (2.3%-6.1%) by other studies on female military recruits during BT, who used the skinfold method to assess lean body mass (Knapik *et al.,* 1980; Patton *et al.,* 1980; Williams *et al.,*1996; Brock & Legg, 1997).

4.4.1.6 Resting blood pressure

This study found that both the male and female participants showed a statistically significant decrease in Systolic and Diastolic resting blood pressure measurements (Figure 4.45). These changes were also significant at the 5% level of significance. A decrease in Systolic Blood Pressure (SBP) (pre - 126.2 ± 3.3 mmHg, post - 111.3 ± 3.5 mmHg) and Diastolic Blood Pressure (DBP) (pre -

76.7± 3.2 mmHg, post - 66.9 ± 2.7 mmHg) was also reported by Jouanin *et al.* (2004) in military recruits following a five week, physically and psychologically challenging, Ranger course.

This is in contrast to the findings by Clarkson *et al.* (1999) who reported that after ten-weeks of BT, 35 British male recruits' Supine Systolic (pre - 119 ± 12 mmHg, post - 120 ± 10 mmHg) and Diastolic Blood Pressure (pre - 72 ± 12 mmHg, post - 73 ± 10 mmHg) remained unchanged.

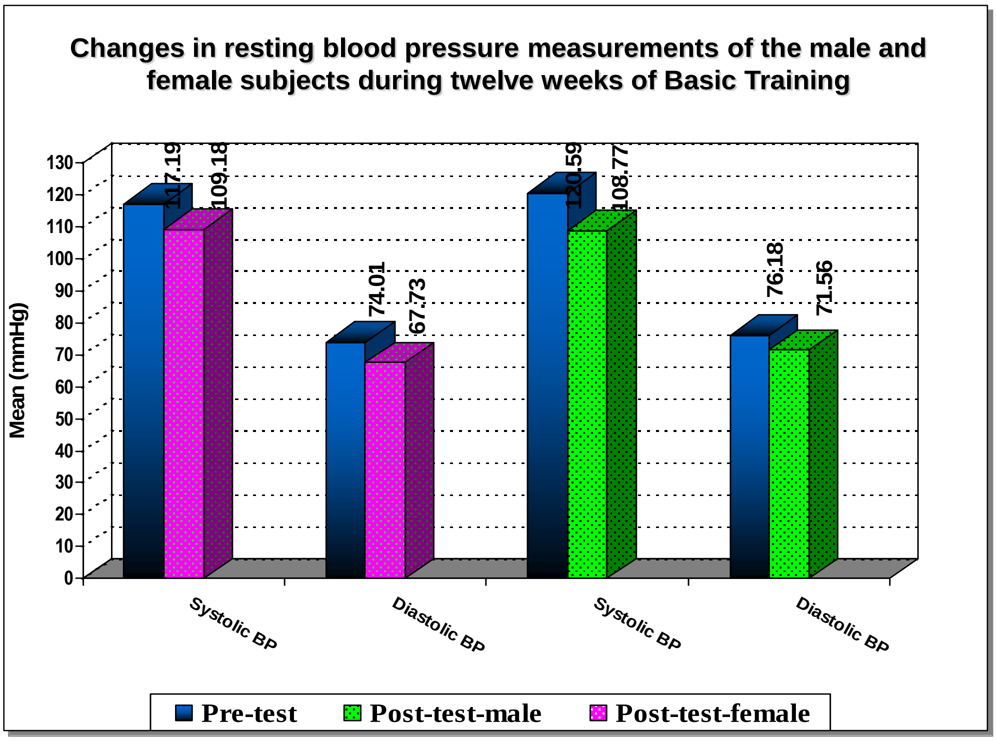


Figure 4.45: Changes in resting blood pressure measurements of male and female participants during 12 weeks of BT

4.4.1.7 Menstrual disturbances

4.4.1.7.1 Sexual hormones

Researchers have reported that stress fractures may be more frequent in female athletes with menstrual disturbances and that menstrual disturbances may also predispose female recruits to stress fractures (Nattiv *et al.,* 1997; Brukner *et al.,* 1999). For this reason, all 83 female participants were requested to complete a questionnaire which provided detailed insight into their menstrual history prior to BT, as well as identifying any changes which may have occurred during the initial part of BT (in the fifth week) (Appendix C).

This questionnaire was developed by the author and included questions pertaining to the onset of menarche, regularity of menstrual cycle, incidence of changes and nature of change in menstrual cycle, as well as the use of female contraception. The questionnaire was repeated at the end of the 12-week BT period. On reviewing literature, it was found that most studies assessing menstrual history and menstrual changes, within the military environment, had the investigators developing their own questionnaires (Winfield *et al.,* 1997; Cline *et al.,* 1998; Lappe *et al.,* 2001; Schneider *et al.,* 2003; Bemben *et al.,* 2004; Armstrong *et al.,* 2004; Rauh *et al.*, 2005; Rauh *et al.,* 2006; Shaffer *et al.,* 2006).

The complete results of this analysis can be found in Appendix Copy Disk - F.

4.4.1.7.2 Menstrual history

The complete results of this section of the menstrual history questionnaire can be found in Tables 7 - 19 in Appendix Copy Disk - F. Table 4.18 below, portrays the regularity of participants' menstrual cycle. The results indicated that most of the participants (70.7%) perceived their menstrual cycles to be very regular. A further 19.5% perceived it to be somewhat regular, with only 9.8% indicating that it was very irregular. The last may be extrapolated to having less than 10 menses per year, which has been linked to an increased risk of stress fracture development.

Table 4.18: Regularity of menstrual cycle

Menstrual cycle regularity		Frequency	%	Valid %	Cumulative %
Very regular (within 3 days)		58	69.9	70.7	70.7
Somewhat irregular (4-10 day variation)		16	19.3	19.5	90.2
Very irregular (variation > 10 days)		8	9.6	9.8	100.0
Total		82	98.8	100.0	
Missing	System	1	1.2		
Total		83	100.0		

In a study of 101 female Marines, the incidence of stress fractures in those with fewer than 10 periods per year, was 37.5% compared to 6.7% in those with 10 to 13 periods per year (Winfield *et al.,* 1997). Similar results, that suggest a history of amenorrhea is a risk factor for stress fractures, support these findings (Friedl *et al.,* 1992, Rauh *et al.*, 2005; Rauh *et al.,* 2006; Shaffer *et al.,* 2006). Shaffer *et al.* (2006) did, however, suggest that only the women who reported no menses during the whole year before commencing with BT, had a greater likelihood of stress fractures than the women who reported 10 - 12 menses.

Only 3.6% reported having experienced their last period earlier than a year before the commencement of BT. They also found that, female recruits who reported secondary amenorrhea during the year before training, were at higher risk for pelvic or femoral stress fractures. It suggests that prolonged lack of menses may be a better predictor of stress fracture incidence during a structured military training programme (Rauh *et al.,* 2006). Conversely, Kelly *et al.* (2000) found no association between secondary amenorrhea and pelvic stress fractures in navy recruits. Cline *et al.* (1998) also found that the menstrual patterns did not differ in a study of 49 female soldiers with stress fractures, compared to the 78 soldiers, with no orthopaedic injuries, although the number of soldiers with menstrual disturbances was relatively low.

The cause for the above may be attributed to lowered estrogen levels, resulting in lower bone density, accelerated bone remodeling or negative calcium balance, or the interaction of these variables. Further research should be conducted where calcium turnover within the blood is evaluated (Drinkwater *et al.,* 1984; Rutherford, 1993; Micklesfield *et al.,* 1995; Tomten *et al.,* 1998). As no stress fracture incidence was reported in this cohort, this study cannot support the above research conversely nor can it support findings by Cline *et al.* (1998).

During the Post-test completed at the end of the twelfth week of training, slightly more participants (15.7%) indicated that their menstrual cycle was very irregular (Appendix Copy Disk - F Table 16). This is similar to findings in both military populations and military cohorts who participate in an intense PT programme (Sanborn *et al.,* 1987; Cokkinades *et al.,* 1990; Cline *et al.,* 1998; Schneider *et al.,* 2003; Bemben *et al.,* 2004).

Similar to that in already published literature, the majority of participants (80.5%) indicated that they experienced changes in their menstrual cycles during BT. The nature of these changes is depicted in Table 4.19.

More than half (61.2%) indicated that their cycle became shorter, with a third (34.4%) indicating that they had developed oligomenorrhea (they could not be considered as having amenorrhea, as menstruation did not stop for six months or more) (Stedman's Medical Dictionary, 2000). Only 12.2% of participants indicated that they were without a menstrual cycle for three months or more, but the exact length of time was not recorded.

Table 4.19: Nature of changes in menstrual period during BT

Nature of change		Frequency	%	Valid %	Cumulative %
Longer		3	3.6	4.5	4.5
Shorter		41	49.4	61.2	65.7
Absent		23	27.7	34.3	100.0
Total		67	80.7	100.0	
Missing	System	16	19.3		
Total		83	100.0		

Although the use of contraceptive pills has been recorded and discussed as a lifestyle behaviour, it is fitting that it be discussed under this section. Very few of the participants (13.3%) indicated that they were using birth control or hormonal pills. This is compared to similarly aged (18.5±0.17) United States Naval Trainees reporting for BT, where 26.92% reported using female contraception (Armstrong *et al.,* 2004). Of the 824 women completing Marine Corps BT at Parris Island in 1999, Rauh *et al.* (2006) reported that 33.25% were making use of contraceptive medication. Due to the low incidence of contraction usage by this cohort, as well as no stress fractures having been reported during BT, it appears as if this study supports the work of those that have failed to associate a protective effect between birth control hormone use and the incidence of stress fractures (Bennell *et al.,* 1996; Cline *et al.,* 1998; Rauh *et al.,* 2006; Shaffer *et al.,* 2006). However, this should be investigated further in a cohort where the use of female contraception and the type of female contraception used is compared to stress fracture cases and non-stress fracture cases.

4.4.1.7.3 Chronological age at menarche onset

All the participants indicated that they had a menstrual cycle. Table 4.20 indicates that 68.3% of the participants had their first menstrual period by the age of 14. All the participants had their first menstrual cycle by the age of 19 years. All but 3 participants had their last period within the year of being tested. Rauh *et al.* (2006) reported that 96.35% of their cohort reached age of menache before the age of 16 years. It appears that this study's cohort reached age of menache later than those reported on the United States Military by Lappe *et al. (*2001) (12.6 ±1.6) and Shaffer *et al.* (2006) (12.9 ±1.4).

Table 4.20: Chronological age of menarche onset in female cohort undergoing 12 weeks of BT

Age (years)	***Frequency***	***%***	***Valid %***	***Cumulative %***
11	5	6.0	6.1	6.1
12	6	7.2	7.3	13.4
13	21	25.3	25.6	39.0
14	24	28.9	29.3	68.3
15	15	18.1	18.3	86.6
16	7	8.4	8.5	95.1
17	1	1.2	1.2	96.3
18	2	2.4	2.4	98.8
19	1	1.2	1.2	100.0
Total	82	98.8	100.0	
Missing on the system	1	1.2		
Total	83	100.0		

The relationship between chronological age at menarche onset and risk of stress fracture is unclear. Some authors have found that athletes with stress fractures have a later chronological age of menarche onset (Carbon *et al.,* 1990; Bennell *et al.,* 1996), while others have found no difference (Myburgh *et al.,* 1990; Armstrong *et al.,* 2004).

An association between delayed onset of menarche and stress fractures may be explained by a lower rate of bone mineral accretion during adolescence and a resultant decrease in peak bone mass (Brukner *et al.,* 1999). A later onset of menarche has also been found in association with menstrual disturbance, decreased body fat or bodyweight, lowered energy intake, and excessive pre-menarcheal training (Frisch *et al.,* 1981; Moisan *et al.,* 1990). All of these could feasibly influence stress fracture risk (Brukner *et al.,* 1999). As with the use of female contraception, this should be investigated further in a cohort where the onset of menarche is compared in stress fracture cases with the onset of menarche in non-stress fracture cases.

4.4.1.8 Health risk behaviours

Questionnaires have been used to study associations of injury risks with lifestyle behaviours and habits among military populations (Heir & Eide, 1997; Jones *et al.,* 1999; Popovich *et al.,* 1999; Lappe *et al.,* 2001). These lifestyle behaviours and habits include smoking, alcohol, history of previous injury, level of previous physical activity and the use of female contraception. The latter two have already been discussed under section 4.4.1.4.1 and 4.4.1.5.1.1, respectively. The others will be discussed in the section below.

4.4.1.8.1 Smoking

Tobacco smoking is a behavioural health risk factor reported to be associated with higher risks of injury amongst military recruits. The complete results of this section of the physical activity and medical history questionnaire, can be found in Tables 17 and 18 in Appendix Copy Disk - H.

Smoking was not a common habit of this population (14.1%), when compared to the 42% of men and 40% of women reporting for BT at Fort Jackson in South Carolina, USA (Altarac *et al.,* 2000). Of the 14.1% that reported to be smokers, only 7.7% indicated that they smoked more than 20 cigarettes per day. Trent *et al.* (2007) studied the pre-military tobacco use of 15,689 male Marine Corps recruits (mean age - 19.5years) and found that 41% were smokers.

When this cohorts' smoking percentage is compared to data available on the prevalence of smoking in South Africa, it is still below the reported 33.6% in 1993, 24.0% in 1998, 27.1% in 2000 and 8.4% (female) and 31.1% (male) in South Africans in 2003 (van Walbeek, 2000). Possible reasons for this could be that 93.5% of this cohort was African and according to van Walbeek (2000) smoking prevalence amongst Africans is much lower, decreasing from 28.1% in 1993 to 22.7% in 1998. Thus smoking prevalence amongst Africans is relatively low and is decreasing at a significant rate. Additionally, smoking prevalence amongst young adults (people aged 16 - 24) is significantly lower than the national average and also shows encouraging decreasing trends (van Walbeek, 2000).

Both current and past histories of smoking have been found to increase the risk of stress fractures, training-related injuries and osteoporotic hip fractures in military female recruits, with the relative risk increasing with increasing packs per day and increased years of smoking (Lappe *et al.,* 2001). These findings were supported by other military studies (Williams *et al.,* 1982; Friedl *et al.,* 1992; Jones *et al.,* 1993b; Grisso *et al.,* 1994; Reynolds *et al.,* 1994; Cummings *et al.,* 1995; Altarac *et al.,* 2000). Since both osteoporotic hip fractures and stress fractures are fragility fractures - they occur during activities which most participants complete without fracturing - it is plausible that smoking might also increase the risk of stress fractures (Lappe *et al.,* 2001). This aspect should be investigated further in a cohort where prevalence of smoking is compared in stress fracture cases to those in non-stress fracture cases.

4.4.1.8.2 Alcohol

A shortcoming of this study was that drinking habits were not included in the Medical History Questionnaire. Long-term excessive alcohol intake has been associated with low bone mass and fragility fractures (Johnell *et al.,* 1982; Felson *et al.,* 1988; Hemenway *et al.,* 1988; Diamond *et al.,* 1989; Seeman, 1996; Lappe *et al.,* 2001). It is also well established that alcohol abuse confers a high risk for fragility fractures, although this risk is said to be more pronounced in men than in women (Johnell *et al.,* 1982; Hemenway *et al.,* 1988; Seeman, 1996). In female recruits on BT, excessive alcohol intake was associated with stress fractures even when controlled for smoking (although the relative risk was much less than the unadjusted risk) (Lappe *et al.,* 2001). Alcoholism has been associated with a number of factors known to increase the risk for osteoporotic fractures, namely: liver disease, poor nutrition, malabsorption, parathyroid dysfunction, hypogonadism, vitamin D deficiency, sub-optimal nutrition and increased cortisol output (Carter *et al.,* 1981). Additional, a study investigating the direct effect of ethanol on bone formation found that excessive alcohol consumption decreases bone formation and leads to defective mineralization (Diamond *et al.,* 1989).

In the current study it was decided that nutritional habits, including alcohol consumption would be excluded. It should however be investigated further within the South African military context, especially considering that in Africa, beer consumption in 15-year-olds rose six-fold between 1961 and 1981 (Oxorio, 1992). Authors have emphasized the enormous ill-health cost and suffering and the likelihood of alcohol consumption rising further, especially among urban dwellers (Seftel, 1985; Walker, 2002).

4.4.1.8.3 Medical history of previous injury

The complete statistical results of the medical history can be found in Appendix Copy Disk - H, Tables 3 -18. None of the participants indicated that they had a history of cholesterol, anemia, high blood pressure, gout or low bone density. The latter was far less than the 9.8% reported by Kelly *et al.* (2000) in their cohort of 86 female recruits entering into BT. One participant indicated that he suffered from Diabetes Mellitus and two participants indicated that they suffered from fatigue. Only 9.8% of participants reported the prevalence of allergies. Popovich *et al.* (2000) also used a Health and Physical Activity Questionnaire, however, did not report on any findings, except for their smoking history reported under 4.4.1.8.1.

The participants were also asked to recall their weight history and reason, if any, for a change in weight. The majority (80.9%) of participants reported that they maintained their weight. Reported reasons for a change in weight included increased food intake, smoking cessation, stopping exercise, increasing exercise volume, stress and the festive holiday period.

A small percentage (7.6%) reported suffering from muscle cramps and the treatment listed included, heat balm, anti-inflammatory medication, drinking water and the local application of ice packs.

The majority of participants indicated that they had no history of previous injuries (93.5%). The incidence and the area of incidence are outlined in Table 4.21. The cohort also reported that the majority (79.9%) had not made use of over-the-counter medicine as well as other prescription medicines (94.4%). Of the 21.1% who had made use of over the counter medicine, most indicated that they had used laxatives.

As studies of risk factors for injury among athletes have shown prior injury to be related to subsequent injury, this is important to document and should be investigated further in a cohort with a stress fracture incidence (Milgrom *et al.,* 1985; Giladi *et al.,* 1986; Macera *et al.,* 1989; Ross & Woodward, 1994; Shaffer *et al.,* 1999b; Rauh *et al.,* 2000; Rauh *et al.,* 2006; Shaffer *et al.,* 2006).

Table 4.21: Previous history of the incidence and area of injury prior to the start of BT

Incidence & area of injury	Frequency	%	Valid %	Cumulative %
None	172	**93.5**	93.5	93.5
Ankle	2	**1.1**	1.1	94.6
Knee	6	**3.3**	3.3	97.8
Arm	1	**0.5**	0.5	98.4
Back	2	**1.1**	1.1	99.5
Neck	1	**0.5**	0.5	100.0
Total	184	100.0	100.0	

This is crucial, especially as other studies have shown no association between lower-extremity injury and stress fractures or non-stress fracture overuse injury during BT (Rauh *et al.,* 2006; Shaffer *et al.,* 2006). Authors speculate that the difference in findings may be related to the severity of the previous injury, differing types of injuries as well as to the difference in how male and female recruits, entering BT, report prior injuries (Rauh *et al.,* 2006; Shaffer *et al.,* 2006). This should guide future research to focusing on the severity and type of injury as well as to making it specific to the sex of the individual.

4.4.2 Extrinsic risk factors

The primary focus of this study was to explore the role of intrinsic factors as potential risk factors for the development of stress fractures. However, intrinsic factors cannot be viewed completely separately from extrinsic risk factors regarding their potential impact on risk of injury and their applicability to prevention. Few studies have examined these extrinsic risk factors which include aspects such as type of physical activity, PT, training surfaces and footwear

(Brukner *et al.,* 1999; Rosental *et al.,* 2003; Välimäki *et al.,* 2005; Rauh *et al.*, 2005; Rauh *et al.,* 2006; Shaffer *et al.,* 2006).

This study was able to explore the type of physical activity and PT (including the type of physical activity and the amount and duration of the PT). It did not investigate the intensity of the PT nor did it assess the role of equipment as a risk for stress fracture development.

4.4.2.1 Type of physical activity

As military service is done on a voluntary basis in South Africa, unlike some countries like Norway, Italy, Greece and Israel where military service is compulsory, the cohort studied was made up of young men and women who wanted to be part of the SANDF (Jordaan & Schwellnus, 1994; Dyrstad *et al.,* 2006). The type of physical activity this cohort followed was what was included in the BT Programme (Copy Disk Appendix: A).

This was characterised by military activities such as drilling (48 periods), regimental aspects (21 periods), general military aspects (53 periods), musketry (58 periods), signal training (8 periods), shooting (26 periods), field crafts (32 periods), mine awareness (8 periods), map reading (36 periods), buddy aid (38 periods), parade rehearsal and execution (55 periods), water orientation (52 periods) and PT (48 periods). These are all critical to operational readiness and similar in content to the BT conducted by other militaries around the world (Kuusela, 1984; Shaffer *et al.,* 1999a; Williams *et al.,* 1999; Kaufman *et al.,* 2000; Jones *et al.,* 2002; Knapik *et al.,* 2003; Rosendal *et al.,* 2003; Knapik *et al.,* 2005).

One factor that was different to other BT programmes reviewed, was the vast amount of time allocated for water orientation for this cohort. These 52 periods were dedicated to teaching the participants how to swim. Swimming was not included in the SANDF in the 1980's; however, it became a priority in 2002, after a number of reported drownings in peacekeeping missions abroad (The Portfolio Committee on Defence, 2005). During the six-weeks of British BT only two periods of BT, are dedicated to swimming (Brock & Legg, 1997) whilst Williams (2005) reported nine periods of swimming activity during the 12 weeks of British BT.

The energy expenditure, for the BT programme followed in this study, was derived by calculating the Basal Metabolic Rate (BMR) - the energy that is necessary to maintain life or organ function in the body (Stedman's Medical Dictionary, 2000)(Table 4.22).

Table 4.22: Mean energy expenditure for male and female participants during 12 weeks of BT

	Mean weight	Daily BMR	Light activity factor	kJ used during PT	Total kJ used during BT
Description		**kJ/day**	**excl. exercise**	**4 x p/w**	**daily activities +PT**
Males	62.5kg	6832.5	1.5	1350	20 084.5
Females	60.3kg	5910	x 1.5	1350	18 700.7
Mean	61.4kg	6371.3	x 1.5	1350	19 392.7

This was determined by taking weight, age and sex into consideration. The daily kilojoules used by men and women were calculated as 6832.5 kJ/day and 5910 kJ/day respectively. Therefore, the mean BMR was 6371.25 ~ 6371.3 kJ/day. The average activity levels were expressed as multiples of BMR, meaning regular daily movements and activity, excluding the PT Programme. All the BT activities could be classified as light levels of activity thus a BMR of 1.5 was used for males and females for calculation purposes. The average total minutes spent on the training programme with basic exercises were 45 minutes, 4 times per week. Thus, 1350kJ were used for PT, four times per week. The average amount of kJ used for BT, per day, were calculated by averaging three hours of exercise per day, resulting in 8485.7kJ used per day.

It is, however, important to understand that the duration and intensity, as well as the activity can differ between countries, within countries, between corps and within corps and between units. This places military personnel at different degrees of risk (Kuusela, 1984; Shaffer *et al.,* 1999a). A shortfall in military studies, outside of the United States, is that research may be reported on, provided that the anonymity of the study participants and the units/ bases involved is insured. This makes it difficult to ascertain the corps as most literature will only provide the level of military training, namely BT, Officers training, Special Forces training. etc. As BT differs between units and between corps, comparisons are difficult.

Public perception exists that the youth of today are less physically fit and fatter than in previous years (Sharp *et al.*, 2002). This perception is supported by a 5% slower running time, over a two-mile distance, for basic trainees in the United States military, over the period 1988-1997 (Knapik, 2000). This decrease in youth physical fitness renders the military's task of recruiting and training physically capable soldiers complicated, especially when one considers that lower levels of physical fitness have also been shown to increase the prevalence of training injuries and reduce the likelihood of successfully completing BT (Knapik, 2000; Sharp *et al.,* 2002). It is, therefore, important that the BT programme and the PT Programme within, complement each other to result in the best possible outcome.

4.4.2.2 PT

Physical fitness is a critical element of soldiering with military historians having repeatedly emphasized its importance, necessary for soldiers to perform their main function (Nye, 1986; Dubik & Fullerton, 1987; DOD policy on Physical Training, DOD Instruction: SG no 00006/2000; Knapik *et al.,* 2005; Dyrstad *et al.,* 2006). The physical fitness standards required, at the end of BT in the SANDF, includes measures of cardiovascular endurance, muscular strength and endurance as well as anaerobic fitness. The efficacy of the training in improving this physical fitness is therefore a crucial aspect of BT (Williams *et al.,* 1999; DOD policy on Physical Training, DOD Instruction: SG no 00006/2000).

The new cyclic-progressive PT Programme for BT, followed by the cohort, with its accompanying manual can be seen in Appendix Copy Disk - B and C. The cohort completed 48 periods of PT consisting of 40 minutes each, over the 12-week period (DOD policy on Physical Training, DOD Instruction: SG no 00006/2000). This differs to the PT programme reported by Knapik *et al.* (2005) who, over a nine-week period, completed 45 periods of PT (60 minutes each) and was almost half the 90 periods allocated to the regular recruits on 12 weeks of British BT (Williams, 2005). The PT programme followed by the SANDF in the 1980's, included 50 PT periods of 40 minutes each over a 10-week period.

The new PT programme was implemented, for the first time, for the period of this study. The efficacy of the Programme on fitness parameters, was determined by comparing the measured changes in fitness of one group, to the changes in fitness measured in another group who completed BT, at the same unit the previous year (as discussed under 4.4.1.4). When compared to the CG that had followed the traditional PT Programme, it was found that this new PT programme yielded superior changes in the cardiovascular component, muscle strength and endurance component but not in the anaerobic component. Additionally it appeared that the greatest improvements in these components were achieved by week five during the first Post-test measurements.

As many studies have shown an association between PT and a high rate of injury and stress fractures, care was taken to implement as many scientifically proven programme guidelines into the new cyclic-progressive PT Programme (Black, 1982; Scully & Besterman, 1982; Milgrom *et al.,* 1985; Milgrom *et al.,* 1988; Giladi *et al.,* 1991; Jones *et al.,* 1994; Almeida *et al.,* 1999; Jones & Knapik, 1999; Beck *et al.,* 2000; Trank *et al.,* 2001; Knapik *et al.,* 2004).

These guidelines included:

- Allowing sufficient periods of recovery from weight-bearing stress during the early weeks of following the PT Programme. This was done by including a progressive build-up, from walking to jogging, as the cardiovascular activity prescribed (Scully & Besterman, 1982; Popovich *et al.*, 2000).
- Gradually increasing the duration, frequency and intensity of the initial training events thereby accommodating the potentially unfit incoming recruits (Heir & Eide, 1997; Rudzki & Cunningham, 1999; Kaufmann *et al.,* 2000; Rosendal *et al.,* 2003; Armstrong *et al.,* 2004; Knapik *et al.,* 2004). By following the exercise principle of overload, the PT Programme emphasized the gradual introduction of the exercises (Knapik *et al.,* 2004). This approach, to start slowly and progressively build up training to avoid injury, is common practice in the athletic world, however as a result of a void in this literature, it is not yet clear whether progressive exercise actually prevents stress reactions and fractures within the SANDF (Shaffer & Uhl, 2006).
- Reducing repetitive weight-bearing activities such as running and marching, as they are the most frequently reported causes of stress fractures (Belkin, 1980; Hulkko & Orava, 1987; Matheson *et al.,* 1987; Jones *et al.,* 1989; Ha *et al.,* 1991). This was very difficult to do due to the limited resources available to conduct aerobic activities. This aspect was rather incorporated into the above-mentioned guideline, by gradually increasing the repetitive weight-bearing activity.

- Eliminating marching and running on concrete (Reinker & Ozburne, 1979; Greaney *et al.,* 1983). This was achieved by conducting the PT periods on grassed sport fields.
- Using running shoes rather than combat boots (Proztman, 1979; Greaney *et al.,* 1983). The participants wore military issued trainers during the PT periods. This differed to the field uniform used two decades ago by the SADF, which included long trousers, long sleeve shirts, metal helmets, web-belts and combat boots (Gordon *et al.,* 1986c).
- Offering a variety of exercises in the PT Programme. There are no studies indicating that a greater variety will reduce injury, however, 'cross training' (different exercises on different days) is often recommended for this purpose (McArdle *et al.,* 1991; Knapik *et al.,* 2004).

As the PT Programme was not only designed to avoid injury, but to obtain maximal improvement in the fitness components evaluated by the Standardised Fitness Test over the 12-week BT period, care was taken to implement as many scientifically proven programme guidelines, in this regard, into the new cyclic-progressive PT Programme. These guidelines included:

- A larger strength component based on a study in the SANDF by Wood and Krűger (2007) on the training of PT Instructors in the SANDF. This was achieved by including 'Pole PT' exercises from the fifth week. Due to the limited strength training facilities and the large number of training recruits undergoing PT training simultaneously pole PT provided a cost-effective and manageable method of strength training which was based on the principle of free-weight training (Daniels *et al.,* 1979; Fleck & Kramer, 1997; Jones *et al.,* 1993b; Knapik *et al.,* 2005; Heyward, 2002).
- A larger aerobic component based on a study during BT in the SANDF by Cilliers and Gordon, (1983). This was achieved by gradually progressing from walking to jogging in the first seven weeks and then introducing

interval training from the seventh week. The duration of the latter was also gradually increased and only performed twice a week and not on consecutive days.

4.4.2.3 Surface and Equipment

Although this study did not include the analysis of the impact of exercise equipment such as footwear, orthotic inserts and training surface, preventative steps were taken in this area (Brukner *et al.,* 1999; Jones *et al.,* 2002).

Firstly, the participants wore military issued trainers during the PT periods, rather than combat boots, unlike in the SANDF recruits in the Gordon *et al.* (1986c) study. Secondly, the PT periods were conducted on grassed sport fields whilst drilling, parade rehearsal and execution were done on a smooth, flat parade ground. Hilly, rocky terrain has been associated with a higher incidence of stress fractures as compared to flatter, smoother terrain (Devas & Sweetnam, 1956; Zahger *et al.,* 1988; Brunet *et al.,* 1990).

4.5 STUDY DESIGN

The prospective cohort design's greatest strength was that each individual's risk profile was established before the stress fracture had occurred. These participants' intrinsic risk factors, which were analysed, showed that this particular cohort was not at great risk for the development of stress fractures.

The extrinsic risk factors, although not analysed, were to a certain extent controlled for, as all possible, logistical, preventative actions were taken to reduce the risk of the extrinsic factors. Combined, this seemed to have reduced the risk for the development of stress fractures in this cohort as no stress fractures were reported.

Both the primary and secondary objectives of this study were outlined and met. However the zero incidences of stress fractures in this particular cohort resulted that the emphasis of the discussion was placed on the effect that the PT programme had on the measurements taken rather than the comparison of these measurements between stress fracture cases and non stress fracture cases. The last chapter provides conclusions, discusses the limitations of this study and offers recommendations for both future research and adaptations to the PT programme which should be made and then investigated.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

As stress fractures represent one of the most common and potentially serious overuse injuries in the military environment, the causative factors and the mechanisms by which they interact must be clearly understood. It is only through this understanding that clear guidelines for prevention can be established and followed (McBryde, 1985; Hulkko & Orava, 1987; Matheson *et al.*, 1987; Jones *et al.*, 1989; Sterling *et al.*, 1992; Beck *et al.,* 2000; Jones *et al.,* 2002; Shaffer *et al.,* 2006; Trone *et al.,* 2007).

Since the first few citations of case studies of soldiers incurring stress fractures in the 19th and early 20th centuries (Bernstein *et al.*, 1946; Belkin, 1980; McBryde, 1985; Markey, 1987; Jones *et al.*, 1989), potential intrinsic and extrinsic risk factors for stress fractures have been researched. Presently, the only physical requirement for enlistment and acceptance into voluntarily military service in the SANDF, is to pass a basic medical examination to ensure that the recruit is physically healthy. No additional biomechanical factors are evaluated, nor is a minimum level of physical fitness a requirement for acceptance. Thus it is imperative that research be conducted to determine whether or not intrinsic factors affect the development of stress fractures during BT (Jones and Knapik, 1999; Kaufmann *et al.*, 2000; Bemben *et al.,* 2004; Shaffer *et al.*, 2006) and how extrinsic factors, such as PT regime, affect the final outcome of both fitness levels and stress fracture development (Jones & Knapik, 1999; Kaufmann *et al.*, 2000; Popovich *et al.*, 2000; Rosendal *et al.*, 2003; Rauh *et al.*, 2006; Shaffer *et al.*, 2006).

Based on conflicting literature, the question, “Will the incidence of stress fractures increase in military recruits who have intrinsic risk factors, as highlighted in the current literature, during BT?” was posed by the author. It was hypothesized that the incidence of stress fractures would increase in military recruits with intrinsic risk factors, as highlighted in the current literature, during BT. Additionally, a sub-hypothesis was formulated from the main hypothesis, that by following clear guidelines, as laid out in the literature on how to prevent stress fracture development it would assist in explaining the low incidence of stress fracture occurrence. In an attempt to answer the research question and prove or disprove the above-mentioned hypothesis and sub-hypothesis the following primary and secondary objectives were set:

- To determine the incidence of stress fractures during 12 weeks of BT;
- To compare the results of risk indicators obtained from the group of participants who suffered stress fractures during their 12 weeks of BT, with the rest of the original group (controls) who didn’t suffer from any stress fractures; and
- To determine whether 12 weeks of BT results in any changes in physical markers whilst following a progressive, scientifically designed, PT Programme.

The approach undertaken to achieve the above-mentioned objectives was to identify and measure the intrinsic risk factors for the development of stress fractures, based on already existing literature, and follow the BT cohort over the 12 weeks BT period during which injury occurrence was monitored and recorded. Additionally, a new 12-week PT Programme was developed and implemented.

The Pre-test and Post-test biokinetic and bone density measurements were done on the prospective EG (who all underwent BT). The standardised fitness test results were also compared to a CG who had undergone BT in the year prior to this cohort. This was done to evaluate the efficacy of the PT Programme in relation to the previously used PT Programme. The limitation of the findings of this study, was that it could only be generalised to the people from the same sample group.

Over the 12-week BT period, a zero incidence of stress fractures was reported amongst the cohort of 183. This made it impossible to compare stress fracture cases to non-stress fracture cases and determine if the stress fracture cases had a greater risk for a particular intrinsic risk factor. The next step taken by the investigator was to determine if the group, as a whole, was at risk for each specific risk factor and establish if this was not possibly the cause for the zero stress fracture incidence. The following findings, with regard to the intrinsic risk factors investigated, were found:

- **Sex** - Although female sex of the participant is the most commonly identified intrinsic demographic risk factor for stress fractures (Proztman & Griffis, 1977; Reinker & Ozbourne, 1979; Kowal, 1980; Brudvig *et al.*, 1983; Lloyd *et al.*, 1986; Barrow & Saha, 1988; Zahger *et al.*, 1988; Brunet *et al.*, 1990; Myburgh *et al.*, 1990; Friedl *et al.*, 1992; Jones *et al.*, 1993; Goldberg & Pecora, 1994; Bennell *et al.*, 1996; Bijur *et al.*, 1997; MacLeod *et al.*, 1999; Beck *et al.*, 2000; Bell *et al.*, 2000; Shaffer *et al.*, 2006) and 45.4% of this cohort comprised of females, this did not place this cohort at risk for stress fractures. This is possibly due to the initial fitness levels and normal BMD of femaleparticipants (Proztman & Griffis, 1977; Reinker & Ozbourne, 1979; Kowal, 1980; Brudvig *et al.*, 1983; Lloyd *et al.*, 1986; Barrow & Saha, 1988; Zahger *et al.*, 1988; Brunet *et al.*, 1990; Myburgh *et al.*, 1990; Friedl *et al.*, 1992; Jones *et al.*, 1993; Goldberg & Pecora, 1994;

World Health Organization, 1994; Bennell *et al.*, 1996; Bijur *et al.*, 1997; MacLeod *et al.*, 1999; Beck *et al.*, 2000; Bell *et al.*, 2000; Jones *et al.*, 2002; Shaffer *et al.*, 2006).

- **Age** - The ages of the participants ranged from 18 to 22 years with 74.3% falling into the category between 19 and 21 years of age. Reviewed studies have indicated that older age may heighten the risk of stress fracture development (Brudvig *et al.*, 1983; Gardner *et al.*, 1988; Shaffer *et al.*, 1999). Due to the cohorts relatively young age it appears that the age did not place them at an increased risk for the development of stress fractures.
- **Race** - The race of the cohort may have provided protection against stress fractures as 93.5% of the participants were African and only 2.7% were Caucasian which has been identified as being a risk factor in both athletes as well as in military personnel (Brudvig *et al.*, 1983; Barrow & Saha, 1988; Gardner *et al.*, 1988; Friedl *et al.*, 1992; Shaffer *et al.*, 1999; Shaffer *et al.*, 2006).
- **Foot morphology** - The risk for stress fractures is greater for in military recruits who have a high-foot arch than in those with a low foot-arch. Only 4% of the male and 1.2% of femaleparticipants were classified as having high arched feet. This small incidence, even if it is a risk factor, may not result in the development of stress fractures (Giladi *et al.*, 1985; Simkin *et al.*, 1989; Brosh & Arcan, 1994; Kaufmann *et al.*, 1999).
- **Q angle** - The mean range for both the male and female Q angle was 9.76° to 11.9°. This cohort was therefore not at ri sk, as their mean Quadriceps angles were not greater than 15°. Recrui ts with a Q angle greater that 15º have a relative risk of stress fractures that is 5.4 times that of individuals who have a angle less than 15º (Montgomery *et al.*, 1989; Cowan *et al.*, 1996).

- **Leg length discrepancy** - A leg length discrepancy within the 1-2cm range was found in 20.00% of the male and 20.48% of femaleparticipants. This was not a sufficient risk to result in stress fracture development.
- **Bone density -** A risk for stress fracture development exists in the Total Body Density T-score measurement of >-2.5. Only 2 of the 68 female participants that underwent the DEXA test fell into this category with 80% having normal bone density measurements for both the Pre-test and Post-test. Additionally, the cohort was 92.8% African, which may have offered a protective factor against stress fractures (Shaffer *et al.*, 2006) and 7.3% of these female participants had suffered a fracture in their past (Phillips & Phillipov, 2006). Therefore, the BMD of the cohort tested was not at risk for the development of stress fractures. No statistically significant difference was found in both the Total Body T-score and Z-score measurements after 12 weeks of BT; however a statistically significant increase was measured in the T and Z-score of the left femur area.
- **Physical fitness** - As this cohort did not suffer any stress fractures, the contribution of physical fitness to the development of stress fractures is difficult to make. However, it does appear that the findings do not support that muscle strength and endurance, as measured by the sit-up test, is a risk factor for the development of stress fractures. The reason for this is that this cohort had lower isotonic, isometric and isokinetic strengths than other cohorts, who did report a relatively high stress fracture incidence (Jones *et al.*, 1993; Beck *et al.*, 2000; Bell *et al.*, 2000).
- The efficacy of the PT Programme followed for the BT period was found to be superior to the previous programme used by the group who had undergone BT the year prior to this cohort, at the same training unit. This is supported by significant improvements shown in both the male and female participants in aerobic fitness as measured by the 2.4km run and

4km walk, and muscular endurance and strength, as measured by the sit-up and push-up test.

- **Flexibility** - The mean hip external rotation was not an intrinsic risk factor as it was below the documented risk of 65º (Giladi *et al.*, 1987; Giladi *et al.*, 1991). The male and female participants of this cohort had a mean ankle dorsiflexion of 17.14º ± 3.65 (L) / 18.25º ± 4.14 (R) and 15.21º ± 3.18 (L) / 16.40º ± 3.53 (R) respectively. Although the cohort had a limited ankle dorsiflexion, no stress fractures were reported.
- The 12-week BT period found that the male participants' plantarflexion and hip external rotation decreased, whilst an improvement was observed in their dorsiflexion. Female participants showed a significant deterioration in left ankle dorsiflexion and hip external rotation whilst their plantarflexion had a significant increase. The decrease in dorsiflexion may be attributed to a shortening of the Achilles tendon, which may be the result of wearing the combat boot during all activities except for PT (Jones & Knapik, 1999). Further study by measuring ankle dorsiflexion with the knee at 0º flexion in the South African context is recommended.
- **Body composition and stature**- The male participants were found to be shorter than their counterparts in other militaries around the world, whilst the female participants were of similar height and mass. Due to the 0% incidence of stress fractures this study failed to prove an association between stress fractures and various parameters of body size, including BMI as in other studies (Taimela *et al.*, 1990; Finestone *et al.*, 1991; Giladi *et al.*, 1991; Winfield *et al.*, 1997; Cline *et al.*, 1998; Rauh *et al.*, 2006; Shaffer *et al.*, 2006). Additionally, there was no acute weight loss which has been found to be a significant risk factor for stress fracture injuries in both male and female recruits (Armstrong *et al.*, 2004).
- The 12 weeks of BT resulted in significant improvements in body composition as measured manually using the Yuhasz (1974) method on

all participants, and in the 68 females who underwent DEXA testing. The male participants experienced increases in lean body mass and mesomorph component and decreases in %BF as well as in the ectomorph and endomorph component. The female participants also experienced these significant changes, except they did not have any change in lean body mass. The anthropometric changes during training were positive, although favourable changes were more prominent in the male recruits. Some changes, specifically in femaleparticipants, although still positive, were of a lesser magnitude than has been shown to be possible during a training programme of similar length.

- **Menstrual disturbances** - Researchers have reported that stress fractures may be more frequent in female athletes with menstrual disturbances and that menstrual disturbances may also predispose female recruits to stress fractures (Nattiv *et al.*, 1997; Brukner *et al.*, 1999). Only 3.6% of the females reported having experienced their last period earlier than a year before the commencement of BT, thus female participants of this cohort were not a great risk with regards to their menstrual disturbances. Further research should be carried out with calcium turnover within the blood being evaluated (Drinkwater *et al.*, 1984; Rutherford, 1993; Micklesfield *et al.*, 1995; Tomten *et al.*, 1998). Akin to already published literature, the majority of participants (80.5%) indicated that they experienced changes in their menstrual cycle during BT.
- **Lifestyle behaviours** - Lifestyle behaviours evaluated in this study included smoking, history of previous injury, level of previous physical activity and the use of female contraception. Further research should be done on alcohol as a potential risk factor.
- **Smoking -** Only 14.1% of the cohort reported to be smokers with a mere 7.7% indicating that they smoked more than 20 cigarettes per day. This is lower than the reported prevalence of smoking amongst the South African

population and other military BT studies (Altarac *et al.*, 2000; Popovich *et al.*, 2000; van Walbeek, 2000; Trent *et al.*, 2007). The low incidence of smoking therefore did not place this cohort at risk for stress fracture development (Friedl *et al.*, 1992; Altarac *et al.*, 2000; Moroz *et al.*, 2006). This aspect should be investigated further in a cohort where prevalence of smoking is compared in stress fracture cases to those in non-stress fracture cases.

- **Female contraception** - Only 13.3% of the participants indicated that they were using birth control or hormonal pills. Due to the low incidence of female contraception usage by this cohort as well as to no stress fractures being reported during BT, this study supports the work of those that have failed to prove a protective effect between birth control hormone use and the incidence of stress fractures (Bennell *et al.*, 1996; Cline *et al.*, 1998; Rauh *et al.*, 2006; Shaffer *et al.*, 2006). However, this should be investigated further in a cohort where the use of female contraception and the type of female contraception used is compared in stress fracture cases to the non-stress fracture cases within the South African military environment.
- **Medical history of previous injury** - The majority of participants indicated that they had no history of previous injuries (93.5%). A history of stress fractures was reported by only 3.8% of the cohort, however this should be interpreted with caution as confusion may have existed with regards to stress fractures and trauma fractures. This was also too small a sample to result in adequate risk. Individuals with a medical history of stress fracture development have a relatively greater risk of developing stress fractures, however, this may be confounded by other factors such as adequacy to recover and levels of past physical activity (Kuusela, 1984; Milgrom *et al.*, 1985; Giladi *et al.*, 1986; Shaffer *et al.*, 1999). This should

therefore guide future research and make it focused on the severity and type of injury as well as making it specific to the sex of the individual.

- Intrinsic factors as potential risk factors for the development of stress fractures cannot be viewed completely separately from potential extrinsic risk factors. The following comments, with regard to the extrinsic risk factors investigated, may be made:
- **Types of physical activity** - Military studies indicate that different units and different types of training may place military personnel at different degrees of risk (Kuusela, 1984; Goldberg & Pecora, 1994; Shaffer *et al.*, 1999). This cohort completed 12 weeks of BT, which was critical to operational readiness and similar in content to the BT conducted by other militaries around the world (Kuusela, 1984; Shaffer *et al.*, 1999; Williams *et al.*, 1999; Kaufman *et al.*, 2000; Jones *et al.*, 2002; Knapik *et al.*, 2003; Rosendal *et al.*, 2003; Knapik *et al.*, 2005).
- **PT** - During BT, 48 periods of 40 minutes of PT were completed (DOD policy on Physical Training, DOD Instruction: SG no 00006/2000). A new cyclic-progressive PT Programme for BT was developed by the author and implemented (Appendix Copy Disk- B and C).
- Care was taken to implement the following scientifically proven programme guidelines into the new cyclic-progressive PT Programme in order to reduce the risk of injury, to allow sufficient periods of recovery, to gradually increase the duration, frequency and intensity of the initial training events, to reduce repetitive weight-bearing activities, including a variety of exercises in the PT Programme using of running shoes, rather than combat boots and to eliminate marching and running on concrete (Proztman, 1979; Reinker & Ozburne, 1979; Belkin, 1980; Scully & Besterman, 1982; Greaney *et al.*, 1983; Gordon *et al.*, 1986; Hulkko & Orava, 1987; Matheson *et al.*, 1987; Jones *et al.*, 1989; Ha *et al.*, 1991; McArdle *et al.*, 1991; Heir & Eide, 1997; Rudzki & Cunningham, 1999;

Popovich *et al.*, 2000; Kaufmann *et al.*, 2000; Rosendal *et al.*, 2003; Armstrong *et al.*, 2004; Knapik *et al.*, 2004; Shaffer & Uhl, 2006).

- Additionally, a large strength and aerobic component was included in the PT Programme, to obtain maximal improvement in the fitness components evaluated by the Standardised Fitness Test over the 12-week BT period (Daniels *et al.*, 1979; Cilliers & Gordon, 1983; Fleck & Kramer, 1997; Jones *et al.*, 1993; Knapik *et al.*, 2005; Heyward, 2006; Wood & Krűger, 2007). In conclusion, a 12-week PT programme for both male and female participants had a positive beneficial effect on body composition, aerobic fitness and strength. As measured by the Standardised Physical Fitness test, the PT Programme was found to be achieving the desired aim, except for no improvement in anaerobic capacity, and yielded greater improvements in physical fitness when compared to the previous programme followed.
- **Equipment** - This study did not include the analysis of the impact of equipment. The preventative steps taken included allowing the participants to wear military issued trainers, rather than combat boots, during the PT periods and the PT periods were conducted on grassed sport fields. Additionally, drilling, parade rehearsal and execution was done on a smooth, flat parade ground hereby reducing the amount of training and time spent on hilly, rocky terrain -. This type of terrain is associated with a higher incidence of stress fracture development (Devas & Sweetnam, 1956; Zahger *et al.*, 1988; Brunet *et al.*, 1990; Brukner *et al.*, 1999; Jones *et al.*, 2002).

5.1 RECOMMENDATIONS AND FUTURE RESEARCH

5.1.1 Study design

The prospective cohort design is considered a ‘strong’ design as it enables accurate comparisons to be made between the injured and the uninjured groups. These comparisons then lead to true assessment of the incidences and risks which may then lead to casual inferences been drawn. The limiting factor of this type of design, is that in order to have enough statistical power, particularly for detection of small differences, sample sizes have to be large. Thus, it is recommended that future studies include a larger size cohort utilizing BT groups from different corps and units in the South African military environment.

5.1.2 Intrinsic risk factors

This study was the first to attempt to investigate the intrinsic risk factors, which have been highlighted in the literature, with regard to stress fracture development in the South African military. Due to no stress fractures being reported in this study, conclusive evidence could not be given with regards to the risk associated with various intrinsic risk factors for the development of stress fractures. Therefore, future research is needed in this area of study, within the South African military setting, where there are stress fracture incidences so that the stress fracture cases can be compared to the non-stress fracture cases. The research should be aimed at addressing these types of training injuries especially with regards to possible physical inclusion and exclusion guidelines for military selection.

Additionally, a limiting factor in this study was that the BMD was only done on a limited number of females. Future research should also include DEXA testing on male recruits to ascertain whether changes, which may be incurred with BT, are comparable to that observed in the female participants.

5.1.3 Extrinsic risk factors

Little and outdated research is available with regards to extrinsic risk factors for the development of stress fractures within the South African setting, with the only research having been done on the PT Programme (Gordon *et al.*, 1986). Future research should definitely look at the role of other potential extrinsic risk factors such as surface and equipment in the South African environment. This advocated research should include a more detailed history of physical activity. This should be compared to initial fitness levels as well as include a one or two mile test as a measure of aerobic capacity as these are the tests utilised by the American military, which forms part of the majority of the research published. This would allow for comparisons to be drawn on changes as well as on initial fitness levels.

This study provided important data regarding the physical changes that occurred in the male and female BT participants, as well as determining whether the training stimulus, provided by the PT Programme, was sufficient to result in improvements in physical fitness. Based on the latter, the following adaptations to the PT Programme and research, in assessing the efficacy of these changes, are recommended:

- A more gradual increase in strength and cardiovascular activities to ensure that the greatest improvement in physical fitness is observed at the end of the 12-week BT period, as compared to the peak observed at the fifth week.
- A greater muscle strength component, especially for the female recruits, to result in an increase in lean body mass, not observed in the female participants.
- To include more anaerobic activity to ensure an improvement in this component.

- To include isolated lower arm training in order to possibly prevent the decrease in handgrip strength observed in the left arm of this cohort.
- To include more hip stretches as well as gastrocnemius and soleus muscle stretches especially in the male participants.

5.2 RESEARCH LIMITATIONS

Several limitations exist when conducting research within the military. These include:

- Military studies have to follow the rules and habits of the military, often resulting in logistical problems which, in turn, often result in no proper randomization, no true control group and difficulties in exact quantification of exercise (Casez *et al.,* 1995).
- When BT recruits have a medical problem, they are seen by a number of different medical care providers in the clinic during the study period and although they are guided by policy, each may have different criteria for assigning restricted duty.
- Due to the large groups studied in the military set-up, multiple variables are often examined which makes it difficult to determine which interventions are most effective.
- Large groups need to undergo the training simultaneously, thus the exercises presented in PT need to be simple, clear and be able to be completed within a small personal space.
- No individual training weights are available, thus exercises need to be designed based on resistance offered by own body weight and progressed to the use of solid timber wooden poles (2.1m in length by 25cm in diameter).

- Most BT trainees have no previous experience in formal exercise activities, thus exercises need to be simple and be easily corrected by the PT instructor.
- Due to financial constraints the Bone Mineral Density (BMD) dual-energy X-ray absorptiometry measurements will only be completed on a limited number (n=70) of female subjects.
- BMD was measured however calcium and Vitamin D daily intake which may influence BMD was not, and could possibly be an area for future research.

Based on the results of this study it is imperative that this study be replicated in other military units within the SANDF to determine if the extrinsic factors such as terrain possibly play a larger role than what has already been suggested by other authors (Brukner *et al.,* 1999; Rosental *et al.,* 2003; Välimäki *et al.,* 2005; Rauh *et al.*, 2005; Rauh *et al.,* 2006; Shaffer *et al.,* 2006) and to further investigate the potential protective properties of a cyclic progressive PT programme. Having concluded this it should be replicated in militaries in other countries around the world to further investigate the possible role ethnicity plays in the development of stress fractures.

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Appendix A

INFORMED CONSENT FORM

AUTHORISATION TO PARTICIPATE IN A RESEARCH PROJECT

TITLE OF STUDY: Prospective study of causative factors in early injuries sustained during Basic Training in the SANDF

THE NATURE AND PURPOSE OF THIS STUDY

A high incidence of shin splints and stress fractures are observed in female recruits during Basic Training. It can result in a great number of training days lost (an average of 21.64 days per stress fracture), loss of manpower, expense of medical care and discharge of affected soldiers. It is therefore of great importance to clearly identify risk factors leading to stress fractures to enable prevention.

Most studies about stress fractures in the military were done overseas, especially first world countries. It is therefore important to investigate which risk factors are the most relevant in our population in South Africa. This study will examine the influence of the following risk factors in South African military recruits:

a. General health, exercise routine and sports participation.
b. Nutrition /calcium intake
c. Body size, composition, skeletal alignment, flexibility and average step length.
d. Muscle strength and fitness.
e. Electrocardiogram (ECG)
f. Additionally the study will examine the bone mineral density in the South African female military recruit.

EXPLANATION OF PROCEDURES TO BE FOLLOWED.

Once the informed consent had been obtained, participants will complete questionnaires on their diet, fitness level, history of sport participation, menstrual history, medication and general health.

A 15-minute ECG will follow: participants will lie down on their backs and relax while their heartbeat will be registered with the aid of electrodes placed on the chest. This registration of the heartbeat is non-invasive and participants will feel no inconvenience. During the 15 minutes the participants will be ask to stand up strait for the last 5 minutes.

This will be followed by assessment of bone density (DEXA scan) and body size (similar to normal x-rays.

A Biokinetic assessment, which will include body size, composition, skeletal alignment, flexibility, muscle strength and standard SANDF fitness will conclude the evaluation.

The ECG and biokinetic assessment will be repeated at the end of the Basic Training.

RISK AND DISCOMFORT INVOLVED.

The risk and discomfort of the examination is minimal. Please take note that the DEXA scan emits a small dose of radiation (10% of a standard chest x-ray). Please do not participate in this study if you are pregnant.

POSSIBLE BENEFITS OF THIS STUDY.

You will be informed of the results of this battery of tests free of charge.

CONFIDENTIALITY.

All records obtained during this study will be regarded as confidential. Results will be published or presented in such a fashion that participants remain unidentifiable.

In order to ensure that the participants' confidentiality and identification remains anonymous each participant of the study will be allocated a number. Each participant will then complete all forms, biokinetic assessments and bone density scans utilising his/her allocated number and not his/her name and force number. Only the principal investigator of the study, namely myself, Maj P.S. Wood will have a list of the participant with the allocated number.

The Participant:

I understand that if I do not want to participate in this study, I will still receive standard treatment and complete my Basic Training.

I may at any time withdraw from this study.

CONSENT TO PARTICIPATE IN THIS STUDY.

I have read or had read to me in a language that I understand the above information before signing this consent form. The content and meaning of this information have been explained to me. I have been given opportunity to ask questions and am satisfied that they have been answered satisfactorily. I hereby volunteer to take part in this study.

Participant

Force Number__________________ Rank______ Initials______ Surname___________________

______________________________ ________________

Participant s signature Date

Investigator

Force Number__________________ Rank______ Initials______ Surname___________________

______________________________ ________________

Investigators's signature Date

Witness

Force Number__________________ Rank______ Initials______ Surname___________________

______________________________ ________________

Witness's signature Date

Appendix B

GENERAL ACTIVITY AND HEALTH INFORMATION QUESTIONNAIRE

Thank you for taking part in this study. In order to accurately evaluate your activity and health status, you are kindly request you to answer all the questions in the questionnaire honestly and in as much detail as possible.

PERSONAL DETAILS	
Project Number	
Date of Birth	
Age	
Gender	
Height	
Weight	
Weight history: Did you loose / gain weight recently? Why?	

MEDICAL HISTORY				
Please indicate whether you have ever suffered from:				
CONDITION	YES	SPECIFY		MEDICATION IF ANY
Diabetes Mellitus		Type 1	Type 2	
Cholesterol				
Anaemia				
Allergy / Intolerance				
High Blood Pressure				
Gout				
Muscle Cramps				
Fatigue		When do you feel fatigued?		

Injuries			
Other			
Other Prescription Medication			
Over-the-counter Medication		Laxatives	
		Anti-inflammatory drugs	
		Diet tablets	
		Other	
Do you smoke?		How many per day?	
NUTRITION RELATED SYMPTOMS			
Please indicate whether you have any of the following nutrition related conditions.			
CONDITION		**FREQUENCY**	
Constipation			
Diarrhoea			
Vomiting			
Heartburn			
Nausea			
Dizziness			
Headache			
Dehydration			
No appetite			
Other			

<table>
<tr><th colspan="6">ACTIVITY</th></tr>
<tr><td colspan="3">Do you participate in any sport?</td><td colspan="3">Kind of Sport?</td></tr>
<tr><td>Level</td><td>Social</td><td>Competitive</td><td>Club Level</td><td>Provincial</td><td>National</td></tr>
<tr><th colspan="6">CURRENT TRAINING DETAILS</th></tr>
<tr><td></td><td>Activity</td><td>Duration</td><td colspan="3">Intensity</td></tr>
<tr><td></td><td>What?
e.g. Running; Gym, Swimming</td><td>How long?
Hr/ min per week?</td><td colspan="3">How hard?
Low/med/high? Heart rate (if known)</td></tr>
<tr><td>Monday</td><td></td><td></td><td colspan="3"></td></tr>
<tr><td>Tuesday</td><td></td><td></td><td colspan="3"></td></tr>
<tr><td>Wednesday</td><td></td><td></td><td colspan="3"></td></tr>
<tr><td>Thursday</td><td></td><td></td><td colspan="3"></td></tr>
<tr><td>Friday</td><td></td><td></td><td colspan="3"></td></tr>
<tr><td>Saturday</td><td></td><td></td><td colspan="3"></td></tr>
<tr><td>Sunday</td><td></td><td></td><td colspan="3"></td></tr>
<tr><td>Competition frequency</td><td colspan="2">_____________ / week / month</td><td colspan="3">Duration: ____________________</td></tr>
</table>

Appendix C

MENSTRUAL HISTORY QUESTIONNAIRE

Demographic Information

1. Participant No:_______________
2. Force No: ________________________________
3. Race (check one): African _____; Asian_____; Caucasian_____; Coloured_____; Other____________.
4. Primary sport you participate in: ________________.
5. Year of participation in this sport: _________.
6. Primary source of nutrition information/education (check only one).

Magazines: _______; Textbooks________; Peers______; Dietician______; Coach_______;

Physician______; Other Medical Profession_____; Health Food Store________; Other (describe)________________.

Musculoskeletal Health History

1. Is there a history of osteoporosis in your family: Yes:_______ No:_________
2. Have you ever been diagnosed with or treated for any of the following (check ? apply)
   a. Low bone density:_______ Scoliosis:__________ Anorexia Nervosa________ Bulimia nervosa____________
3. Have you ever suffered a stress fracture as a result of training or competition? Yes: _____ No: ______.
4. Have you ever suffered a soft tissue (e.g. muscle, tendon or ligament injury as a result of training of no competition? Yes____; No_____.
5. If you answered Yes, how many soft tissues injuries have you had? ______________

Menstrual History

1. Have you ever had a menstrual period? Yes:________ No:__________
2. How old were you when you had your first menstrual period? ______________
3. When was your last menstrual period? ____________/____________ (year)
4. How many menstrual periods have you had in the last 12 months?_____________
5. How many menstrual periods have you had in the last 5 months? __________________
6. Please describe the regularity of your cycle? (check one).
7. I am very regular (within 3 day) ________
8. I am somewhat irregular 14-10 day variation)____
9. I am very irregular (variation greater than 10 days. ____

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COPY DISK

APPENDICES A – G

A Basic Training block programme
B Physical Training programme
C Physical Training Instructors Manual
- Part 1
- Part 2
- Part 3
- Part 4
- Part 5
- Part 6
- Part 7
- Part 8

D Biokinetic variables descriptive statistics
E Bone Density Descriptive statistics
F Descriptive statistics of menstrual history questionnaire
G Fitness test descriptive statistics

BLOCK PROGRAMME

MSD BASIC MILITARY TRAINING

03/07/2006-29/09/2006

BLOCK PROGRAMME: MSD BASIC MILITARY TRAINING

DURATION 03 JULY 2006-29 SEPTEMBER 2006

WEEK 0/12: 03/07/06- 09/07/06 (PREPARATION)

Date	05:00-06:00	06:00-06:30	06:30-07:00	07:00-07:40	07:45-08:25	08:30-09:10	09:15-09:55	10:00-10:40	10:45-12:00	12:00-12:40	12:45-13:25	13:30-14:10	14:15-14:55	15:00-15:40	15:45-16:25	16:30-18:00	After Hrs
Mo03/07/06	Clearing in at Training Formation (Research pre-testing)																
Tue04/07/06	Clearing in at Training Formation (Research pre-testing)																
Wed05/07/06	Clearing in at Training Formation (Research pre-testing)																
Thurs 06/07/ 06	Clearing in at Training Formation (Research pre-testing)																
Friday 07/07/ 06	Clearing in at Training Formation (Research pre-testing)																
Sat 08/07/06	Movement to Training Unit									Arrival at Training Unit, Kit issue, Fire Training						Supper	Routine
Sun 09/07/06			Reveille Prep for inspection	Coffee Roll call	Church parade		Induction Training		Brunch	Induction training						Supper	Routine

WEEK 1/12: 10/07/06- 16/07/06

WEEK 2/12: 17/07/06- 23/07/06

Date	05:00-06:00	06:00-06:30	06:30-07:00	07:00-07:40	07:45-08:25	08:30-09:10	09:15-09:55	10:00-10:40	10:45-12:00	12:00-12:40	12:45-13:25	13:30-14:10	14:15-14:55	15:00-15:40	15:45-16:25	16:30-18:00	After Hrs
Mo 10/07/ 06	Reveille	Coffee	Roll Call	Induction Training		Opening address	Induction Training		Brunch	Regimental aspects: Dress regulations					PT	Supper	Routine
										General dress		Dress prescriptions		Rank			
Tue 11/07/ 06	Reveille	Coffee	Coffee	Drill		Compliments and Saluting			Brunch	Comp & Saluting		Genl. Aspects: Pers induction			PT	Supper	Routine
	Prep for Inspection	Inspection	Roll Call	Lesson 1		Lesson 1	Lesson 2	Lesson 3		Lesson 3 (cont.)		Lesson 1	Lesson 2				
Wed 12/07/ 06	Reveille	Coffee	Coffee	Drill		Communication Period		Rgt Aspects	Brunch	Regimental Aspects: Regimental Duties					PT	Supper	Routine
	Prep for Inspection	Inspection	Roll Call	Lesson 2		OC/RSM	Chaplain	Lesson 1		Lesson 2	Lesson 3		Lesson 4	Lesson 5			
Thurs 13/07/06	Reveille	Coffee	Coffee	Drill		Regimental duties: Fire Fighting			Brunch	Fire Fighting and Prevention			Admin period		PT	Supper	Routine
	Prep for Inspection	Inspection	Roll Call	Lesson 3		Lesson 1	Lesson 2	Lesson 3		Lesson 3	Lesson 4	Lesson 5					
Friday 14/07/ 06	Reveille	Coffee	Coffee	Drill		CHATSEC Course			Brunch	CHATSEC Course						Supper	Routine
	Prep for Inspection	Inspection	Roll Call	Lesson 4													
Sat 15/07/06		Reveille		Coffee	CHATSEC Course				Brunch	CHATSEC Course						Supper	Routine
		Prep for inspection		Roll call													
Sun 16/07/06		Reveille		Coffee	Church Parade				Brunch	CHATSEC Course						Supper	Routine
		Prep for inspection		Roll call	CHATSEC Course												

Date	05:00-06:00	06:00-06:30	06:30-07:00	07:00-07:40	07:45-08:25	08:30-09:10	09:15-09:55	10:00-10:40	10:45-12:00	12:00-12:40	12:45-13:25	13:30-14:10	14:15-14:55	15:00-15:40	15:45-16:25	16:30-18:00	After Hrs
Mo 17/07/ 06	Reveille	Coffee	Roll Call	Fitness Evaluation					Brunch	Fitness Evaluation						Supper	Routine
Tue 18/07/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Drill Lesson 5		Regimental duties: Guards Lesson 1	Lesson 2	Lesson 3	Brunch	Regimental duties: Guards and Sentries Lesson 3	Lesson 4	Lesson 5	Lesson 6	Lesson 7	PT	Supper	Routine
Wed 19/07/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Drill Lesson 6		Communication period OC/RSM	Chaplain	Admin period	Brunch	Sport Parade					PT	Supper	Routine
Thurs 20/07/06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Drill Lesson 7		General Military Aspects: Mil Law Lesson 1		Lesson 2	Brunch	General Military Aspects: Mil Law Lesson 2	Lesson 3		Lesson 4	Lesson 5	PT	Supper	Routine
Friday 21/07/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Drill Lesson 8		General Military Aspects: LOAC			Brunch	General Military Aspects: LOAC					PT	Supper	Routine
Sat 22/07/06		Reveille Prep for inspection		Coffee Roll call	Evaluation: Regimental Aspects				Brunch	Saturday routine/ Retraining						Supper	Routine
Sun 23/07/06		Reveille Prep for inspection		Coffee Roll call	Church Parade				Brunch	Sunday Routine						Supper	Routine

WEEK 3/12: 24/07/06- 30/07/06

Date	05:00-	06:00-	06:30-	07:00-	07:45-	08:30-	09:15-	10:00-	10:45-	12:00-	12:45-	13:30-	14:15-	15:00-	15:45-	16:30-	After

	06:00	06:30	07:00	07:40	08:25	09:10	09:55	10:40	12:00	12:40	13:25	14:10	14:55	15:40	16:25	18:00	Hrs
Mo 24/07/ 06	Reveille	Coffee	Roll Call	Drill		General Military Aspects: Hygiene			Brunch	General Military Aspects: Life Skills					PT	Supper	Routine
				Lesson 9		Lesson 1	Lesson 2	Lesson 3		Lesson 1&2		Lesson 3		Lesson 4			
Tue 25/07/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Drill		General Military Aspects: Mess Etiquette			Brunch	General Military Aspects: Civic Education					PT	Supper	Routine
				Lesson 10						Lesson 1		Lesson 2					
Wed 26/07/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Drill		Communication period		Admin period	Brunch	Sport Parade						Supper	Routine
				Lesson 11		OC/RSM	Chaplain										
Thurs 27/07/06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Drill		General Military Aspects			Brunch	General Military Aspects: Soldiering					PT	Supper	Routine
				Lesson 12		Military Security		Labour relation		Lesson 1		Lesson 2		Lesson 3			
Friday 28/07/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Drill		General Military Aspects: Equal Opportunities			Brunch	Base maintenance/ OC Inspection					PT	Supper	Routine
				Lesson 13													
Sat 29/07/06		Reveille Prep for inspection		Coffee Roll call	Evaluation: General Military Aspects				Brunch	Saturday routine/ Retraining						Supper	Routine
Sun 30/07/06		Reveille Prep for inspection		Coffee Roll call	Church Parade				Brunch	Sunday Routine						Supper	Routine

WEEK 4/12: 31/07/06- 06/08/06

Date	05:00-	06:00-	06:30-	07:00-	07:45-	08:30-	09:15-	10:00-	10:45-	12:00-	12:45-	13:30-	14:15-	15:00-	15:45-	16:30-	After

	06:00	06:30	07:00	07:40	08:25	09:10	09:55	10:40	12:00	12:40	13:25	14:10	14:55	15:40	16:25	18:00	Hrs
Mo 31/07/ 06	Reveille	Coffee	Roll Call	Drill Lesson 14		Town Pass			Brunch	Town Pass					PT	Supper	Routine
Tue 01/08/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Issue weapons		Musketry Lesson 1			Brunch	Musketry Lesson 2		Lesson 3			PT	Supper	Routine
Wed 02/08/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Drill Lesson 15		Communication period OC/RSM	Chaplain	Admin period	Brunch	Sport Parade						Supper	Routine
Thurs 03/08/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Drill Lesson 16		Musketry Issue weapons		Lesson 4	Brunch	Musketry Lesson 5		Lesson 6		Hand Back weapons	PT	Supper	Routine
Friday 04/08/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Drill Lesson 16 Cont.		Musketry Issue weapons	Lesson 7		Brunch	Musketry Lesson 8			Lesson 9		PT	Supper	Routine
Sat 05/08/ 06		Reveille Prep for inspection		Coffee Roll call	Musketry Safety exams				Brunch	Musketry						Supper	Routine
Sun 06/08/ 06		Reveille Prep for inspection		Coffee Roll call	Church Parade				Brunch	Sunday Routine						Supper	Routine

WEEK 5/12: 07/08/06- 13/08/06

Date	05:00-	06:00-	06:30-	07:00-	07:45-	08:30-	09:15-	10:00-	10:45-	12:00-	12:45-	13:30-	14:15-	15:00-	15:45-	16:30-	After

	06:00	06:30	07:00	07:40	08:25	09:10	09:55	10:40	12:00	12:40	13:25	14:10	14:55	15:40	16:25	18:00	Hrs
Mo 07/08/ 06	Reveille	Coffee	Roll Call	Drill		Musketry			Brunch	Musketry					PT	Supper	Routine
				Lesson 17		Issue weapons	Lesson 10			Lesson 11			Lesson 12				
Tue 08/08/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Drill		Musketry			Brunch	Musketry					PT	Supper	Routine
				Lesson 18		Issue weapons	Lesson 13			Lesson 13		Practical					
Wed 09/08/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Drill		Table 1 Shooting exercise			Brunch	Table 1 Shooting exercise						Supper	Routine
				Lesson 15													
Thurs 10/08/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Drill		Signals training			Brunch	Signals training					PT	Supper	Routine
				Lesson 16													
Friday 11/08/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Drill		Mine Awareness			Brunch	Mine Awareness					PT	Supper	Routine
				Lesson 16 Cont.													
Sat 12/08/ 06		Reveille Prep for inspection		Coffee Roll call	Fitness Evaluation				Brunch	Fitness Evaluation						Supper	Routine
Sun 13/08/ 06		Reveille Prep for inspection		Coffee Roll call	Church Parade				Brunch	Sunday Routine						Supper	Routine

WEEK 6/12: 14/08/06- 20/08/06

Date	05:00-06:00	06:00-06:30	06:30-07:00	07:00-07:40	07:45-08:25	08:30-09:10	09:15-09:55	10:00-10:40	10:45-12:00	12:00-12:40	12:45-13:25	13:30-14:10	14:15-14:55	15:00-15:40	15:45-16:25	16:30-18:00	After Hrs

Mo 14/08/ 06	Reveille	Coffee	Roll Call	Drill Lesson 21 Cont.		Reality Check			Brunch	Reality Check					PT	Supper	Routine
Tue 15/08/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Drill Lesson 22		Table 1 Shooting exercise			Brunch	Table 1 Shooting exercise					PT	Supper	Routine
Wed 16/08/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Drill Lesson 23		Communication Period OC/RSM	Chaplain	Admin Period	Brunch	Selection Board						Supper	Routine
Thurs 17/08/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Drill Lesson 24		Selection Board			Brunch	Selection Board					PT	Supper	Routine
Friday 18/08/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Drill Lesson 24 Cont.		Selection Board			Brunch	Selection Board					PT	Supper	Routine
Sat 19/08/ 06		Reveille Prep for inspection		Coffee Roll call	Base maintenance				Brunch	Base maintenance						Supper	Routine
Sun 20/08/ 06		Reveille Prep for inspection		Coffee Roll call	Church Parade				Brunch	Sunday Routine						Supper	Routine

WEEK 7/12: 21/08/06- 27/08/06

Date	05:00-06:00	06:00-06:30	06:30-07:00	07:00-07:40	07:45-08:25	08:30-09:10	09:15-09:55	10:00-10:40	10:45-12:00	12:00-12:40	12:45-13:25	13:30-14:10	14:15-14:55	15:00-15:40	15:45-16:25	16:30-18:00	After Hrs

Mo 21/08/ 06	Reveille	Coffee	Roll Call	Drill Lesson 25.		Map Reading Lesson 1			Brunch	Map Reading Lesson 2			Lesson 3	Lesson 4	PT	Supper	Routine
Tue 22/08/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Drill Lesson 26		Map Reading Lesson 5			Brunch	Map Reading Lesson 6			Lesson 7		PT	Supper	Routine
Wed 23/08/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Drill Lesson 27		Communication Period OC/RSM	Chaplain	Admin Period	Brunch	Sport Parade						Supper	Routine
Thurs 24/08/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Drill Lesson 28		Map Reading Lesson 8			Brunch	Map Reading Lesson 9			Lesson 10		PT	Supper	Routine
Friday 25/08/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Drill Lesson 29		Map Reading Lesson 11			Brunch	Map Reading Lesson 11 (cont.)					PT	Supper	Routine
Sat 26/08/ 06		Reveille Prep for inspection		Coffee Roll call	Evaluation: Map reading				Brunch							Supper	Routine
Sun 27/08/ 06		Reveille Prep for inspection		Coffee Roll call	Church Parade				Brunch	Sunday Routine						Supper	Routine

WEEK 8/12: 28/08/06- 03/09/06

Date	**05:00-06:00**	**06:00-06:30**	**06:30-07:00**	**07:00-07:40**	**07:45-08:25**	**08:30-09:10**	**09:15-09:55**	**10:00-10:40**	**10:45-12:00**	**12:00-12:40**	**12:45-13:25**	**13:30-14:10**	**14:15-14:55**	**15:00-15:40**	**15:45-16:25**	**16:30-18:00**	**After Hrs**
Mo 28/08/	Reveille	Coffee	Roll	Drill		Buddy Aid			Brunch	Buddy Aid					PT	Supper	Routine

06			Call	Lesson 30	Lesson 1	Lesson 2		Lesson 2 Practical				
Tue 29/08/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Drill	Buddy Aid		Brunch	Buddy Aid		PT	Supper	Routine
				Lesson 31	Lesson 3			Lesson 4	Lesson 5			
Wed 30/08/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Drill	Communication Period	Admin Period	Brunch	Sport Parade			Supper	Routine
				Lesson 32	OC/RSM	Chaplain						
Thurs 31/08/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Drill	Buddy Aid		Brunch	Buddy Aid		PT	Supper	Routine
				Lesson 33	Lesson 6			Lesson 7	Practical			
Friday 01/09/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Drill	Buddy Aid		Brunch	Buddy Aid		PT	Supper	Routine
				Lesson 34	Lesson 8			Lesson 9	Practical			
Sat 02/09/ 06		Reveille Prep for inspection		Coffee Roll call	Town Pass		Brunch	Evaluation: Buddy Aid			Supper	Routine
Sun 03/09/ 06		Reveille Prep for inspection		Coffee Roll call	Church Parade		Brunch	Sunday Routine			Supper	Routine

WEEK 9/12: 04/09/06- 10/09/06

Date	05:00-06:00	06:00-06:30	06:30-07:00	07:00-07:40	07:45-08:25	08:30-09:10	09:15-09:55	10:00-10:40	10:45-12:00	12:00-12:40	12:45-13:25	13:30-14:10	14:15-14:55	15:00-15:40	15:45-16:25	16:30-18:00	After Hrs
Mo 04/09/	Reveille	Coffee	Roll	Drill		Field Craft			Brunch	Field Craft					PT	Supper	Routine

06			Call	Revision	Lesson 1 / Lesson 2		Lesson 3 Practical			
Tue 05/09/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Drill Revision	Field Craft Lesson 4	Brunch	Field Craft Lesson 5	PT	Supper	Routine
Wed 06/09/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Drill Revision	Communication Period OC/RSM / Chaplain Admin Period	Brunch	Sport Parade		Supper	Routine
Thurs 07/09/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Drill Revision	Field Craft Lesson 6	Brunch	Field Craft Lesson 7 / Lesson 8	PT	Supper	Routine
Friday 08/09/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Drill Revision	Field Craft Lesson 9	Brunch	Field Craft Lesson 10	PT	Supper	Field Craft Lesson 11 Night Training
Sat 09/09/ 06		Reveille Prep for inspection		Coffee Roll call	Base Maintenance	Brunch			Supper	Routine
Sun 10/09/ 06		Reveille Prep for inspection		Coffee Roll call	Church Parade	Brunch	Sunday Routine		Supper	Routine

WEEK 10/12: 11/09/06- 17/09/06

Date	05:00-06:00	06:00-06:30	06:30-07:00	07:00-07:40	07:45-08:25	08:30-09:10	09:15-09:55	10:00-10:40	10:45-12:00	12:00-12:40	12:45-13:25	13:30-14:10	14:15-14:55	15:00-15:40	15:45-16:25	16:30-18:00	After Hrs
Mo 11/09/ 06	Reveille	Coffee	Roll Call	Drill Revision		Social Services Programme			Brunch	Water orientation					PT	Supper	Routine

Tue 12/09/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Drill Revision		Social Services Programme			Brunch	Water orientation					PT	Supper	Routine
Wed 13/09/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Drill Revision		Communication Period OC/RSM	Chaplain	Admin Period	Brunch	Water orientation						Supper	Routine
Thurs 14/09/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Drill Revision		Social Services Programme			Brunch	Water orientation					PT	Supper	Routine
Friday 15/09/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Drill Revision		Social Services Programme			Brunch	Water orientation					PT	Supper	Routine
Sat 16/09/ 06		Reveille Prep for inspection		Coffee Roll call	Base Maintenance				Brunch							Supper	Routine
Sun 17/09/ 06		Reveille Prep for inspection		Coffee Roll call	Church Parade				Brunch	Sunday Routine						Supper	Routine

WEEK 11/12: 18/09/06- 24/09/06

Date	**05:00-06:00**	**06:00-06:30**	**06:30-07:00**	**07:00-07:40**	**07:45-08:25**	**08:30-09:10**	**09:15-09:55**	**10:00-10:40**	**10:45-12:00**	**12:00-12:40**	**12:45-13:25**	**13:30-14:10**	**14:15-14:55**	**15:00-15:40**	**15:45-16:25**	**16:30-18:00**	**After Hrs**
Mo 18/09/ 06	Reveille	Coffee	Roll Call	Preparation of parade grounds					Brunch	Water orientation					PT	Supper	Routine

Tue 19/09/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Preparation of parade grounds					Brunch	Water orientation					PT	Supper	Routine
Wed 20/09/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Drill Revision		Communication Period OC/RSM	Chaplain	Admin Period	Brunch	Water orientation						Supper	Routine
Thurs 21/09/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Parade Rehearsal					Brunch	Water orientation					PT	Supper	Routine
Friday 22/09/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Parade Rehearsal					Brunch	Water orientation					PT	Supper	Routine
Sat 23/09/ 06		Reveille Prep for inspection		Coffee Roll call	Base Maintenance				Brunch							Supper	Routine
Sun 24/09/ 06		Reveille Prep for inspection		Coffee Roll call	Church Parade				Brunch	Sunday Routine						Supper	Routine

WEEK 12/12: 25/09/06- 29/09/06

Date	**05:00-06:00**	**06:00-06:30**	**06:30-07:00**	**07:00-07:40**	**07:45-08:25**	**08:30-09:10**	**09:15-09:55**	**10:00-10:40**	**10:45-12:00**	**12:00-12:40**	**12:45-13:25**	**13:30-14:10**	**14:15-14:55**	**15:00-15:40**	**15:45-16:25**	**16:30-18:00**	**After Hrs**
Mo 25/09/ 06	Reveille	Coffee	Roll Call	Parade Rehearsal					Brunch	Parade Rehearsal					PT	Supper	Routine

Tue 26/09/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Parade Rehearsal	Brunch	Parade Rehearsal	PT	Supper	Routine
Wed 27/09/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Parade Rehearsal	Brunch	Parade Rehearsal	PT	Supper	Routine
Thurs 28/09/ 06	Reveille Prep for Inspection	Coffee Inspection	Coffee Roll Call	Passing Out Parade	Brunch	Clearing out	PT	Supper	Routine
Friday 29/09/ 06	Travel to Training Formation				Brunch	Clearing in at Training Formation		Supper	Routine

PHYSICAL TRAINING PROGRAMME FOR SAMHS BASIC TRAINING

(03/07/06-29/09/06)

PHYSICAL TRAINING PROGRAMME

WEEK 1- DAY 1 (10/7/2006) (1)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Normal push-ups	1	2	10-12
3	Leg exercise	Squats	40	2	10-12
4	Upper body exercise	Tricep extensions	6	2	10-12
5	Abdominal exercise	Sit-ups	29	2	maximum
6	Back exercise	Back extension on floor (upper body only)	19	2	10-12
7	Leg exercise	Sitting single straight leg raise	41	2	10-12
8	Abdominal exercise	Hip flexors	28	2	maximum
9	Cardiovascular activity	/walking/ Jogging		45 sec walking/ 15 sec jogging 20= 20 min	
10	Stretching exercise- upper body	Overhead tricep stretch	101	3	20s each
12	Stretching exercise- legs body	Lying hamstring stretch	58	3	20s each
13	Stretching exercise- legs body	Side lying quadriceps stretch	68	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

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PHYSICAL TRAINING PROGRAMME

WEEK 1- DAY 2 (11/7/2006) (2)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Push-ups –hands together	2	2	10-12
3	Leg exercise	Lunges	46	2	10-12
4	Upper body exercise	Shoulder press	5	2	10-12
5	Abdominal exercise	Crunches	30	2	Maximum
6	Back exercise	Back extension on floor (ljust legs)	20	2	10-12
7	Leg exercise	Sitting single straight leg raise	41	2	20
8	Abdominal exercise	Hip flexors	28	2	Maximum
9	Cardiovascular activity	Walking/ Jogging		45 sec walking/ 15 sec jogging 20= 20 min	
10	Stretching exercise- upper body	Shoulder extensor stretch	100	3	20s each
12	Stretching exercise- legs body	Straddle hamstring stretch	62	3	20s each
13	Stretching exercise- legs body	Standing quadriceps stretch	69	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 1- DAY 3 (12/7/2006) (3)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Normal push-ups	1	2	10-12
3	Leg exercise	Squats	40	2	10-12
4	Upper body exercise	Tricep extensions	6	2	10-12
5	Abdominal exercise	Sit-ups	29	2	Maximum
6	Back exercise	Back extension on floor (upper body only)	19	2	10-12
7	Leg exercise	Sitting single straight leg raise	41	2	10-12
8	Abdominal exercise	Hip flexors	28	2	Maximum
9	Cardiovascular activity	/walking/ Jogging		45 sec walking/ 15 sec jogging 20= 20 min	
10	Stretching exercise- upper body	Overhead tricep stretch	101	3	20s each
12	Stretching exercise- legs body	Lying hamstring stretch	58	3	20s each
13	Stretching exercise- legs body	Side lying quadriceps stretch	68	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 1- DAY 4 (13/7/2006) (4)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Push-ups –hands wide apart	4	2	10-12
3	Leg exercise	Side lunges	47A	2	10-12
4	Upper body exercise	Tricep extension	6	2	10-12
5	Abdominal exercise	Sit-ups	29	2	Maximum
6	Back exercise	Back extension on floor (upper body)	19	2	10-12
7	Leg exercise	Abduction leg raise	44	2	20
8	Abdominal exercise	Reverse crunch	31	2	Maximum
9	Cardiovascular activity	Walking/ Jogging		45 sec walking/ 15 sec jogging 20= 20 min	
10	Stretching exercise- upper body	Overhead tricep stretch	101	3	20s each
12	Stretching exercise- legs body	Lying hamstring stretch	58	3	20s each
13	Stretching exercise- legs body	Side lying quadriceps stretch	68	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 2- DAY 1 (18/07/06) (5)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Normal push-ups	1	2	15
3	Leg exercise	Squats	40	2	15
4	Upper body exercise	Tricep extensions	6	2	15
5	Abdominal exercise	Sit-ups	29	2	maximum
6	Back exercise	Back extension on floor (upper body only)	19	2	15
7	Leg exercise	Sitting single straight leg raise	41	2	20
8	Abdominal exercise	Hip flexors	28	2	maximum
9	Cardiovascular activity	/walking/ Jogging		30 sec walking/ 30 sec jogging 20= 20 min	
10	Stretching exercise- upper body	Overhead tricep stretch	101	3	20s each
12	Stretching exercise- legs body	Lying hamstring stretch	58	3	20s each
13	Stretching exercise- legs body	Side lying quadriceps stretch	68	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 2- DAY 2 (19/7/2006) (6)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Push-ups –hands together	2	2	15
3	Leg exercise	Lunges	46	2	15
4	Upper body exercise	Shoulder press	5	2	15
5	Abdominal exercise	Crunches	30	2	maximum
6	Back exercise	Back extension on floor (ljust legs)	20	2	15
7	Leg exercise	Sitting single straight leg raise	41	2	20
8	Abdominal exercise	Hip flexors	28	2	maximum
9	Cardiovascular activity	Walking/ Jogging		30 sec walking/ 30 sec jogging 20= 20 min	
10	Stretching exercise- upper body	Shoulder extensor stretch	100	3	20s each
12	Stretching exercise- legs body	Straddle hamstring stretch	62	3	20s each
13	Stretching exercise- legs body	Standing quadriceps stretch	69	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 2- DAY 3 (20/7/2006) (7)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Normal push-ups	1	2	15
3	Leg exercise	Squats	40	2	15
4	Upper body exercise	Tricep extensions	6	2	15
5	Abdominal exercise	Sit-ups	29	2	maximum
6	Back exercise	Back extension on floor (upper body only)	19	2	15
7	Leg exercise	Sitting single straight leg raise	41	2	20
8	Abdominal exercise	Hip flexors	28	2	maximum
9	Cardiovascular activity	/walking/ Jogging		30 sec walking/ 30 sec jogging 20= 20 min	
10	Stretching exercise- upper body	Overhead tricep stretch	101	3	20s each
12	Stretching exercise- legs body	Lying hamstring stretch	58	3	20s each
13	Stretching exercise- legs body	Side lying quadriceps stretch	68	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 2- DAY 4 (21 /7/2006) (8)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Push-ups –hands wide apart	4	2	15
3	Leg exercise	Side lunges	47A	2	15
4	Upper body exercise	Tricep extension	6	2	15
5	Abdominal exercise	Sit-ups	29	2	maximum
6	Back exercise	Back extension on floor (upper body)	19	2	15
7	Leg exercise	Abduction leg raise	44	2	20
8	Abdominal exercise	Reverse crunch	31	2	maximum
9	Cardiovascular activity	Walking/ Jogging		30 sec walking/ 30 sec jogging 20= 20 min	
10	Stretching exercise- upper body	Overhead tricep stretch	101	3	20s each
12	Stretching exercise- legs body	Lying hamstring stretch	58	3	20s each
13	Stretching exercise- legs body	Side lying quadriceps stretch	68	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 3- DAY 1 (24/07/06) (9)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Normal push-ups	1	2	15
3	Leg exercise	Squats	40	2	15
4	Upper body exercise	Tricep extensions	6	2	15
5	Abdominal exercise	Sit-ups	29	2	maximum
6	Back exercise	Back extension on floor (upper body only)	19	2	15
7	Leg exercise	Sitting single straight leg raise	41	2	20
8	Abdominal exercise	Hip flexors	28	2	maximum
9	Cardiovascular activity	/walking/ Jogging		15 sec walking/ 45 sec jogging 20= 20 min	
10	Stretching exercise- upper body	Overhead tricep stretch	101	3	20s each
12	Stretching exercise- legs body	Lying hamstring stretch	58	3	20s each
13	Stretching exercise- legs body	Side lying quadriceps stretch	68	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

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PHYSICAL TRAINING PROGRAMME

WEEK 3- DAY 2 (25/7/2006) (10)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Push-ups –hands together	2	2	15
3	Leg exercise	Lunges	46	2	15
4	Upper body exercise	Shoulder press	5	2	15
5	Abdominal exercise	Crunches	30	2	maximum
6	Back exercise	Back extension on floor (ljust legs)	20	2	15
7	Leg exercise	Sitting single straight leg raise	41	2	20
8	Abdominal exercise	Hip flexors	28	2	maximum
9	Cardiovascular activity	Walking/ Jogging		15 sec walking/ 45 sec jogging 20= 20 min	
10	Stretching exercise- upper body	Shoulder extensor stretch	100	3	20s each
12	Stretching exercise- legs body	Straddle hamstring stretch	62	3	20s each
13	Stretching exercise- legs body	Standing quadriceps stretch	69	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 3- DAY 3 (27/7/2006) (11)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Normal push-ups	1	2	15
3	Leg exercise	Squats	40	2	15
4	Upper body exercise	Tricep extensions	6	2	15
5	Abdominal exercise	Sit-ups	29	2	maximum
6	Back exercise	Back extension on floor (upper body only)	19	2	15
7	Leg exercise	Sitting single straight leg raise	41	2	20
8	Abdominal exercise	Hip flexors	28	2	maximum
9	Cardiovascular activity	/walking/ Jogging		15 sec walking/ 45 sec jogging 20= 20 min	
10	Stretching exercise- upper body	Overhead tricep stretch	101	3	20s each
12	Stretching exercise- legs body	Lying hamstring stretch	58	3	20s each
13	Stretching exercise- legs body	Side lying quadriceps stretch	68	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

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PHYSICAL TRAINING PROGRAMME

WEEK 3- DAY 4 (28/7/2006) (12)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Push-ups –hands wide apart	4	2	15
3	Leg exercise	Side lunges	47A	2	15
4	Upper body exercise	Tricep extension	6	2	15
5	Abdominal exercise	Sit-ups	29	2	maximum
6	Back exercise	Back extension on floor (upper body)	19	2	15
7	Leg exercise	Abduction leg raise	44	2	20
8	Abdominal exercise	Reverse crunch	31	2	maximum
9	Cardiovascular activity	Walking/ Jogging		15 sec walking/ 45 sec jogging 20= 20 min	
10	Stretching exercise- upper body	Overhead tricep stretch	101	3	20s each
12	Stretching exercise- legs body	Lying hamstring stretch	58	3	20s each
13	Stretching exercise- legs body	Side lying quadriceps stretch	68	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 4- DAY 1 (31/07/06) (13)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Normal push-ups	1	3	10-12
3	Leg exercise	Squats	40	3	10-12
4	Upper body exercise	Tricep extensions	6	3	10-12
5	Abdominal exercise	Sit-ups	29	3	maximum
6	Back exercise	Back extension on floor (upper body only)	19	3	10-12
7	Leg exercise	Sitting single straight leg raise	41	3	10-12
8	Abdominal exercise	Hip flexors	28	3	maximum
9	Cardiovascular activity	/walking/ Jogging		5 sec walking/ 55 sec jogging 25= 25 min	
10	Stretching exercise- upper body	Overhead tricep stretch	101	3	20s each
12	Stretching exercise- legs body	Lying hamstring stretch	58	3	20s each
13	Stretching exercise- legs body	Side lying quadriceps stretch	68	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 4- DAY 2 (01/8/2006) (14)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Push-ups – (alt. side to side)	3	3	10-12
3	Leg exercise	Lunges	46	3	10-12
4	Upper body exercise	Shoulder press	5	3	10-12
5	Abdominal exercise	Scissors	25	3	Maximum
6	Back exercise	Back extension on floor (opp. Leg with opp. Arm)	20	3	10-12
7	Leg exercise	Calf raises (both legs)	51	3	20
8	Abdominal exercise	Reverse crunch	31	3	Maximum
9	Cardiovascular activity	Walking/ Jogging		5 sec walking/ 55 sec jogging 25= 25 min	
10	Stretching exercise- upper body	Shoulder extensor stretch	100	3	20s each
12	Stretching exercise- legs body	Straddle hamstring stretch	62	3	20s each
13	Stretching exercise- legs body	Standing quadriceps stretch	69	3	20s each
14	Stretching exercise- lower leg	Tibialis anterior stretch	57	3	20s each

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PHYSICAL TRAINING PROGRAMME

WEEK 4- DAY 3 (03/8/2006) (15)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Normal push-ups	1	3	10-12
3	Leg exercise	Squats	40	3	10-12
4	Upper body exercise	Tricep extensions	6	3	10-12
5	Abdominal exercise	Sit-ups	29	3	maximum
6	Back exercise	Back extension on floor (upper body only)	19	3	10-12
7	Leg exercise	Sitting single straight leg raise	41	3	10-12
8	Abdominal exercise	Hip flexors	28	3	maximum
9	Cardiovascular activity	/walking/ Jogging		5 sec walking/ 55 sec jogging 25= 25 min	
10	Stretching exercise- upper body	Overhead tricep stretch	101	3	20s each
12	Stretching exercise- legs body	Lying hamstring stretch	58	3	20s each
13	Stretching exercise- legs body	Side lying quadriceps stretch	68	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 4- DAY 4 (04/8/2006) (16)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Push-ups –hands wide apart	4	3	10-12
3	Leg exercise	Side lunges	47A	3	10-12
4	Upper body exercise	Tricep extension	6	3	10-12
5	Abdominal exercise	Sit-ups	29	3	Maximum
6	Back exercise	Back extension on floor (upper body)	19	3	10-12
7	Leg exercise	Abduction leg raise	44	3	20
8	Abdominal exercise	Reverse crunch	31	3	Maximum
9	Cardiovascular activity	Walking/ Jogging		5 sec walking/ 55 sec jogging 25= 25 min	
10	Stretching exercise- upper body	Overhead tricep stretch	101	3	20s each
12	Stretching exercise- legs body	Lying hamstring stretch	58	3	20s each
13	Stretching exercise- legs body	Side lying quadriceps stretch	68	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 5- DAY 1 (07/08/06) (17) : EQUIPMENT- POLES

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Bicep curls	7	2	10-12
3	Leg exercise	Squats	50	2	10-12
4	Upper body exercise	Tricep extensions	14	2	10-12
5	Abdominal exercise	Sit-ups	38	2	maximum
6	Back exercise	Bent over row	23	2	10-12
7	Leg exercise	Calf raises	51	2	10-12
8	Abdominal exercise	Reverse crunch	31	3	maximum
9	Cardiovascular activity	Walking/ Jogging		5 sec walking/ 55 sec jogging 25= 25 min	
10	Stretching exercise- upper body	Overhead tricep stretch	101	3	20s each
12	Stretching exercise- legs body	Lying hamstring stretch	58	3	20s each
13	Stretching exercise- legs body	Side lying quadriceps stretch	68	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 5- DAY 2 (08/08/2006) (18)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Push-ups – (alt. side to side)	3	3	10-12
3	Leg exercise	Lunges	46	3	10-12
4	Upper body exercise	Shoulder press	5	3	10-12
5	Abdominal exercise	Scissors	25	3	Maximum
6	Back exercise	Back extension on floor (opp. Leg with opp. Arm)	20	3	10-12
7	Leg exercise	Calf raises (both legs)	51	3	20
8	Abdominal exercise	Reverse crunch	31	3	Maximum
9	Cardiovascular activity	Walking/ Jogging		25 min jogging	
10	Stretching exercise- upper body	Shoulder extensor stretch	100	3	20s each
12	Stretching exercise- legs body	Straddle hamstring stretch	62	3	20s each
13	Stretching exercise- legs body	Standing quadriceps stretch	69	3	20s each
14	Stretching exercise- lower leg	Tibialis anterior stretch	57	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 5- DAY 3 (10/08/2006) (19)EQUIPMENT- POLES

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Bicep curls	7	2	10-12
3	Leg exercise	Squats	50	2	10-12
4	Upper body exercise	Tricep extensions	14	2	10-12
5	Abdominal exercise	Sit-ups	38	2	maximum
6	Back exercise	Bent over row	23	2	10-12
7	Leg exercise	Calf raises	51	2	10-12
8	Abdominal exercise	Reverse crunch	31	3	maximum
9	Cardiovascular activity	Walking/ Jogging		5 sec walking/ 55 sec jogging 25= 25 min	
10	Stretching exercise- upper body	Overhead tricep stretch	101	3	20s each
12	Stretching exercise- legs body	Lying hamstring stretch	58	3	20s each
13	Stretching exercise- legs body	Side lying quadriceps stretch	68	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 5- DAY 4 (11/08/2006) (20)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Push-ups –hands wide apart	4	3	10-12
3	Leg exercise	Side lunges	47A	3	10-12
4	Upper body exercise	Tricep extension	6	3	10-12
5	Abdominal exercise	Sit-ups	29	3	Maximum
6	Back exercise	Back extension on floor (upper body)	19	3	10-12
7	Leg exercise	Abduction leg raise	44	3	20
8	Abdominal exercise	Reverse crunch	31	3	Maximum
9	Cardiovascular activity	Walking/ Jogging		25 min jogging	
10	Stretching exercise- upper body	Overhead tricep stretch	101	3	20s each
12	Stretching exercise- legs body	Lying hamstring stretch	58	3	20s each
13	Stretching exercise- legs body	Side lying quadriceps stretch	68	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 6- DAY 1 (14/08/06) (21): EQUIPMENT- POLES

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Chest press	11	2	10-12
3	Leg exercise	Squats	50	2	10-12
4	Upper body exercise	Pull-overs	13	2	10-12
5	Abdominal exercise	Sit-ups	38	2	maximum
6	Back exercise	Dead lift	22	2	10-12
7	Leg exercise	Alt. calf raises	52	2	10-12
8	Abdominal exercise	Bent knee U crunch	35	3	maximum
9	Cardiovascular activity	Walking/ Jogging		25 min jogging	
10	Stretching exercise- upper body	Overhead tricep stretch	101	3	20s each
12	Stretching exercise- legs body	Lying hamstring stretch	58	3	20s each
13	Stretching exercise- legs body	Side lying quadriceps stretch	68	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 6- DAY 2 (15/08/2006) (22)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Push-ups – (alt. side to side)	3	3	10-12
3	Leg exercise	Lunges	46	3	10-12
4	Upper body exercise	Shoulder press	5	3	10-12
5	Abdominal exercise	Scissors	25	3	Maximum
6	Back exercise	Back extension on floor (opp. Leg with opp. Arm)	20	3	10-12
7	Leg exercise	Calf raises (both legs)	51	3	20
8	Abdominal exercise	Reverse crunch	31	3	Maximum
9	Cardiovascular activity	Walking/ Jogging		5 sec walking/ 55 sec jogging x30= 30 min	
10	Stretching exercise- upper body	Shoulder extensor stretch	100	3	20s each
12	Stretching exercise- legs body	Straddle hamstring stretch	62	3	20s each
13	Stretching exercise- legs body	Standing quadriceps stretch	69	3	20s each
14	Stretching exercise- lower leg	Tibialis anterior stretch	57	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 6- DAY 3 (17/08/2006) (23)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Chest press	11	2	10-12
3	Leg exercise	Squats	50	2	10-12
4	Upper body exercise	Pull-overs	13	2	10-12
5	Abdominal exercise	Sit-ups	38	2	maximum
6	Back exercise	Dead lift	22	2	10-12
7	Leg exercise	Alt. calf raises	52	2	10-12
8	Abdominal exercise	Bent knee U crunch	35	3	maximum
9	Cardiovascular activity	Walking/ Jogging		25 min jogging	
10	Stretching exercise- upper body	Overhead tricep stretch	101	3	20s each
12	Stretching exercise- legs body	Lying hamstring stretch	58	3	20s each
13	Stretching exercise- legs body	Side lying quadriceps stretch	68	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 6- DAY 4 (18/08/2006) (24)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Push-ups –hands wide apart	4	3	10-12
3	Leg exercise	Side lunges	47A	3	10-12
4	Upper body exercise	Tricep extension	6	3	10-12
5	Abdominal exercise	Sit-ups	29	3	Maximum
6	Back exercise	Back extension on floor (upper body)	19	3	10-12
7	Leg exercise	Abduction leg raise	44	3	20
8	Abdominal exercise	Reverse crunch	31	3	Maximum
9	Cardiovascular activity	Walking/ Jogging		5 sec walking/ 55 sec jogging x30= 30 min	
10	Stretching exercise- upper body	Overhead tricep stretch	101	3	20s each
12	Stretching exercise- legs body	Lying hamstring stretch	58	3	20s each
13	Stretching exercise- legs body	Side lying quadriceps stretch	68	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 7- DAY 1 (21/08/06) (25): EQUIPMENT- POLES

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Bicep curls	7	3	10-12
3	Leg exercise	Squats	50	3	10-12
4	Upper body exercise	Tricep extensions	14	3	10-12
5	Abdominal exercise	Sit-ups	38	3	maximum
6	Back exercise	Bent over row	23	3	10-12
7	Leg exercise	Calf raises	51	3	10-12
8	Abdominal exercise	Reverse crunch	31	3	maximum
9	Cardiovascular activity	Walking/ Jogging		1min slow jog/ 30 sec sprint x 15= 7.5min + 15 minutes jogging	
10	Stretching exercise- upper body	Overhead tricep stretch	101	3	20s each
12	Stretching exercise- legs body	Lying hamstring stretch	58	3	20s each
13	Stretching exercise- legs body	Side lying quadriceps stretch	68	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 7- DAY 2 (22/08/2006) (26)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Normal push-ups	1	3	15
3	Leg exercise	Lunges	46	3	15
4	Upper body exercise	Shoulder press	5	3	15
5	Abdominal exercise	Scissors	25	3	Maximum
6	Back exercise	Back extension on floor (opp. Leg with opp. Arm)	20	3	15
7	Leg exercise	Calf raises (both legs)	51	3	20
8	Abdominal exercise	Reverse crunch	31	3	Maximum
9	Cardiovascular activity	Walking/ Jogging		30 min jogging	
10	Stretching exercise- upper body	Shoulder extensor stretch	100	3	20s each
12	Stretching exercise- legs body	Straddle hamstring stretch	62	3	20s each
13	Stretching exercise- legs body	Standing quadriceps stretch	69	3	20s each
14	Stretching exercise- lower leg	Tibialis anterior stretch	57	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 7- DAY 3 (24/08/2006) (27)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Chest press	11	3	10-12
3	Leg exercise	Squats	50	3	10-12
4	Upper body exercise	Pull-overs	13	3	10-12
5	Abdominal exercise	Sit-ups	38	3	maximum
6	Back exercise	Dead lift	22	3	10-12
7	Leg exercise	Alt. calf raises	52	3	10-12
8	Abdominal exercise	Bent knee U crunch	35	3	maximum
9	Cardiovascular activity	Walking/ Jogging		1min slow jog/ 30 sec sprint x 15= 7.5min + 15 minutes jogging	
10	Stretching exercise- upper body	Overhead tricep stretch	101	3	20s each
12	Stretching exercise- legs body	Lying hamstring stretch	58	3	20s each
13	Stretching exercise- legs body	Side lying quadriceps stretch	68	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 7- DAY 4 (25/08/2006) (28)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Push-ups –hands wide apart	4	3	15
3	Leg exercise	Side lunges	47A	3	15
4	Upper body exercise	Tricep extension	6	3	15
5	Abdominal exercise	Sit-ups	29	3	Maximum
6	Back exercise	Back extension on floor (upper body)	19	3	15
7	Leg exercise	Abduction leg raise	44	3	20
8	Abdominal exercise	Reverse crunch	31	3	Maximum
9	Cardiovascular activity	Walking/ Jogging		30 min jogging	
10	Stretching exercise- upper body	Overhead tricep stretch	101	3	20s each
12	Stretching exercise- legs body	Lying hamstring stretch	58	3	20s each
13	Stretching exercise- legs body	Side lying quadriceps stretch	68	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 8- DAY 1 (28/08/06) (29): EQUIPMENT- POLES

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Upward row	8	3	10-12
3	Leg exercise	Lunges	50	3	10-12
4	Upper body exercise	Shoulder press	12	3	10-12
5	Abdominal exercise	Jack knives	26	3	maximum
6	Back exercise	Dead lift	23	3	10-12
7	Leg exercise	Alt. calf raises	52	3	10-12
8	Abdominal exercise	Sit-ups	38	3	maximum
9	Cardiovascular activity	Walking/ Jogging		45 seconds slow jog/ 30 sec sprint x 20= 23 min	
10	Stretching exercise- upper body	Overhead tricep stretch	101	3	20s each
12	Stretching exercise- legs body	Lying hamstring stretch	58	3	20s each
13	Stretching exercise- legs body	Side lying quadriceps stretch	68	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 8- DAY 2 (29/08/2006) (30)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Push-ups (hands together)	1	3	15
3	Leg exercise	Abduction leg raise	44	3	15
4	Upper body exercise	Tricep extension	6	3	15
5	Abdominal exercise	Straight leg U crunch	34	3	Maximum
6	Back exercise	Back extension on floor (opp. Leg with opp. Arm)	21	3	15
7	Leg exercise	Adduction leg raise	45	3	20
8	Abdominal exercise	Single hip flexion	32	3	Maximum
9	Cardiovascular activity	Walking/ Jogging		30 min jogging	
10	Stretching exercise- upper body	Shoulder extensor stretch	100	3	20s each
12	Stretching exercise- legs body	Straddle hamstring stretch	62	3	20s each
13	Stretching exercise- legs body	Standing quadriceps stretch	69	3	20s each
14	Stretching exercise- lower leg	Tibialis anterior stretch	57	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 8- DAY 3 (31/08/2006) (31)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Shoulder shrugs	9	3	10-12
3	Leg exercise	Squats	50	3	10-12
4	Upper body exercise	Pull-overs	13	3	10-12
5	Abdominal exercise	Sit-ups	38	3	Maximum
6	Back exercise	Bent over row	23	3	10-12
7	Leg exercise	Calf raises (both legs)	51	3	10-12
8	Abdominal exercise	Bicycle crunch	33	3	Maximum
9	Cardiovascular activity	Walking/ Jogging		45 seconds slow jog/ 30 sec sprint x 20= 23 min	
10	Stretching exercise- upper body	Overhead tricep stretch	101	3	20s each
12	Stretching exercise- legs body	Lying hamstring stretch	58	3	20s each
13	Stretching exercise- legs body	Side lying quadriceps stretch	68	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 8- DAY 4 (09/09/2006) (32)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Push-ups –alt. Side to side	3	3	15
3	Leg exercise	Sitting single leg raise (foot position turned out)	43	3	20
4	Upper body exercise	Shoulder press	6	3	15
5	Abdominal exercise	Alt. Jack knives	26	3	Maximum
6	Back exercise	Back extension on floor (upper body)	19	3	15
7	Leg exercise	Side lunges	47A	3	20
8	Abdominal exercise	Hip flexors	28	3	Maximum
9	Cardiovascular activity	Walking/ Jogging		30 min jogging	
10	Stretching exercise- upper body	Overhead tricep stretch	101	3	20s each
12	Stretching exercise- legs body	Lying hamstring stretch	58	3	20s each
13	Stretching exercise- legs body	Side lying quadriceps stretch	68	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 9- DAY 1 (04/09/06) (33): EQUIPMENT- POLES

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Bicep curls	7	3	10-12
3	Leg exercise	Squats	50	3	10-12
4	Upper body exercise	Tricep extensions	14	3	10-12
5	Abdominal exercise	Sit-ups	38	3	Maximum
6	Back exercise	Bent over row	23	3	10-12
7	Leg exercise	Calf raises	51	3	10-12
8	Abdominal exercise	Reverse crunch	31	3	Maximum
9	Cardiovascular activity	Walking/ Jogging		30 slow jog/ 30 sec sprint x 15= 15min + 10 minutes jogging	
10	Stretching exercise- upper body	Overhead tricep stretch	101	3	20s each
12	Stretching exercise- legs body	Lying hamstring stretch	58	3	20s each
13	Stretching exercise- legs body	Side lying quadriceps stretch	68	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 9- DAY 2 (05/09/2006) (34)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Normal push-ups	1	3	15
3	Leg exercise	Lunges	46	3	15
4	Upper body exercise	Shoulder press	5	3	15
5	Abdominal exercise	Scissors	25	3	Maximum
6	Back exercise	Back extension on floor (opp. Leg with opp. Arm)	20	3	15
7	Leg exercise	Calf raises (both legs)	51	3	20
8	Abdominal exercise	Reverse crunch	31	3	Maximum
9	Cardiovascular activity	Walking/ Jogging		30 min jogging	
10	Stretching exercise- upper body	Shoulder extensor stretch	100	3	20s each
12	Stretching exercise- legs body	Straddle hamstring stretch	62	3	20s each
13	Stretching exercise- legs body	Standing quadriceps stretch	69	3	20s each
14	Stretching exercise- lower leg	Tibialis anterior stretch	57	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 9- DAY 3 (07/09/2006) (35)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Chest press	11	3	10-12
3	Leg exercise	Squats	50	3	10-12
4	Upper body exercise	Pull-overs	13	3	10-12
5	Abdominal exercise	Sit-ups	38	3	Maximum
6	Back exercise	Dead lift	22	3	10-12
7	Leg exercise	Alt. calf raises	52	3	10-12
8	Abdominal exercise	Bent knee U crunch	35	3	Maximum
9	Cardiovascular activity	Walking/ Jogging		30sec slow jog/ 30 sec sprint x 15=15min + 10 minutes jogging	
10	Stretching exercise- upper body	Overhead tricep stretch	101	3	20s each
12	Stretching exercise- legs body	Lying hamstring stretch	58	3	20s each
13	Stretching exercise- legs body	Side lying quadriceps stretch	68	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 9- DAY 4 (08/09/2006) (36)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Push-ups –hands wide apart	4	3	15
3	Leg exercise	Side lunges	47A	3	15
4	Upper body exercise	Tricep extension	6	3	15
5	Abdominal exercise	Sit-ups	29	3	Maximum
6	Back exercise	Back extension on floor (upper body)	19	3	15
7	Leg exercise	Abduction leg raise	44	3	20
8	Abdominal exercise	Reverse crunch	31	3	Maximum
9	Cardiovascular activity	Walking/ Jogging		30 min jogging	
10	Stretching exercise- upper body	Overhead tricep stretch	101	3	20s each
12	Stretching exercise- legs body	Lying hamstring stretch	58	3	20s each
13	Stretching exercise- legs body	Side lying quadriceps stretch	68	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 10- DAY 1 (11/09/06) (37): EQUIPMENT- POLES

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Upward row	8	3	10-12
3	Leg exercise	Lunges	50	3	10-12
4	Upper body exercise	Shoulder press	12	3	10-12
5	Abdominal exercise	Jack knives	26	3	Maximum
6	Back exercise	Dead lift	23	3	10-12
7	Leg exercise	Alt. calf raises	52	3	10-12
8	Abdominal exercise	Sit-ups	38	3	Maximum
9	Cardiovascular activity	Walking/ Jogging		30 seconds slow jog/ 30 sec sprint x 20= 20 min + 5 minutes jog	
10	Stretching exercise- upper body	Overhead tricep stretch	101	3	20s each
12	Stretching exercise- legs body	Lying hamstring stretch	58	3	20s each
13	Stretching exercise- legs body	Side lying quadriceps stretch	68	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 10- DAY 2 (12/09/2006) (38)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Push-ups (hands together)	1	3	15
3	Leg exercise	Abduction leg raise	44	3	15
4	Upper body exercise	Tricep extension	6	3	15
5	Abdominal exercise	Straight leg U crunch	34	3	Maximum
6	Back exercise	Back extension on floor (opp. Leg with opp. Arm)	21	3	15
7	Leg exercise	Adduction leg raise	45	3	20
8	Abdominal exercise	Single hip flexion	32	3	Maximum
9	Cardiovascular activity	Walking/ Jogging		30 min jogging	
10	Stretching exercise- upper body	Shoulder extensor stretch	100	3	20s each
12	Stretching exercise- legs body	Straddle hamstring stretch	62	3	20s each
13	Stretching exercise- legs body	Standing quadriceps stretch	69	3	20s each
14	Stretching exercise- lower leg	Tibialis anterior stretch	57	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 10- DAY 3 (14/09/2006) (39)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Shoulder shrugs	9	3	10-12
3	Leg exercise	Squats	50	3	10-12
4	Upper body exercise	Pull-overs	13	3	10-12
5	Abdominal exercise	Sit-ups	38	3	maximum
6	Back exercise	Bent over row	23	3	10-12
7	Leg exercise	Calf raises (both legs)	51	3	10-12
8	Abdominal exercise	Bicycle crunch	33	3	maximum
9	Cardiovascular activity	Walking/ Jogging		30 seconds slow jog/ 30 sec sprint x 20= 20 min + 5 min jog	
10	Stretching exercise- upper body	Overhead tricep stretch	101	3	20s each
12	Stretching exercise- legs body	Lying hamstring stretch	58	3	20s each
13	Stretching exercise- legs body	Side lying quadriceps stretch	68	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 10- DAY 4 (15/09/2006) (40)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Push-ups –alt. Side to side	3	3	15
3	Leg exercise	Sitting single leg raise (foot position turned out)	43	3	20
4	Upper body exercise	Shoulder press	6	3	15
5	Abdominal exercise	Alt. Jack knives	26	3	Maximum
6	Back exercise	Back extension on floor (upper body)	19	3	15
7	Leg exercise	Side lunges	47A	3	20
8	Abdominal exercise	Hip flexors	28	3	Maximum
9	Cardiovascular activity	Walking/ Jogging		30 min jogging	
10	Stretching exercise- upper body	Overhead tricep stretch	101	3	20s each
12	Stretching exercise- legs body	Lying hamstring stretch	58	3	20s each
13	Stretching exercise- legs body	Side lying quadriceps stretch	68	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 11- DAY 1 (18/09/06) (41): EQUIPMENT- POLES

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Upward row	8	3	
3	Leg exercise	Squats	50	3	15
4	Upper body exercise	Tricep extensions	14	3	15
5	Abdominal exercise	Sit-ups	38	3	Maximum
6	Back exercise	Bent over row	23	3	15
7	Leg exercise	Calf raises	51	3	15
8	Abdominal exercise	Side lift old and twist	37	3	Maximum
9	Cardiovascular activity	Walking/ Jogging		30 slow jog/ 30 sec sprint x 25= 25min	
10	Stretching exercise- upper body	Overhead tricep stretch	101	3	20s each
12	Stretching exercise- legs body	Lying hamstring stretch	58	3	20s each
13	Stretching exercise- legs body	Side lying quadriceps stretch	68	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 11- DAY 2 (19/09/2006) (42)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Push-ups – alt. Side to side	1	3	15
3	Leg exercise	Lunges	46	3	15
4	Upper body exercise	Shoulder press	5	3	15
5	Abdominal exercise	Alt. Jack knives	26	3	Maximum
6	Back exercise	Back extension on floor (opp. Leg with opp. Arm)	21	3	15
7	Leg exercise	Calf raises (both legs)	51	3	20
8	Abdominal exercise	Reverse crunch	31	3	Maximum
9	Cardiovascular activity	Walking/ Jogging		30 min jogging	
10	Stretching exercise- upper body	Shoulder extensor stretch	100	3	20s each
12	Stretching exercise- legs body	Straddle hamstring stretch	62	3	20s each
13	Stretching exercise- legs body	Standing quadriceps stretch	69	3	20s each
14	Stretching exercise- lower leg	Tibialis anterior stretch	57	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 11- DAY 3 (21/09/2006) (43)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Chest press	11	3	15
3	Leg exercise	Squats	50	3	15
4	Upper body exercise	Pull-overs	13	3	15
5	Abdominal exercise	Sit-ups	38	3	Maximum
6	Back exercise	Dead lift	22	3	15
7	Leg exercise	Alt. calf raises	52	3	15
8	Abdominal exercise	Bent knee U crunch	35	3	Maximum
9	Cardiovascular activity	Walking/ Jogging		30sec slow jog/ 30 sec sprint x 25=25min	
10	Stretching exercise- upper body	Overhead tricep stretch	101	3	20s each
12	Stretching exercise- legs body	Lying hamstring stretch	58	3	20s each
13	Stretching exercise- legs body	Side lying quadriceps stretch	68	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 11- DAY 4 (22/09/2006) (44)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Push-ups –hands wide apart	4	3	15
3	Leg exercise	Side lunges	47A	3	15
4	Upper body exercise	Tricep extension	6	3	15
5	Abdominal exercise	Sit-ups	29	3	Maximum
6	Back exercise	Back extension on floor (upper body)	19	3	15
7	Leg exercise	Abduction leg raise	44	3	20
8	Abdominal exercise	Side lift hold and twist	37	3	Maximum
9	Cardiovascular activity	Walking/ Jogging		30 min jogging	
10	Stretching exercise- upper body	Overhead tricep stretch	101	3	20s each
12	Stretching exercise- legs body	Lying hamstring stretch	58	3	20s each
13	Stretching exercise- legs body	Side lying quadriceps stretch	68	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 12- DAY 1 (25/09/06) (45): EQUIPMENT- POLES

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Upward row	8	3	15
3	Leg exercise	Lunges	50	3	15
4	Upper body exercise	Shoulder press	12	3	15
5	Abdominal exercise	Jack knives	26	3	Maximum
6	Back exercise	Dead lift	23	3	15
7	Leg exercise	Alt. calf raises	52	3	15
8	Abdominal exercise	Sit-ups	38	3	Maximum
9	Cardiovascular activity	Walking/ Jogging		20 seconds slow jog/ 30 sec sprint x 25 min= 20 min	
10	Stretching exercise- upper body	Overhead tricep stretch	101	3	20s each
12	Stretching exercise- legs body	Lying hamstring stretch	58	3	20s each
13	Stretching exercise- legs body	Side lying quadriceps stretch	68	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 12- DAY 2 (26/09/2006) (46)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Push-ups (hands together)	1	3	15
3	Leg exercise	Abduction leg raise	44	3	15
4	Upper body exercise	Tricep extension	6	3	15
5	Abdominal exercise	Straight leg U crunch	34	3	Maximum
6	Back exercise	Back extension on floor (opp. Leg with opp. Arm)	21	3	15
7	Leg exercise	Adduction leg raise	45	3	20
8	Abdominal exercise	Single hip flexion	32	3	Maximum
9	Cardiovascular activity	Walking/ Jogging		30 min jogging	
10	Stretching exercise- upper body	Shoulder extensor stretch	100	3	20s each
12	Stretching exercise- legs body	Straddle hamstring stretch	62	3	20s each
13	Stretching exercise- legs body	Standing quadriceps stretch	69	3	20s each
14	Stretching exercise- lower leg	Tibialis anterior stretch	57	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 12- DAY 3 (27/09/2006) (47)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Shoulder shrugs	9	3	15
3	Leg exercise	Squats	50	3	15
4	Upper body exercise	Pull-overs	13	3	15
5	Abdominal exercise	Sit-ups	38	3	maximum
6	Back exercise	Bent over row	23	3	15
7	Leg exercise	Calf raises (both legs)	51	3	15
8	Abdominal exercise	Bicycle crunch	33	3	maximum
9	Cardiovascular activity	Walking/ Jogging		20 seconds slow jog/ 30 sec sprint x 25 min= 20 min	
10	Stretching exercise- upper body	Overhead tricep stretch	101	3	20s each
12	Stretching exercise- legs body	Lying hamstring stretch	58	3	20s each
13	Stretching exercise- legs body	Side lying quadriceps stretch	68	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

PHYSICAL TRAINING PROGRAMME

WEEK 12- DAY 4 (28/09/2006) (48)

Ser No.	Exercise description	Exercise no	No	No. of sets	Reps
1	Warm-up	Arm circles- forward		2	12
		Arm circles- backwards		2	12
		Jog gently on the spot		3 minutes	
		Standing ITB stretch	76	2	20s each
		Standing lateral torso stretch	89	2	20s each
2	Upper body exercise	Push-ups –alt. Side to side	3	3	15
3	Leg exercise	Sitting single leg raise (foot position turned out)	43	3	20
4	Upper body exercise	Shoulder press	6	3	15
5	Abdominal exercise	Alt. Jack knives	26	3	Maximum
6	Back exercise	Back extension on floor (upper body)	19	3	15
7	Leg exercise	Side lunges	47A	3	20
8	Abdominal exercise	Hip flexors	28	3	Maximum
9	Cardiovascular activity	Walking/ Jogging		30 min jogging	
10	Stretching exercise- upper body	Overhead tricep stretch	101	3	20s each
12	Stretching exercise- legs body	Lying hamstring stretch	58	3	20s each
13	Stretching exercise- legs body	Side lying quadriceps stretch	68	3	20s each
14	Stretching exercise- back	Sitting upper back stretch	92	3	20s each

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PHYSICAL TRAINING PROGRAMME

Table of Contents

Part 1

PHYSICAL TRAINING FOR MEMBERS OF THE SOUTH AFRICAN NATIONAL DEFENCE FORCE

MANUAL ON PHYSICAL TRAINING IN THE SANDF

Introduction

Physical training is an important mechanism, together with sport and recreation, in preparing and maintaining combat and mission ready members of the SANDF. Physical fitness, as only one aspect of total fitness, is achieved through mandatory physical training programmes, supplemented by the participation in sport and recreational activities.

AIm

The primary aim of this manual is to provide clear scientifically based guidelines to Physical Training Instructors' on the how, what, when and why, of the Physical Training that they must present, in order to achieve the best improvement in physical fitness in the members under their instruction.

What is fitness?

Total fitness includes mental, emotional, social and physical aspects and is characterized by the following forms of ability:

- Emotional ability or stability that implies a balanced emotional life.
- Intellectual ability, which implies mental security.
- Social ability; and
- Bodily or physical fitness.

Thus **total fitness** is a broad term denoting dynamic qualities that allow one to satisfy needs regarding mental and emotional stability, social consciousness and adaptability, spirituality, and physical health.

Physical fitness can be defined as the healthy and efficient functioning of various body systems that allows one to engage in activities of daily living, recreation and leisure.

Physical fitness

Physical fitness is classified into fitness components, namely:

- Cardiorespiratory endurance
- Muscular strength
- Muscular endurance
- Flexibility
- Speed
- Power
- Agility

Cardiorespiratory endurance

Cardiorespiratory endurance is the ability to persist in a physical activity requiring oxygen for physical exertion without experiencing undue fatigue. The soldier who runs 2.4km or walks 4km is displaying cardiorespiratory endurance.

The functioning of the heart, lungs and blood vessels is essential for distribution of oxygen and nutrients and the removal of wastes from the body. For performance of vigorous activities, efficient functioning of the heart and lungs is necessary. The more efficient they function, the easier it is to walk, run, study and concentrate for longer periods of time. A more efficient soldier will be able to maintain effort for a longer period of time.

Cardiorespiratory function is characterized by moderate contractions of large muscle groups for a relatively long time, during which adjustments of the cardiorespiratory system to the activity are necessary, as in distance running or swimming.

Cardiorespiratory function may be assessed using a number of tests that measure or predict the maximum rate at which oxygen can be used during exercise.

The SANDF uses the 2.4km run and 4km walk as assessments of the soldiers' cardiorespiratory endurance. It thus stands to reason that should the majority of the soldiers perform poorly in the above-mentioned tests that they then must follow a PT programme designed to improve this component.

In order to improve cardiorespiratory endurance the following guidelines must be adhered to:

- **Frequency**: minimum 3 x/week;
- **Duration**: at least 20 min at desired HR;
- **Intensity**: 70-85% of max HR.

As heart rate is linearly related to the intensity of the exercise and to the rate of oxygen consumption, it becomes a relatively simple process to identify a specific workload (pace) that will make the heart rate plateau at a desired level. By monitoring the heart rate we can determine whether the pace is too fast d too slow to get the heart rate into a target range.

- **How?** The heart rate can be monitored for 10 seconds by placing the your index and middle fingers on the thumb side of the flexor tendon and then multiply it by 6 to give you the number of beats per minute. Regardless of where the heart rate is taken, it should be monitored within 15 seconds of stopping -the exercise.
- **Calculating HR.** Maximum HR= 220 – age.
- **Type**: Aerobic activities that involve repetitive, whole-body; large-muscle movement that are rhythmical in nature and that use large amounts of oxygen, elevate the heart rate and maintain it at that level for an extended period of time.

Basic training activities /methods to develop cardiorespiratory endurance

- Walking
- Jogging/ Running
- Cycling,
- Swimming,
- Rope skipping,

- Stepping,
- Aerobic dance exercise.

Note: Alternate the above activities in order to reduce the risk of developing overuse injuries. These activities should be used to develop cardiorespiratory endurance for at least a period of 3 weeks or the members should have passed their 2.4km run and/4km walk before advanced training methods are incorporated into the training programme.

Advanced training methods to develop cardiorespiratory endurance

Interval training.

Alternating periods of relative intense work with periods of active recovery.

Recommended Interval Training Workout	
Mode	**Detail**
Intensity during training period	70-95% of MHR
Intensity during recovery period	30-45% of MHR
Frequency	1-2x/week
Duration	Least 20 min of training period
Type	Use the basic method and turn into advanced by changing the intensity and frequency

Example of interval training using walking and running: runs 2 sets of 4 x 40 min in 70 sec with 2 min20sec walking recovery period

Fartlek training.

A type of workout that involves jogging at varying speed over varying terrain.

Par Cours.

A technique for improving endurance that combines continous training and circuit training.

Cardiorespiratory beginners training program

This programme should be followed for all the members who fail the cardiovascular component of the fitness assessment. I.e. all members who fail the 2.4km run and/or the 4km walk. This programme must be followed for a minimum of 3 weeks with a minimum of 3 training sessions per week before moving on to the intermediate programme.

Ser No.	Exercise description	Exercise no	Intensity	Time
1	Warm-up			7 min
2	Activity	Walking; Cycling; Swimming; Stepping, Low impact aerobic dance exercise	50-60% of max HR	20 min
3	Cool-down			5 min

Cardiorespiratory intermediate training program

This programme should be followed for all the members who pass the cardiovascular component (2.4km run and/or the 4km walk) of the fitness assessment and achieve a 60-70% pass rate. This programme must be followed for a minimum of 3 weeks with a minimum of 3 training sessions per week before proceeding to the advanced programme.

Ser No.	Exercise description	Exercise no	Intensity	Time
1	Warm-up			7 min
2	Activity	Walking; Jogging/ Running; Cycling; Swimming; Rope skipping; Stepping, Aerobic dance exercise	60-75% of max HR	30 min
3	Cool-down			5 min

Cardiorespiratory advanced training program

This programme should be followed for all the members who pass the cardiovascular component (2.4km run and/or the 4km walk) of the fitness assessment and achieve more than a 70% pass rate. This programme must be followed for a minimum of 3 weeks with a minimum of 3 training sessions per week.

Ser No.	Exercise description	Exercise no	Intensity	Time
1	Warm-up			7 min
2	Activity	Jogging/ Running; Cycling; Swimming; Rope skipping; Stepping, Aerobic dance exercise	75-80% of max HR	45 min
3	Cool-down			5 min

Muscular strength

Muscular strength is the ability or capacity of a muscle or muscle group to exert a maximal force against resistance, one time through a full range of motion. This is referred to as the one- repetition maximum, or the 1-RM.

To determine your 1-RM select a weight that you know you can lift at least one time. After a proper warm-up, try to execute several repetitions. If you can perform more than one repetition, add weight and try again to execute several repetitions. Continue doing this until you are unable to lift the weight more than a single repetition. This last weight you are able to lift only once is your 1-RM.

Strength is an important element in all kinds of work, physical and athletic activity. Muscle strength provides greater endurance, power and resistance to fatigue. Additionally it also helps to prevent injuries by providing support to the joints.

No component of the SANDF fitness test directly assesses the individuals muscular strength however strength forms the basis for the following components, namely:

Strength training techniques

There is no such thing as an optimal strength training program Perhaps the most confusing aspect of training is the terminology used to describe specific programs. The following list of terms with their operational definitions may provide some clarifications.

Terms	**Definitions**
Repetitions	Number of times you repeat a specific movement
Repetition maximum (RM)	Maximum number of repetitions at a given weight
Set	A particular number of repetitions
Intensity	The amount of weight or resistance lifted
Recovery period	The rest interval between sets
Frequency	The number of times an exercise is done in a week's period.

Muscular endurance

Is the ability of a muscle or muscle group to perform a series of dynamic contractions or to sustain a static sub maximal muscle contraction repeatedly over a period of time. For example, a person can lift a weight 25 times. If muscular strength is increased by 10% through weight training, it is very likely that the maximum number of repetitions will also be increased because it is easier for the person to lift the weight.

Muscular strength versus Muscular endurance

People who possess great levels of strength tend to exhibit great levels of muscular endurance when asked to perform repeated submaximal contractions against resistance.

Sets and Reps.

To develop muscular strength you should use heavier weights (resistance) with a lower number of repetitions. Conversely to develop muscular endurance you should use lighter weights (resistance) with a higher number of repetitions.

When trying to increase muscular strength, for any given exercise the amount of weight (resistance) selected should be sufficient to allow 6 to 8 repetitions maximum (RM) in each of the three sets with a recovery period of 1 to 2 minutes between sets. Initial selection of a starting weight may require some trial and error to achieve the 6 to 8 RM range. If at least 3 sets of 6 repetitions cannot be completed, the weight is too heavy and should be reduced. If it is possible to do more than 3 sets of 8 repetitions, the weight is too light.

Progression to heavier weights is then determined by the ability to perform at least 8 repetitions maximum in each of the 3 sets. When progressing weight, an increase of about 10% of the current weight being lifted should still allow at least 6 RM in each of the three sets.

To concentrate more on muscular endurance you should use three sets of 10 to 12 reps. The amount of weight used should be selected and progressed according to the same procedure described above. Thus training regimes for both muscular strength and muscular endurance are similar in terms of sets and number of repetitions.

Frequency of exercise.

To most effectively improve muscular strength and endurance, a particular muscle or muscle group should be exercised at least 3 times a week and not more than 4 times per week.

Teaching guidelines for muscular strength and endurance

You can teach muscular strength and endurance concepts and conduct training sessions whether you have state-of-the-art equipment or not. Surgical tubing for resistance bands is inexpensive and readily available. Collect and use cans of food for small weights. You can use balls too, which incorporate balance and strength. There are always body weight and partner-resisted exercises. If you are planning to purchase equipment, focus on buying items that will meet the primary needs of your students. Using traditional weight-training equipment represents only a small segment of exercises and activities. It's important to first manage one's own body weight before lifting increased weights.

Overload, fitt, progression and specificity principles

The principle of overload-progressively placing greater –than-normal demands on the musculature of the body – suggests that individuals involved with activities designed to improve muscular strength and/or muscular endurance will need to increase their workload periodically throughout the course of the program. Specifically, to develop muscular strength, the overload principle dictates increasing the resistance against the muscles involved to a level greater than that used before. To develop muscular endurance, the overload principle dictates increasing the number of repetitions, increasing the length (time) of the repetition, decreasing the rest interval between activities, or a combination of two or three methods. The amount of increase must be appropriate for the age and fitness level of the students.

The principle of progression refers to incorporating a systematic approach to increasing frequency of exercise, the volume of repetitions, and/or the intensity of the activity. To avoid injuries, however, students must understand appropriate progression and set goals accordingly. For example, they should know that adding only a couple kilograms at a time is safer and more realistic than increasing by an excessive amount. There may be instances in which one component may be increased, whereas the other components may actually be decreased. For example, as intensity increases, volume will decrease, and vice versa.

The principle of specificity technically states that the type of demand placed in the body controls the type of adaptation that will occur. Specificity suggests that the activities you select should provide the outcome represented by that day's class objectives.

The table below summarizes how to apply the FITT (frequency, intensity, time and type) principle, based on fitness level goals.

Training principles applied to muscular strength and muscular endurance, based on fitness goals			
	Base health-related fitness	**Intermediate health-related fitness**	**Athletic performance fitness**
Frequency	2-3 times per week; allow for minimum one-day rest between training sessions	3-4 times per week; alternating upper- and lower-body segments will allow for consecutive training days	4-5 times per week; training activities are specific to sport participation
Intensity	Very light, less than 40% of a "projected" maximal effort	Light to moderate, 50%-70% of "projected" maximal effort	Specific load adaptation required for sport participation
Time	2-3 sets of 6-8 (strength)/ 10-12 (endurance) repetitions	2-3 sets of 6-8 (strength)/ 10-12 (endurance) repetitions	2-3 sets of 6-8 (strength)/ 10-12 (endurance) repetitions
Type	Body weight, single and multijoint activities involving major muscle groups	Resistance exercise such as leg press, bench press, pull-ups additional presses and pulls	Advanced sport-specific, multijoint lofts (clean pulls, power presses, Olympic style lifts)
Overload	Not necessary to bring child to overload during base level	Introduce one of the components of overload; 1-2 times per week	Program design should stress variable intensities and durations to bring student into overload; 2-3 times per week
Progression and specificity	Let student get the idea of correct movement. Progression is minimal	Introduce program design and incorporate variation	Specific sets, repetitions, and exercises to meet desired outcomes

Periodise for strength.

As with any goal-orientated activity, one needs to start at a level that can be managed and was determined by the fitness test and progress with a training programme with the aim, of being able to peak at the required time. Planning for this process is called Training Periodisation, which, in its simplest form, includes General Preparation, Specific Preparation, Pre-peak and Peak Phases.

General Preparation	Specific Preparation	Pre-Peak	Peak
Basic Strength	Maximum strength	Conversion: Endurance Power	Maintenance

Assessment/ Fitness evaluation Peak/ Follow-up fitness evaluation

Note well: these phases represent a progression. Latter phases should not be attempted without having adequately completed the previous training phases.

Basic strength:

The aim of this phase is to lay a foundation correct technique is paramount and this phase must concentrate on most muscle groups of the body broadly categorized as chest, back, shoulders, arms, legs and abdominals.

Training methods for muscular strength and endurance

Body weight training

Although it is difficult to quantify intensity, sit-ups, curl-ups, push-ups, and flexed arm hangs all help built muscular strength and endurance with little or no equipment.

This type of resistance training is appropriate for the very young (K-4) or the student who is just beginning resistance training activity. It has the advantages of not requiring equipment, which means it's an inexpensive part of a strength and endurance training program throughout adulthood.

Circuit training

Circuit training uses a series of exercise stations that consist of various combinations of weight training, flexibility, calisthenics, and brief aerobic exercises. Circuits may be designed to accomplish many different training goals. With circuit training, you move rapidly from one station to the next and perform whatever exercise is to be done at that station within a specified time period. A typical circuit would consist of eight to twelve stations, and the entire circuit would be repeated three times.

Circuit training is definitely an effective technique for improving strength and flexibility. Certainly, if the pace or the time interval between stations is rapid and if workload is maintained at a high level of intensity with heart rates at or above target training levels for a minimum of 20 minutes, the cardiorespiratory system may benefit from this circuit. However, there is little research evidence that shows that circuit training is very effective in improving cardiorespiratory endurance. It should be and is most often used as a technique for developing and improving muscular strength and endurance. Figure 6-11 provides an example of a simple circuit training setup that can be easily completed by healthy college students.

Plyometric Exercise

Plyometric exercise is a technique that uses specific exercises that encompass a rapid stretch of a muscle eccentrically followed immediately by a rapid concentric contraction of that muscle for the purpose of facilitating and developing a forceful explosive movement over a short period of time. The greater the stretch put on the muscle from its resting length immediately before the concentric contraction, the greater the resistance the muscle can overcome.

Plyometrics emphasize the speed of the eccentric phase. The rate of stretch is more critical than the magnitude of the stretch. An advantage to using plyometric exercise is that it can help develop eccentric control in dynamic movements. Plyometric exercises involve hops, bounds, and depth jumping for the lower extremity and the use of medicine balls and other types of weighted equipment for the upper extremity. Depth jumping is an example of a plyometric exercise in which an individual jumps to the ground from a specified height and then quickly jumps again as soon as ground contact is made.

Plyometrics tend to place a great deal of stress on the musculoskeletal system. The learning and perfection of specific jumping skills and other plyometric exercises must be technically correct and specific to one's age, activity, physical and skill development.

Partner-Resisted training

This training method is an extension of basic body weight exercises. Using simple equipment, such as a towel, or no equipment, partners can better isolate individual muscle groups than solo body weight exercises, much as weight machines do. When selecting partners, match height, weight, and strength levels as closely as possible to ensure safety and ease of working together. Encourage good communication and demand mature, safe behaviour: Partners should also help each other maintain correct technique and high motivation through monitoring and encourage each other.

Resistance band training

This training method involves using surgical tubing, rubber cords, or bands manufactured specifically for muscular strength and endurance training, such as the Exertube, Dyna Band, Flexi-Cord, or Therma-Band. Use thicker tubing for greater resistance and thinner tubing for less resistance. In addition, a student can adjust resistance by prestretching the cord more or less.

Weight training

A program may use free or machine weights or both, depending on goals, equipment availability, and space in which to safely conduct a weight-training program. Introduce exercises one at a time by discussing each one’s purpose, demonstrating correct technique, and outlining ranges of appropriate weight loads, repetitions and speed. In addition, relate these factors to intensity, program goals, and individual goals. While you may opt to use weight training in addition to or in place of other forms of training, also teach students alternative exercises that target the same muscle group.

Beginners muscular strength training programme

This programme should be followed for all the members who fail the muscular endurance/ strength component of the fitness assessment. I.e. all members who fail the sit-up and/or the push-ups. This programme must be followed for a minimum of 3 weeks with a minimum of 3 training sessions per week before moving on to the intermediate programme.

Ser No.	Exercise description	Exercise no	Intensity	No. of sets	Reps
1	Warm-up				
2	Upper body exercise			2-3	10-12
3	Leg exercise			2-3	10-12
4	Upper body exercise			2-3	10-12
5	Abdominal exercise			2-3	maximum
6	Back exercise			2-3	10-12
7	Leg exercise			2-3	10-12
8	Abdominal exercise			2-3	maximum
9	Leg exercise			2-3	10-12
10	Abdominal exercise			2-3	maximum
11	Stretching exercise- upper body			3	20s each
12	Stretching exercise- legs body			3	20s each
13	Stretching exercise- back			3	20s each

Intermediate muscular strength training programme

This programme should be followed for all the members who pass the muscular endurance/ strength component of the fitness assessment and achieve a 60-70% pass rate. i.e. all members who obtain points for the sit-ups and/or the push-ups. This programme must be followed for a minimum of 3 weeks with a minimum of 3 training sessions per week before proceeding to the advanced programme.

Ser No.	Exercise description	Exercise no	Intensity	No. of sets	Reps
1	Warm-up				
2	Upper body exercise			2-3	10-12
3	Leg exercise			2-3	10-12
4	Upper body exercise			2-3	10-12
5	Abdominal exercise			2-3	maximum
6	Back exercise			2-3	10-12
7	Leg exercise			2-3	10-12
8	Abdominal exercise			2-3	maximum
9	Leg exercise			2-3	10-12
10	Abdominal exercise			2-3	maximum
11	Stretching exercise- upper body			3	20s each
12	Stretching exercise- legs body			3	20s each
13	Stretching exercise- back			3	20s each

Advanced muscular strength training programme

This programme should be followed for all the members who pass the muscular endurance/ strength component and achieve above 70% pass rate for this component during the fitness assessment. i.e. all members who obtain points and above for the sit-ups and/or the push-ups. This programme must be followed for a minimum of 3 weeks with a minimum of 3 training sessions per week.

Ser No.	Exercise description	Exercise no	Intensity	No. of sets	Reps
1	Warm-up				
2	Upper body exercise			3	10-12
3	Leg exercise			3	10-12
4	Upper body exercise			3	10-12
5	Abdominal exercise			3	maximum
6	Back exercise			3	10-12
7	Leg exercise			3	10-12
8	Abdominal exercise			3	maximum
9	Leg exercise			3	10-12

Ser No.	Exercise description	Exercise no	Intensity	No. of sets	Reps
10	Abdominal exercise			3	maximum
11	Stretching exercise- upper body			3	20s each
12	Stretching exercise- legs body			3	20s each
13	Stretching exercise- back			3	20s each

General Physical Training Programme to maintain and improve fitness levels

This programme should be followed for all the members who pass the all the components of the fitness test and need to maintain and/or improve all the components. As the fitness test is conducted every six months the physical training programme should be designed so as to progressively improve all the components and be ready for the next physical fitness test. Thus the programme below should be followed from week 1 to week 12.

Ser No.	Exercise description	Exercise no	Intensity	No. of sets	Reps
1	Warm-up				
2	Upper body exercise			3	10-12
3	Leg exercise			3	10-12
4	Upper body exercise			3	10-12
5	Abdominal exercise			3	maximum
6	Back exercise			3	10-12
7	Leg exercise			3	10-12
8	Abdominal exercise			3	maximum
9	Cardiovascular activity	Jogging/ Running; Cycling; Swimming; Rope skipping; Stepping, Aerobic dance exercise		3	10-12
10	Stretching exercise- upper body			3	20s each
11	Stretching exercise- legs body			3	20s each
12	Stretching exercise- back			3	20s each

The programme below should be followed from week 13 to week 24.

Ser No.	Exercise description	Exercise no	Intensity	No. of sets	Reps
1	Warm-up				
2	Upper body exercise			3	10-12
3	Leg exercise			3	10-12
4	Upper body exercise			3	10-12
5	Abdominal exercise			3	maximum
6	Back exercise			3	10-12
7	Leg exercise			3	10-12
8	Abdominal exercise			3	maximum
9	Cardiovascular activity	Jogging/ Running; Cycling; Swimming; Rope skipping; Stepping, Aerobic dance exercise		3	10-12
10	Stretching exercise- upper body			3	20s each
11	Stretching exercise- legs body			3	20s each
12	Stretching exercise- back			3	20s each

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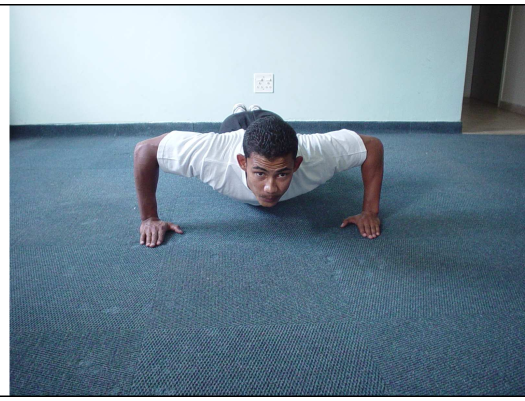
PART 2

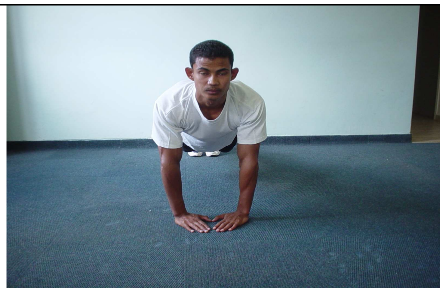
Formal exercises to develop upper body muscular strength and endurance

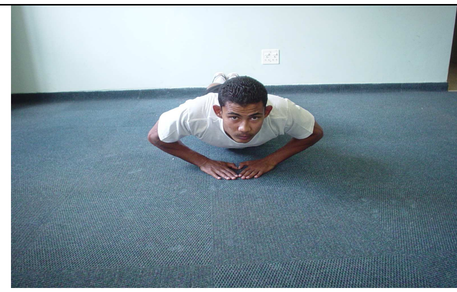
Body weight training exercises

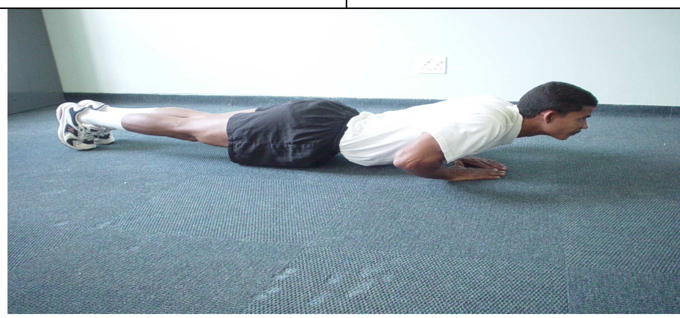
Exercise No 1: Normal push-ups	
Illustration	
	
Objective	To push the body up by straightening the arms at the elbow with hands shoulder width apart.
Primary Muscles	Pectoralis major, triceps and anterior deltoids
Starting Position/ Command	Front support, position, ready
Exercise Description	Keep the upper body and legs in a straight line with hands shoulder width apart. Keeping the knees rigid, flex the elbows and lower the body as a single unit until the chest is approximately 10 cm from the ground. Return to the starting position.
PTI Pointers	Avoid hyper extending the back. Keep the neck relaxed. Don’t turtle! Don’t rest all the weight on the wrist. Try to distribute it across all of the fingers. Go through the full range of motion. Beginner’s can do this exercise on the knees (easy), on an incline (easier) or against a wall (easiest).

Exercise No 2: Push-ups (hands together)

Illustration



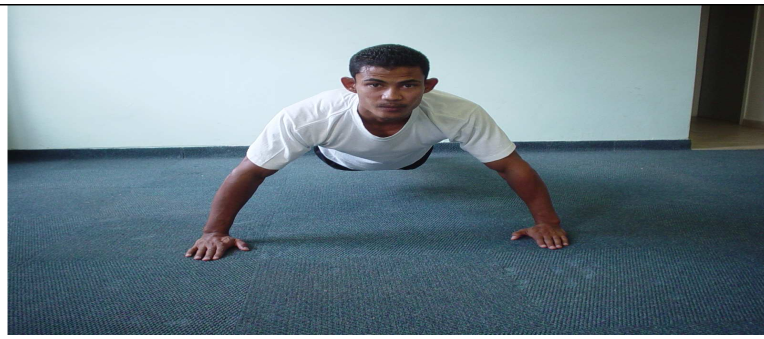


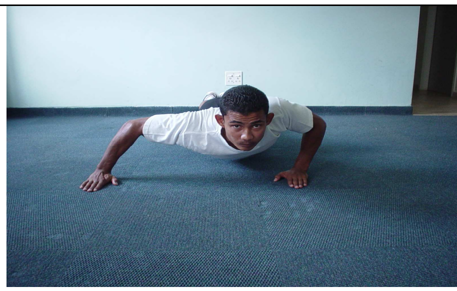


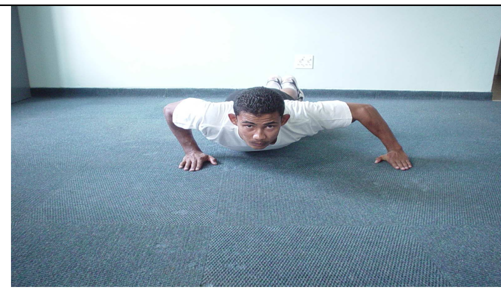
Objective	To push the body up by straightening the arms at the elbow with hand close together.
Primary Muscles	Pectoralis major, triceps and anterior deltoids
Starting Position/ Command	Front support, position, ready. Hands together.
Exercise Description	Keep the upper body and legs in a straight line with hands together forming a triangle. Keeping the knees rigid, flex the elbows and lower the body as a single unit until the chest is +/-10 cm from the ground. Return to the starting position.
PTI Pointers	Avoid hyper extending the back. Keep the neck relaxed. Don't turtle! Don't rest all the weight on the wrist. Try to distribute it across all of the fingers. Go through the full range of motion. Beginner's can do this exercise on the knees (easy), on an incline (easier) or against a wall (easiest).

Exercise No 3: Push-ups (alt. side to side)

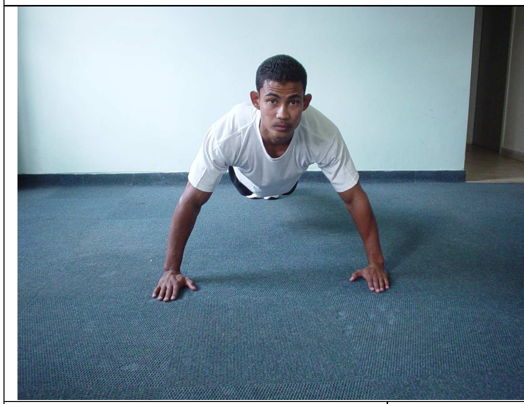
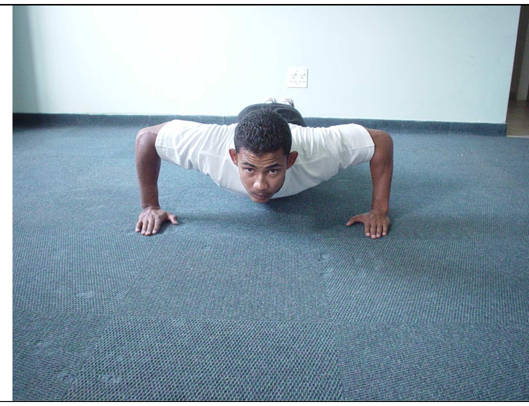
Illustration





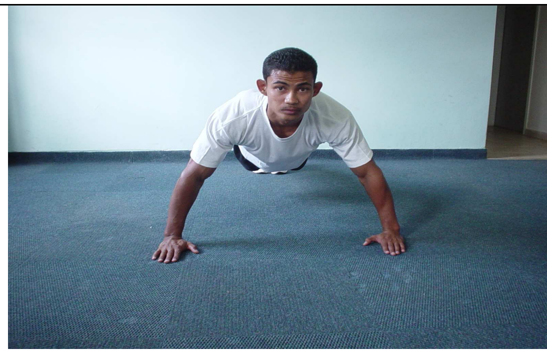


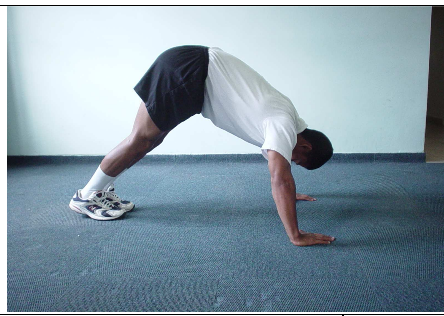
Objective	To push the body from side to side up by almost straightening the left arm at the elbow if moving to the right and by almost straightening the right elbow if moving to the left.
Primary Muscles	Pectoralis major, triceps and anterior deltoids
Starting Position/ Command	Front support, position, ready. Hands wide apart.
Exercise Description	Keep the upper body and legs in a straight line with hands wide apart. Keeping the knees rigid, flex the elbows and lower the body as a single unit to the right until the chest is approximately 10 cm from the ground then move whole body to the left.
PTI Pointers	Avoid hyper extending the back. Keep the neck relaxed. Don’t turtle! Don’t rest all the weight on the wrist. Try to distribute it across all of the fingers. Go through the full range of motion. Beginner’s can do this exercise on the knees (easy), on an incline (easier) or against a wall (easiest).

Exercise No 4: Push-ups (hands wide apart)	
Illustration	
	
Objective	To push the body up by straightening the arms at the elbow with hands wide apart.
Primary Muscles	Pectoralis major, triceps and anterior deltoids
Starting Position/ Command	Front support, position, ready. Hands wide apart.
Exercise Description	Keep the upper body and legs in a straight line with hands wide apart. Keeping the knees rigid, flex the elbows and lower the body as a single unit to the right until the chest is approximately 10 cm from the ground then move whole body to the left.
PTI Pointers	Avoid hyper extending the back. Keep the neck relaxed. Don't turtle! Don't rest all the weight on the wrist. Try to distribute it across all of the fingers. Go through the full range of motion. Beginner's can do this exercise on the knees (easy), on an incline (easier) or against a wall (easiest).

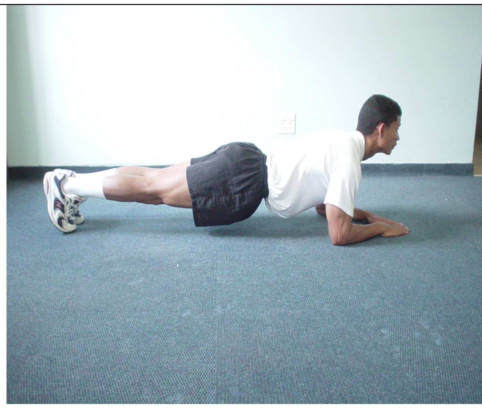
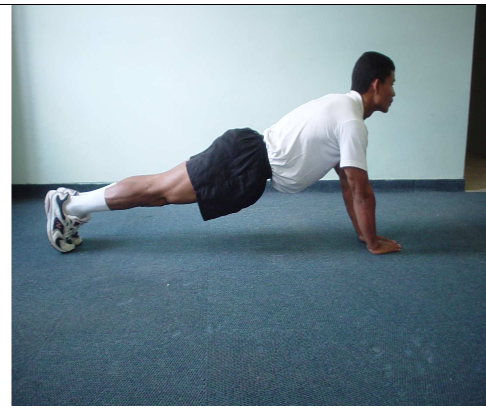
Exercise No 5: Shoulder press

Illustration

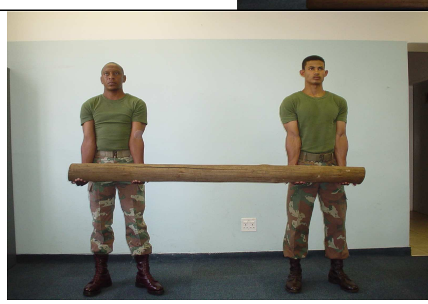
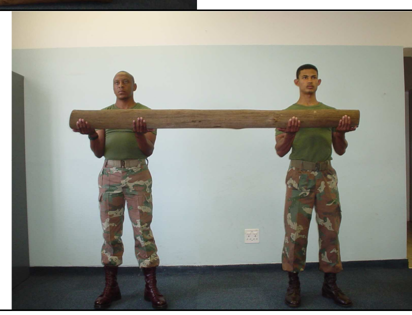




Objective	To push the upper body up by straightening the arms at the elbow with hands wide apart.
Primary Muscles	Deltoids and triceps
Starting Position/ Command	Front support, position, ready. Walk in with your feet.
Exercise Description	Keep the upper body and legs in a straight line with hands wide apart. Walk the feet in until body forms a 45-degree angle. Keeping the body in a piked position, flex the elbows and lower the upper body as far as possible without letting the head touch the ground. Straighten the arms an lock the elbows as the end position.
PTI Pointers	Keep the neck relaxed. Don’t turtle! Don’t rest all the weight on the wrist. Try to distribute it across all of the fingers. Go through the full range of motion. Beginner’s can do this exercise on an incline (easy) or against a wall (easiest).

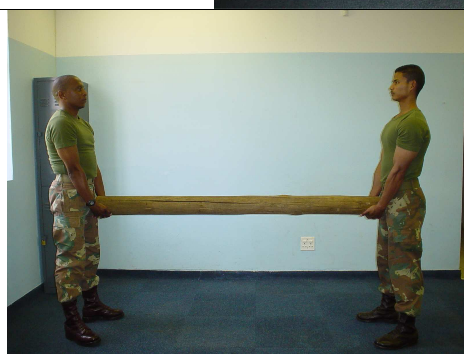
Exercise No 6: Tricep extension	
Illustration	
	
Objective	To push the body up by straightening the arms at the elbow with hands in a triangle form.
Primary Muscles	Triceps
Starting Position/ Command	Front support, position, ready. Elbows on the ground, hands together.
Exercise Description	Keep the upper body and legs in a straight line with elbows bent at 90-degrees, on the ground and hands in a triangle shape. Keeping the knees rigid, straighten the elbows and lift the body as a single unit to a locked elbow position. Return to the starting position.
PTI Pointers	Avoid hyper extending the back. Keep the neck relaxed. Don't turtle! Don't rest all the weight on the wrist. Try to distribute it across all of the fingers. Go through the full range of motion. Beginner's can do this exercise on the knees (easy), on an incline (easier) or against a wall (easiest).

Weight training (poles)

Exercise No 7: Bicep curls	
Illustration	
	
	
Objective	To flex the elbows.
Primary muscles	Biceps
Starting Position/ Command	Pole bicep curl, position ready.
Exercise Description	Grasp he pole with a shoulder-width (or slightly wider), palms-up grip. Feet are firmly planted and knees slightly bent. Keeping the upper arms against the sides of the body, curl the pole up by flexing at the elbow joint.
PTI Pointers	Keep the body still. Do not rock the body back. Keep wrists straight though the whole exercise. If can’t keep back from rocking, make sure the knees are kept soft. If that fails, let the exercise be executed standing against a wall utilise a lighter pole.

Exercise No 8: Upward Row

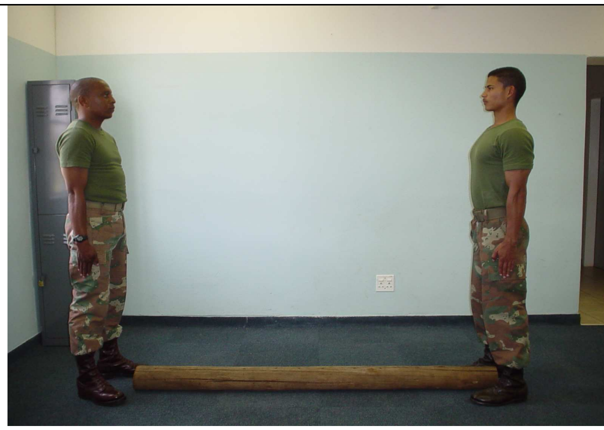
Illustration



Objective	To lift the upper arms, leading with the elbows.
Primary muscles	Trapezius, rhomboids and deltoids
Starting Position/ Command	Pole upright row, position ready.
Exercise Description	Face each other with pole in-between the legs keeping the pole very close to the body; pull the pole up until it is under the chin. At this point the elbows should be just below ear level. Lower back to starting position.
PTI Pointers	Do not swing the upper body. It should remain still. Lead with the elbows. Do not shrug shoulders towards the ears. Keep knees soft and relaxed.

Exercise No 9: Shoulder Shrugs

Illustration



Objective	To pull the shoulders up towards the ears while keeping the arms straight.
Primary muscles	Levator scapulae, trapezius and rhomboids.
Starting Position/ Command	Pole shoulder shrugs, position ready.
Exercise Description	Face each other with pole in-between the legs keeping the pole very close to the body and the elbows frozen; shrug the shoulders up towards the ears. Lower back to starting position.
PTI Pointers	Don't flex or extend the elbows. Don't roll the shoulders back and forth. The shoulders should elevate not rotate. Keep the pole extremely close to the body. Keep knees soft and relaxed.

Exercise No 10: Shoulder Rolls

Illustration

Objective	To rotate the pull the shoulders backwards while keeping the arms straight.
Primary muscles	Levator scapulae, trapezius and rhomboids.
Starting Position/ Command	Pole shoulder rolls, position ready.
Exercise Description	Face each other with pole in-between the legs keeping the pole close to the body and the elbows frozen; shrug the shoulders up towards the ears and rotate the upper arm backwards to starting position.
PTI Pointers	Don’t flex or extend the elbows. Keep the pole extremely close to the body. Go through the full range of motion. Keep knees soft and relaxed.

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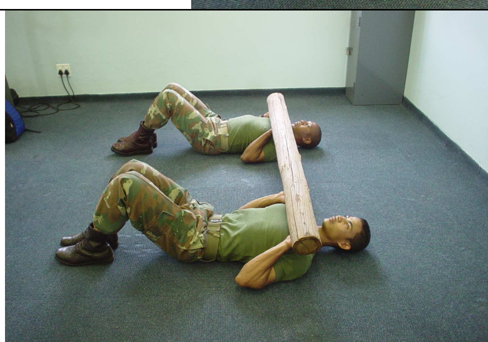
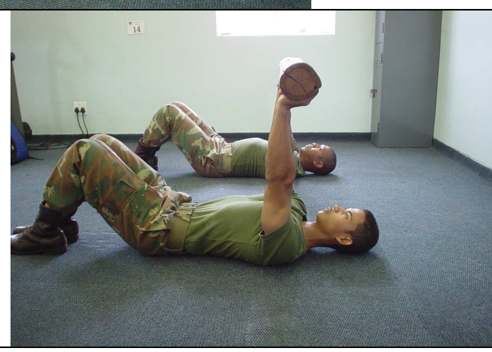
PART 3

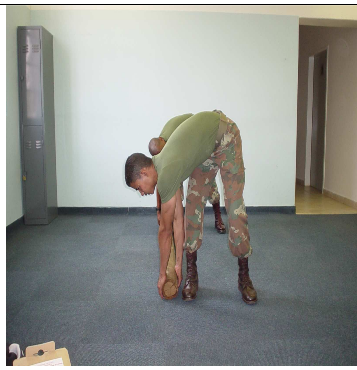
Exercise No 11: Chest Press

Illustration





Objective	To press the pole up by straightening the arms.
Primary muscles	Pectoralis major, anterior deltoid and triceps.
Starting Position/ Command	Pole chest press position ready.
Exercise Description	Lie in a sit up position. Grasp the pole with a shoulder-width (and no wider) grip. Press the pole upwards slowly and under control and then return to the starting position.
PTI Pointers	Keep the wrists rigid. Keep the shoulder blades down and together and a neutral arch in the lower back throughout the exercise. Watch for uneven arm elevation. Pole should be at about the midpoint of the sternum throughout the exercise.

Exercise No 12: Shoulder Press	
Illustration	
  	
 	
Objective	To press the pole overhead by straightening the arms.
Primary muscles	Deltoids
Starting Position/ Command	Pole shoulder press, position, ready.
Exercise Description	Two members in standing position with pole on the left hand side, feet shoulder width apart. Pick up pole and place on left shoulder. Press the pole up by straightening the arms elbows in a locked position at the furthest point of the exercise. Bend elbow and lower pole to the right shoulder. Repeat to place pole on left shoulder.

PTI Pointers	Keep neck in neutral position and do not turtle. Ensure good posture is maintained throughout the movement.

Exercise No 13: Pull-overs

Illustration

Objective	To move the upper arms parallel to the head.
Primary muscles	Serratus anterior
Starting Position/ Command	Pole pull-overs position ready.
Exercise Description	Lie in sit up position. Grasp pole with under grip and with straight arms pull pole overhead until the arms form a 90-degree angle with the torso. Return to starting position.
PTI Pointers	Keep the shoulder blades together and a natural arch in the lower back throughout the exercise.

Exercise No 14: Tricep Extension

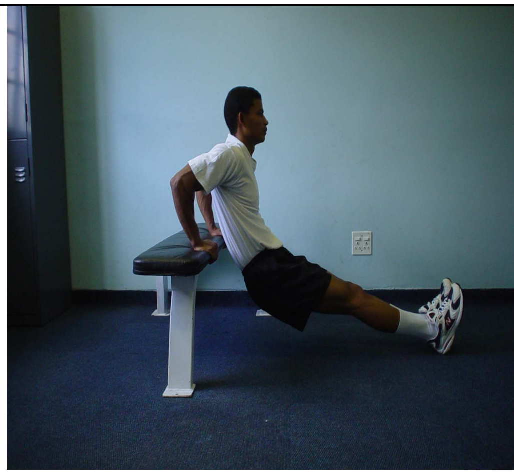
Illustration

Objective	To bend and straighten the arms at the elbow whist holding a pole.
Primary muscles	Triceps
Starting Position/ Command	Pole tricep extensions position ready
Exercise Description	Standing position holding pole in an under grip with elbows bent and as close to the ears as possible. Straighten the elbows and push the pole overhead. Return to bent elbow position.

PTI Pointers	Do not move the upper arms. Concentrate on moving at the elbow joint and flexing the triceps. Do not arch the back. Keep the knees soft.

informal exercises to develop upper body muscular strength and endurance

Body weight training exercises

Exercise No 15: Bench Dips	
Illustration	
	
Objective	To bend and straighten the arms at the elbow.
Primary muscles	Triceps
Exercise Description	Sit on bench with hands next to the hips. Legs straight lift body off the bench. Lower body by flexing the elbows to 90-degrees. Return to starting position by straightening arms at the elbows.
PTI Pointers	Do not move excessively at the hip joint, as the main axis of rotation is the elbow. Flex the elbow to 90-degrees. Keep the upper trapezius and neck relaxed. Make sure the hands are shoulder width apart.

Weight training (poles)

None

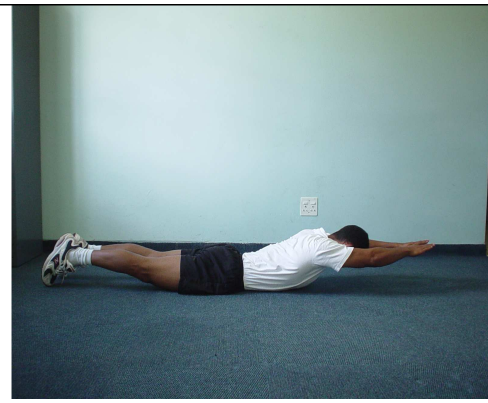
Weight training (poles and rope-informal)

Exercise No 16: Lateral Raise	
Objective	To lift the upper arms away from the body whist holding the rope connected to the pole
Primary muscles	Deltoids
Exercise Description	Hold rope in each hand palms facing the inside. Lift arms out to the side until they are shoulder level. Lower to starting position.
PTI Pointers	Keep the elbow joint soft, but straight. Do not tense the neck muscles. Do not turtle.
Exercise No 17: Frontal Raise (palms down)	
Objective	To lift the arms in front of the body whilst holding a pole.
Primary muscles	Anterior deltoid, serratus anterior
Exercise Description	Stand holding rope attached to poles with palms facing down and directly in front of the thighs. Raise arms in front of body with the elbow kept slightly bent. Return to start position.
PTI Pointers	Don't rock or twist the body. The spine should stay still and relaxed, as the shoulder is the only axis of rotation. Keep the wrist rigid. Do not flex or extend the elbow. Keep it frozen. Keep the knees soft and relaxed.
Exercise No 18: Frontal Raise (palms up)	
Objective	To lift the arms in front of the body whilst holding a pole.
Primary muscles	Anterior deltoid, serratus anterior
Exercise Description	Stand holding rope attached to pole with palms facing up and directly in front of the thighs. Raise arms in front of body with the elbow kept slightly bent. Return to start position.

PTI Pointers	Don't rock or twist the body. The spine should stay still and relaxed, as the shoulder is the only axis of rotation. Keep the wrist rigid. Do not flex or extend the elbow. Keep it frozen. Keep the knees soft and relaxed.

Formal exercises to develop back muscular strength and endurance

Body weight training exercises

<table>
<tr><th colspan="2">Exercise No 19: Back Extension on floor (upper body)</th></tr>
<tr><td colspan="2">Illustration</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Objective</td><td>To lift the upper torso 20-30cm from the floor by activating the erector spinae muscles.</td></tr>
<tr><td>Primary muscles</td><td>Spinal erectors (erector spinae) and lower back muscles</td></tr>
<tr><td>Starting Position/ Command</td><td>Lie on your stomach, arms extended to the front, position ready.</td></tr>
<tr><td>Exercise Description</td><td>Lie on your front in neutral with your arms straight and extending forward and the tip of your nose on the floor. Keep your pelvis in neutral and your legs extending along the floor. Draw your abdominals in and engage your pelvic floor muscles to maintain neutral and prevent the lower back from curving inward too much. Slowly raise your arms off the floor. Lower your arms back to the floor.</td></tr>
<tr><td>PTI Pointers</td><td>Keep the pelvis firmly pressed against the floor.

Avoid rotating, twisting or hyper extending the lumbar spine any time during the exercise.

Work slowly, and keep tension in the erector spinae.

Keep the head and neck in a neutral position.</td></tr>
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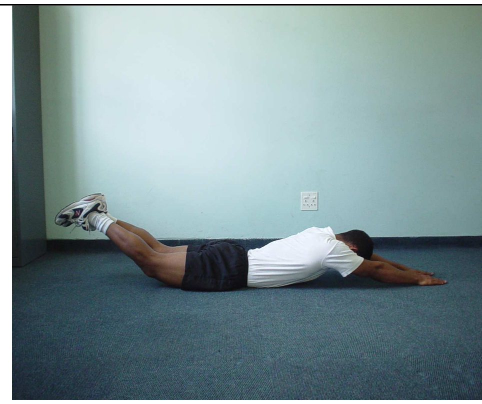
Exercise No 20: Back Extension on floor (just legs)	
Illustration	
	
Objective	To lift the legs 20-30cm from the floor by activating the erector spinae muscles.
Primary muscles	Spinal erectors (erector spinae) and lower back muscles
Starting Position/ Command	Lie on your stomach, arms extended to the front, position ready.
Exercise Description	Lie on your front in neutral with your arms straight and extending forward and the tip of your nose on the floor. Keep your pelvis in neutral and your legs extending along the floor. Draw your abdominals in and engage your pelvic floor muscles to maintain neutral and prevent the lower back from curving inward too much. Slowly raise your legs off the floor. Lower your legs back to the floor.
PTI Pointers	Keep the pelvis firmly pressed against the floor. Avoid rotating, twisting or hyper extending the lumbar spine any time during the exercise. Work slowly, and keep tension in the erector spinae. Keep the head and neck in a neutral position.

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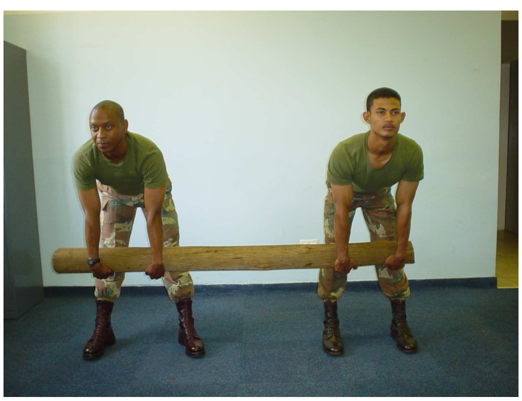
PART 4

Exercise No 21: Back Extension on floor (opposite leg with opposite arm)	
Illustration	
	
Objective	To simultaneously lift the opposite arm and opposite leg 20-30cm from the ground by activating the erector spinae muscles
Primary muscles	Spinal erectors (erector spinae) and lower back muscles
Starting Position/ Command	Lie on your stomach, arms extended to the front, position ready.
Exercise Description	Lie on your front in neutral with your arms straight and extending forward and the tip of your nose on the floor. Keep your pelvis in neutral and your legs extending along the floor. Draw your abdominals in and engage your pelvic floor muscles to maintain neutral and prevent the lower back from curving inward too much. Slowly raise your left leg and right arm off the floor. Lengthen through the arm and leg as you lift. Keep your right shoulder stable and not hunched toward your head. Alternate right arm and left leg with left arm and right leg.
PTI Pointers	Keep the pelvis firmly pressed against the floor. Avoid rotating, twisting or hyper extending the lumbar spine any time during the exercise. Work slowly, and keep tension in the erector spinae. Keep the head and neck in a neutral position.

Weight training (poles)

Exercise No 22: Dead Lift

Illustration



Objective	To lift the pole by activating the back muscles in order to straighten the torso to an upright position
Primary muscles	Lower back, trapezius, gluteus, quadriceps
Starting Position/ Command	Pole dead lift, position ready.

Exercise Description	Stand facing the pole with your feet slightly spread. Keep your back motionless and a little arched. Flex your knees until your thighs are almost parallel to the floor. Take an overhead grip on the pole, with your hands slightly more than shoulder width apart. Inhale, contract your abdominal and low back muscles, and lift the pole by straightening your legs (contracting your abdominals and keeping your back straight), raising it in front of your shins. When the pole reaches your knees, extend your torso so you are standing erect with your arms straight down at your sides, exhaling as you complete the movement. Hold this straightened position for 2 seconds, and then return the pole to the floor, making sure you do not hyperextend or arch your back.
PTI Pointers	Keep the hands and arms as relaxed as possible, and concentrate on pulling the back muscles. Keep the head and neck in a neutral position. Keep the knees soft. Make sure your back is never rounded throughout the movement. In any movement, whenever you use heavy weight, you must 'block'. Stick out your chest by taking a deep breath and filling your lungs with air like a balloon. In this way, you will stiffen your rib cage and prevent your upper torso from bending forward. Contract all the abdominal muscles to increase intra-abdominal pressure so your shoulders are pulled back when you are in the top position of the movement. Finally, contract the lower back muscles to arch your lower back and extend the bottom of the spine. These 3 simultaneous actions are called blocking. Their function is 2 avoid rounding the back (or flexing the spine) which may cause a slipped disk if you work with heavy weight.

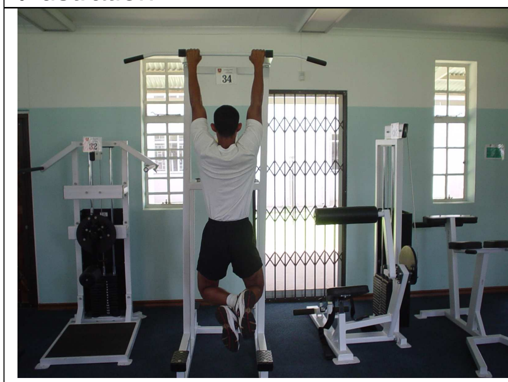
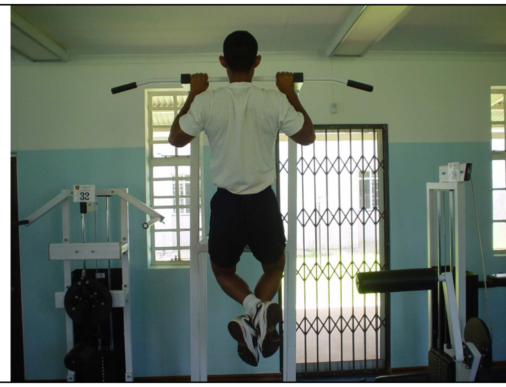
Exercise No 23: Bent Over Row

Illustration

Objective	To lift the pole by pulling the shoulder blades in towards the spine.
Primary muscles	Latissimus dorsi, teres major, posterior deltoids, arm flexors, biceps, brachialis, brachioradialis
Starting Position/ Command	Pole bent over row, position ready.
Exercise Description	Stand with your knees slightly flexed. Bend your torso at an angle of about 45 degrees, keeping your back straight. Take an overhand grip on the pole with your hands more than shoulder width apart and your arms dangling straight down from your shoulders. Inhale, contract your abdominals isometrically, and pull the pole straight up until it touches your chest. Return to starting position – exhale.
PTI Pointers	Make sure your back is never rounded throughout the movement. Concentrate on pulling the shoulder blades in towards the spine and down towards the lower back. Don’t turtle. Don’t swing the pole. Do not twist the torso. Keep the neck straight to keep the cervical vertebrae in a neutral position.

Informal exercises to develop back muscular strength and endurance

Body weigth training exercises

Exercise No 24: Pull-ups	
Illustration	
	
Objective	To lift the body with the arms and the back.
Primary muscles	Latissimus dorsi, teres major, biceps, brachialis, trapezius, rhomboids, pectorals.
Exercise Description	Extend your arms and take an underhand grip on the bar with your hands more than shoulder width apart. Inhale, and stick your chest out to pull yourself upward until your chin I as the level of the bar. Exhale as you complete the movement.
PTI Pointers	Don't hunch forwards. Keep the head up. Focus on the motion of the scapula, which should be back and down. Advanced exercise.

Weight training (poles)

None

Weight training (poles and rope)

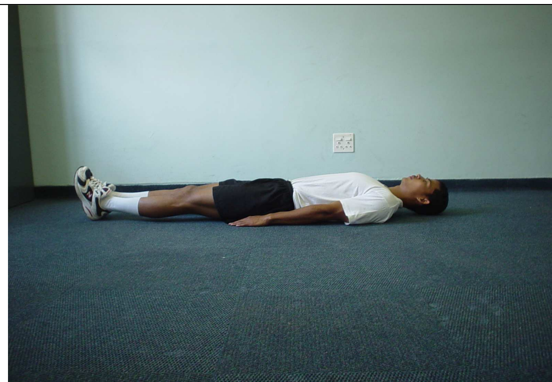
None

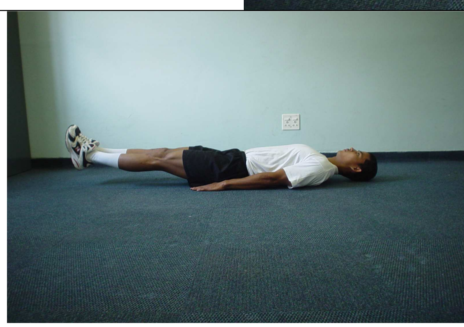
Formal exercises to develop abdominal muscular strength and endurance

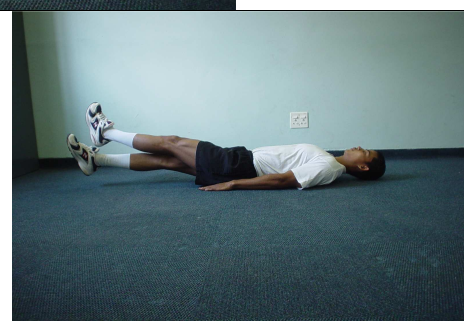
Body weight training exercises

Exercise No 25: Scissors

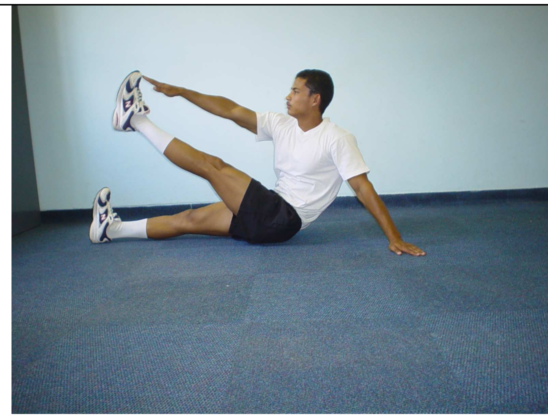
Illustration

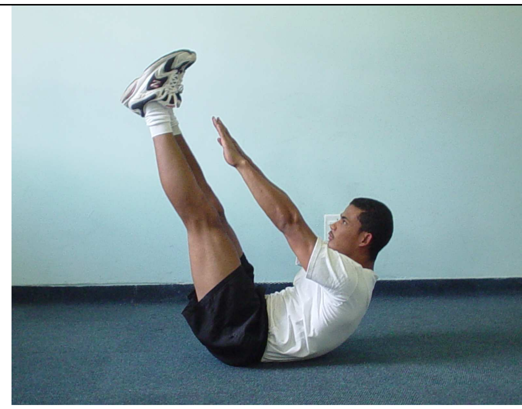






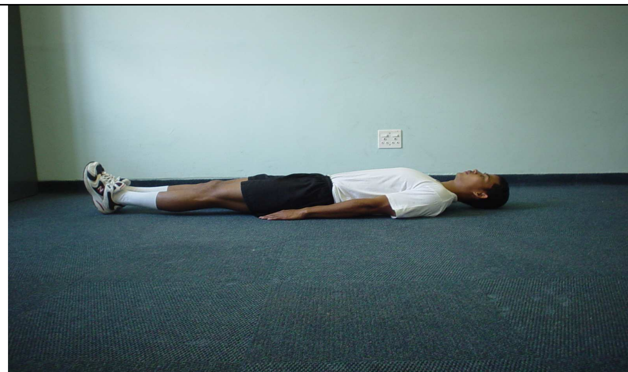
Objective	To cross the legs over each other in a lying position.
Primary muscles	Iliopsoas, rectus femoris and transverse oblique.
Starting Position/ Command	Lie on your back, arms at the sides, position ready.
Exercise Description	Lie on the back with arms straight next to the sides. Lift straight legs 10cm from the ground. Open straight legs to the side and then close them and place the left leg over the right. Open the legs again then close them and place right leg over the left.
PTI Pointers	Work slowly and keep tension in the abdominals. Concentrate on pulling the belly button to the floor and keeping the rib cage down. Keep the head and neck in a neutral position.

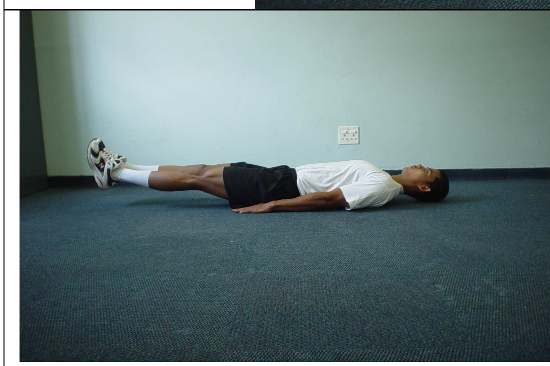
Exercise No 26: Alt. Jack Knives	
Illustration	
	
Objective	Lift alt. arm and alt. leg to touch each other.
Primary muscles	Rectus abdominis, Rectus femoris, internal obliques.
Starting Position/ Command	Lie on your back, arms extended, position ready.
Exercise Description	Lie on your back, arms extended lift opposite arm and opposite leg towards each other. Return to start position.
PTI Pointers	Advanced abdominal exercise. Do not rotate or flex the neck. Keep the transverse abdominis activated. Keep the leg straight. The axis of rotation is the hip.

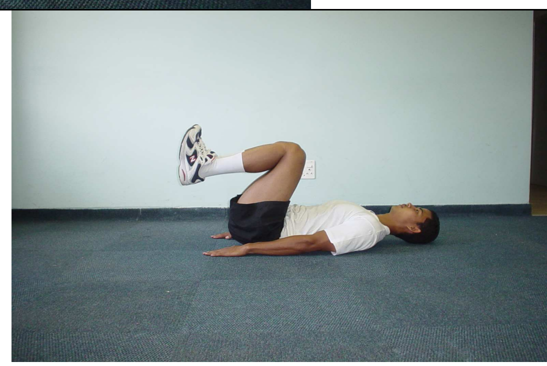
Exercise No 27: Jacknives	
Illustration	
	
Objective	Lift torso and straight legs towards each other.
Primary muscles	Rectus abdominis, Rectus femoris, internal obliques.
Starting Position/ Command	Lie on your back, arms extended, position ready.
Exercise Description	Lie on your back, arms extended lift torso and straight legs towards each other with arms held alongside the torso. Return to start position.
PTI Pointers	Advanced abdominal exercise. Do not rotate or flex the neck. Keep the transverse abdominis activated. Keep the leg straight. The axis of rotation is the hip.

Exercise No 28: Hip Flexors

Illustration



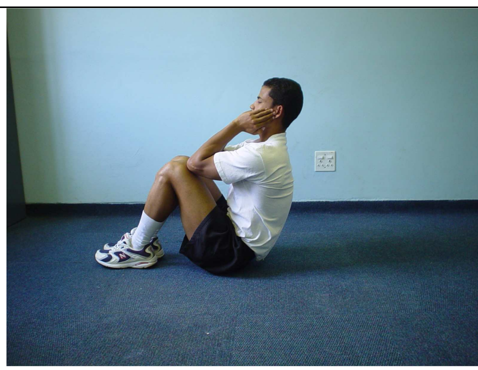


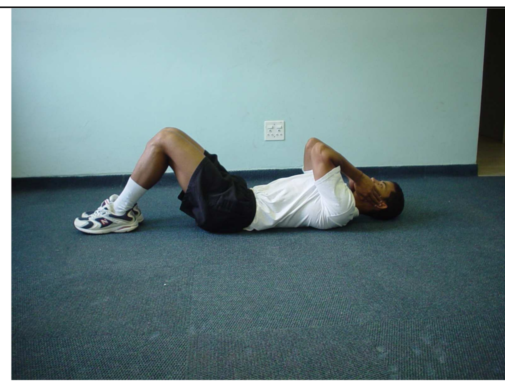


Objective	To lift both bent legs by flexing the hip.
Primary muscles	Iliopsoas, rectus femoris.
Starting Position/ Command	Lie on your back, arms next to the side, position ready.
Exercise Description	Lie on your back with straight legs and arms next to the side. Flex the hip and lift both legs of the floor to a 90-degree bend knee position so that the upper leg is perpendicular to the torso. Return to starting position.
PTI Pointers	Keep the lower pressed firmly against the floor. Keep the shoulder blades down and together throughout the exercise. Keep the head and neck in a neutral position throughout the exercise.

Exercise No 29: Sit-ups

Illustration

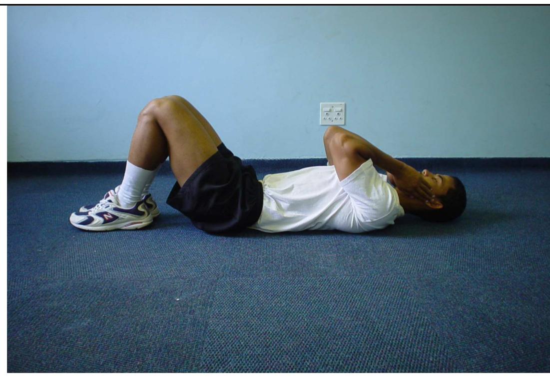


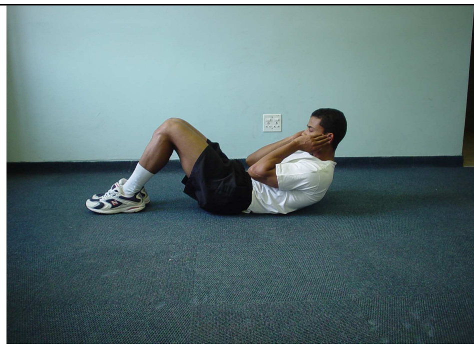


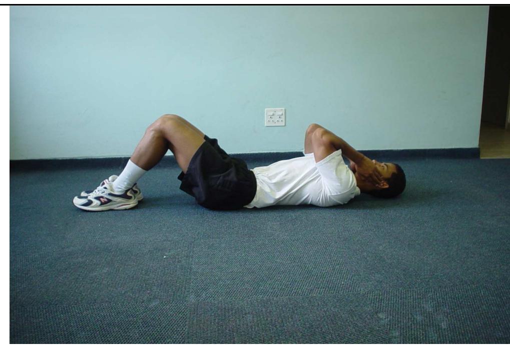
Objective	To lift the shoulder of the ground and lift the torso to the knee.
Primary muscles	Rectus abdominis, obliques and hip flexors
Starting Position/ Command	Sit-up, position, ready!
Exercise Description	Lie on the back with legs bent and feet on the floor. Place hands alongside the ears. Inhale and curl the torso off the floor until the elbow touch the knees, exhale as the movement is completed. Return to the starting position without resting the torso on the floor.
PTI Pointers	For more balance allow another learner to hold the feet. Extend arms forward to make the exercise easier. Perform the exercise on a decline to make it easier and on an incline to increase the intensity.

Exercise No 30: Crunches

Illustration







Objective	To shorten the torso moving the pubis closer to the breastbone by deliberately contracting the abdominals.
Primary muscles	Rectus abdominis.
Starting Position/ Command	Crunch position ready.
Exercise Description	Lie on the back with legs bent and feet on the floor. Place hands alongside the ears. Inhale and curl the torso off the floor (approximately 30cm off the floor), exhale as the movement is completed. Return to the starting position without resting the torso on the floor.
PTI Pointers	For more balance allow another learner to hold the feet. Extend arms forward to make the exercise easier. Perform the exercise on a decline to make it easier and on an incline to increase the intensity.

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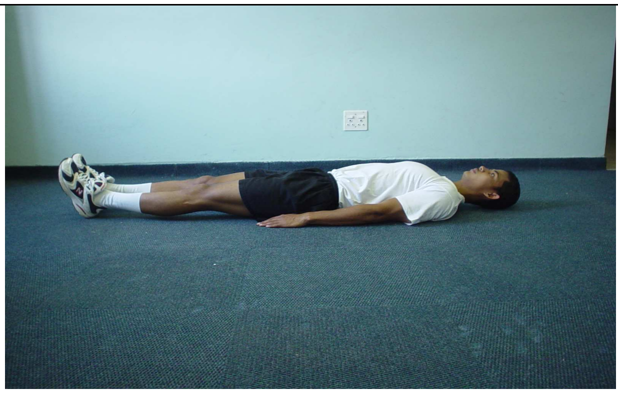
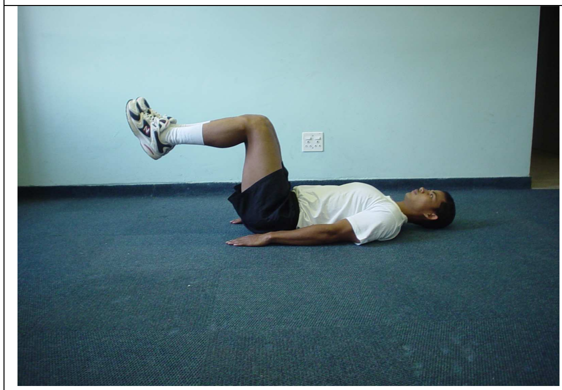
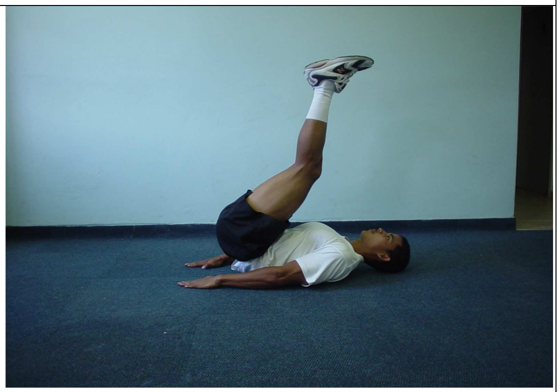
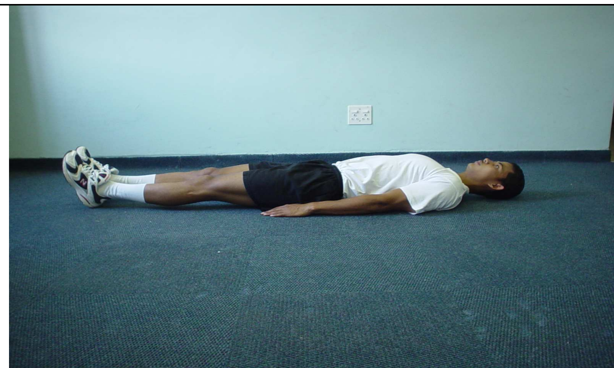
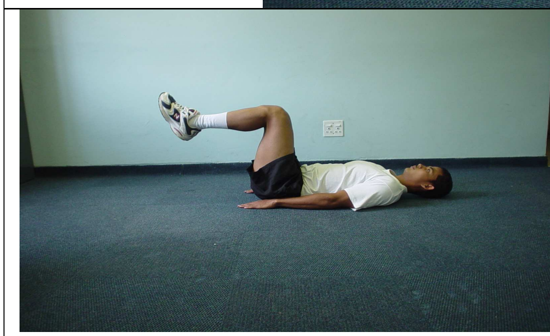
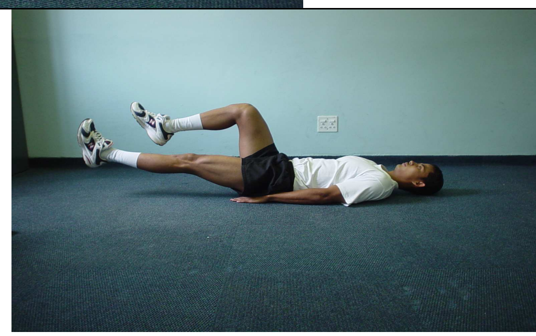
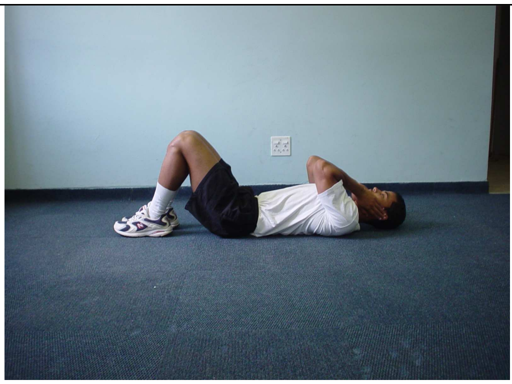
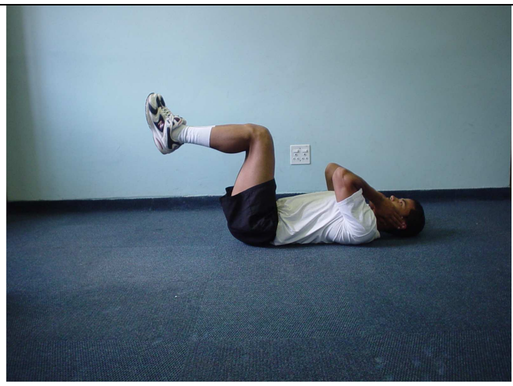
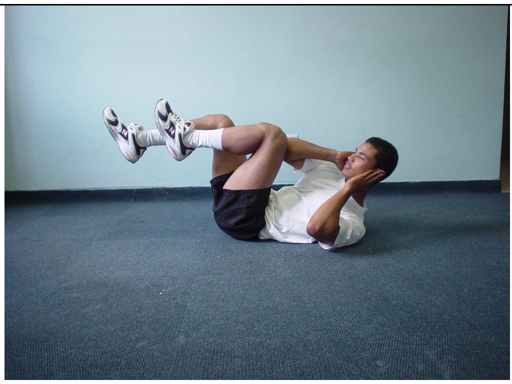
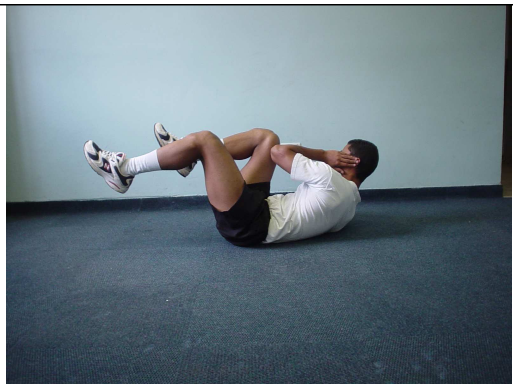
Exercise No 31: Reverse Crunch	
Illustration	
	
	
Objective	To move the pelvis towards the rib cage.
Primary muscles	Rectus abdominis
Starting Position/ Command	Lie on your back, arms next to the side, position, ready.
Exercise Description	Lie on the back with feet on the floor and knees flexed at 90-degrees. Place hands next to the side. Keeping the knees at 90-degrees of flexion, lift the feet off upwards.
PTI Pointers	Feel each vertebrae lifting off the floor. Don't move the thighs back and forth. The objective is to lift the pelvis, not the legs. Keep the neck and shoulders relaxed. Keep the transvers abdominis tight. Lower the pelvis very slowly.

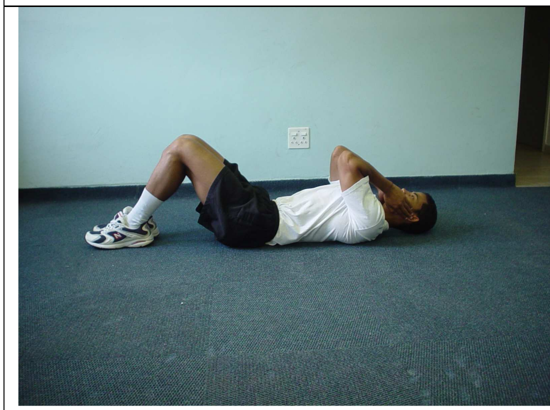
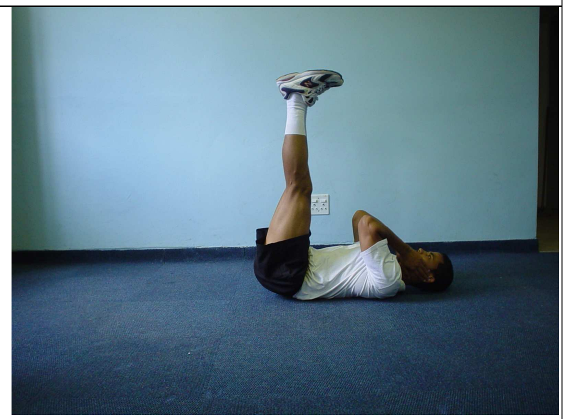
Exercise No 32: Single Hip Flexion	
Illustration	
	
	
Objective	To lift and lower the leg by flexing the hip.
Primary muscles	Rectus abdominis.
Starting Position/ Command	Lie on your back, arms next to the side, position, ready.
Exercise Description	Lie on the back. Lift the feet off the floor and flex the knees to 90 degrees. Keep the natural curve of the lower back. Tighten the transverse abdominis. Straighten the left leg to 45 degrees of flexion. Keeping the left leg frozen, move the left leg towards the floor until the heel almost touches the floor. Return to the starting position.
PTI Pointers	Keep the transverse abdominis tight. Keep the knee frozen. The axis of rotation is the hip. Be sure that the natural curve of the back is maintained. Beginners should do this exercise with the knee of the working leg flexed at 90-degrees. The straighter the leg, the more difficult the exercise.

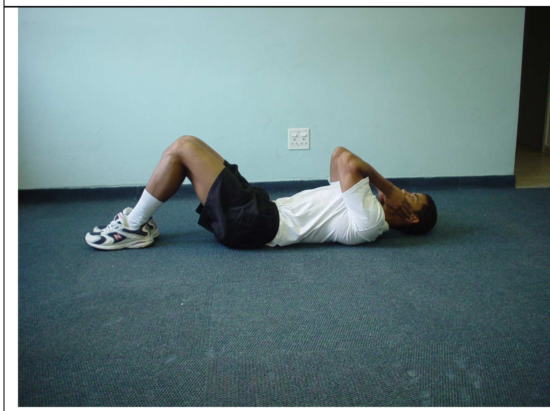
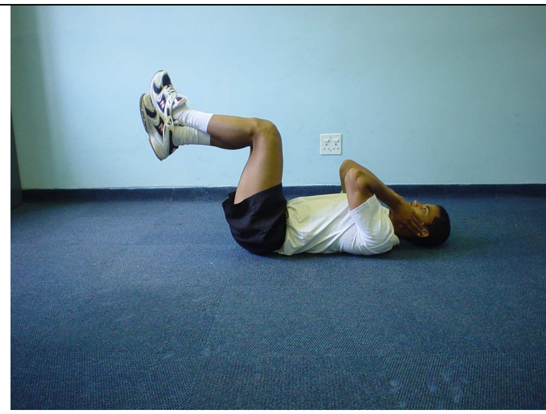
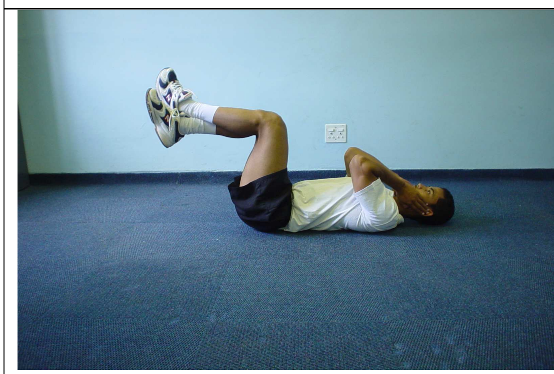
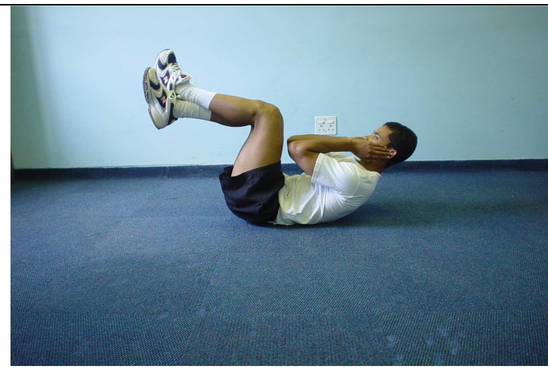
Exercise No 33: Bicycle Crunch

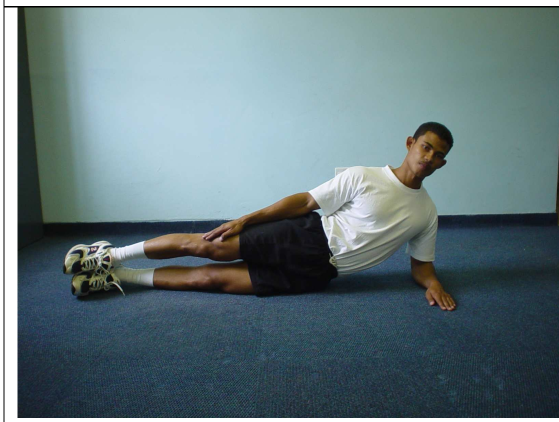
Illustration

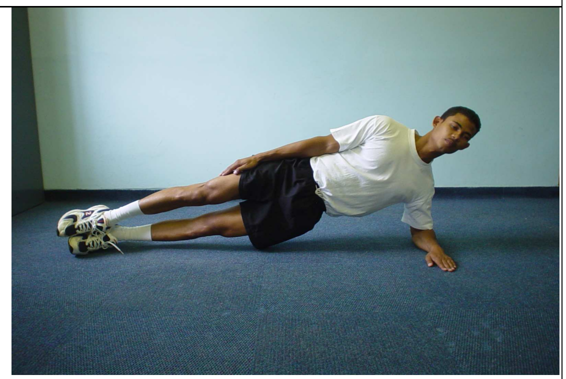
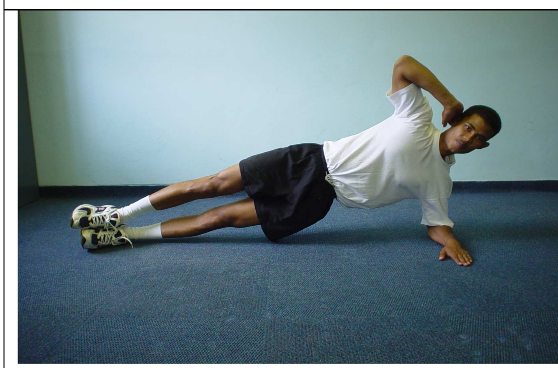





Objective	To lift and rotate the shoulder and the opposite thigh by flexing the spine.
Primary muscles	Rectus abdominis
Starting Position/ Command	Bicycle crunch position, ready.
Exercise Description	Lie on the back with the knees bent. Place hands next to the ears. Lift the feet off the floor. Tilt the pelvis up and press the lower back down. Begin with the knees at 90-degrees of flexion and the hands next to the ears. Lift and twist the right shoulder while bringing the left knee in to meet it. Repeat for the required number of repetitions. Switch sides.
PTI Pointers	Don't rotate or flex the neck. Focus on rotating the spine. Keep the transverse abdominis activated.

Exercise No 34: Straight Leg U Crunches	
Illustration	
	
Objective	To lift and rotate the pelvis towards the rib cage while lifting the shoulders off the ground.
Primary muscles	Rectus abdominis
Starting Position/ Command	Straight leg U crunch, position ready.
Exercise Description	Lie on the back. Place hands next to the ears. Lift the feet off the floor and straighten the legs so that the heels are facing the ceiling. Tighten the transverse abdominis. Keeping the knees rigid, lift the pelvis towards the ceiling.
PTI Pointers	Relax the neck and shoulders. Do the exrcise slowly and under control.

Exercise No 35: Bent Knee U Crunch	
Illustration	
	
	
Objective	To lift the pelvis and ribcage towards each other.
Primary muscles	Rectus abdominis
Starting Position/ Command	Bent knee U crunch, position, ready.
Exercise Description	Lie on the back. Flex the knees to 90-degrees and lift the feet off the ground. Place hands next to the ears. Simultaneously lift the shoulders and pelvis towards each other. Return to start position.
PTI Pointers	Keep the neck relaxed. Do not bounce the pelvis of the ground. This should be a controlled lift. Keep the transverse oblique activated.

Exercise No 36: Side Lift-hold	
Illustration	
	
Objective	Lift body off the floor balancing it on forearm and inside foot
Primary muscles	External oblique
Starting Position/ Command	Lie on your stomach, arms next to the side, position ready.
Exercise Description	Lie on side with forearm perpendicular to the upper arm and upper arm at 45-degrees to the torso. Contracting the abdominal muscles and keeping the body rigid lift the whole side of the body off the floor to increase the upper-arm angle to 90-degrees. Return to starting position without resting the body on the ground.
PTI Pointers	Keep the abdominal muscles active throughout. Ensure that the body is kept in a straight line throughout the exercise.

Exercise No 37: Side Lift-hold and Twist	
Illustration	
	
	
Objective	Lift body off the floor balancing it on forearm and inside foot
Primary muscles	External obliques, internal obliques.
Starting Position/ Command	Lie on your stomach, arms next to the side, position ready.
Exercise Description	Lie on side with forearm perpendicular to the upper arm and upper arm at 45-degrees to the torso. Contracting the abdominal muscles and keeping the body rigid lift the whole side of the body off the floor to increase the upper-arm angle to 90-degrees. Place upper hand next to the ear and twist upper elbow towards the ground and back again.
PTI Pointers	Keep the abdominal muscles active throughout. Ensure that the body is kept in a straight line throughout the exercise. The twisting movement is a controlled slow movement.

Weight training (poles)

Exercise No 38: Sit-ups	
Illustration	
	
Objective	To lift the shoulder of the ground and lift the torso to the knee whilst holding a pole.
Primary muscles	Rectus abdominis, obliques and hip flexors
Starting Position/ Command	Pole sit-up, position, ready!
Exercise Description	Lie on the back with legs bent and feet on the floor. Hold pole against the chest between the forearm nd upper arms. Inhale and curl the torso off the floor until the elbows touch the knees, exhale as the movement is completed. Return to the starting position without resting the torso on the floor.
PTI Pointers	For more balance allow another learner to hold the feet. Extend arms forward to make the exercise easier. Perform the exercise on a decline to make it easier and on an incline to increase the intensity.

informal exercises to develop abdominal muscular strength and endurance

None.

Weight training (poles)

None

Weight training (poles and rope)

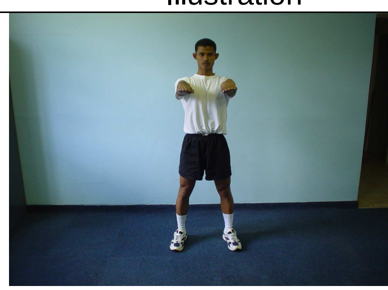
None

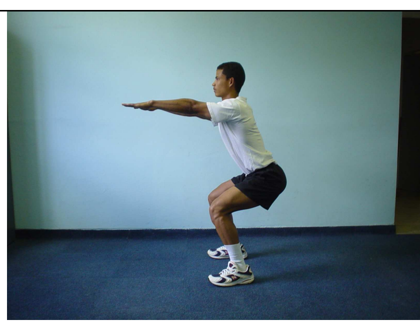
Formal exercises to develop leg muscular strength and endurance

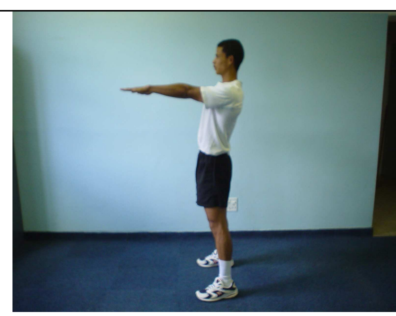
Body weight training exercises

Exercise No 40: Squats

Illustration







Objective	To bend the knees in a slow controlled manner until the thighs is parallel to the ground by looking straight ahead with the chest out and the back flat
Primary muscles	Gluteus, quadriceps, hamstrings, adductors, spinal erectors, abdominals.
Starting Position/ Command	Straddle stand, arms extended to the front, position ready.

Exercise Description	Stand with the feet shoulder width apart (the feet should point slightly outward). Bend the legs in a slow controlled manner, until the thighs are parallel to the ground. While bending, keep looking straight ahead, with the chest out and the back flat
PTI Pointers	Bend knee no further than 90 degrees. Keep the back straight. Once thighs are parallel to the floor, extend your legs and straighten your torso to return to the starting position.

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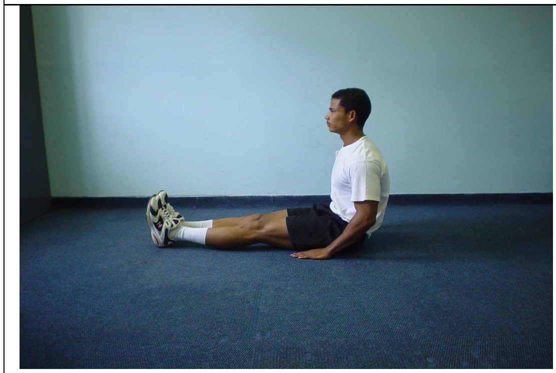
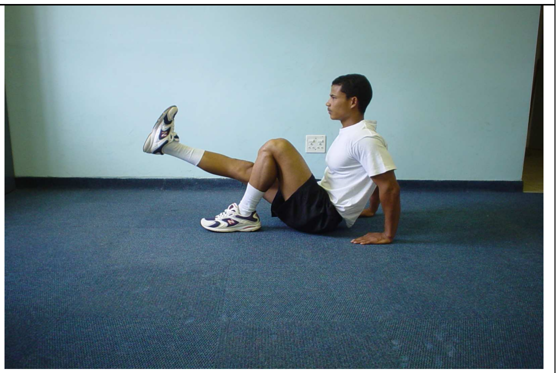
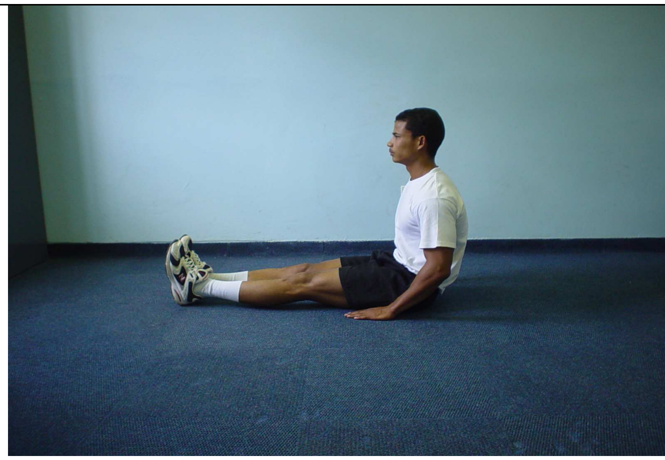
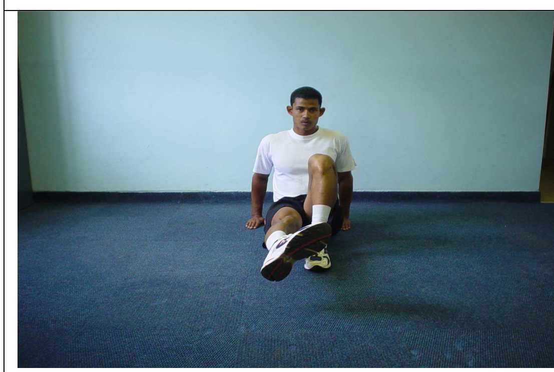
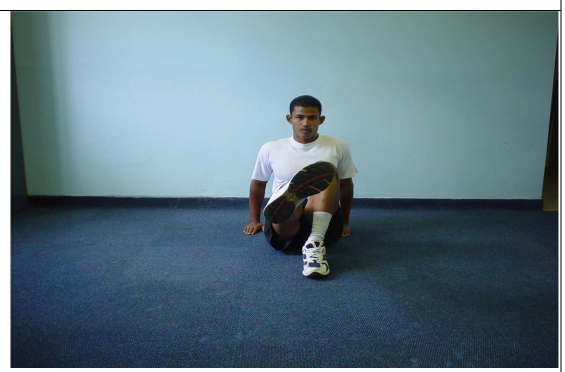
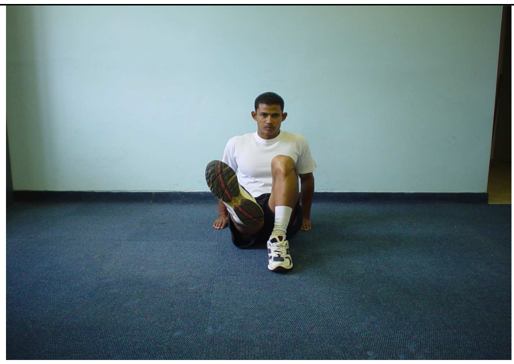
PART 6

Exercise No 41: Sitting single straight leg raise	
Illustration	
	
	
Objective	Activating the quadriceps muscle and lifting the straight leg 30cm from the ground with the foot in a normal position.
Primary muscles	Quadriceps
Starting Position/ Command	Sit, hands on the ground, position, ready.
Exercise Description	Lift straight leg 45-deg30cm from the ground. Sit on the ground with the legs forward, hands next to the side. Lift one leg with a dorsiflexed ankle, foot in a normal position and extended knee. During the exercise the opposite knee must be bend 90 degrees.
PTI Pointers	Ensure that the weight is distributed on to the arms and not onto the lower back. It is not necessary to lift the foot higher than 30cm from the ground. Keep the leg straight throughout the movement.

Exercise No 42: Sitting single straight leg raise (foot position turned in)	
Illustration	
	
	
Objective	Activating the quadriceps muscle and lifting the straight leg 30cm from the ground with the foot turned inwards.
Primary muscles	Quadriceps
Starting Position/ Command	Sit, hands on the ground, position, ready.
Exercise Description	Sit on the ground with the legs forward, hands next to the side. Lift one leg with the foot turned in (inversion) and keep the knee extended. During this exercise the opposite knee must be bent 90 degrees.
PTI Pointers	Ensure that the weight is distributed on to the arms and not onto the lower back. It is not necessary to lift the foot higher than 30cm from the ground. Keep the leg straight throughout the movement.

Exercise No 43: Sitting single straight leg raise (foot position turned out)

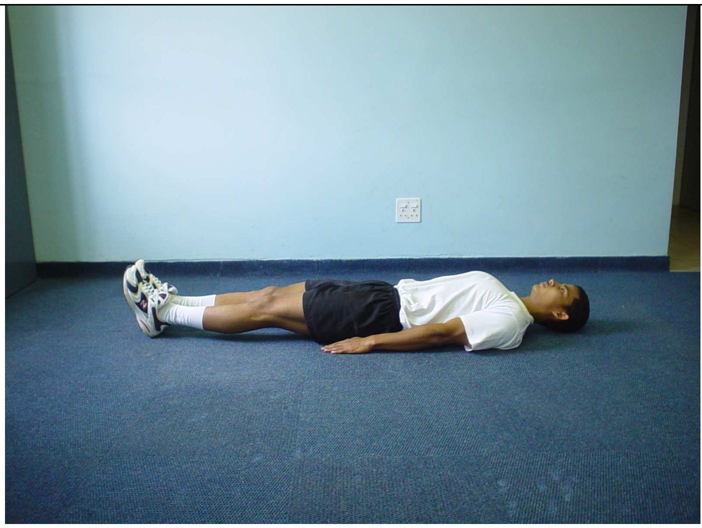
Illustration



Objective	Activating the quadriceps muscle and lifting the straight leg 30cm from the ground with the foot turned outwards.
Primary muscles	Quadriceps
Starting Position/ Command	Sit, hands on the ground, position, ready.
Exercise Description	Sit on the ground with the legs forward, hands next to the side. Lift one leg with the foot turned out (eversion) and keep the knee extended. Opposite knee must be bent 90 degrees.
PTI Pointers	Ensure that the weight is distributed on to the arms and not onto the lower back. It is not necessary to lift the foot higher than 30cm from the ground. Keep the leg straight throughout the movement.

Exercise No 44: Abduction Leg Raise

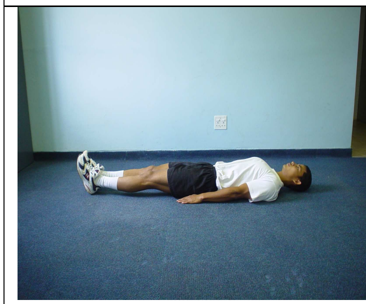
Illustration

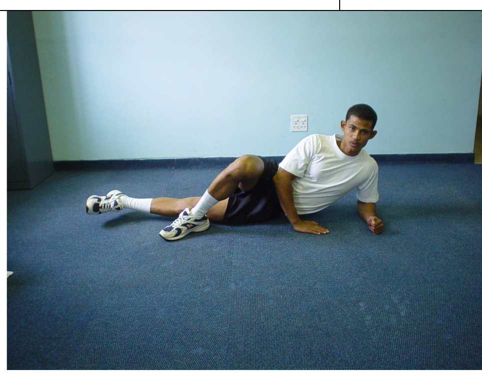
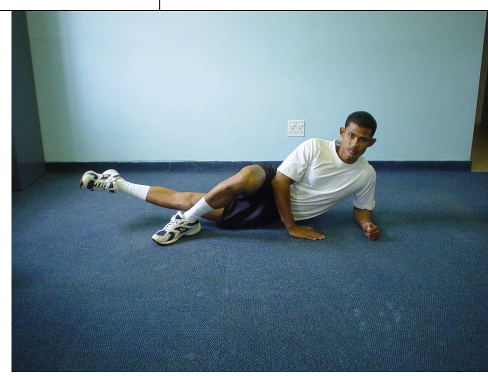


Objective	Hip abduction. Lifting the leg up.
Primary muscles	Abductors, gluteus medius and gluteus minimus
Starting Position/ Command	Lie on your back, arms next to the side, position ready.
Exercise Description	Lie on your side with your head and shoulders in line. Lift your leg to an angle of 70 degrees (at the most) of the floor always keeping your knee extended. Return to the starting position and repeat.
PTI Pointers	Always keep the knee extended Controlled slow movement

Exercise No 45: Adduction Leg Raise

Illustration

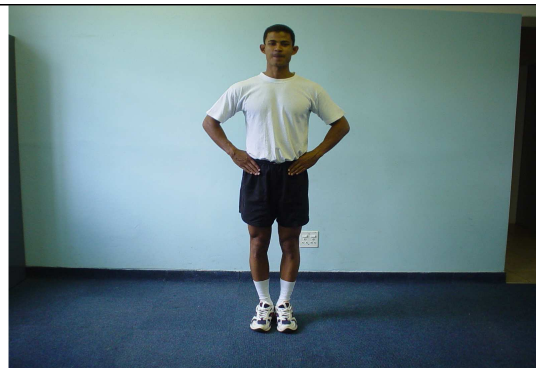


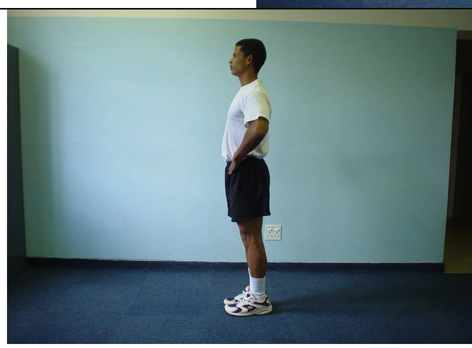




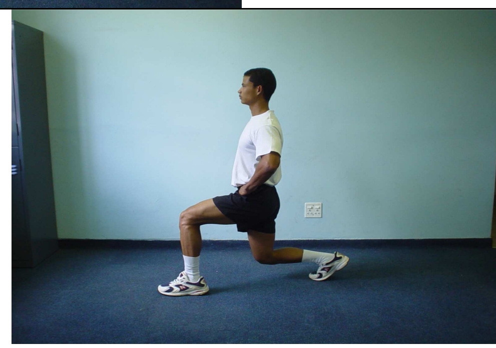
Objective	Hip adduction. Lifting the bottom leg up.
Primary muscles	Adductors (adductor longus, adductor magnus, gracilis)
Starting Position/ Command	Lie on your back, arms next to the side, position ready.
Exercise Description	Lie on the floor with your head and shoulders in line. Keep one leg straight and cross the opposite leg over the straight leg. Lift the straight leg 6-8 cm of the floor, always keeping your knee extended.
PTI Pointers	Always keep the knee extended Controlled slow movement

Exercise No 46: Lunges

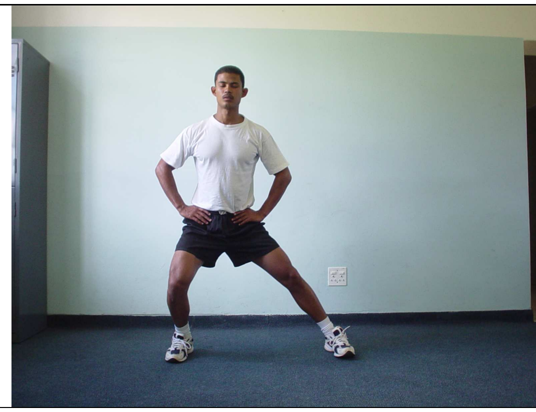
Illustration

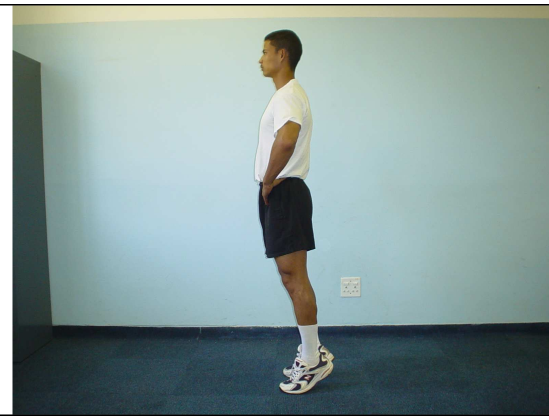


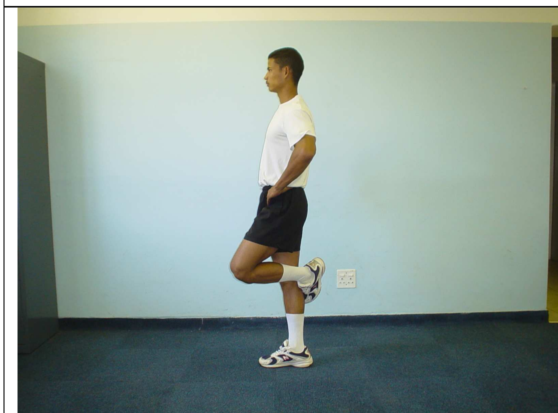




Objective	To lower the body toward the ground by stepping forward and flexing both knees and the hips.
Primary muscles	Hamstring, gluteus, quadriceps
Starting Position/ Command	Attention position, hands on the hips, position ready.
Exercise Description	Stand with the feet six to eight inches apart. Take a large step forward and drop the hips until the thighs are parallel with the floor. As you lunge forward, you put all of your weight on your leading leg. Return the leg to the starting position. Keep the trunk erect throughout the exercise by looking straight ahead and keeping the chest out. Alternate legs.
PTI Pointers	Keep the trunk erect throughout the exercise. Keep the chest out. Be sure to flex both knees. Ensure that the front knee does not go past the foot.

Exercise No 47: Side Lunges	
Illustration	
	
Objective	To lower the body toward the ground by stepping sideways and flexing both knees and the hips.
Primary muscles	Hamstring, gluteus, quadriceps and adductors.
Starting Position/ Command	Attention position, hands on the hips, position ready.
Exercise Description	Step directly to the right or left side, sinking into a squat position. Alternate between the left and right sides.
PTI Pointers	Keep the trunk erect throughout the exercise. Keep the chest out. Be sure to flex both knees. Ensure that the knees do not bend so deeply that they go past the front part of the feet.

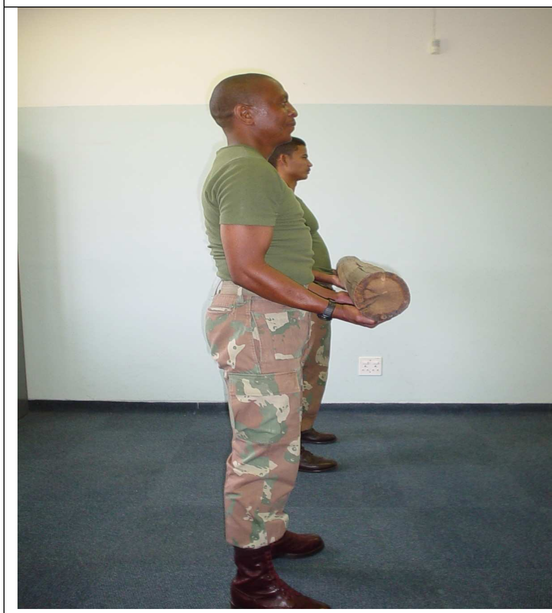
Exercise No 47: Calf Raises (both legs)	
Illustration	
	
Objective	To raise the body onto toes using both calves..
Primary muscles	Gastrocnemius (lateral and medial heads)
Starting Position/ Command	Attention position, hands on the hips, position ready.
Exercise Description	Stand with your back straight, feet slightly apart, hands on the hips. Rise up as high as you can on your toes (plantarflexion) while keeping your knees extended. Return to starting position.
PTI Pointers	Keep the knees locked but not hyperextended. Try varying foot positions (parallel, toes in, and toes out) to work all angles of the gastrocnemius. Make sure you flex your foot completely as you perform every repetition.

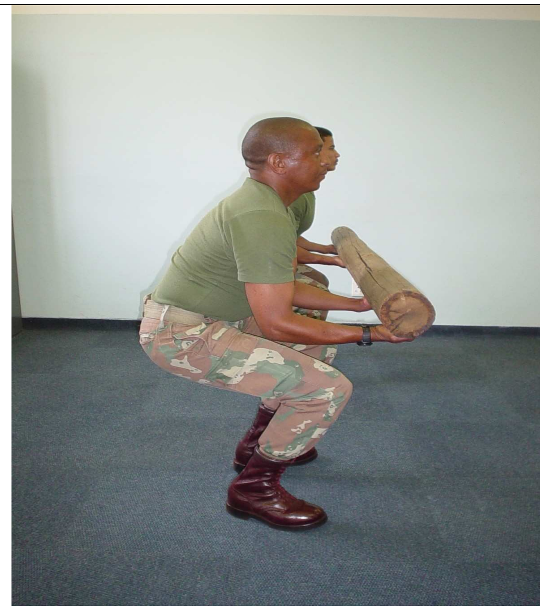
Exercise No 48: Calf Raises (single leg)	
Illustration	
	
Objective	To raise the body onto toes using a single calf.
Primary muscles	Gastrocnemius (lateral and medial heads)
Starting Position/ Command	Attention position, hands on the hips, position ready.
Exercise Description	Stand on one foot, back straight, hands on the hips. Rise up as high as you can on your toes (plantarflexion) keeping your knee extended. Return to starting position.
PTI Pointers	Keep the knees locked but not hyperextended. Try varying foot positions (parallel, toes in, and toes out) to work all angles of the gastrocnemius. Make sure you flex your foot completely as you perform every repetition.

Weight training (poles)

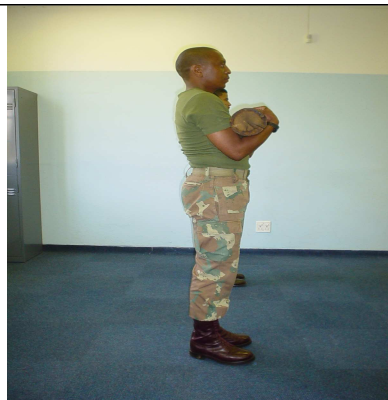
Exercise No 49: Squats

Illustration





Objective	To lower the body as if sitting in a chair whilst holding a pole.
Primary muscles	Quadriceps, gluteus, hamstrings, abdominals, spinal erectors.
Starting Position/ Command	Pole squat, position ready.
Exercise Description	Stand with your feet shoulder width apart. Position the pole across the abdomen, hold your forearms parallel to the floor, and look straight ahead. Bend the knees in a slow controlled manner until the thighs are parallel to the ground. Keep the back flat. Return to the starting position.
PTI Pointers	Bend knee no further than 90 degrees. Do not bend forward; keep your back perfectly straight. Be sure to initiate the movement at the hip joint, not the knees. Keep the weight back on the heels.

Exercise No 50: Lunges	
Illustration	
	
	
Objective	To lower the body toward the ground by stepping forward and flexing both knees and the hips whilst holding a pole.
Primary muscles	Hamstring, gluteus, quadriceps
Starting Position/ Command	Pole lunges, position ready.
Exercise Description	Stand with the feet 20cm apart. Take a big step forward and drop the hips until the thighs are parallel with the floor. As you lunge forward, you put all of your weight on your leading leg. Return the leg to the starting position. Keep the trunk erect throughout the exercise by looking straight ahead and keeping the chest out. Alternate legs.
PTI Pointers	Keep the trunk erect throughout the exercise. Keep the chest out and be sure to flex both knees. Ensure that the front knee does not go past the foot.

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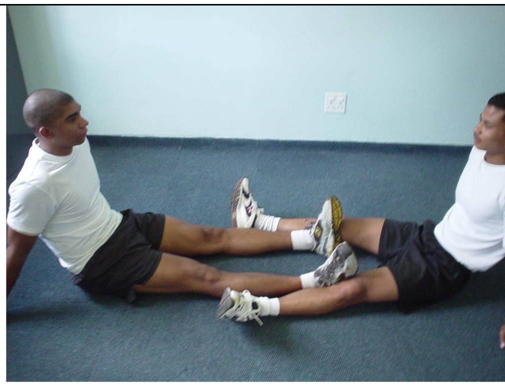
PART 7

Exercise No 51: Calf Raises (both legs)	
Illustration	
	
Objective	To raise the body onto toes using both calves.
Primary muscles	Gastrocnemius (lateral and medial heads)
Starting Position/ Command	Pole calf- raise, position ready.
Exercise Description	Stand with your back straight. Place the pole on your shoulder. Rise up as high as you can on your toes (plantarflexion) while keeping your knees extended. Return to starting position.
PTI Pointers	To stretch the muscles correctly, be sure to rise up as high as possible on your toes as you perform every repetition. Keep the knees locked but not hyperextended. Try varying foot positions (parallel, toes in, and toes out) to work all angles of the gastrocnemius. Make sure you flex your foot completely as you perform every repetition.

Exercise No 52: Alt. Calf Raises	
Illustration	
	
Objective	To raise the body onto toes using a single calf.
Primary muscles	Gastrocnemius (lateral and medial heads)
Starting Position/ Command	Pole alternative, calf raise, position ready.
Exercise Description	Stand on one foot, back straight. Place the pole on the shoulder. Rise up as high as you can on your toes (plantarflexion) keeping your knee extended or very slightly bent. Return to starting position.
PTI Pointers	Make sure you flex your foot completely as you perform every repetition. Keep the knees locked but not hyperextended. Try varying foot positions (parallel, toes in, and toes out) to work all angles of the gastrocnemius. Make sure you flex your foot completely as you perform every repetition.

Informal exercises to develop leg muscular strength and endurance

Body weight training exercises

Exercise No 53: Isometric V sit adduction (with partner)	
Illustration	
	
Objective	To push the partners' legs closed whilst the partner offers resistance.
Primary muscles	Adductor muscles. Partner uses abductor muscles.
Exercise Description	Both learners sit with legs straight in a 'V' sit position. The active leaner places his/her feet on the outside of the learner's legs. On the instructors whistle the active learner activates his adductor muscles and pushes inwards as hard as possible whilst the passive learner resist this by activating his abductor muscles and pushes outwards. This isometric contraction should be held between 5-10 seconds depending on the fitness level of the learner.
PTI Pointers	Avoid ballistic movements and sudden force/ contraction of the adductor. Abductor muscles.

Exercise No 54: Isometric V Sit abduction (with partner)

Illustration

Objective	To push the partners legs open whilst the partner offers resistance.
Primary muscles	Abductor muscles. Partner uses adductor muscles.
Exercise Description	Both learners sit with legs straight in a 'V' sit position. The active leaner places his/her feet on the inside of the learner's legs. On the instructors whistle the active learner activates his abductor muscles and pushes outwards as hard as possible whilst the passive learner resist this by activating his adductor muscles and pushes inwards. This isometric contraction should be held between 5-10 seconds depending on the fitness level of the learner.
PTI Pointers	Avoid ballistic movements and sudden force/ contraction of the adductor. Abductor muscles.

Exercise No 55: Forward Lunges on Step	
Illustration	
	
Objective	To lower the body toward the ground by stepping forward and flexing both knees and the hips.
Primary muscles	Hamstring, gluteus, quadriceps
Starting Position/ Command	Attention position, hands on the hips position ready.
Exercise Description	Stand with the feet six to eight inches apart. Take a large step forward onto a step of ± 30cm or less. As you lunge forward, you put all of your weight on your leading leg. Return the leg to the starting position. Keep the trunk erect throughout the exercise by looking straight ahead and keeping the chest out. Alternate legs.
PTI Pointers	Keep the trunk erect throughout the exercise. Keep the chest out. Be sure to flex both knees. Ensure that the front knee does not go past the foot.

Exercise No 56: Side Lunges on Step	
Illustration	
	
Objective	To lower the body toward the ground by stepping sideways and flexing both knees and the hips.
Primary muscles	Hamstring, gluteus, quadriceps and adductors.
Starting Position/ Command	Attention position, hands on the hips, position ready.
Exercise Description	Step directly to the right or left side, sinking into a squat position. Alternate between the left and right sides.
PTI Pointers	Keep the trunk erect throughout the exercise. Keep the chest out. Be sure to flex both knees. Ensure that the knees do not bend so deeply that they go past the front part of the feet.

Weight training (poles)

None

Weight training (poles and rope)

None

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PART 8

Flexibility

Correct stretching techniques and good flexibility provides many health- related fitness benefits. Specifically, a well-designed flexibility training program (stretching on a regular basis in a progressively intense manner) can help muscles relax; improve overall health-related fitness, posture, and body symmetry; relieve muscle cramps and soreness; and reduce the risk of injury – all of which make physical activities of all types easier and safer to do.

Defining flexibility

Flexibility is the ability of a joint and the muscles and tendons surrounding it to move freely and comfortably through its intended full range of motion (ROM). Simply put, it is the range of motion available in a joint or group of joints. Optimal flexibility, then allows a joint or group of joints to move efficiently. Flexibility – and the stretches that foster it – can be classified as follows:

- Static – using the ROM of a joint slowly and steadily in a held position
- Dynamic – moving (quickly or slowly) in a ROM necessary for a sport movement
- Ballistic – quickly and briefly bouncing, rebounding, or using rhythmic motion in a joint's ROM (usually to mimic sport movements)
- PNF (proprioceptive neuromuscular facilitation) – using the body's reflexes to relax a muscle before stretching it, so it can be stretched farther

Overload, fitt, progression and specificity principles

It is important to know how to apply the overload, FITT, and progression principles to achieve the basic level of health-related fitness in the area of flexibility. Flexibility intensity involves how the stretch feels; time is the length of time a stretch is held multiplied by the number of times each stretch is performed; and type is the specific muscles the stretch addresses. That is, you must stretch leg muscles to have more flexible legs and arm muscles to have more flexible arms. The table below outlines these principles applied to flexibility, based on fitness goals.

The FITT principle applied to flexibility training, based on fitness goals			
	Base health-related fitness	**Intermediate health-related fitness**	**Athletic performance fitness**
Frequency	Before and after each activity/exercise session (minimum of 3 times per week)	Before and after each activity/exercise session (daily)	Before and after each training session
Intensity	To mild tension, or slight muscular discomfort	To mild tension, or slight muscular discomfort	To mild tension, or slight muscular discomfort, at a level appropriate for sport participation
Time	10-15 s; 2 times per stretch	10-15s; 3 times per stretch	Dependent on static, dynamic, or ballistic (usually conducted by qualified trainer/coach)
Type	Static; major muscle groups	Static; major muscle groups, introduction of dynamic stretching	Usually dynamic and/ or ballistic; major muscle groups and sport-specific stretches
Overload	Not necessary at base level	Ask student to identify level of stretch intensity; if appropriate for activity, have student stretch slightly farther than previous same stretch	As dynamic and ballistic stretches dominate advanced level, overload is not appropriate to ballistic stretching
Progression	Start very easy into stretch; slow movements with minimal applied resistance to muscle involved	Stretch major core muscles first, then move to extremities; begin introduction of dynamic flexibility	Start with easy multijoint dynamic movements, progression to more resistive dynamic movements, followed by moderate static and/or PNF stretching

A warm-up of full body movement, such as walking, jogging or stationary bicycle must precede any flexibility training activities. Be sure the student has sufficiently had time to warm up all muscles, primarily those muscles involved in the flexibility activities.

Each individual should gradually progress to a higher level of fitness in flexibility, depending on his or her goals, abilities, and interests.

Intensity is an extremely important factor in a safe and effective flexibility-training program. A static stretch that goes beyond the point of mild discomfort to point merely increases the likelihood of injury. When it comes to intensity and flexibility, overloading is moving just beyond the existing ROM. Overloading may also involve one or more of the other parts of the FITT principle; stretching more often (frequency), holding a stretch longer (time), or stretching specific muscles (type). Naturally, safe overloading involves increasing all aspects of the FITT principle in a gradual, progressive manner. Indeed, as with other aspects of health related physical fitness, overloading without pain is the only way to increase flexibility.

Training methods for flexibility

The two main types of flexibility of interest to physical educators are also the names of the two main types of training: static and ballistic.

Static stretching

The static stretching technique is still an extremely effective and popular technique of stretching. This technique involves passively stretching a given antagonist muscle by placing it in a maximal position of stretch and holding it there for an extended time. Much research has been done comparing ballistic and static stretching techniques for the improvement of flexibility. Both static and ballistic stretching are effective in increasing flexibility, and there are no significant differences between the two. However, with static stretching there is less danger of exceeding the extensibility limits of the involved joints because the stretch is more controlled. Ballistic stretching is apt to cause muscular soreness, whereas static stretching generally does not and is commonly used in injury rehabilitation of sore strained muscles.

Static stretching is certainly a much safer stretching technique, especially for sedentary or untrained individuals. However, many physical activities involve dynamic movement. Thus stretching, as a warm-up for these types of activities should begin with static stretching followed by ballistic stretching, which more closely resembles the dynamic activity.

Ballistic stretching

If you were to walk out to the track on any spring or fall afternoon and watch people who are warming up to run by dong their stretching exercises, you would probably see them using bouncing movements to stretch a particular muscle. This bouncing technique is more appropriately known as ballistic stretching, in which repetitive contractions of the agonist muscle are used to produce quick stretches of the antagonist muscle. The ballistic stretching technique, although apparently effective in improving range of motion, is seldom recommended.

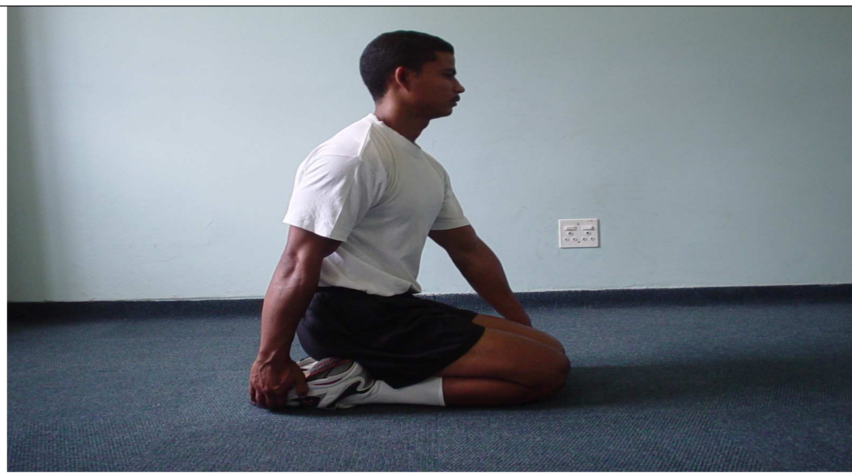
Priopriocеptive Neuromuscular Facilitation (PNF) Techniques

PNF techniques were first used by physical therapists for treating patients who had various types of neuromuscular paralysis. Only recently have PNF stretching exercises been used as a stretching technique for increasing flexibility. There are a number of different PNF techniques currently being used for stretching, including slow-reversal-hold- relax, contract- relax, and hold- relax techniques. All involve some combination of altering contraction and relaxation of both agonist and antagonist muscles (a 10-second pushing phase followed by a 10 second relaxing phase.)

Using a hamstring stretching technique as an example, the slow-reversal-hold-relax technique would be done as follows. Lying on your back with the knee extended and the ankle flexed to back with the knee extended ant the ankle flexed to 90 degrees, a partner passively flexes your leg at the hip joint to the point at which you feel slight discomfort in the muscle. At this point you begin pushing against your partner's resistance by contracting the hamstring muscle. After pushing for 10 seconds, the hamstring muscles are relaxed and the agonist quadriceps muscle is contracted while your partner applies passive pressure to further stretch the antagonist hamstrings. The push-relax sequence is repeated at least three times.

The contract-relax and hold-relax techniques are variations on the slow-reversal-hold-relax method. In the contract-relax method, the hamstrings are isotonically contracted so that the leg actually moves toward the floor during the push phase. During the relax phase, both techniques involve relaxation of hamstrings and quadriceps while the hamstrings are passively stretched. This same basic PNF technique can be used to stretch any muscle in the body. PNF stretching techniques are perhaps best performed with a partner, although they may also be done using a wall as resistance.

Formal leg flexibility exercises

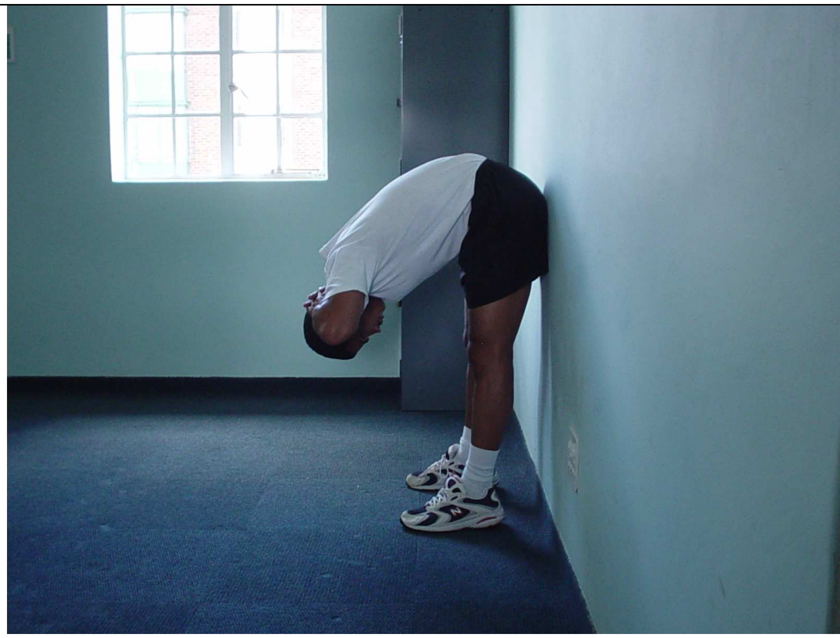
Flexibility exercise No 57: Tibialis anterior stretch	
Illustration	
	
Objective	Increase flexibility of the anterior lower leg.
Primary Muscles	Tibialis anterior
Starting Position/ Command	Kneeling, hands on the heels, position ready.
Exercise Description	Kneel with toes pointing backwards, exhale, and sit on top of the heel. Grasp the top portion of the toes and pull them towards the head.
PTI Pointers	Feel the stretch along the shin. This stretch can help prevent shin splints. Ensure that the buttocks sit on top of the heels and not between the feet. Do not do this stretch if learner presents with knee problems.

Flexibility exercise No 58: Lying hamstring stretch	
Illustration	
	
Objective	Increase flexibility of the Achilles tendon and the posterior lower leg.
Primary Muscles	Gastrocnemius and hamstrings
Starting Position/ Command	Lie on your back, knees bent, hands next to the side, position ready
Exercise Description	Lie on the back, flex one leg and slide the foot towards the buttocks. Raise the opposite leg towards the face, grasp behind the knee, and slowly dorsiflex the foot towards the face.
PTI Pointers	If learner suffers from back problems allow him/her to flex the extended leg and lower it on the floor after the stretch.

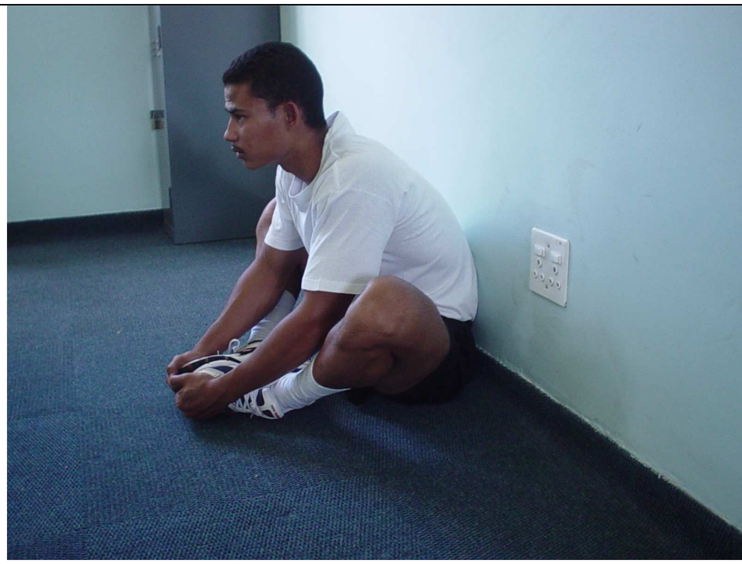
Flexibility exercise No 59: Gastrocnemeus stretch	
Illustration	
	
Objective	Increase flexibility of the Achilles tendon and the posterior lower leg.
Primary Muscles	Gastrocnemius and hamstrings
Starting Position/ Command	Front support position ready. Walk in with your feet
Exercise Description	From a push-up position move the hands closer to the feet to raise the hips and form a triangle. At the highest point of the triangle slowly press the heels to the floor, or alternate slowly flexing one knee while keeping the opposite leg extended.
PTI Pointers	Do not jerk the heel flat onto the floor.

Flexibility exercise No 60: Seated hamstring stretch	
Illustration	
	
Objective	Increase flexibility behind the knee.
Primary Muscles	Gastrocnemius , hamstrings and erector spinae.
Starting Position/ Command	Sit, knees slightly bent, hands on the toes, position ready.
Exercise Description	Sit on the floor with the knees flexed, grasp the toes and the ball of one foot, and extend the leg. Exhale; keeping the leg straight, pull the foot towards the trunk and bend at the hip so that the upper torso leans towards the extended thigh.
PTI Pointers	Avoid this stretch if learner has hyperexetended knees. Contracting and relaxing the quadriceps of the extended leg tends to alleviate some tension and discomfort behind the knee.

Flexibility exercise No 61: Lying hamstring stretch- advanced	
Illustration	
	
Objective	Increase flexibility of the hamstring muscles.
Primary Muscles	Hamstrings
Starting Position/ Command	Lie on your back, knees bent, hands next to the side, position ready
Exercise Description	Lie on the back with the legs flexed and the heels close to the buttocks. Inhale and extend one leg upwards. Exhale and slowly pull the raised leg towards the face, keeping the leg straight.
PTI Pointers	Contract the quadriceps to alleviate tension in the hamstrings.

Flexibility exercise No 62: Straddle hamstring stretch	
Illustration	
	
Objective	Increase flexibility of the hamstrings.
Primary Muscles	Hamstrings
Starting Position/ Command	Straddle stand, hands behind the head, position ready.
Exercise Description	Stand with legs spread and the back of the heels approximately 30 cm from the wall. Interlock the hands behind the head. Keeping the legs straight, extend the upper back, bend forward at the hips, and lower the trunk towards the thighs. Exhale and bend the knees or round the upper torso when returning to the upright position.
PTI Pointers	Remember to extend the upper back and keep it straight.

Flexibility exercise No 63: Sitting adductor stretch	
Illustration	
	
Objective	Increase flexibility of the inside thigh (adductors).
Primary Muscles	Adductors
Starting Position/ Command	Sit, knees slightly bent , hands on the ankles, position ready.
Exercise Description	Sit on the floor with buttocks against the wall, legs flexed and spread, heels touching each other. Grasp the feet or ankles and pull them as close to the groin as possible. Place the elbows on the inner thighs or knees, exhale, and push the legs to the floor.
PTI Pointers	Be sure to keep the back straight when performing this stretch.

Flexibility exercise No 64: Sitting forward adductor stretch	
Illustration	
	
Objective	Increase flexibility of the inside thigh (adductors).
Primary Muscles	Adductors
Starting Position/ Command	Sit, knees slightly bent , hands on the toes, position ready.
Exercise Description	Lie on the back and flex the knees, bringing the heels and soles of the feet together as they are pulled toward the buttocks. Exhale and spread the knees as wide as possible, keeping the soles of the feet intact.
PTI Pointers	Exercise will feel more intense if performed on a narrow bench. Focus on moving the upper thighs outward and the knees.

Flexibility exercise No 65: Straddle adductor stretch	
Illustration	
	
Objective	Increase flexibility of the inside thigh (adductors).
Primary Muscles	Adductors and hamstrings.
Starting Position/ Command	Sit, hands on the side, position ready.
Exercise Description	Sit on the floor and spread the legs as wide as possible. Exhale, rotate the trunk slowly, extend the upper torso onto one leg and grasp the foot.
PTI Pointers	Concentrate on keeping the lower back and legs extended and the heels on the floor.

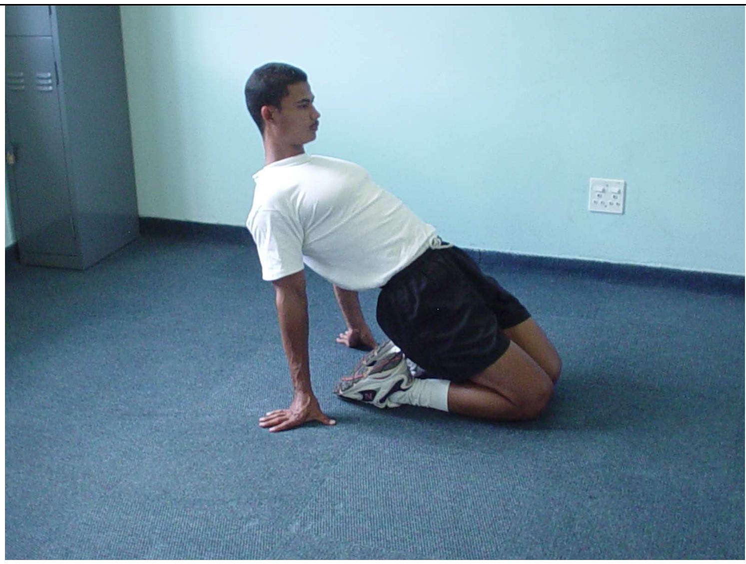
Flexibility exercise No 66: **Lunge adductor stretch**	
Illustration	
	
Objective	Increase flexibility of the inside thigh (adductors).
Primary Muscles	Adductors and hamstrings.
Starting Position/ Command	Attention position, hands on the hips, position ready.
Exercise Description	Stand with legs spread about 60cm apart and turn the right foot 90-degrees sideways to the right, keeping the toes and heel in line with the body. Place the hands on the hips, exhale, lunge forward with the left leg, and press down on the right hip.
PTI Pointers	Remember to turn the foot 90-degrees sideways.

Flexibility exercise No 67: Prone lying quadriceps stretch	
Illustration	
	
Objective	Increase flexibility of the thigh (quadriceps).
Primary Muscles	Quadriceps.
Starting Position/ Command	Lie on your stomach, arms next to the side, position ready.
Exercise Description	Lie face down, flex one knee, and raise the heel towards the buttocks. Exhale, grasp the raised ankle, and pull the heel toward the buttock without over compressing the knee.
PTI Pointers	To maximise the stretch, make sure the medial sides of the legs tough each other and that the pelvis rotates backwards. Do not arch the lower back or twist the pelvis.

Flexibility exercise No 68: Side lying quadriceps stretch	
Illustration	
	
Objective	Increase flexibility of the thigh (quadriceps).
Primary Muscles	Quadriceps.
Starting Position/ Command	Lie on your stomach, arms next to the side, position ready.
Exercise Description	Lie on the side, flex one knee, and raise the heel towards the buttocks. Exhale, grasp the raised ankle, and pull the heel toward the buttock without over compressing the knee.
PTI Pointers	To maximise the stretch, make sure the medial sides of the legs tough each other and that the pelvis rotates backwards. Do not arch the lower back or twist the pelvis.

Flexibility exercise No 69: Standing quadriceps stretch	
Illustration	
	
Objective	Increase flexibility of the thigh (quadriceps).
Primary Muscles	Quadriceps.
Starting Position/ Command	Attention position, fingers stretched, position ready.
Exercise Description	Stand holding onto soothing for balance. Flex one knee and raise the heel to the buttocks. Slightly flex the supporting leg, exhale, and grasp the raised foot with one hand. Inhale and slowly pull the heel towards the buttock without over compressing the knee.
PTI Pointers	To maximise the stretch, make sure the medial sides of the legs tough each other and that the pelvis rotates backwards. Do not arch the lower back or twist the pelvis.

Flexibility exercise No 70: Lying quadriceps stretch	
Illustration	
	
Objective	Increase flexibility of the thigh (quadriceps).
Primary Muscles	Quadriceps.
Starting Position/ Command	Sit, hands on the side, position ready.
Exercise Description	Sit on the floor and bend the right leg behind so that the inside of the knee and thigh are on the floor and the foot points along the line of the lower leg in a relaxed position. Exhale; lean diagonally back onto the forearm and elbow opposite the rear leg without arching the lower back. Continue leaning backward until flat on the back.
PTI Pointers	To increase the stretch, contact the gluteals and lift the hip of the floor. Do not let the foot of the rear leg flare out to the side. To guard against excessive stress on the lumbar spine, keep the forward leg in a slightly flexed position..

Flexibility exercise No 71: Kneeling quadriceps stretch	
Illustration	
	
Objective	Increase flexibility of the thigh (quadriceps).
Primary Muscles	Quadriceps and hip flexors.
Starting Position/ Command	Kneel, hands next to the side, position ready.
Exercise Description	Kneel on knees keeping the knees together, buttock on the floor, and heels by the sides of the thighs, and toes pointing backward. Exhale and lean backward without letting the feet flare out to the sides.
PTI Pointers	Do not arch the back. Instead, contract the gluteal and rotate the pelvis backward. Do not allow the knees to rise off the floor or spread apart.

Flexibility exercise No 72: Hip flexor stretch	
Illustration	
	
Objective	Increase flexibility of the anterior hip area.
Primary Muscles	Hip flexors.
Starting Position/ Command	Attention position, hands on the hips, position ready.
Exercise Description	Stand with legs spread about two feet apart. Flex one knee, lower the body, and place opposite knee on the floor. Roll the back foot under so that the top instep rests on the floor. Place the hands on the hips and keep the front knee bent at 90-degree angle. Exhale and push the front of the hip of the back leg towards the floor.
PTI Pointers	Do not bend the knee further than 90-degrees. Do not arch the back.

Flexibility exercise No 73: Lying gluteus stretch	
Illustration	
	
Objective	Increase flexibility of the gluteal area.
Primary Muscles	Gluteals.
Starting Position/ Command	Lie on your back, hands behind your head, position ready.
Exercise Description	Lie on back with left leg crossed over right knee. Exhale and flex right knee, lifting the right foot off the floor, and let it slowly push the left foot towards the face, keeping the head, shoulders, and back flat on the floor.
PTI Pointers	Keep the neck and head relaxed and in a neutral position.

Flexibility exercise No 74: ITB sitting single leg cross-over stretch	
Illustration	
	
Objective	Increase flexibility of the gluteal area.
Primary Muscles	Gluteals and iliotibial band..
Starting Position/ Command	Sit, hands next to the side, position ready.
Exercise Description	Sit on the floor with hands behind the hips and legs extended. Cross the left foot over the right leg and slide the heel towards the buttocks. Place the right elbow on the outside of the left knee. Exhale and look over the left shoulder while turning the trunk and gently pushing on the knee with the right elbow.
PTI Pointers	Keep the neck and head relaxed and in a neutral position.

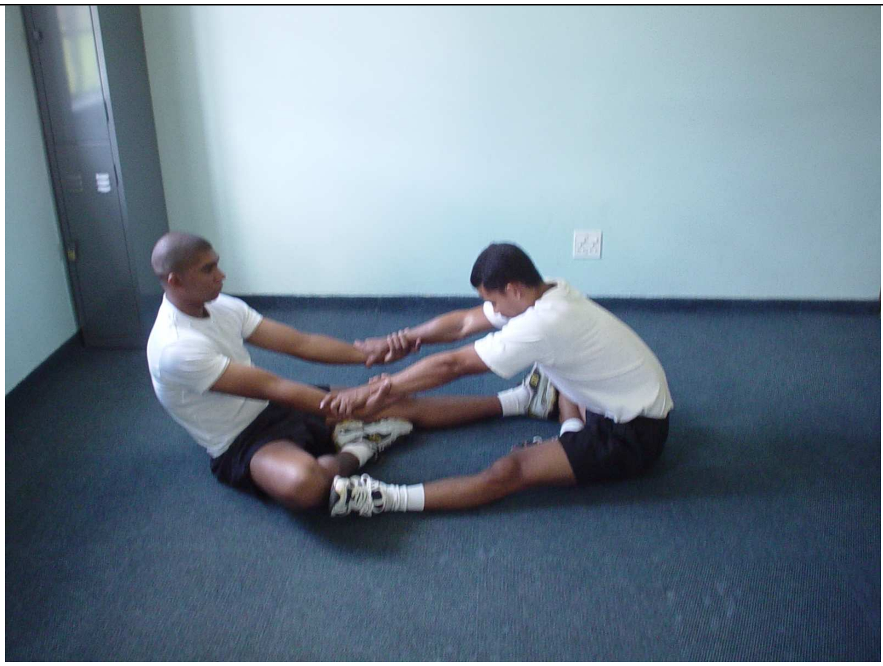
Flexibility exercise No 75: ITB sitting double cross-over stretch	
Illustration	
	
Objective	Increase flexibility of the gluteal area.
Primary Muscles	Gluteals and iliotibial band..
Starting Position/ Command	Sit, hands next to the side, position ready.
Exercise Description	Sit on the floor and cross one knee over the other. Exhale and lean forward.
PTI Pointers	Keep the neck and head relaxed and in a neutral position. Avoid this exercise if learner has knee problems.

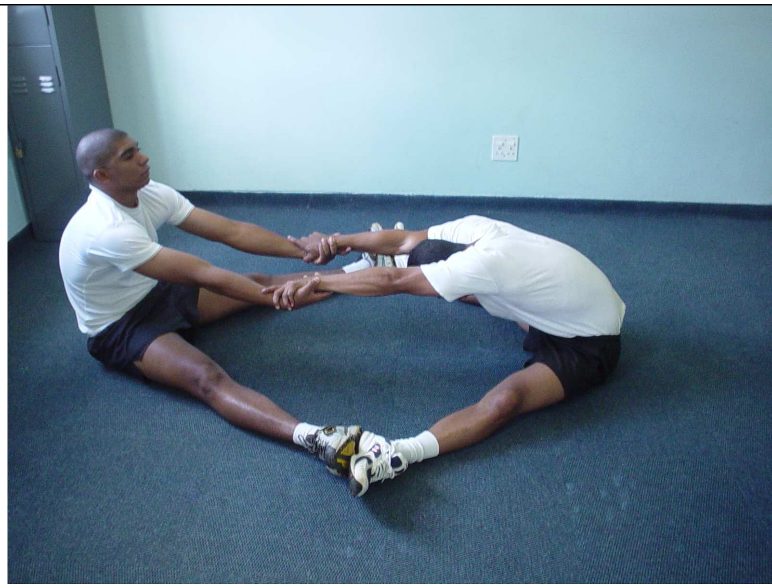
Flexibility exercise No 76: Standing ITB stretch	
Illustration	
	
Objective	Increase flexibility of the gluteal area.
Primary Muscles	Iliotibial band (ITB)
Starting Position/ Command	Attention position, fingers stretched, position ready.
Exercise Description	Stand with hands on the side and extend and adduct the left leg as far as possible. Exhale and flex the trunk laterally towards the right side, keeping the hands by the hips.
PTI Pointers	Keep abdominals activated to assist with balance.

Flexibility exercise No 77: Bend over standing ITB stretch	
Illustration	
	
Objective	Increase flexibility of the gluteal area.
Primary Muscles	Iliotibial band (ITB)
Starting Position/ Command	Attention position, fingers stretched, position ready.
Exercise Description	Stand with hands on the side and extend and adduct the left leg as far as possible. Exhale and flex the trunk laterally towards the right side. Try and touch the heel of the left leg with both hands. Exhale, round the upper torso, and return to the starting position.
PTI Pointers	Keep abdominals activated to assist with balance. This is a severe stretch since it incorporates both spinal flexion and rotation.

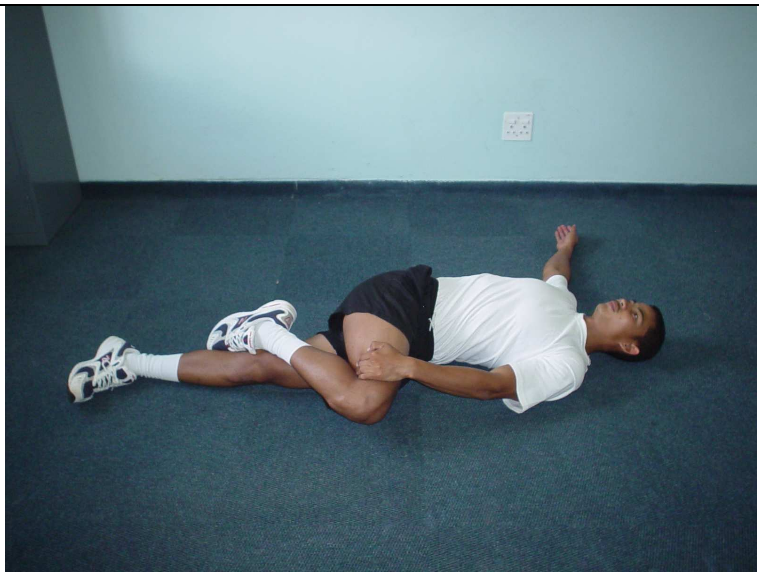
Informal leg flexibility exercises

Flexibility exercise No 78: Achilles stretch	
Illustration	
	
Objective	Increase flexibility of the Achilles tendon and the posterior lower leg.
Primary Muscles	Gastrocnemius and hamstrings
Exercise Description	Lean forward against a wall with one leg bent forward and the opposite leg straight. Keep the rear foot flat on the floor and both feet pointing straight forward. Bend the arms, lean towards the wall, and shift the weight forward. Exhale and flex the forward knee toward the wall.
PTI Pointers	Keep the head, neck, spine, rear leg, and ankle in a straight line.

Flexibility exercise No 79: Buddy hamstring stretch	
Illustration	
	
Objective	Increase flexibility of the hamstrings.
Primary Muscles	Hamstrings and erector spinae.
Exercise Description	Sitting on the floor with the legs extended and spread apart, flex one knee until its heel touches the groin on the other leg. The partner assumes the same position while the other braces an extended leg against the partners flexed leg and vice versa; interlock hands. Exhale, bend forward at the hips and lower the trunk onto the extended thigh as the partner leans backwards and pulls on the hands.
PTI Pointers	Ensure that no excessive pull is exerted from the partner.

Flexibility exercise No 80: Buddy adductor stretch	
Illustration	
	
Objective	Increase flexibility of the inside thigh (adductors).
Primary Muscles	Adductors and hamstrings.
Exercise Description	Sit on the floor with the legs spread. The partner assumes the same position with feet braced against each other. Lean forward and grasp each other's wrists. Exhale, keeping the legs straight, extend the upper torso and bend forward at the hips and the partner leans backwards and pull on the wrists.
PTI Pointers	Ensure that no sudden pulling occurs.

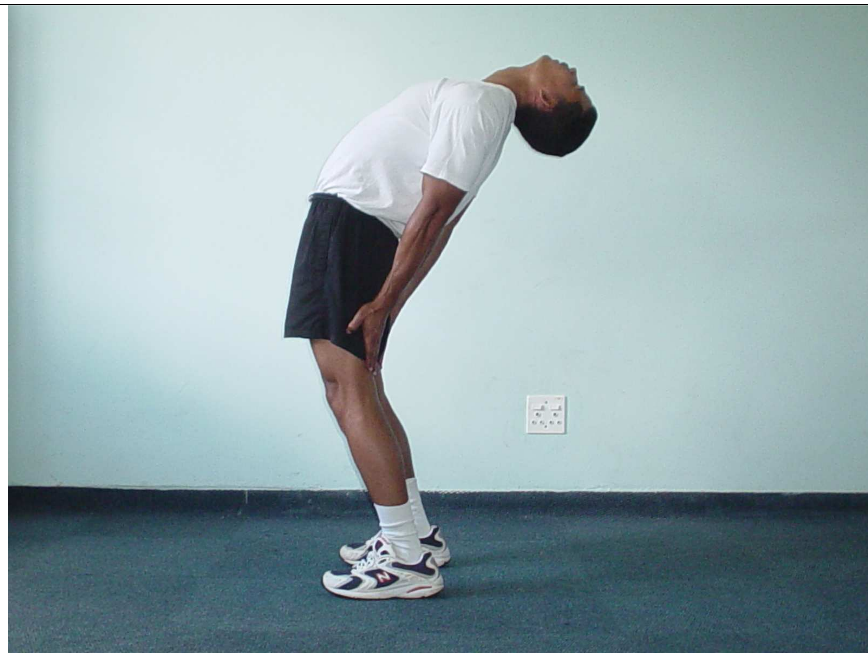
Flexibility exercise No 81: Cross standing quadriceps stretch	
Illustration	
	
Objective	Increase flexibility of the thigh (quadriceps).
Primary Muscles	Quadriceps.
Exercise Description	Stand holding onto soothing for balance. Flex one knee and raise the heel to the buttocks. Lean forward, slightly flex the supporting leg, and grasp the raised foot with opposite hand. Exhale, pull the heel towards the buttock and crisscross the raised knee behind the knee of the supporting leg. Pull the heel towards the buttocks without over compressing the knee.
PTI Pointers	Do not arch the lower back or twist the pelvis.

Flexibility exercise No 82: ITB lying cross-over stretch	
Illustration	
	
Objective	Increase flexibility of the gluteal area.
Primary Muscles	Iliotibial band (ITB)
Exercise Description	Lie on the back with legs extended. Flex one knee, raise it tot the chest, and grasp it with the opposite hand. Exhale and pull the knee across the body to the floor, keeping the elbows, head and shoulders flat on the floor.
PTI Pointers	Keep the neck and head relaxed and in a neutral position. Do not do ant sudden movements and ensure that this is a slow stretch.

Formal Lower torso flexibility exercises

Flexibility exercise No 83: Prone abdominal stretch	
Illustration	
	
Objective	Increase flexibility of the anterior lower torso area..
Primary Muscles	Abdominals.
Starting Position/ Command	Lie on your stomach, arms next to the side, position ready.
Exercise Description	Lie face down on the floor with the body extended. Place the palms on the floor by the hips with the fingers pointing forward. Exhale, and press down on the floor, raise the head and trunk, and arch the back whiles contracting the gluteals to prevent excessive compression of the lower back.
PTI Pointers	Ensure that the lower back does not hyper extend excessively.

Flexibility exercise No 84: Bridge abdominal stretch	
Illustration	
	
Objective	Increase flexibility of the anterior lower torso area..
Primary Muscles	Abdominals.
Starting Position/ Command	Kneel, hands on the ankles, position ready.
Exercise Description	Kneel on the floor with the legs slightly apart and parallel with toes pointing backward. Place the palms on the upper hips, arch the back, contract the buttocks, and push the hips forward. Exhale, continue to arch the back, drop the head backward and gradually slide the hands onto the heels.
PTI Pointers	Ensure that the lower back does not hyper extend excessively.

Flexibility exercise No 85: Standing abdominal stretch	
Illustration	
	
Objective	Increase flexibility of the anterior lower torso area.
Primary Muscles	Abdominals.
Starting Position/ Command	Straddle stand, hands on the hips, position ready.
Exercise Description	Stand with legs spread about one metre apart and hands on the buttocks. Arch the back, contract the buttocks, and push the hips forward. Exhale, continue arching the back, drop the head backward and gradually slide the hands below the buttocks.
PTI Pointers	Ensure that the lower back does not hyper extend excessively.

Flexibility exercise No 86: Cat stretch	
Illustration	
	
Objective	Increase flexibility of the lower back.
Primary Muscles	Erector spinae, quadratus lumborum.
Starting Position/ Command	Front support, position ready.
Exercise Description	Kneel on all fours with toes pointing backwards. Inhale, contract the abdominals, and round the back. Exhale, relax the abdominals, and return to the 'flat back' position.
PTI Pointers	Do not pass the 'flat back' position into hyperextension of the lower back.

Flexibility exercise No 87: Lying back stretch	
Illustration	
	
Objective	Increase flexibility of the lower back.
Primary Muscles	Erector spinae, quadratus lumborum.
Starting Position/ Command	Lie on your back, knees bent, hands on the side, position ready.
Exercise Description	Lie on the back, flex the knees, and slide the feet towards the buttocks. Grasp behind the thighs to prevent hypextension of the knees. Exhale, pull the knees towards your chest and shoulders, and elevate your kips from the floor. Reextend the legs one at a time to prevent possible spasm or pain.
PTI Pointers	Keep the neck and head relaxed and in a neutral position.

Flexibility exercise No 88: Straddle lateral torso stretch	
Illustration	
	
Objective	Increase flexibility of the lateral torso.
Primary Muscles	External obliques, erector spinae, latissimus dorsi.
Starting Position/ Command	Sit, hands next to the side, position ready.
Exercise Description	Sit on the floor with the legs spread. Interlock the hands behind the head. Exhale and bend the upper torso from the hip, attempting to touch the right elbow to the floor outside the right thigh while keeping the left shoulder and elbow back.
PTI Pointers	Do not twist the spine.

Flexibility exercise No 89: Standing lateral torso stretch	
Illustration	
	
Objective	Increase flexibility of the lateral torso.
Primary Muscles	External obliques, erector spinae, latissimus dorsi.
Starting Position/ Command	Straddle stand ,hands next to the side, position ready.
Exercise Description	Stand with feet slightly apart and hands interlocking and overhead. Exhale, and drop one ear towards the shoulder, and lower the arm sideways.
PTI Pointers	Do not rotate the spine.

Informal Lower torso flexibility exercises

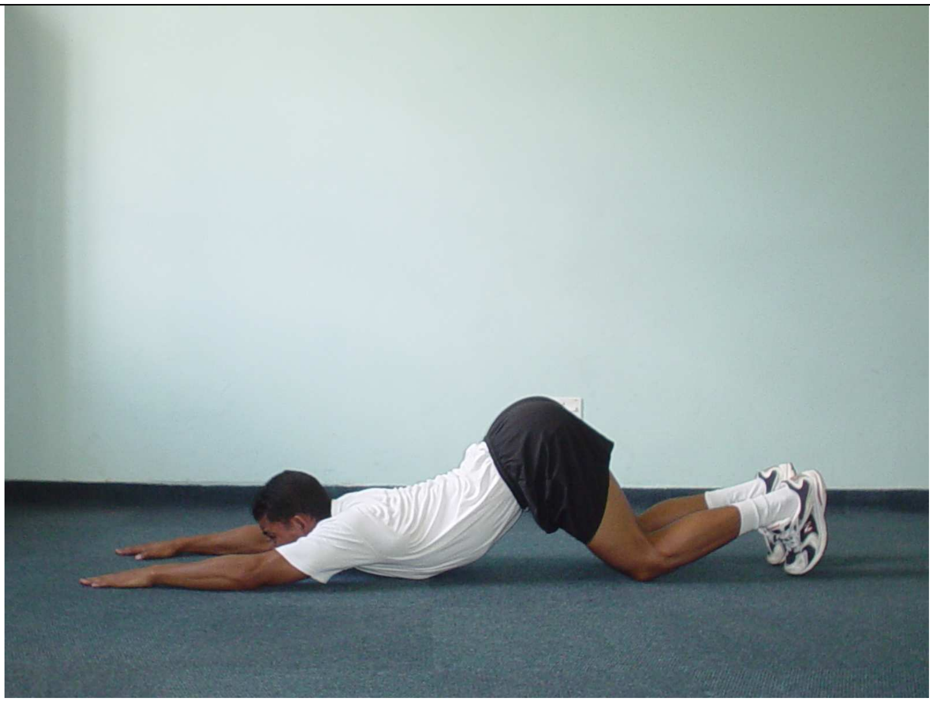
Flexibility exercise No 90: Advanced back stretch	
Illustration	
	
Objective	Increase flexibility of the lower back.
Primary Muscles	Erector spinae, trapezius and hamstrings.
Exercise Description	Lie on the back with arms by the hips, palms sown. Inhale, push on the floor with the palms, raise the legs to a vertical position, and support the body with the hands placed on the lower back. Exhale, keep the legs straight and together, and lower the feet to the floor.
PTI Pointers	This stretch should also be felt in the posterior neck and hamstrings. Avoid excessive flexion of the neck.

Flexibility exercise No 91: Side back stretch	
Illustration	
	
Objective	Increase flexibility of the lower back.
Primary Muscles	Erector spinae, external obliques..
Exercise Description	Kneel on all fours. Straighten the arms, reach forward as far as possible, and lower the chest to the floor. Exhale, slightly twist the upper torso, and press the palms and forearms on the floor.
PTI Pointers	Do not twist the spine.

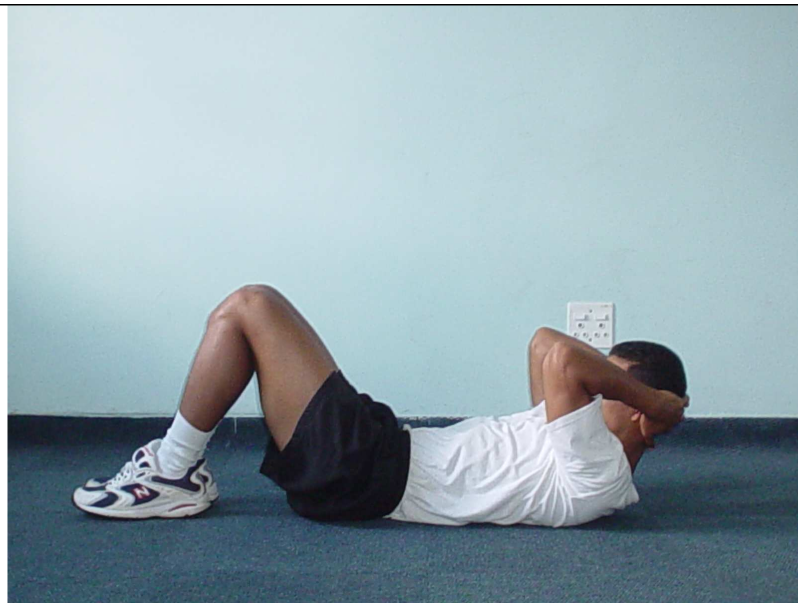
Formal Upper back flexibility exercises

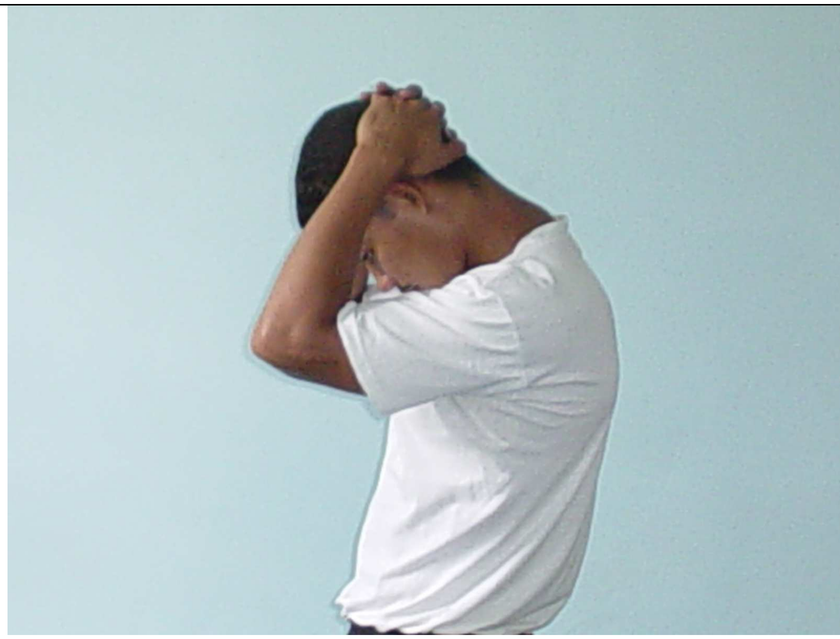
Flexibility exercise No 92: Sitting upper back stretch	
Illustration	
	
Objective	Increase flexibility of the upper back.
Primary Muscles	Trapezius, infraspinatus, teres major and latissimus dorsi.
Starting Position/ Command	Sit, knees slightly bent, hands on the knees, position ready.
Exercise Description	Sit on the floor with the knees slightly flexed, upper torso resting on the thighs, elbows under the knees, and hands grasping the thighs. Exhale, lean forward, and pull back on the thighs while keeping the feet on the floor..
PTI Pointers	The stretch should also be felt between the shoulder blades (rhomboids). Round the back to intensify the stretch..

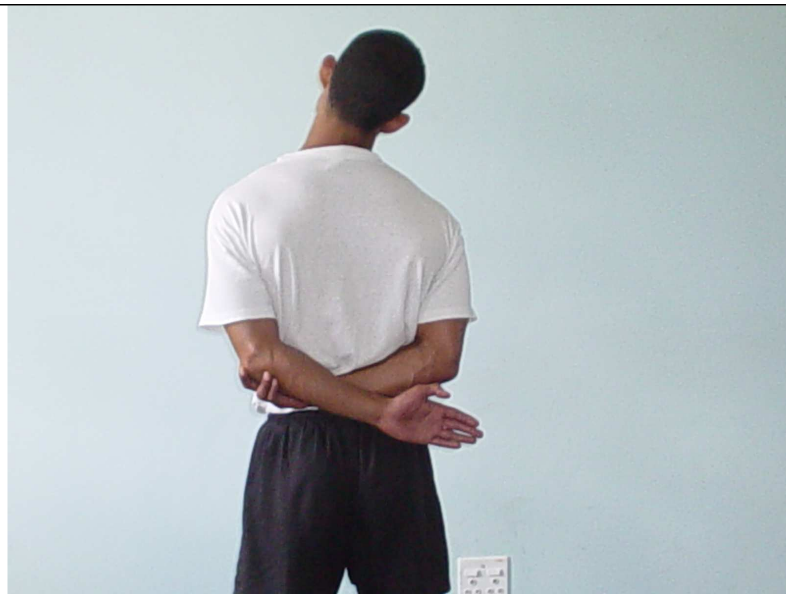
Informal Upper back flexibility exercises

Flexibility exercise No 93: Prone upper back stretch	
Illustration	
	
Objective	Increase flexibility of the upper back.
Primary Muscles	Trapezius, infraspinatus, teres major and latissimus dorsi.
Exercise Description	Kneel on all fours, extend the arms forward, and lower the chest to the floor. Exhale, extend the shoulders, and press on the floor with the arms to arch the back.
PTI Pointers	Keep head and neck in a neutral position.

Formal Neck flexibility exercises

Flexibility exercise No 94: Lying neck stretch	
Illustration	
	
Objective	Increase flexibility of the posterior neck.
Primary Muscles	Trapezius
Starting Position/ Command	Lie on your back, knees bent, hands behind the head, position ready.
Exercise Description	Lie on the floor on the back with both knees flexed. Interlock the hands behind the head near the crown. Exhale and pull the head onto the chest while keeping the shoulder blades flat on the floor.
PTI Pointers	The stretch will be dissipated if the shoulder blades lift off the floor.

Flexibility exercise No 95: Standing neck stretch	
Illustration	
	
Objective	Increase flexibility of the posterior neck.
Primary Muscles	Trapezius
Starting Position/ Command	Straddle stand, hands on the hips, position ready.
Exercise Description	Stand or sit and interlock the hands behind the head near the crown. Exhale and pull the head forward, and allow the chin to rest on the chest. Keep the shoulders depressed during the stretch.
PTI Pointers	The stretch will be dissipated if the shoulder do not remain depressed.

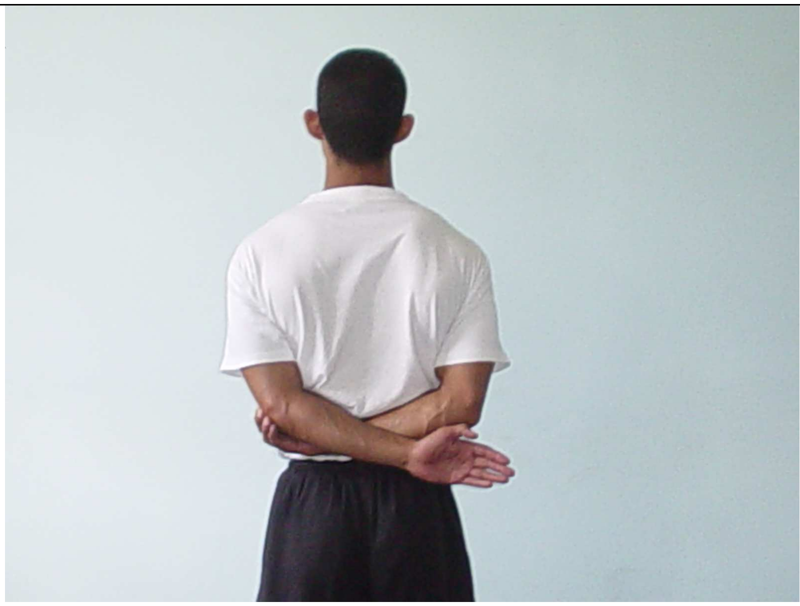
Flexibility exercise No 96: Anchored shoulder neck stretch	
Illustration	
	
Objective	Increase flexibility of the lateral neck.
Primary Muscles	Trapezius, sternocleidomastoid and scalene.
Starting Position/ Command	Straddle stand, hands on the hips, position ready.
Exercise Description	Sit or stand with the left arm flexed behind the back. Grasp the elbow from behind with the opposite hand and pull it across the midline of the back to keep the left shoulder stabilised. Exhale and lower the right ear to the right shoulder.
PTI Pointers	The stretch will be dissipitated on the release of the anchored shoulder.

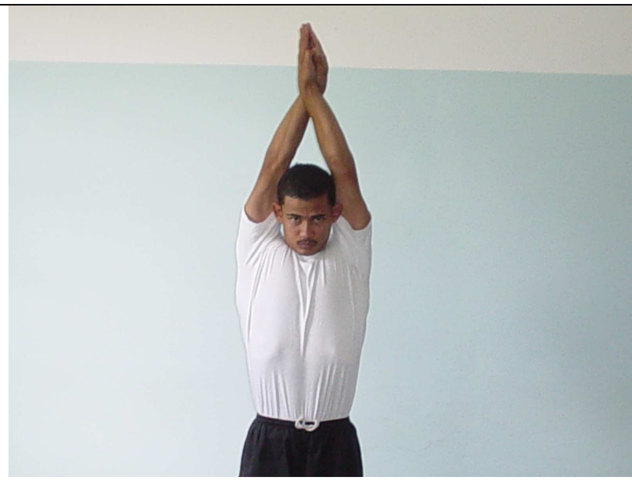
Informal Neck flexibility exercises

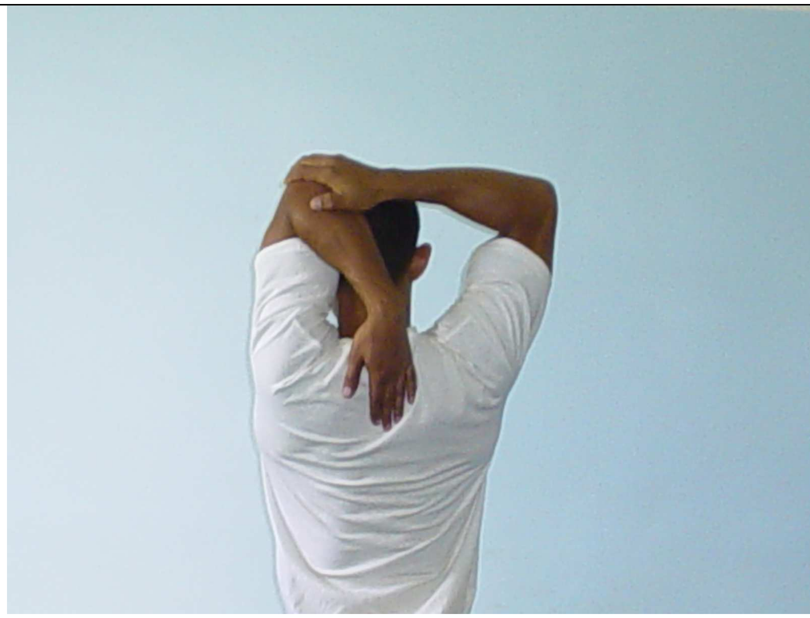
Flexibility exercise No 97: Standing/ sitting lateral neck stretch	
Illustration	
	
Objective	Increase flexibility of the lateral neck.
Primary Muscles	Trapezius, sternocleidomastoid and scalene.
Exercise Description	Sit on a chair with the right hand grasping the lowest part of the chair frame to stabilise the right shoulder. Place the left hand on the upper right side of the head. Exhale and pull the left side of the head onto the left shoulder.
PTI Pointers	The stretch will be dissipitated on the release of the chair.

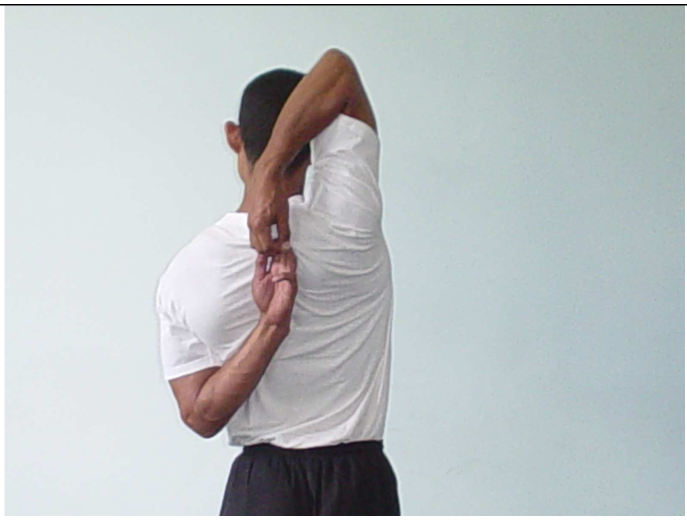
Formal upper limb flexibility exercises

Flexibility exercise No 98: Lateral shoulder stretch	
Illustration	
	
Objective	Increase flexibility of the lateral shoulders.
Primary Muscles	Deltoids, trapezius, infraspinatus, teres major, latissimus dorsi.
Starting Position/ Command	Straddle stand, arms crossed high, position ready. (Standing)
Exercise Description	Sit or stand with one arm raised to shoulder height; flex the arm across the other shoulder. Grasp the raised elbow with the opposite hand, exhale, and pull the elbow backwards.
PTI Pointers	Experiment with flexing and extending the arm of the stretched shoulder to find the most effective stretch.

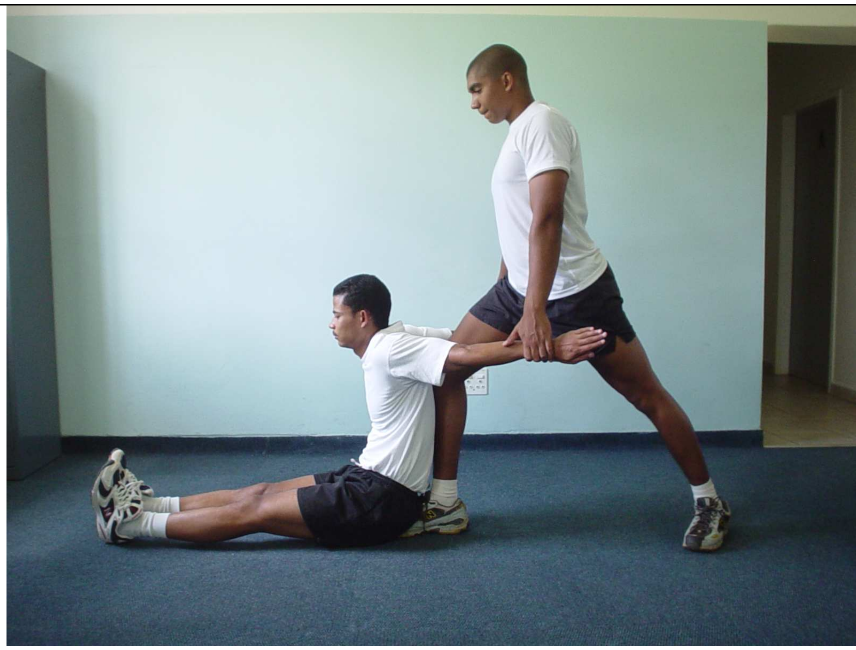
Flexibility exercise No 99: Posterior shoulder stretch	
Illustration	
	
Objective	Increase flexibility of the shoulder external rotators.
Primary Muscles	Deltoids.
Starting Position/ Command	Straddle stand, hands on the hips, position ready.
Exercise Description	Sit or stand with one arm flexed behind the back and grasp the elbow from behind with the opposite hand. Exhale and pull the elbow across the midline of the back. Grasp the wrist if the elbow is out of reach.
PTI Pointers	Keep the head and neck in a neutral position.

Flexibility exercise No 100: Shoulder extensor stretch	
Illustration	
	
Objective	Increase flexibility of the shoulder extensors
Primary Muscles	Deltoids, trapezius, infraspinatus, teres major, latissimus dorsi.
Starting Position/ Command	Straddle stand, arms crossed high, position ready.
Exercise Description	Sitting or standing, cross one wrist over the other and interlock the hands. Inhale then straighten and extend the arms behind the head. The elbows should be behind the ears.
PTI Pointers	Keep the head and neck in a neutral position.

Flexibility exercise No 101: Overhead tricep stretch	
Illustration	
	
Objective	Increase flexibility of the triceps brachi.
Primary Muscles	Tricep brachi
Starting Position/ Command	Straddle stand, arms crossed high, position ready.
Exercise Description	Sit or stand with one arm flexed, raised overhead next to the ear, and the hand resting on the shoulder blade. Grasp the elbow with the other hand, exhale, and pull the elbow behind the head.
PTI Pointers	This stretch is most effective when the elbow is against the wall.

Flexibility exercise No 102: Double tricep stretch	
Illustration	
	
Objective	Increase flexibility of the triceps brachi.
Primary Muscles	Tricep brachi
Starting Position/ Command	Straddle stand, hands on the hips, position ready.
Exercise Description	Sit or stand with one arm behind the back and as far up on the back as possible. Lift the other arm overhead, flex the elbow, and interlock the fingers.
PTI Pointers	This stretch is most effective when the raised elbow is against the wall.

Informal upper limb flexibility exercises

Flexibility exercise No 103: Buddy pec stretch	
Illustration	
	
Objective	Increase flexibility of the shoulders.
Primary Muscles	Deltoids, pectoralis major
Exercise Description	Sit on the floor with the hands about 30cm behind the hips, fingers pointing away from the body, palms sown, and legs extended forward. The partner kneels directly behind and holds both wrists. Exhale as the partner gently pulls the arms backwards and downwards.
PTI Pointers	Be sure to communicate with each other. It is not necessary for the wrists to touch each other. Variation is when the partner gently pulls the arms backwards in a horizontal plane.

Flexibility exercise No 104: Wrist extensors stretch	
Illustration	
	
Objective	Increase flexibility of the wrist extensors.
Primary Muscles	Brachioradialis
Exercise Description	Kneel on all fours, flex the wrists, and place the top of the hands against the floor, fingers pointing towards the knees. Exhale and lean against the floor.
PTI Pointers	Do not place to much body weight on the wrists.

Flexibility exercise No 105: Wrist flexors stretch	
Objective	Increase flexibility of the wrist flexors.
Primary Muscles	Finger flexors.
Exercise Description	Sit or stand on the floor with the wrists bent backwards. Place the heel of the one hand against the upper portion of the fingers of the one hand, and press the heel of the hand against the fingers.
PTI Pointers	Repeat on both hands.

Speed

Speed is the ability to perform a particular movement very rapidly. It is a function of distance and time. It is an important component for successful performance in many competitive athletic situations.

Speed training

Speed (velocity): use high-speed contractions with little resistance
Example: have athletes run 3 repetitions of 50m at top speed, taking a full recovery of 3min after each repetition. Be sure each runner's pulse drops under 120 BPM before starting the next interval.

Power

Power, the explosive aspect of strength, is the product of strength and speed of movement.

Power = (force x distance)/time

Two individuals can each bench-press 200kg, moving the weight the same distance. The one who can do it half the time has twice the power of the slower individual. Although absolute strength is an important component of performance, power is even more important for most activities. In football, for example, an offensive linesman with a bench-press 1 RM of 200 kg may be unable to control a defensive linesman with a bench-press 1 RM of only 150kg if the defensive linesman can move his 1 RM at a much faster speed. The offensive linesman is 50kg stronger, but the defensive linesman's faster speed coupled with good strength gives him the performance edge.

Power training

To best develop power it is suggested high-intensity training with resistance greater that that lifted at 10-RM, varying the intensity over time (e.g. 1- to 5-RM 6- to 10-RM) yet completing no more than 5 repetitions per set and emphasizing speed of movement. There should be a moderate to long rest periods between sets and exercises.

Agility

Agility is not easily defined because it is the culmination of nearly all the physical abilities that an athlete possesses. When integrated with a coordination system, agility permits an athlete to react to a stimulus, start quickly and efficiently, move in the correct direction, and be ready to change direction or stop quickly to make a play in a fast, smooth, efficient, and repeatable manner. People possess several types of agility:

- Whole-body horizontal changes of direction such as faking and avoiding
- Whole-body vertical changes of direction such as jumping and leaping
- Rapid movements of body parts that control movement of implements in sports such as tennis, squash, and hockey.

An athlete who possesses high-quality agility can use it to advantage in competition. High quality agility decreases the potential for injury, improve performance and evasiveness by allowing the athlete to fake or neutralize the completion, and refines the athlete's ability to adjust to an outside object such as a puck or ball.

An athlete can be compared with a computer system; both demonstrate a lot of power and potential. Without agility, however, the athlete is as ineffective as a computer that lacks the appropriate software – great potential but limited performance. There are two critical elements in developing agility, coordination and skill. The role of coordination is to execute the movements chosen in response to a stimulus. The role of skill is to orchestrate these coordinated abilities into an efficient and effective set of general, special, and sport-specific movements. These movements should be executed in a manner that uses maximum certainty with minimum time and energy. Specific acts require the use of unique qualities. When athletes struggle to achieve great agility, it is usually due to a deficiency in one or more of the qualities illustrated in figure 8.

Designing an agility program

A drill is an exercise designed to address a specific aspect of a greater skill. Today we see people train by "just doing" a myriad of drills meant to improve speed, agility, or quickness without understanding how the drills will help. Coaches continue to use these drills repeatedly without analysing them or having a specific goal or outcome in mind.

It is important to classify drills based on how much they contribute (by percentage) to the desired motor ability (mobility, biomechanics, strength, energy system development, and so forth). Drills should be classified as to whether they are general, special, or sport-specific exercises for a given skill, movement, player, sport, or position.

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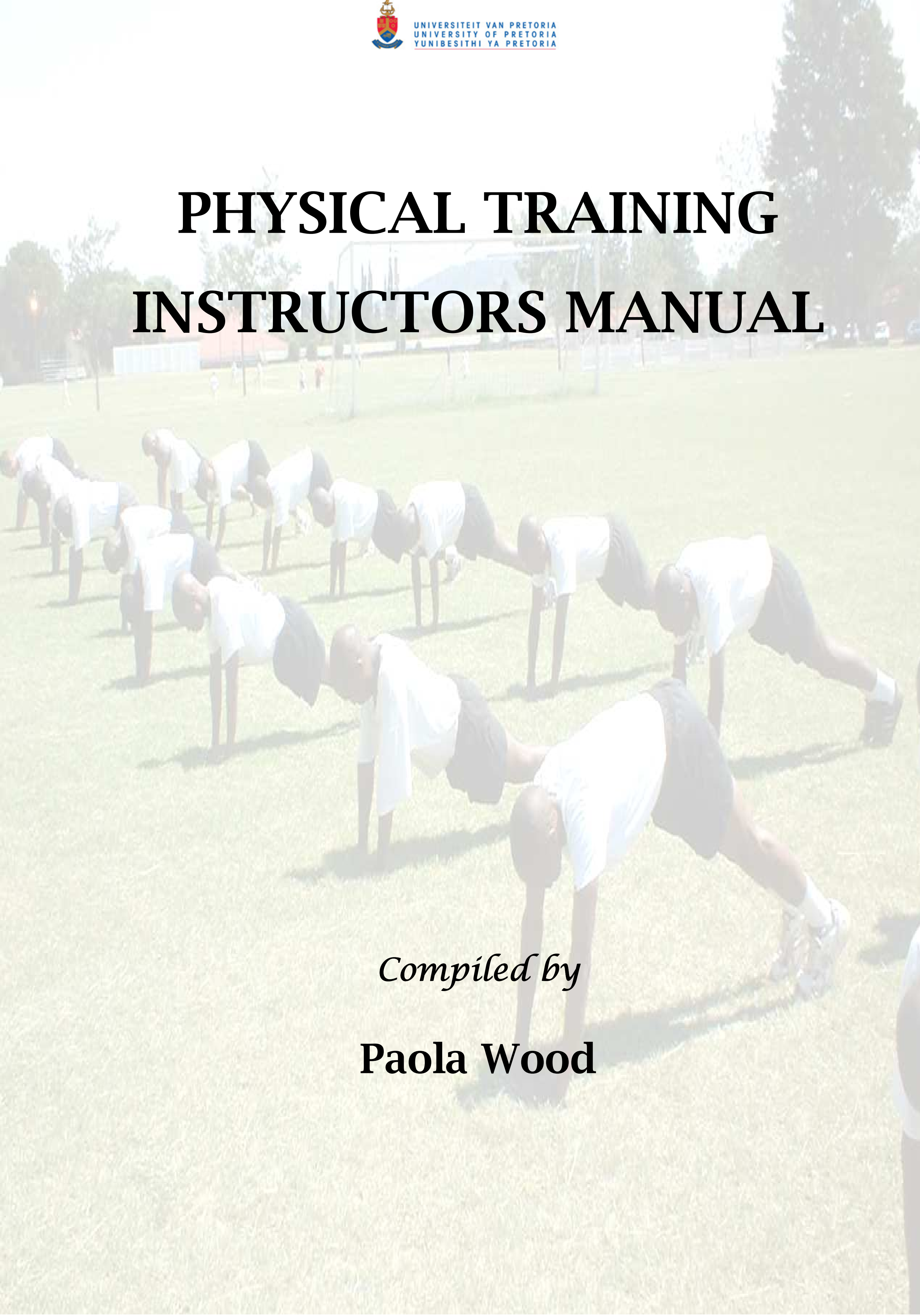

PHYSICAL TRAINING INSTRUCTORS MANUAL

Compiled by

Paola Wood

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Appendix C

Physical training
Instructors manual

Manual-Part 1
Manual-Part 2
Manual-Part 3
Manual-Part 4
Manual-Part 5
Manual-Part 6
Manual-Part 7
Manual-Part 8

Description of Sample Based on Biographical data - Biokinetics data

Age in Years

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	17	1	0.5	0.5	0.5
	18	16	8.7	8.7	9.3
	19	40	21.9	21.9	31.1
	20	57	31.1	31.1	62.3
	21	39	21.3	21.3	83.6
	22	30	16.4	16.4	100.0
	Total	183	100.0	100.0	

GENDER

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	100	54.6	54.6	54.6
	Female	83	45.4	45.4	100.0
	Total	183	100.0	100.0	

ACTIVE

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	136	74.3	74.3	74.3
	No	47	25.7	25.7	100.0
	Total	183	100.0	100.0	

Frequencies of Skeletal Alignment - Foot type by gender

Biokinetics Pre: Foot type (left)

GENDER			Frequency	Percent	Valid Percent	Cumulative Percent
Male	Valid	Flat	22	22.0	22.0	22.0
		Neutral	75	75.0	75.0	97.0
		High	3	3.0	3.0	100.0
		Total	100	100.0	100.0	
Female	Valid	Flat	18	21.7	21.7	21.7
		Neutral	64	77.1	77.1	98.8
		High	1	1.2	1.2	100.0
		Total	83	100.0	100.0	

Biokinetics Pre: Foot type (right)

GENDER			Frequency	Percent	Valid Percent	Cumulative Percent
Male	Valid	Flat	20	20.0	20.0	20.0
		Neutral	75	75.0	75.0	95.0
		High	5	5.0	5.0	100.0
		Total	100	100.0	100.0	
Female	Valid	Flat	18	21.7	21.7	21.7
		Neutral	64	77.1	77.1	98.8
		High	1	1.2	1.2	100.0
		Total	83	100.0	100.0	

RESULTS FOR MALES ON BIOKINETIC DATA

T-Tests - Testing differences between pre- and post -test Anthropometric measurements: Mass to Calf measurements

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Biokinetics Pre: Mass (kg)	61.7770	100	6.88952	0.68895
	Biokinetics Post: Mass (kg)	63.1760	100	6.60569	0.66057
Pair 2	Biokinetics Pre: Triceps	7.3320	100	3.26505	0.32651
	Biokinetics Post: Triceps	6.8720	100	1.99647	0.19965
Pair 3	Biokinetics Pre: Subscapula	9.6220	100	2.75709	0.27571
	Biokinetics Post: Subscapula	9.2940	100	2.30598	0.23060
Pair 4	Biokinetics Pre: Suprailiac	11.2960	100	7.15364	0.71536
	Biokinetics Post: Suprailiac	9.9740	100	3.77441	0.37744
Pair 5	Biokinetics Pre: Abdominal	11.4680	100	7.53364	0.75336
	Biokinetics Post: Abdominal	8.2820	100	3.38100	0.33810
Pair 6	Biokinetics Pre: Mid-thigh	10.5100	100	6.22204	0.62220
	Biokinetics Post: Mid-thigh	10.6460	100	3.24947	0.32495
Pair 7	Biokinetics Pre: Calf	8.1440	100	5.31999	0.53200
	Biokinetics Post: Calf	7.7460	100	3.48107	0.34811
Pair 8	Biokinetics Pre: Humerus	6.6680	100	0.34608	0.03461
	Biokinetics Post: Humerus	6.7860	100	0.34319	0.03432
Pair 9	Biokinetics Pre: Femur	9.1010	100	0.54337	0.05434
	Biokinetics Post: Femur	9.5550	100	0.45045	0.04504
Pair 10	Biokinetics Pre: Bicep	29.4120	100	2.47261	0.24726
	Biokinetics Post: Bicep	30.9130	100	2.09408	0.20941
Pair 11	Biokinetics Pre: Calf	33.8580	100	2.47305	0.24731
	Biokinetics Post: Calf	34.6200	100	2.27716	0.22772

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Biokinetics Pre: Mass (kg) & Biokinetics Post: Mass (kg)	100	0.742	0.000
Pair 2	Biokinetics Pre: Triceps & Biokinetics Post: Triceps	100	0.745	0.000
Pair 3	Biokinetics Pre: Subscapula & Biokinetics Post: Subscapula	100	0.702	0.000
Pair 4	Biokinetics Pre: Suprailiac & Biokinetics Post: Suprailiac	100	0.723	0.000
Pair 5	Biokinetics Pre: Abdominal & Biokinetics Post: Abdominal	100	0.862	0.000
Pair 6	Biokinetics Pre: Mid-thigh & Biokinetics Post: Mid-thigh	100	0.670	0.000
Pair 7	Biokinetics Pre: Calf & Biokinetics Post: Calf	100	0.555	0.000
Pair 8	Biokinetics Pre: Humerus & Biokinetics Post:	100	0.768	0.000
Pair 9	Biokinetics Pre: Femur & Biokinetics Post: Femur	100	0.760	0.000
Pair 10	Biokinetics Pre: Bicep & Biokinetics Post: Bicep	100	0.866	0.000
Pair 11	Biokinetics Pre: Calf & Biokinetics Post: Calf	100	0.741	0.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower			
Pair 1	Biokinetics Pre: Mass (kg) - Biokinetics Post: Mass (kg)	-1.39900	4.84961	0.48496	-2.36127	-0.43673	-2.885	99	0.005
Pair 2	Biokinetics Pre: Triceps - Biokinetics Post: Triceps	0.46000	2.21979	0.22198	0.01955	0.90045	2.072	99	0.041
Pair 3	Biokinetics Pre: Subscapula - Biokinetics Post: Subscapula	0.32800	1.99788	0.19979	-0.06842	0.72442	1.642	99	0.104
Pair 4	Biokinetics Pre: Suprailiac - Biokinetics Post: Suprailiac	1.32200	5.13565	0.51356	0.30298	2.34102	2.574	99	0.012
Pair 5	Biokinetics Pre: Abdominal - Biokinetics Post: Abdominal	3.18600	4.92926	0.49293	2.20793	4.16407	6.463	99	0.000
Pair 6	Biokinetics Pre: Mid-thigh - Biokinetics Post: Mid-thigh	-0.13600	4.71146	0.47115	-1.07086	0.79886	-0.289	99	0.773
Pair 7	Biokinetics Pre: Calf - Biokinetics Post: Calf	0.39800	4.45816	0.44582	-0.48659	1.28259	0.893	99	0.374
Pair 8	Biokinetics Pre: Humerus - Biokinetics Post: Humerus	-0.11800	0.23501	0.02350	-0.16463	-0.07137	-5.021	99	0.000
Pair 9	Biokinetics Pre: Femur - Biokinetics Post: Femur	-0.45400	0.35545	0.03555	-0.52453	-0.38347	-12.772	99	0.000
Pair 10	Biokinetics Pre: Bicep - Biokinetics Post: Bicep	-1.50100	1.23864	0.12386	-1.74677	-1.25523	-12.118	99	0.000
Pair 11	Biokinetics Pre: Calf - Biokinetics Post: Calf	-0.76200	1.71816	0.17182	-1.10292	-0.42108	-4.435	99	0.000

T-Tests - Testing differences between pre- and post -test Anthroprometric measurements: Sum of Skinfolds to Ectomorph measurements

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Biokinetics Pre: Sum of skinfolds	58.3720	100	27.87370	2.78737
	Biokinetics Post: Sum of skinfolds	52.9580	100	14.50459	1.45046
Pair 2	Biokinetics Pre: Fat %	8.7199	100	2.92955	0.29296
	Biokinetics Post: Fat %	8.1509	100	1.52443	0.15244
Pair 3	Biokinetics Pre: Lean body mass	56.2877	100	5.52276	0.55228
	Biokinetics Post: Lean body mass	57.9521	100	6.00390	0.60039
Pair 4	Biokinetics Pre: Fat mass	5.4893	100	2.39003	0.23900
	Biokinetics Post: Fat mass	5.2889	100	2.29167	0.22917
Pair 5	Biokinetics Pre: Ideal fat mass	6.2542	100	0.61364	0.06136
	Biokinetics Post: Ideal fat mass	6.4391	100	0.66710	0.06671
Pair 6	Biokinetics Pre: Ideal body mass	62.5419	100	6.13640	0.61364
	Biokinetics Post: Ideal body mass	64.3912	100	6.67100	0.66710
Pair 7	Biokinetics Pre: Ideal fat %	10.0000(a)	100	0.00000	0.00000
	Biokinetics Post: Ideal fat %	10.0000(a)	100	0.00000	0.00000
Pair 8	Biokinetics Pre: Endomorph	2.7878	100	1.15658	0.11566
	Biokinetics Post: Endomorph	2.6051	100	0.76825	0.07683
Pair 9	Biokinetics Pre: Mesomorph	3.9548	100	1.05876	0.10588
	Biokinetics Post: Mesomorph	4.7649	100	1.02032	0.10203
Pair 10	Biokinetics Pre: Ectotomorph	3.4150	100	1.14067	0.11407
	Biokinetics Post: Ectotomorph	3.1460	100	1.05752	0.10575

a. The correlation and t cannot be computed because the standard error of the difference is 0.

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Biokinetics Pre: Sum of skinfolds & Biokinetics Post: Sum of skinfolds	100	0.841	0.000
Pair 2	Biokinetics Pre: Fat % & Biokinetics Post: Fat %	100	0.841	0.000
Pair 3	Biokinetics Pre: Lean body mass & Biokinetics Post: Lean body mass	100	0.752	0.000
Pair 4	Biokinetics Pre: Fat mass & Biokinetics Post: Fat mass	100	0.788	0.000
Pair 5	Biokinetics Pre: Ideal fat mass & Biokinetics Post: Ideal fat mass	100	0.752	0.000
Pair 6	Biokinetics Pre: Ideal body mass & Biokinetics Post: Ideal body mass	100	0.752	0.000
Pair 8	Biokinetics Pre: Endomorph & Biokinetics Post: Endomorph	100	0.769	0.000
Pair 9	Biokinetics Pre: Mesomorph & Biokinetics Post: Mesomorph	100	0.854	0.000
Pair 10	Biokinetics Pre: Ectotomorph & Biokinetics Post: Ectotomorph	100	0.684	0.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower			
Pair 1	Biokinetics Pre: Sum of skinfolds - Biokinetics Post: Sum of skinfolds	5.41400	17.53211	1.75321	1.93525	8.89275	3.088	99	0.003
Pair 2	Biokinetics Pre: Fat % - Biokinetics Post: Fat %	0.56897	1.84267	0.18427	0.20334	0.93459	3.088	99	0.003
Pair 3	Biokinetics Pre: Lean body mass - Biokinetics Post: Lean body mass	-1.66442	4.08225	0.40823	-2.47443	-0.85441	-4.077	99	0.000
Pair 4	Biokinetics Pre: Fat mass - Biokinetics Post: Fat mass	0.20042	1.52677	0.15268	-0.10253	0.50336	1.313	99	0.192
Pair 5	Biokinetics Pre: Ideal fat mass - Biokinetics Post: Ideal fat mass	-0.18494	0.45358	0.04536	-0.27494	-0.09493	-4.077	99	0.000
Pair 6	Biokinetics Pre: Ideal body mass - Biokinetics Post: Ideal body mass	-1.84935	4.53584	0.45358	-2.74936	-0.94935	-4.077	99	0.000
Pair 8	Biokinetics Pre: Endomorph - Biokinetics Post: Endomorph	0.18263	0.74867	0.07487	0.03407	0.33118	2.439	99	0.016
Pair 9	Biokinetics Pre: Mesomorph - Biokinetics Post: Mesomorph	-0.81011	0.56332	0.05633	-0.92188	-0.69833	-14.381	99	0.000
Pair 10	Biokinetics Pre: Ectotomorph - Biokinetics Post: Ectotomorph	0.26903	0.87714	0.08771	0.09499	0.44307	3.067	99	0.003

T-Tests - Testing differences between pre- and post -test Anthroprometric measurements: X-Axis to Diastolic Blood Pressure

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Biokinetics Pre: X-axis	0.6272	100	2.09579	0.20958
	Biokinetics Post: X-axis	0.5409	100	1.57401	0.15740
Pair 2	Biokinetics Pre: Y-axis	1.7069	100	2.79796	0.27980
	Biokinetics Post: Y-axis	3.7787	100	2.67642	0.26764
Pair 3	Biokinetics Pre: Waist	71.7800	100	4.70242	0.47024
	Biokinetics Post: Waist	72.5350	100	3.47212	0.34721
Pair 4	Biokinetics Pre: Hip	91.9100	100	5.03542	0.50354
	Biokinetics Post: Hip	91.4330	100	4.68874	0.46887
Pair 5	Biokinetics Pre: Systolic blood pressure	120.5900	100	9.61595	0.96160
	Biokinetics Post: Systolic blood pressure	108.7700	100	13.33247	1.33325
Pair 6	Biokinetics Pre: Diastolic blood pressure	76.1800	100	10.56331	1.05633
	Biokinetics Post: Diastolic blood pressure	71.5600	100	8.56505	0.85650

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Biokinetics Pre: X-axis & Biokinetics Post: X-axis	100	0.750	0.000
Pair 2	Biokinetics Pre: Y-axis & Biokinetics Post: Y-axis	100	0.842	0.000
Pair 3	Biokinetics Pre: Waist & Biokinetics Post: Waist	100	0.541	0.000
Pair 4	Biokinetics Pre: Hip & Biokinetics Post: Hip	100	0.678	0.000
Pair 5	Biokinetics Pre: Systolic blood pressure & Biokinetics Post: Systolic blood pressure	100	0.155	0.124
Pair 6	Biokinetics Pre: Diastolic blood pressure & Biokinetics Post: Diastolic blood pressure	100	0.099	0.329

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower			
Pair 1	Biokinetics Pre: X-axis - Biokinetics Post: X-axis	0.08637	1.38731	0.13873	-0.18890	0.36164	0.623	99	0.535
Pair 2	Biokinetics Pre: Y-axis - Biokinetics Post: Y-axis	-2.07182	1.54134	0.15413	-2.37766	-1.76598	-13.442	99	0.000
Pair 3	Biokinetics Pre: Waist - Biokinetics Post: Waist	-0.75500	4.06031	0.40603	-1.56065	0.05065	-1.859	99	0.066
Pair 4	Biokinetics Pre: Hip - Biokinetics Post: Hip	0.47700	3.91196	0.39120	-0.29922	1.25322	1.219	99	0.226
Pair 5	Biokinetics Pre: Systolic blood pressure - Biokinetics Post: Systolic blood pressure	11.82000	15.18198	1.51820	8.80757	14.83243	7.786	99	0.000
Pair 6	Biokinetics Pre: Diastolic blood pressure - Biokinetics Post: Diastolic blood pressure	4.62000	12.92619	1.29262	2.05516	7.18484	3.574	99	0.001

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T-Tests - Testing differences between pre- and post-test ROM/Flexibility measurements

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Biokinetics Pre: Modified Sit Reach (cm)	9.9200	100	5.62719	0.56272
	Biokinetics Post: Modified Sit Reach (cm)	10.8000	100	6.54742	0.65474
Pair 2	Biokinetics Pre: Plantar flexion (left)	49.2300	100	8.34951	0.83495
	Biokinetics Post: Plantar flexion (left)	40.3500	100	16.37526	1.63753
Pair 3	Biokinetics Pre: Plantar flexion (right)	45.6700	100	7.88690	0.78869
	Biokinetics Post: Plantar flexion (right)	39.0800	100	15.15354	1.51535
Pair 4	Biokinetics Pre: Dosiflexion (left)	17.1400	100	3.65154	0.36515
	Biokinetics Post: Dosiflexion (left)	24.5800	100	15.71731	1.57173
Pair 5	Biokinetics Pre: Dosiflexion (right)	18.2500	100	4.14235	0.41424
	Biokinetics Post: Dosiflexion (right)	25.2800	100	14.83381	1.48338
Pair 6	Biokinetics Pre: Hip external rotation (left)	25.5700	100	4.13718	0.41372
	Biokinetics Post: Hip external rotation (left)	21.1800	100	4.70628	0.47063
Pair 7	Biokinetics Pre: Hip external rotation (right)	23.4000	100	3.71728	0.37173
	Biokinetics Post: Hip external rotation (right)	21.0400	100	4.90500	0.49050

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Biokinetics Pre: Modified Sit Reach (cm) & Biokinetics Post: Modified Sit Reach (cm)	100	0.743	0.000
Pair 2	Biokinetics Pre: Plantar flexion (left) & Biokinetics Post: Plantar flexion (left)	100	-0.061	0.549
Pair 3	Biokinetics Pre: Plantar flexion (right) & Biokinetics Post: Plantar flexion (right)	100	-0.110	0.276
Pair 4	Biokinetics Pre: Dosiflexion (left) & Biokinetics Post: Dosiflexion (left)	100	0.043	0.670
Pair 5	Biokinetics Pre: Dosiflexion (right) & Biokinetics Post: Dosiflexion (right)	100	0.076	0.454
Pair 6	Biokinetics Pre: Hip external rotation (left) & Biokinetics Post: Hip external rotation (left)	100	0.384	0.000
Pair 7	Biokinetics Pre: Hip external rotation (right) & Biokinetics Post: Hip external rotation (right)	100	0.303	0.002

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower			
Pair 1	Biokinetics Pre: Modified Sit Reach (cm) - Biokinetics Post: Modified Sit Reach (cm)	-0.88000	4.44615	0.44462	-1.76221	0.00221	-1.979	99	0.051
Pair 2	Biokinetics Pre: Plantar flexion (left) - Biokinetics Post: Plantar flexion (left)	8.88000	18.82631	1.88263	5.14445	12.61555	4.717	99	0.000
Pair 3	Biokinetics Pre: Plantar flexion (right) - Biokinetics Post: Plantar flexion (right)	6.59000	17.83657	1.78366	3.05084	10.12916	3.695	99	0.000
Pair 4	Biokinetics Pre: Dosiflexion (left) - Biokinetics Post: Dosiflexion (left)	-7.44000	15.98188	1.59819	-10.61115	-4.26885	-4.655	99	0.000
Pair 5	Biokinetics Pre: Dosiflexion (right) - Biokinetics Post: Dosiflexion (right)	-7.03000	15.09596	1.50960	-10.02537	-4.03463	-4.657	99	0.000
Pair 6	Biokinetics Pre: Hip external rotation (left) - Biokinetics Post: Hip external rotation (left)	4.39000	4.92960	0.49296	3.41186	5.36814	8.905	99	0.000
Pair 7	Biokinetics Pre: Hip external rotation (right) - Biokinetics Post: Hip external rotation (right)	2.36000	5.18062	0.51806	1.33205	3.38795	4.555	99	0.000

T-Tests - Testing differences between pre- and post-test Skeletal Alignment measurements

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Biokinetics Pre: Q angle (left)	9.9300(a)	100	2.82577	0.28258
	Biokinetics Pre: Q angle (left)	9.9300(a)	100	2.82577	0.28258
Pair 2	Biokinetics Pre: Q angle (right)	9.7600(a)	100	2.55888	0.25589
	Biokinetics Pre: Q angle (right)	9.7600(a)	100	2.55888	0.25589

a. The correlation and t cannot be computed because the standard error of the difference is 0.

T-Tests - Testing differences between pre- and post-test Isokinetic Muscle streng Knee measurements

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Biokinetics Pre: Knee extension/flexion: Extensors absolute (left)	170.0700	100	34.82257	3.48226
	Biokinetics Post: Knee extension/flexion: Extensors absolute (left)	173.7660	100	32.11948	3.21195
Pair 2	Biokinetics Pre: Knee extension/flexion: Extensors absolute (right)	164.2800	100	38.72907	3.87291
	Biokinetics Post: Knee extension/flexion: Extensors absolute (right)	169.0860	100	30.87616	3.08762
Pair 3	Biokinetics Pre: Knee extension/flexion: Extensors relative (left)	2.7543	100	0.45605	0.04561
	Biokinetics Post: Knee extension/flexion: Extensors relative (left)	2.7451	100	0.40116	0.04012
Pair 4	Biokinetics Pre: Knee extension/flexion: Extensors relative (right)	2.6592	100	0.53421	0.05342
	Biokinetics Post: Knee extension/flexion: Extensors relative (right)	2.6776	100	0.42735	0.04274
Pair 5	Biokinetics Pre: Knee extension/flexion: Flexor absolute (left)	106.3400	100	24.09251	2.40925
	Biokinetics Post: Knee extension/flexion: Flexor absolute (left)	120.3130	100	23.25405	2.32540
Pair 6	Biokinetics Pre: Knee extension/flexion: Flexor absolute (right)	103.5100	100	25.70245	2.57025
	Biokinetics Post: Knee extension/flexion: Flexor absolute (right)	123.7220	100	24.29040	2.42904
Pair 7	Biokinetics Pre: Knee extension/flexion: Flexor relative (left)	1.7218	100	0.32632	0.03263
	Biokinetics Post: Knee extension/flexion: Flexor relative (left)	1.9057	100	0.32848	0.03285
Pair 8	Biokinetics Pre: Knee extension/flexion: Flexor relative (right)	1.6751	100	0.36659	0.03666
	Biokinetics Post: Knee extension/flexion: Flexor relative (right)	1.9626	100	0.37865	0.03786
Pair 9	Biokinetics Pre: Knee extension/flexion: Knee flexor/extensor ratio (left-%)	64.2700	100	15.72738	1.57274
	Biokinetics Post: Knee extension/flexion: Knee flexor/extensor ratio (left-%)	69.9046	100	10.21523	1.02152
Pair 10	Biokinetics Pre: Knee extension/flexion: Knee flexor/extensor ratio (right-%)	64.7200	100	14.71485	1.47149
	Biokinetics Post: Knee extension/flexion: Knee flexor/extensor ratio (right-%)	73.8403	100	11.28783	1.12878

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Biokinetics Pre: Knee extension/flexion: Extensors absolute (left) & Biokinetics Post: Knee extension/flexion: Extensors absolute (left)	100	0.703	0.000
Pair 2	Biokinetics Pre: Knee extension/flexion: Extensors absolute (right) & Biokinetics Post: Knee extension/flexion: Extensors absolute (right)	100	0.649	0.000
Pair 3	Biokinetics Pre: Knee extension/flexion: Extensors relative (left) & Biokinetics Post: Knee extension/flexion: Extensors relative (left)	100	0.564	0.000
Pair 4	Biokinetics Pre: Knee extension/flexion: Extensors relative (right) & Biokinetics Post: Knee extension/flexion: Extensors relative (right)	100	0.480	0.000
Pair 5	Biokinetics Pre: Knee extension/flexion: Flexor absolute (left) & Biokinetics Post: Knee extension/flexion: Flexor absolute (left)	100	0.700	0.000
Pair 6	Biokinetics Pre: Knee extension/flexion: Flexor absolute (right) & Biokinetics Post: Knee extension/flexion: Flexor absolute (right)	100	0.725	0.000
Pair 7	Biokinetics Pre: Knee extension/flexion: Flexor relative (left) & Biokinetics Post: Knee extension/flexion: Flexor relative (left)	100	0.577	0.000
Pair 8	Biokinetics Pre: Knee extension/flexion: Flexor relative (right) & Biokinetics Post: Knee extension/flexion: Flexor relative (right)	100	0.556	0.000
Pair 9	Biokinetics Pre: Knee extension/flexion: Knee flexor/extensor ratio (left-%) & Biokinetics Post: Knee extension/flexion: Knee flexor/extensor ratio (left-%)	100	0.432	0.000
Pair 10	Biokinetics Pre: Knee extension/flexion: Knee flexor/extensor ratio (right-%) & Biokinetics Post: Knee extension/flexion: Knee flexor/extensor ratio (right-%)	100	0.307	0.002

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower			
Pair 1	Biokinetics Pre: Knee extension/flexion: Extensors absolute (left) - Biokinetics Post: Knee extension/flexion: Extensors absolute (left)	-3.69600	25.91893	2.59189	-8.83888	1.44688	-1.426	99	0.157
Pair 2	Biokinetics Pre: Knee extension/flexion: Extensors absolute (right) - Biokinetics Post: Knee extension/flexion: Extensors absolute (right)	-4.80600	30.01235	3.00124	-10.76110	1.14910	-1.601	99	0.112
Pair 3	Biokinetics Pre: Knee extension/flexion: Extensors relative (left) - Biokinetics Post: Knee extension/flexion: Extensors relative (left)	0.00915	0.40304	0.04030	-0.07082	0.08912	0.227	99	0.821
Pair 4	Biokinetics Pre: Knee extension/flexion: Extensors relative (right) - Biokinetics Post: Knee extension/flexion: Extensors relative (right)	-0.01841	0.49904	0.04990	-0.11743	0.08061	-0.369	99	0.713
Pair 5	Biokinetics Pre: Knee extension/flexion: Flexor absolute (left) - Biokinetics Post: Knee extension/flexion: Flexor absolute (left)	-13.97300	18.35273	1.83527	-17.61458	#######	-7.614	99	0.000
Pair 6	Biokinetics Pre: Knee extension/flexion: Flexor absolute (right) - Biokinetics Post: Knee extension/flexion: Flexor absolute (right)	-20.21200	18.58308	1.85831	-23.89929	#######	-10.877	99	0.000
Pair 7	Biokinetics Pre: Knee extension/flexion: Flexor relative (left) - Biokinetics Post: Knee extension/flexion: Flexor relative (left)	-0.18390	0.30104	0.03010	-0.24363	-0.12416	-6.109	99	0.000
Pair 8	Biokinetics Pre: Knee extension/flexion: Flexor relative (right) - Biokinetics Post: Knee extension/flexion: Flexor relative (right)	-0.28758	0.35113	0.03511	-0.35725	-0.21791	-8.190	99	0.000
Pair 9	Biokinetics Pre: Knee extension/flexion: Knee flexor/extensor ratio (left-%) - Biokinetics Post: Knee extension/flexion: Knee flexor/extensor ratio (left-%)	-5.63463	14.59216	1.45922	-8.53003	-2.73923	-3.861	99	0.000
Pair 10	Biokinetics Pre: Knee extension/flexion: Knee flexor/extensor ratio (right-%) - Biokinetics Post: Knee extension/flexion: Knee flexor/extensor ratio (right-%)	-9.12029	15.55847	1.55585	-12.20743	-6.03316	-5.862	99	0.000

T-Tests - Testing differences between pre- and post-test Isokinetic Muscle Strenght Ancle measurements

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Biokinetics Pre: Ankle plantar/ dorsiflexion: Plantarflexion absolute (left)	68.4700	100	17.27932	1.72793
	Biokinetics Post: Ankle plantar/ dorsiflexion: Plantarflexion absolute (left)	72.5100	100	17.40167	1.74017
Pair 2	Biokinetics Pre: Ankle plantar/ dorsiflexion: Plantarflexion absolute (right)	68.2100	100	17.85989	1.78599
	Biokinetics Post: Ankle plantar/ dorsiflexion: Plantarflexion absolute (right)	77.9210	100	18.28340	1.82834
Pair 3	Biokinetics Pre: Ankle plantar/ dorsiflexion: Plantarflexion relative (left)	1.1115	100	0.27122	0.02712
	Biokinetics Post: Ankle plantar/ dorsiflexion: Plantarflexion relative (left)	1.1301	100	0.31092	0.03109
Pair 4	Biokinetics Pre: Ankle plantar/ dorsiflexion: Plantarflexion relative (right)	1.1094	100	0.28753	0.02875
	Biokinetics Post: Ankle plantar/ dorsiflexion: Plantarflexion relative (right)	1.2186	100	0.34634	0.03463
Pair 5	Biokinetics Pre: Ankle plantar/ dorsiflexion: Dorsiflexion absolute (left)	28.6300	100	5.01846	0.50185
	Biokinetics Post: Ankle plantar/ dorsiflexion: Dorsiflexion absolute (left)	27.4500	100	5.13922	0.51392
Pair 6	Biokinetics Pre: Ankle plantar/ dorsiflexion: Dorsiflexion absolute (right)	28.5200	100	5.07217	0.50722
	Biokinetics Post: Ankle plantar/ dorsiflexion: Dorsiflexion absolute (right)	28.2700	100	5.57566	0.55757
Pair 7	Biokinetics Pre: Ankle plantar/ dorsiflexion: Dorsiflexion relative (left)	0.4636	100	0.06348	0.00635
	Biokinetics Post: Ankle plantar/ dorsiflexion: Dorsiflexion relative (left)	0.4389	100	0.07721	0.00772
Pair 8	Biokinetics Pre: Ankle plantar/ dorsiflexion: Dorsiflexion relative (right)	0.4624	100	0.06857	0.00686
	Biokinetics Post: Ankle plantar/ dorsiflexion: Dorsiflexion relative (right)	0.4513	100	0.07994	0.00799

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Biokinetics Pre: Ankle plantar/ dorsiflexion: Plantarflexion absolute (left) & Biokinetics Post: Ankle plantar/ dorsiflexion: Plantarflexion absolute (left)	100	0.560	0.000
Pair 2	Biokinetics Pre: Ankle plantar/ dorsiflexion: Plantarflexion absolute (right) & Biokinetics Post: Ankle plantar/ dorsiflexion: Plantarflexion absolute (right)	100	0.620	0.000
Pair 3	Biokinetics Pre: Ankle plantar/ dorsiflexion: Plantarflexion relative (left) & Biokinetics Post: Ankle plantar/ dorsiflexion: Plantarflexion relative (left)	100	0.404	0.000
Pair 4	Biokinetics Pre: Ankle plantar/ dorsiflexion: Plantarflexion relative (right) & Biokinetics Post: Ankle plantar/ dorsiflexion: Plantarflexion relative (right)	100	0.433	0.000
Pair 5	Biokinetics Pre: Ankle plantar/ dorsiflexion: Dorsiflexion absolute (left) & Biokinetics Post: Ankle plantar/ dorsiflexion: Dorsiflexion absolute (left)	100	0.693	0.000
Pair 6	Biokinetics Pre: Ankle plantar/ dorsiflexion: Dorsiflexion absolute (right) & Biokinetics Post: Ankle plantar/ dorsiflexion: Dorsiflexion absolute (right)	100	0.596	0.000
Pair 7	Biokinetics Pre: Ankle plantar/ dorsiflexion: Dorsiflexion relative (left) & Biokinetics Post: Ankle plantar/ dorsiflexion: Dorsiflexion relative (left)	100	0.425	0.000
Pair 8	Biokinetics Pre: Ankle plantar/ dorsiflexion: Dorsiflexion relative (right) & Biokinetics Post: Ankle plantar/ dorsiflexion: Dorsiflexion relative (right)	100	0.350	0.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	Interval of the Upper	Interval of the Lower			
Pair 1	Biokinetics Pre: Ankle plantar/ dorsiflexion: Plantarflexion absolute (left) - Biokinetics Post: Ankle plantar/ dorsiflexion: Plantarflexion absolute (left)	-4.04000	16.25797	1.62580	-7.26593	-0.81407	-2.485	99	0.015
Pair 2	Biokinetics Pre: Ankle plantar/ dorsiflexion: Plantarflexion absolute (right) - Biokinetics Post: Ankle plantar/ dorsiflexion: Plantarflexion absolute (right)	-9.71100	15.76887	1.57689	-12.83989	-6.58211	-6.158	99	0.000
Pair 3	Biokinetics Pre: Ankle plantar/ dorsiflexion: Plantarflexion relative (left) - Biokinetics Post: Ankle plantar/ dorsiflexion: Plantarflexion relative (left)	-0.01861	0.31948	0.03195	-0.08200	0.04478	-0.582	99	0.562
Pair 4	Biokinetics Pre: Ankle plantar/ dorsiflexion: Plantarflexion relative (right) - Biokinetics Post: Ankle plantar/ dorsiflexion: Plantarflexion relative (right)	-0.10922	0.34103	0.03410	-0.17688	-0.04155	-3.202	99	0.002
Pair 5	Biokinetics Pre: Ankle plantar/ dorsiflexion: Dorsiflexion absolute (left) - Biokinetics Post: Ankle plantar/ dorsiflexion: Dorsiflexion absolute (left)	1.18000	3.98071	0.39807	0.39014	1.96986	2.964	99	0.004
Pair 6	Biokinetics Pre: Ankle plantar/ dorsiflexion: Dorsiflexion absolute (right) - Biokinetics Post: Ankle plantar/ dorsiflexion: Dorsiflexion absolute (right)	0.25000	4.80609	0.48061	-0.70363	1.20363	0.520	99	0.604
Pair 7	Biokinetics Pre: Ankle plantar/ dorsiflexion: Dorsiflexion relative (left) - Biokinetics Post: Ankle plantar/ dorsiflexion: Dorsiflexion relative (left)	0.02474	0.07631	0.00763	0.00960	0.03988	3.242	99	0.002
Pair 8	Biokinetics Pre: Ankle plantar/ dorsiflexion: Dorsiflexion relative (right) - Biokinetics Post: Ankle plantar/ dorsiflexion: Dorsiflexion relative (right)	0.01101	0.08519	0.00852	-0.00589	0.02791	1.292	99	0.199

T-Tests - Testing differences between pre- and post-test Hand Grip measurements

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Biokinetics Pre: Hand grip (left)	45.3100	100	7.37960	0.73796
	Biokinetics Post: Hand grip (left)	44.8000	100	6.57206	0.65721
Pair 2	Biokinetics Pre: Hand grip (right)	46.8200	100	7.72296	0.77230
	Biokinetics Post: Hand grip (right)	47.5500	100	6.71704	0.67170
Pair 3	Biokinetics Pre: Hand grip relative (left)	0.7385	100	0.12445	0.01244
	Biokinetics Post: Hand grip relative (left)	0.7120	100	0.10186	0.01019
Pair 4	Biokinetics Pre: Hand grip relative(right)	0.7622	100	0.12287	0.01229
	Biokinetics Post: Hand grip relative(right)	0.7556	100	0.10390	0.01039

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Biokinetics Pre: Hand grip (left) & Biokinetics Post: Hand grip (left)	100	0.722	0.000
Pair 2	Biokinetics Pre: Hand grip (right) & Biokinetics Post: Hand grip (right)	100	0.719	0.000
Pair 3	Biokinetics Pre: Hand grip relative (left) & Biokinetics Post: Hand grip relative (left)	100	0.654	0.000
Pair 4	Biokinetics Pre: Hand grip relative(right) & Biokinetics Post: Hand grip relative(right)	100	0.594	0.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower			
Pair 1	Biokinetics Pre: Hand grip (left) - Biokinetics Post: Hand grip (left)	0.51000	5.25221	0.52522	-0.53215	1.55215	0.971	99	0.334
Pair 2	Biokinetics Pre: Hand grip (right) - Biokinetics Post: Hand grip (right)	-0.73000	5.49169	0.54917	-1.81967	0.35967	-1.329	99	0.187
Pair 3	Biokinetics Pre: Hand grip relative (left) - Biokinetics Post: Hand grip relative (left)	0.02652	0.09631	0.00963	0.00741	0.04563	2.753	99	0.007
Pair 4	Biokinetics Pre: Hand grip relative(right) - Biokinetics Post: Hand grip relative(right)	0.00666	0.10352	0.01035	-0.01388	0.02720	0.644	99	0.521

FEMALE DATA

T-Tests - Testing differences between pre- and post-test Anthroprometric measurements: Mass to Calf measurements

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Biokinetics Pre: Mass (kg)	60.2157	83	8.99072	0.98686
	Biokinetics Post: Mass (kg)	60.0361	83	7.47874	0.82090
Pair 2	Biokinetics Pre: Triceps	19.4084	83	7.40442	0.81274
	Biokinetics Post: Triceps	18.7675	83	6.10765	0.67040
Pair 3	Biokinetics Pre: Subscapula	16.0373	83	6.52830	0.71657
	Biokinetics Post: Subscapula	13.8289	83	4.38869	0.48172
Pair 4	Biokinetics Pre: Suprailiac	23.2783	83	9.82931	1.07891
	Biokinetics Post: Suprailiac	19.1711	83	6.67753	0.73295
Pair 5	Biokinetics Pre: Abdominal	21.5422	83	8.66259	0.95084
	Biokinetics Post: Abdominal	16.1108	83	6.43582	0.70642
Pair 6	Biokinetics Pre: Mid-thigh	35.8024	83	13.41112	1.47206
	Biokinetics Post: Mid-thigh	28.7277	83	10.01542	1.09934
Pair 7	Biokinetics Pre: Calf	24.1759	83	8.60564	0.94459
	Biokinetics Post: Calf	20.7675	83	7.02532	0.77113
Pair 8	Biokinetics Pre: Humerus	5.8157	83	0.32176	0.03532
	Biokinetics Post: Humerus	6.0145	83	0.34006	0.03733
Pair 9	Biokinetics Pre: Femur	8.4807	83	0.53201	0.05840
	Biokinetics Post: Femur	9.3253	83	0.68962	0.07570
Pair 10	Biokinetics Pre: Bicep	27.2880	83	2.73997	0.30075
	Biokinetics Post: Bicep	28.0349	83	2.54929	0.27982
Pair 11	Biokinetics Pre: Calf	34.4651	83	2.83181	0.31083
	Biokinetics Post: Calf	35.6193	83	2.49504	0.27387

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Biokinetics Pre: Mass (kg) & Biokinetics Post: Mass (kg)	83	0.895	0.000
Pair 2	Biokinetics Pre: Triceps & Biokinetics Post: Triceps	83	0.637	0.000
Pair 3	Biokinetics Pre: Subscapula & Biokinetics Post: Subscapula	83	0.631	0.000
Pair 4	Biokinetics Pre: Suprailiac & Biokinetics Post: Suprailiac	83	0.566	0.000
Pair 5	Biokinetics Pre: Abdominal & Biokinetics Post: Abdominal	83	0.760	0.000
Pair 6	Biokinetics Pre: Mid-thigh & Biokinetics Post: Mid-thigh	83	0.531	0.000
Pair 7	Biokinetics Pre: Calf & Biokinetics Post: Calf	83	0.190	0.085
Pair 8	Biokinetics Pre: Humerus & Biokinetics Post: Humerus	83	0.426	0.000
Pair 9	Biokinetics Pre: Femur & Biokinetics Post: Femur	83	0.779	0.000
Pair 10	Biokinetics Pre: Bicep & Biokinetics Post: Bicep	83	0.609	0.000
Pair 11	Biokinetics Pre: Calf & Biokinetics Post: Calf	83	0.897	0.000

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	Interval of the Upper	Interval of the Lower			
Pair 1	Biokinetics Pre: Mass (kg) - Biokinetics Post: Mass (kg)	0.17952	4.04311	0.44379	-0.70332	1.06236	0.405	82	0.687
Pair 2	Biokinetics Pre: Triceps - Biokinetics Post: Triceps	0.64096	5.87504	0.64487	-0.64189	1.92381	0.994	82	0.323
Pair 3	Biokinetics Pre: Subscapula - Biokinetics Post: Subscapula	2.20843	5.07322	0.55686	1.10066	3.31620	3.966	82	0.000
Pair 4	Biokinetics Pre: Suprailiac - Biokinetics Post: Suprailiac	4.10723	8.17591	0.89742	2.32197	5.89249	4.577	82	0.000
Pair 5	Biokinetics Pre: Abdominal - Biokinetics Post: Abdominal	5.43133	5.63512	0.61854	4.20086	6.66179	8.781	82	0.000
Pair 6	Biokinetics Pre: Mid-thigh - Biokinetics Post: Mid-thigh	7.07470	11.72446	1.28693	4.51459	9.63481	5.497	82	0.000
Pair 7	Biokinetics Pre: Calf - Biokinetics Post: Calf	3.40843	10.02013	1.09985	1.22048	5.59639	3.099	82	0.003
Pair 8	Biokinetics Pre: Humerus - Biokinetics Post: Humerus	-0.19880	0.35493	0.03896	-0.27630	-0.12129	-5.103	82	0.000
Pair 9	Biokinetics Pre: Femur - Biokinetics Post: Femur	-0.84458	0.43231	0.04745	-0.93898	-0.75018	-17.799	82	0.000
Pair 10	Biokinetics Pre: Bicep - Biokinetics Post: Bicep	-0.74699	2.34439	0.25733	-1.25890	-0.23508	-2.903	82	0.005
Pair 11	Biokinetics Pre: Calf - Biokinetics Post: Calf	-1.15422	1.25410	0.13765	-1.42806	-0.88038	-8.385	82	0.000

T-Tests - Testing differences between pre- and post-test Anthropormetric measurements: Sum of Skinfolds to Ectomorph

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Biokinetics Pre: Sum of skinfolds	140.2458	83	42.55412	4.67092
	Biokinetics Post: Sum of skinfolds	117.3735	83	29.93305	3.28558
Pair 2	Biokinetics Pre: Fat %	17.3248	83	4.47249	0.49092
	Biokinetics Post: Fat %	14.9210	83	3.14596	0.34531
Pair 3	Biokinetics Pre: Lean body mass	49.4784	83	5.45816	0.59911
	Biokinetics Post: Lean body mass	50.1142	83	5.37430	0.58991
Pair 4	Biokinetics Pre: Fat mass	10.7409	83	4.27362	0.46909
	Biokinetics Post: Fat mass	9.9220	83	4.75946	0.52242
Pair 5	Biokinetics Pre: Ideal fat mass	8.6886	83	1.00525	0.11034
	Biokinetics Post: Ideal fat mass	8.8031	83	1.00752	0.11059
Pair 6	Biokinetics Pre: Ideal body mass	58.1634	83	6.39413	0.70185
	Biokinetics Post: Ideal body mass	58.9172	83	6.32230	0.69396
Pair 7	Biokinetics Pre: Ideal fat %	14.9398(a)	83	0.54882	0.06024
	Biokinetics Post: Ideal fat %	14.9398(a)	83	0.54882	0.06024
Pair 8	Biokinetics Pre: Endomorph	5.8680	83	1.64123	0.18015
	Biokinetics Post: Endomorph	5.3679	83	1.25942	0.13824
Pair 9	Biokinetics Pre: Mesomorph	3.6504	83	1.09129	0.11978
	Biokinetics Post: Mesomorph	4.7276	83	1.16326	0.12768
Pair 10	Biokinetics Pre: Ectotomorph	1.4829	83	1.42648	0.15658
	Biokinetics Post: Ectotomorph	1.4612	83	1.12661	0.12366

a. The correlation and t cannot be computed because the standard error of the difference is 0.

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Biokinetics Pre: Sum of skinfolds & Biokinetics Post: Sum of skinfolds	83	0.687	0.000
Pair 2	Biokinetics Pre: Fat % & Biokinetics Post: Fat %	83	0.687	0.000
Pair 3	Biokinetics Pre: Lean body mass & Biokinetics Post: Lean body mass	83	0.746	0.000
Pair 4	Biokinetics Pre: Fat mass & Biokinetics Post: Fat mass	83	0.608	0.000
Pair 5	Biokinetics Pre: Ideal fat mass & Biokinetics Post: Ideal fat mass	83	0.772	0.000
Pair 6	Biokinetics Pre: Ideal body mass & Biokinetics Post: Ideal body mass	83	0.745	0.000
Pair 8	Biokinetics Pre: Endomorph & Biokinetics Post: Endomorph	83	0.673	0.000
Pair 9	Biokinetics Pre: Mesomorph & Biokinetics Post: Mesomorph	83	0.807	0.000
Pair 10	Biokinetics Pre: Ectotomorph & Biokinetics Post: Ectotomorph	83	0.902	0.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower			
Pair 1	Biokinetics Pre: Sum of skinfolds - Biokinetics Post: Sum of skinfolds	22.87229	30.94173	3.39630	16.11597	29.62860	6.734	82	0.000
Pair 2	Biokinetics Pre: Fat % - Biokinetics Post: Fat %	2.40387	3.25203	0.35696	1.69377	3.11397	6.734	82	0.000
Pair 3	Biokinetics Pre: Lean body mass - Biokinetics Post: Lean body mass	-0.63574	3.86381	0.42411	-1.47942	0.20795	-1.499	82	0.138
Pair 4	Biokinetics Pre: Fat mass - Biokinetics Post: Fat mass	0.81887	4.02453	0.44175	-0.05991	1.69765	1.854	82	0.067
Pair 5	Biokinetics Pre: Ideal fat mass - Biokinetics Post: Ideal fat mass	-0.11450	0.68009	0.07465	-0.26300	0.03400	-1.534	82	0.129
Pair 6	Biokinetics Pre: Ideal body mass - Biokinetics Post: Ideal body mass	-0.75385	4.53963	0.49829	-1.74510	0.23741	-1.513	82	0.134
Pair 8	Biokinetics Pre: Endomorph - Biokinetics Post: Endomorph	0.50006	1.22365	0.13431	0.23287	0.76725	3.723	82	0.000
Pair 9	Biokinetics Pre: Mesomorph - Biokinetics Post: Mesomorph	-1.07723	0.70326	0.07719	-1.23079	-0.92366	-13.955	82	0.000
Pair 10	Biokinetics Pre: Ectotomorph - Biokinetics Post: Ectotomorph	0.02174	0.63563	0.06977	-0.11705	0.16053	0.312	82	0.756

T-Tests - Testing differences between pre- and post-test X-Axis to Diastolic Blood Pressure measurements

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Biokinetics Pre: X-axis	-4.3849	83	2.90997	0.31941
	Biokinetics Post: X-axis	-3.9067	83	2.23810	0.24566
Pair 2	Biokinetics Pre: Y-axis	-0.0496	83	2.57430	0.28257
	Biokinetics Post: Y-axis	2.6262	83	2.65928	0.29189
Pair 3	Biokinetics Pre: Waist	71.4940	83	7.21850	0.79233
	Biokinetics Post: Waist	71.5831	83	8.51556	0.93470
Pair 4	Biokinetics Pre: Hip	99.3133	83	7.99989	0.87810
	Biokinetics Post: Hip	99.7000	83	6.58139	0.72240
Pair 5	Biokinetics Pre: Systolic blood pressure	117.1928	83	7.71514	0.84685
	Biokinetics Post: Systolic blood pressure	109.1807	83	10.89209	1.19556
Pair 6	Biokinetics Pre: Diastolic blood pressure	74.0120	83	8.26909	0.90765
	Biokinetics Post: Diastolic blood pressure	67.7349	83	9.30130	1.02095

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Biokinetics Pre: X-axis & Biokinetics Post: X-axis	83	0.811	0.000
Pair 2	Biokinetics Pre: Y-axis & Biokinetics Post: Y-axis	83	0.760	0.000
Pair 3	Biokinetics Pre: Waist & Biokinetics Post: Waist	83	0.472	0.000
Pair 4	Biokinetics Pre: Hip & Biokinetics Post: Hip	83	0.801	0.000
Pair 5	Biokinetics Pre: Systolic blood pressure & Biokinetics Post: Systolic blood pressure	83	0.036	0.746
Pair 6	Biokinetics Pre: Diastolic blood pressure & Biokinetics Post: Diastolic blood pressure	83	-0.069	0.535

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower			
Pair 1	Biokinetics Pre: X-axis - Biokinetics Post: X-axis	-0.47820	1.70582	0.18724	-0.85068	-0.10573	-2.554	82	0.013
Pair 2	Biokinetics Pre: Y-axis - Biokinetics Post: Y-axis	-2.67574	1.81584	0.19931	-3.07224	-2.27924	-13.425	82	0.000
Pair 3	Biokinetics Pre: Waist - Biokinetics Post: Waist	-0.08916	8.16221	0.89592	-1.87143	1.69311	-0.100	82	0.921
Pair 4	Biokinetics Pre: Hip - Biokinetics Post: Hip	-0.38675	4.79005	0.52578	-1.43268	0.65919	-0.736	82	0.464
Pair 5	Biokinetics Pre: Systolic blood pressure - Biokinetics Post: Systolic blood pressure	8.01205	13.11813	1.43990	5.14763	10.87647	5.564	82	0.000
Pair 6	Biokinetics Pre: Diastolic blood pressure - Biokinetics Post: Diastolic blood pressure	6.27711	12.86545	1.41217	3.46786	9.08636	4.445	82	0.000

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T-Tests - Testing differences between pre- and post-test ROM/Flexibility measurements

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Biokinetics Pre: Modified Sit Reach (cm)	11.6585	82	5.54158	0.61197
	Biokinetics Post: Modified Sit Reach (cm)	11.7159	82	5.17982	0.57201
Pair 2	Biokinetics Pre: Plantar flexion (left)	48.1446	83	7.54035	0.82766
	Biokinetics Post: Plantar flexion (left)	51.5663	83	6.29013	0.69043
Pair 3	Biokinetics Pre: Plantar flexion (right)	44.3614	83	9.48629	1.04126
	Biokinetics Post: Plantar flexion (right)	50.2169	83	6.53517	0.71733
Pair 4	Biokinetics Pre: Dosiflexion (left)	15.2169	83	3.18169	0.34924
	Biokinetics Post: Dosiflexion (left)	14.0482	83	3.73808	0.41031
Pair 5	Biokinetics Pre: Dosiflexion (right)	16.4096	83	3.52703	0.38714
	Biokinetics Post: Dosiflexion (right)	16.5060	83	3.66051	0.40179
Pair 6	Biokinetics Pre: Hip external rotation (left)	26.1928	83	4.64721	0.51010
	Biokinetics Post: Hip external rotation (left)	22.0361	83	4.16561	0.45724
Pair 7	Biokinetics Pre: Hip external rotation (right)	24.7831	83	4.15272	0.45582
	Biokinetics Post: Hip external rotation (right)	21.7229	83	3.73616	0.41010

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Biokinetics Pre: Modified Sit Reach (cm) & Biokinetics Post: Modified Sit Reach (cm)	82	0.776	0.000
Pair 2	Biokinetics Pre: Plantar flexion (left) & Biokinetics Post: Plantar flexion (left)	83	0.205	0.063
Pair 3	Biokinetics Pre: Plantar flexion (right) & Biokinetics Post: Plantar flexion (right)	83	-0.062	0.576
Pair 4	Biokinetics Pre: Dosiflexion (left) & Biokinetics Post: Dosiflexion (left)	83	0.331	0.002
Pair 5	Biokinetics Pre: Dosiflexion (right) & Biokinetics Post: Dosiflexion (right)	83	0.398	0.000
Pair 6	Biokinetics Pre: Hip external rotation (left) & Biokinetics Post: Hip external rotation (left)	83	0.478	0.000
Pair 7	Biokinetics Pre: Hip external rotation (right) & Biokinetics Post: Hip external rotation (right)	83	0.333	0.002

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower			
Pair 1	Biokinetics Pre: Modified Sit Reach (cm) - Biokinetics Post: Modified Sit Reach (cm)	-0.05732	3.60113	0.39768	-0.84857	0.73394	-0.144	81	0.886
Pair 2	Biokinetics Pre: Plantar flexion (left) - Biokinetics Post: Plantar flexion (left)	-3.42169	8.77235	0.96289	-5.33718	-1.50619	-3.554	82	0.001
Pair 3	Biokinetics Pre: Plantar flexion (right) - Biokinetics Post: Plantar flexion (right)	-5.85542	11.84980	1.30069	-8.44290	-3.26794	-4.502	82	0.000
Pair 4	Biokinetics Pre: Dosiflexion (left) - Biokinetics Post: Dosiflexion (left)	1.16867	4.02680	0.44200	0.28940	2.04795	2.644	82	0.010
Pair 5	Biokinetics Pre: Dosiflexion (right) - Biokinetics Post: Dosiflexion (right)	-0.09639	3.94355	0.43286	-0.95748	0.76471	-0.223	82	0.824
Pair 6	Biokinetics Pre: Hip external rotation (left) - Biokinetics Post: Hip external rotation (left)	4.15663	4.52225	0.49638	3.16916	5.14409	8.374	82	0.000
Pair 7	Biokinetics Pre: Hip external rotation (right) - Biokinetics Post: Hip external rotation (right)	3.06024	4.56751	0.50135	2.06290	4.05759	6.104	82	0.000

T-Tests - Testing differences between pre- and post-test Skeletal Alignment measurements

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Biokinetics Pre: Q angle (left)	11.6506	83	2.10941	0.23154
	Biokinetics Pre: Q angle (left)	11.9036	83	2.89918	0.31823
Pair 2	Biokinetics Pre: Q angle (right)	11.1928	83	2.18898	0.24027
	Biokinetics Pre: Q angle (right)	11.5301	83	3.56930	0.39178

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Biokinetics Pre: Q angle (left) & Biokinetics Pre: Q angle (left)	83	0.617	0.000
Pair 2	Biokinetics Pre: Q angle (right) & Biokinetics Pre: Q angle (right)	83	0.517	0.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	Interval of the Upper	Interval of the Lower			
Pair 1	Biokinetics Pre: Q angle (left) - Biokinetics Pre: Q angle (left)	-0.25301	2.30505	0.25301	-0.75633	0.25031	-1.000	82	0.320
Pair 2	Biokinetics Pre: Q angle (right) - Biokinetics Pre: Q angle (right)	-0.33735	3.07340	0.33735	-1.00844	0.33375	-1.000	82	0.320

T-Tests - Testing differences between pre- and post-test Isokinetic Muscle Strenght Knee measurements

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Biokinetics Pre: Knee extension/flexion: Extensors absolute (left)	111.6145	83	22.71501	2.49330
	Biokinetics Post: Knee extension/flexion: Extensors absolute (left)	105.8759	83	26.72436	2.93338
Pair 2	Biokinetics Pre: Knee extension/flexion: Extensors absolute (right)	106.1928	83	23.66249	2.59730
	Biokinetics Post: Knee extension/flexion: Extensors absolute (right)	107.9470	83	19.96017	2.19091
Pair 3	Biokinetics Pre: Knee extension/flexion: Extensors relative (left)	1.8737	83	0.35960	0.03947
	Biokinetics Post: Knee extension/flexion: Extensors relative (left)	1.7781	83	0.44041	0.04834
Pair 4	Biokinetics Pre: Knee extension/flexion: Extensors relative (right)	1.7856	83	0.38881	0.04268
	Biokinetics Post: Knee extension/flexion: Extensors relative (right)	1.8058	83	0.29740	0.03264
Pair 5	Biokinetics Pre: Knee extension/flexion: Flexor absolute (left)	67.3855	83	12.82227	1.40743
	Biokinetics Post: Knee extension/flexion: Flexor absolute (left)	71.0518	83	14.13357	1.55136
Pair 6	Biokinetics Pre: Knee extension/flexion: Flexor absolute (right)	66.2289	83	17.01171	1.86728
	Biokinetics Post: Knee extension/flexion: Flexor absolute (right)	73.7602	83	13.01433	1.42851
Pair 7	Biokinetics Pre: Knee extension/flexion: Flexor relative (left)	1.1374	83	0.24134	0.02649
	Biokinetics Post: Knee extension/flexion: Flexor relative (left)	1.1902	83	0.21819	0.02395
Pair 8	Biokinetics Pre: Knee extension/flexion: Flexor relative (right)	1.1150	83	0.27748	0.03046
	Biokinetics Post: Knee extension/flexion: Flexor relative (right)	1.2379	83	0.21900	0.02404
Pair 9	Biokinetics Pre: Knee extension/flexion: Knee flexor/extensor ratio (left-%)	61.3373	83	10.63734	1.16760
	Biokinetics Post: Knee extension/flexion: Knee flexor/extensor ratio (left-%)	82.5449	83	130.98849	14.37785
Pair 10	Biokinetics Pre: Knee extension/flexion: Knee flexor/extensor ratio (right-%)	63.1325	83	11.81232	1.29657
	Biokinetics Post: Knee extension/flexion: Knee flexor/extensor ratio (right-%)	69.8694	83	14.75048	1.61908

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Biokinetics Pre: Knee extension/flexion: Extensors absolute (left) & Biokinetics Post: Knee extension/flexion: Extensors absolute (left)	83	0.489	0.000
Pair 2	Biokinetics Pre: Knee extension/flexion: Extensors absolute (right) & Biokinetics Post: Knee extension/flexion: Extensors absolute (right)	83	0.430	0.000
Pair 3	Biokinetics Pre: Knee extension/flexion: Extensors relative (left) & Biokinetics Post: Knee extension/flexion: Extensors relative (left)	83	0.393	0.000
Pair 4	Biokinetics Pre: Knee extension/flexion: Extensors relative (right) & Biokinetics Post: Knee extension/flexion: Extensors relative (right)	83	0.411	0.000
Pair 5	Biokinetics Pre: Knee extension/flexion: Flexor absolute (left) & Biokinetics Post: Knee extension/flexion: Flexor absolute (left)	83	0.582	0.000
Pair 6	Biokinetics Pre: Knee extension/flexion: Flexor absolute (right) & Biokinetics Post: Knee extension/flexion: Flexor absolute (right)	83	0.484	0.000
Pair 7	Biokinetics Pre: Knee extension/flexion: Flexor relative (left) & Biokinetics Post: Knee extension/flexion: Flexor relative (left)	83	0.555	0.000
Pair 8	Biokinetics Pre: Knee extension/flexion: Flexor relative (right) & Biokinetics Post: Knee extension/flexion: Flexor relative (right)	83	0.516	0.000
Pair 9	Biokinetics Pre: Knee extension/flexion: Knee flexor/extensor ratio (left-%) & Biokinetics Post: Knee extension/flexion: Knee flexor/extensor ratio (left-%)	83	0.167	0.131
Pair 10	Biokinetics Pre: Knee extension/flexion: Knee flexor/extensor ratio (right-%) & Biokinetics Post: Knee extension/flexion: Knee flexor/extensor ratio (right-%)	83	0.540	0.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower			
Pair 1	Biokinetics Pre: Knee extension/flexion: Extensors absolute (left) - Biokinetics Post: Knee extension/flexion: Extensors absolute (left)	5.73855	25.23193	2.76956	0.22901	11.24810	2.072	82	0.041
Pair 2	Biokinetics Pre: Knee extension/flexion: Extensors absolute (right) - Biokinetics Post: Knee extension/flexion: Extensors absolute (right)	-1.75422	23.49331	2.57873	-6.88412	3.37569	-0.680	82	0.498
Pair 3	Biokinetics Pre: Knee extension/flexion: Extensors relative (left) - Biokinetics Post: Knee extension/flexion: Extensors relative (left)	0.09563	0.44579	0.04893	-0.00171	0.19297	1.954	82	0.054
Pair 4	Biokinetics Pre: Knee extension/flexion: Extensors relative (right) - Biokinetics Post: Knee extension/flexion: Extensors relative (right)	-0.02025	0.38031	0.04174	-0.10330	0.06279	-0.485	82	0.629
Pair 5	Biokinetics Pre: Knee extension/flexion: Flexor absolute (left) - Biokinetics Post: Knee extension/flexion: Flexor absolute (left)	-3.66627	12.38554	1.35949	-6.37072	-0.96181	-2.697	82	0.008
Pair 6	Biokinetics Pre: Knee extension/flexion: Flexor absolute (right) - Biokinetics Post: Knee extension/flexion: Flexor absolute (right)	-7.53133	15.63708	1.71639	-10.94578	-4.11687	-4.388	82	0.000
Pair 7	Biokinetics Pre: Knee extension/flexion: Flexor relative (left) - Biokinetics Post: Knee extension/flexion: Flexor relative (left)	-0.05274	0.21772	0.02390	-0.10028	-0.00520	-2.207	82	0.030
Pair 8	Biokinetics Pre: Knee extension/flexion: Flexor relative (right) - Biokinetics Post: Knee extension/flexion: Flexor relative (right)	-0.12297	0.24943	0.02738	-0.17743	-0.06850	-4.491	82	0.000
Pair 9	Biokinetics Pre: Knee extension/flexion: Knee flexor/extensor ratio (left-%) - Biokinetics Post: Knee extension/flexion: Knee flexor/extensor ratio (left-%)	-21.20752	129.63398	14.22918	-49.51389	7.09885	-1.490	82	0.140
Pair 10	Biokinetics Pre: Knee extension/flexion: Knee flexor/extensor ratio (right-%) - Biokinetics Post: Knee extension/flexion: Knee flexor/extensor ratio (right-%)	-6.73684	13.00036	1.42697	-9.57555	-3.89814	-4.721	82	0.000

T-Tests - Testing differences between pre- and post-test Isokinetic Muscle Strent Ankle measurements

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Biokinetics Pre: Ankle plantar/ dorsiflexion: Plantarflexion absolute (left)	47.4458	83	12.88055	1.41382
	Biokinetics Post: Ankle plantar/ dorsiflexion: Plantarflexion absolute (left)	49.6627	83	12.11860	1.33019
Pair 2	Biokinetics Pre: Ankle plantar/ dorsiflexion: Plantarflexion absolute (right)	44.2771	83	11.31405	1.24188
	Biokinetics Post: Ankle plantar/ dorsiflexion: Plantarflexion absolute (right)	52.9157	83	12.92021	1.41818
Pair 3	Biokinetics Pre: Ankle plantar/ dorsiflexion: Plantarflexion relative (left)	0.7961	83	0.21766	0.02389
	Biokinetics Post: Ankle plantar/ dorsiflexion: Plantarflexion relative (left)	0.8338	83	0.20586	0.02260
Pair 4	Biokinetics Pre: Ankle plantar/ dorsiflexion: Plantarflexion relative (right)	0.7465	83	0.19857	0.02180
	Biokinetics Post: Ankle plantar/ dorsiflexion: Plantarflexion relative (right)	0.8874	83	0.20917	0.02296
Pair 5	Biokinetics Pre: Ankle plantar/ dorsiflexion: Dorsiflexion absolute (left)	19.9639	83	4.17439	0.45820
	Biokinetics Post: Ankle plantar/ dorsiflexion: Dorsiflexion absolute (left)	19.6506	83	5.44470	0.59763
Pair 6	Biokinetics Pre: Ankle plantar/ dorsiflexion: Dorsiflexion absolute (right)	19.1084	83	3.71225	0.40747
	Biokinetics Post: Ankle plantar/ dorsiflexion: Dorsiflexion absolute (right)	20.2289	83	5.25757	0.57709
Pair 7	Biokinetics Pre: Ankle plantar/ dorsiflexion: Dorsiflexion relative (left)	0.3358	83	0.07503	0.00824
	Biokinetics Post: Ankle plantar/ dorsiflexion: Dorsiflexion relative (left)	0.3292	83	0.08365	0.00918
Pair 8	Biokinetics Pre: Ankle plantar/ dorsiflexion: Dorsiflexion relative (right)	0.3233	83	0.06759	0.00742
	Biokinetics Post: Ankle plantar/ dorsiflexion: Dorsiflexion relative (right)	0.3391	83	0.08067	0.00885

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Biokinetics Pre: Ankle plantar/ dorsiflexion: Plantarflexion absolute (left) & Biokinetics Post: Ankle plantar/ dorsiflexion: Plantarflexion absolute (left)	83	0.603	0.000
Pair 2	Biokinetics Pre: Ankle plantar/ dorsiflexion: Plantarflexion absolute (right) & Biokinetics Post: Ankle plantar/ dorsiflexion: Plantarflexion absolute (right)	83	0.624	0.000
Pair 3	Biokinetics Pre: Ankle plantar/ dorsiflexion: Plantarflexion relative (left) & Biokinetics Post: Ankle plantar/ dorsiflexion: Plantarflexion relative (left)	83	0.520	0.000
Pair 4	Biokinetics Pre: Ankle plantar/ dorsiflexion: Plantarflexion relative (right) & Biokinetics Post: Ankle plantar/ dorsiflexion: Plantarflexion relative (right)	83	0.607	0.000
Pair 5	Biokinetics Pre: Ankle plantar/ dorsiflexion: Dorsiflexion absolute (left) & Biokinetics Post: Ankle plantar/ dorsiflexion: Dorsiflexion absolute (left)	83	0.517	0.000
Pair 6	Biokinetics Pre: Ankle plantar/ dorsiflexion: Dorsiflexion absolute (right) & Biokinetics Post: Ankle plantar/ dorsiflexion: Dorsiflexion absolute (right)	83	0.534	0.000
Pair 7	Biokinetics Pre: Ankle plantar/ dorsiflexion: Dorsiflexion relative (left) & Biokinetics Post: Ankle plantar/ dorsiflexion: Dorsiflexion relative (left)	83	0.434	0.000
Pair 8	Biokinetics Pre: Ankle plantar/ dorsiflexion: Dorsiflexion relative (right) & Biokinetics Post: Ankle plantar/ dorsiflexion: Dorsiflexion relative (right)	83	0.379	0.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower			
Pair 1	Biokinetics Pre: Ankle plantar/ dorsiflexion: Plantarflexion absolute (left) - Biokinetics Post: Ankle plantar/ dorsiflexion: Plantarflexion absolute (left)	-2.21687	11.16293	1.22529	-4.65436	0.22063	-1.809	82	0.074
Pair 2	Biokinetics Pre: Ankle plantar/ dorsiflexion: Plantarflexion absolute (right) - Biokinetics Post: Ankle plantar/ dorsiflexion: Plantarflexion absolute (right)	-8.63855	10.61359	1.16499	-10.95610	-6.32101	-7.415	82	0.000
Pair 3	Biokinetics Pre: Ankle plantar/ dorsiflexion: Plantarflexion relative (left) - Biokinetics Post: Ankle plantar/ dorsiflexion: Plantarflexion relative (left)	-0.03773	0.20770	0.02280	-0.08308	0.00763	-1.655	82	0.102
Pair 4	Biokinetics Pre: Ankle plantar/ dorsiflexion: Plantarflexion relative (right) - Biokinetics Post: Ankle plantar/ dorsiflexion: Plantarflexion relative (right)	-0.14091	0.18105	0.01987	-0.18044	-0.10137	-7.090	82	0.000
Pair 5	Biokinetics Pre: Ankle plantar/ dorsiflexion: Dorsiflexion absolute (left) - Biokinetics Post: Ankle plantar/ dorsiflexion: Dorsiflexion absolute (left)	0.31325	4.85630	0.53305	-0.74715	1.37365	0.588	82	0.558
Pair 6	Biokinetics Pre: Ankle plantar/ dorsiflexion: Dorsiflexion absolute (right) - Biokinetics Post: Ankle plantar/ dorsiflexion: Dorsiflexion absolute (right)	-1.12048	4.53549	0.49783	-2.11083	-0.13013	-2.251	82	0.027
Pair 7	Biokinetics Pre: Ankle plantar/ dorsiflexion: Dorsiflexion relative (left) - Biokinetics Post: Ankle plantar/ dorsiflexion: Dorsiflexion relative (left)	0.00663	0.08471	0.00930	-0.01187	0.02513	0.713	82	0.478
Pair 8	Biokinetics Pre: Ankle plantar/ dorsiflexion: Dorsiflexion relative (right) - Biokinetics Post: Ankle plantar/ dorsiflexion: Dorsiflexion relative (right)	-0.01579	0.08330	0.00914	-0.03398	0.00240	-1.727	82	0.088

T-Tests - Testing differences between pre- and post-test Hand Grip measurements

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Biokinetics Pre: Hand grip (left)	31.0000	83	5.58526	0.61306
	Biokinetics Post: Hand grip (left)	29.5422	83	5.26447	0.57785
Pair 2	Biokinetics Pre: Hand grip (right)	31.6506	83	5.67286	0.62268
	Biokinetics Post: Hand grip (right)	31.1084	83	5.42580	0.59556
Pair 3	Biokinetics Pre: Hand grip relative (left)	0.5201	83	0.09330	0.01024
	Biokinetics Post: Hand grip relative (left)	0.4964	83	0.09100	0.00999
Pair 4	Biokinetics Pre: Hand grip relative(right)	0.5321	83	0.10026	0.01100
	Biokinetics Post: Hand grip relative(right)	0.5222	83	0.09019	0.00990

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Biokinetics Pre: Hand grip (left) & Biokinetics Post: Hand grip (left)	83	0.556	0.000
Pair 2	Biokinetics Pre: Hand grip (right) & Biokinetics Post: Hand grip (right)	83	0.600	0.000
Pair 3	Biokinetics Pre: Hand grip relative (left) & Biokinetics Post: Hand grip relative (left)	83	0.483	0.000
Pair 4	Biokinetics Pre: Hand grip relative(right) & Biokinetics Post: Hand grip relative(right)	83	0.564	0.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower			
Pair 1	Biokinetics Pre: Hand grip (left) - Biokinetics Post: Hand grip (left)	1.45783	5.12122	0.56213	0.33958	2.57608	2.593	82	0.011
Pair 2	Biokinetics Pre: Hand grip (right) - Biokinetics Post: Hand grip (right)	0.54217	4.96648	0.54514	-0.54229	1.62663	0.995	82	0.323
Pair 3	Biokinetics Pre: Hand grip relative (left) - Biokinetics Post: Hand grip relative (left)	0.02372	0.09376	0.01029	0.00325	0.04420	2.305	82	0.024
Pair 4	Biokinetics Pre: Hand grip relative(right) - Biokinetics Post: Hand grip relative(right)	0.00992	0.08932	0.00980	-0.00958	0.02943	1.012	82	0.314

T-Test: TEST DIFFERENCES BETWEEN PRE AND POST FOR BONE DENSITY: BONE MINERAL DENSITY

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test Head:Bone Mineral Density (g/cm2)	2.2596	68	0.22099	0.02680
	Post-test Head:Bone Mineral Density (g/cm2)	2.3261	68	0.23746	0.02880
Pair 2	Pre-test Arms:Bone Mineral Density (g/cm2)	0.8408	68	0.05212	0.00632
	Post-test Arms:Bone Mineral Density (g/cm2)	0.8328	68	0.05025	0.00609
Pair 3	Pre-test Legs:Bone Mineral Density (g/cm2)	1.2207	68	0.08863	0.01075
	Post-test Legs:Bone Mineral Density (g/cm2)	1.2271	68	0.08312	0.01008
Pair 4	Pre-test Trunk:Bone Mineral Density (g/cm2)	0.9340	68	0.06657	0.00807
	Post-test Trunk:Bone Mineral Density (g/cm2)	0.9223	68	0.06744	0.00818
Pair 5	Pre-test Ribs:Bone Mineral Density (g/cm2)	0.7078	68	0.05601	0.00679
	Post-test Ribs:Bone Mineral Density (g/cm2)	0.6969	68	0.05208	0.00632
Pair 6	Pre-test Pelvis:Bone Mineral Density (g/cm2)	1.1583	68	0.08844	0.01073
	Post-test Pelvis:Bone Mineral Density (g/cm2)	1.2988	68	1.11891	0.13569
Pair 7	Pre-test Spine:Bone Mineral Density (g/cm2)	1.0616	68	0.09711	0.01178
	Post-test Spine:Bone Mineral Density (g/cm2)	1.0312	68	0.10758	0.01305
Pair 8	Pre-test Total:Bone Mineral Density (g/cm2)	1.1522	68	0.06753	0.00819
	Post-test Total:Bone Mineral Density (g/cm2)	1.1491	68	0.06551	0.00794

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre-test Head:Bone Mineral Density (g/cm2) & Post-test Head:Bone Mineral Density (g/cm2)	68	0.944	0.000
Pair 2	Pre-test Arms:Bone Mineral Density (g/cm2) & Post-test Arms:Bone Mineral Density (g/cm2)	68	0.935	0.000
Pair 3	Pre-test Legs:Bone Mineral Density (g/cm2) & Post-test Legs:Bone Mineral Density (g/cm2)	68	0.977	0.000
Pair 4	Pre-test Trunk:Bone Mineral Density (g/cm2) & Post-test Trunk:Bone Mineral Density (g/cm2)	68	0.948	0.000
Pair 5	Pre-test Ribs:Bone Mineral Density (g/cm2) & Post-test Ribs:Bone Mineral Density (g/cm2)	68	0.904	0.000
Pair 6	Pre-test Pelvis:Bone Mineral Density (g/cm2) & Post-test Pelvis:Bone Mineral Density (g/cm2)	68	-0.136	0.270
Pair 7	Pre-test Spine:Bone Mineral Density (g/cm2) & Post-test Spine:Bone Mineral Density (g/cm2)	68	0.933	0.000
Pair 8	Pre-test Total:Bone Mineral Density (g/cm2) & Post-test Total:Bone Mineral Density (g/cm2)	68	0.977	0.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower			
Pair 1	Pre-test Head:Bone Mineral Density (g/cm2) - Post-test Head:Bone Mineral Density (g/cm2)	-0.06656	0.07851	0.00952	-0.08556	-0.04756	-6.991	67	0.000
Pair 2	Pre-test Arms:Bone Mineral Density (g/cm2) - Post-test Arms:Bone Mineral Density (g/cm2)	0.00801	0.01853	0.00225	0.00353	0.01250	3.566	67	0.001
Pair 3	Pre-test Legs:Bone Mineral Density (g/cm2) - Post-test Legs:Bone Mineral Density (g/cm2)	-0.00644	0.01939	0.00235	-0.01113	-0.00175	-2.739	67	0.008
Pair 4	Pre-test Trunk:Bone Mineral Density (g/cm2) - Post-test Trunk:Bone Mineral Density (g/cm2)	0.01171	0.02160	0.00262	0.00648	0.01693	4.469	67	0.000
Pair 5	Pre-test Ribs:Bone Mineral Density (g/cm2) - Post-test Ribs:Bone Mineral Density (g/cm2)	0.01091	0.02401	0.00291	0.00510	0.01672	3.748	67	0.000
Pair 6	Pre-test Pelvis:Bone Mineral Density (g/cm2) - Post-test Pelvis:Bone Mineral Density (g/cm2)	-0.14043	1.13429	0.13755	-0.41498	0.13413	-1.021	67	0.311
Pair 7	Pre-test Spine:Bone Mineral Density (g/cm2) - Post-test Spine:Bone Mineral Density (g/cm2)	0.03034	0.03877	0.00470	0.02095	0.03972	6.453	67	0.000
Pair 8	Pre-test Total:Bone Mineral Density (g/cm2) - Post-test Total:Bone Mineral Density (g/cm2)	0.00309	0.01433	0.00174	-0.00038	0.00656	1.777	67	0.080

T-Test: TEST DIFFERENCES BETWEEN PRE AND POST FOR ANCILLARY HEALTH: YOUNG ADULT % TO AGE-MATCHED Z-SCORE

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Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test Young Adult %	102.49	68	5.954	0.722
	Post-test Young Adult %	102.13	68	5.808	0.704
Pair 2	Pre-test Young Adult T-score	0.41	68	1.694	0.205
	Post-test Young Adult T-score	0.296	68	0.8163	0.0990
Pair 3	Pre-test Age-matched %	102.51	68	12.771	1.549
	Post-test Age-matched %	101.94	68	13.599	1.649
Pair 4	Pre-test Age-matched Z-score	0.63	68	1.802	0.219
	Post-test Age-matched Z-score	0.485	68	0.7768	0.0942

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre-test Young Adult % & Post-test Young Adult %	68	0.981	0.000
Pair 2	Pre-test Young Adult T-score & Post-test Young Adult T-score	68	0.610	0.000
Pair 3	Pre-test Age-matched % & Post-test Age-matched %	68	0.097	0.429
Pair 4	Pre-test Age-matched Z-score & Post-test Age-matched Z-score	68	0.574	0.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower			
Pair 1	Pre-test Young Adult % - Post-test Young Adult %	0.353	1.143	0.139	0.076	0.630	2.546	67	0.013
Pair 2	Pre-test Young Adult T-score - Post-test Young Adult T-score	0.1162	1.3597	0.1649	-0.2129	0.4453	0.705	67	0.484
Pair 3	Pre-test Age-matched % - Post-test Age-matched %	0.572	17.725	2.149	-3.718	4.863	0.266	67	0.791
Pair 4	Pre-test Age-matched Z-score - Post-test Age-matched Z-score	0.1441	1.4974	0.1816	-0.2183	0.5066	0.794	67	0.430

T-Test:TEST DIFFERENCES BETWEEN PRE AND POST - ANCILLARY HEALTH : BONE MINERAL CONTENT

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test Head:Bone Mineral Content (g)	491.19	68	58.683	7.116
	Post-test Head:Bone Mineral Content (g)	471.82	68	58.755	7.125
Pair 2	Pre-test Arms:Bone Mineral Content (g)	281.97	68	41.987	5.092
	Post-test Arms:Bone Mineral Content (g)	281.81	68	43.590	5.286
Pair 3	Pre-test Legs:Bone Mineral Content (g)	879.49	68	116.892	14.175
	Post-test Legs:Bone Mineral Content (g)	894.49	68	120.616	14.627
Pair 4	Pre-test Trunk:Bone Mineral Content (g)	797.97	68	148.196	17.971
	Post-test Trunk:Bone Mineral Content (g)	778.91	68	150.825	18.290
Pair 5	Pre-test Ribs:Bone Mineral Content (g)	268.38	68	58.894	7.142
	Post-test Ribs:Bone Mineral Content (g)	260.96	68	61.751	7.488
Pair 6	Pre-test Pelvis:Bone Mineral Content (g)	298.09	68	57.410	6.962
	Post-test Pelvis:Bone Mineral Content (g)	292.84	68	55.549	6.736
Pair 7	Pre-test Spine:Bone Mineral Content (g)	231.51	68	38.654	4.687
	Post-test Spine:Bone Mineral Content (g)	225.07	68	40.489	4.910
Pair 8	Pre-test Total:Bone Mineral Content (g)	2,450.59	68	312.907	37.946
	Post-test Total:Bone Mineral Content (g)	2,427.03	68	324.920	39.402

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre-test Head:Bone Mineral Content (g) & Post-test Head:Bone Mineral Content (g)	68	0.944	0.000
Pair 2	Pre-test Arms:Bone Mineral Content (g) & Post-test Arms:Bone Mineral Content (g)	68	0.976	0.000
Pair 3	Pre-test Legs:Bone Mineral Content (g) & Post-test Legs:Bone Mineral Content (g)	68	0.976	0.000
Pair 4	Pre-test Trunk:Bone Mineral Content (g) & Post-test Trunk:Bone Mineral Content (g)	68	0.864	0.000
Pair 5	Pre-test Ribs:Bone Mineral Content (g) & Post-test Ribs:Bone Mineral Content (g)	68	0.806	0.000
Pair 6	Pre-test Pelvis:Bone Mineral Content (g) & Post-test Pelvis:Bone Mineral Content (g)	68	0.901	0.000
Pair 7	Pre-test Spine:Bone Mineral Content (g) & Post-test Spine:Bone Mineral Content (g)	68	0.862	0.000
Pair 8	Pre-test Total:Bone Mineral Content (g) & Post-test Total:Bone Mineral Content (g)	68	0.951	0.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower			
Pair 1	Pre-test Head:Bone Mineral Content (g) - Post-test Head:Bone Mineral Content (g)	19.368	19.704	2.390	14.598	24.137	8.105	67	0.000
Pair 2	Pre-test Arms:Bone Mineral Content (g) - Post-test Arms:Bone Mineral Content (g)	0.162	9.470	1.148	-2.131	2.454	0.141	67	0.888
Pair 3	Pre-test Legs:Bone Mineral Content (g) - Post-test Legs:Bone Mineral Content (g)	-15.000	26.511	3.215	-21.417	-8.583	-4.666	67	0.000
Pair 4	Pre-test Trunk:Bone Mineral Content (g) - Post-test Trunk:Bone Mineral Content (g)	19.059	77.894	9.446	0.204	37.913	2.018	67	0.048
Pair 5	Pre-test Ribs:Bone Mineral Content (g) - Post-test Ribs:Bone Mineral Content (g)	7.426	37.645	4.565	-1.686	16.539	1.627	67	0.108
Pair 6	Pre-test Pelvis:Bone Mineral Content (g) - Post-test Pelvis:Bone Mineral Content (g)	5.250	25.218	3.058	-0.854	11.354	1.717	67	0.091
Pair 7	Pre-test Spine:Bone Mineral Content (g) - Post-test Spine:Bone Mineral Content (g)	6.441	20.870	2.531	1.390	11.493	2.545	67	0.013
Pair 8	Pre-test Total:Bone Mineral Content (g) - Post-test Total:Bone Mineral Content (g)	23.559	100.667	12.208	-0.808	47.925	1.930	67	0.058

T-Test: TEST DIFFERENCES BETWEEN PRE AND POST - ANCILLARY HEALTH: AREA (CM)

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test Head:Area (cm)	217.21	68	12.426	1.507
	Post-test Head:Area (cm)	202.75	68	13.271	1.609
Pair 2	Pre-test Arms:Area (cm)	334.41	68	37.068	4.495
	Post-test Arms:Area (cm)	337.19	68	38.259	4.640
Pair 3	Pre-test Legs:Area (cm)	719.29	68	70.370	8.534
	Post-test Legs:Area (cm)	727.68	68	75.000	9.095
Pair 4	Pre-test Trunk:Area (cm)	849.66	68	116.747	14.158
	Post-test Trunk:Area (cm)	839.09	68	114.511	13.886
Pair 5	Pre-test Ribs:Area (cm)	376.38	68	62.171	7.539
	Post-test Ribs:Area (cm)	371.13	68	66.177	8.025
Pair 6	Pre-test Pelvis:Area (cm)	256.26	68	39.293	4.765
	Post-test Pelvis:Area (cm)	250.82	68	35.593	4.316
Pair 7	Pre-test Spine:Area (cm)	217.07	68	22.369	2.713
	Post-test Spine:Area (cm)	217.10	68	21.577	2.617
Pair 8	Pre-test Total:Area (cm)	2,120.65	68	198.749	24.102
	Post-test Total:Area (cm)	2,106.71	68	206.859	25.085

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre-test Head:Area (cm) & Post-test Head:Area (cm)	68	0.644	0.000
Pair 2	Pre-test Arms:Area (cm) & Post-test Arms:Area (cm)	68	0.919	0.000
Pair 3	Pre-test Legs:Area (cm) & Post-test Legs:Area (cm)	68	0.926	0.000
Pair 4	Pre-test Trunk:Area (cm) & Post-test Trunk:Area (cm)	68	0.809	0.000
Pair 5	Pre-test Ribs:Area (cm) & Post-test Ribs:Area (cm)	68	0.761	0.000
Pair 6	Pre-test Pelvis:Area (cm) & Post-test Pelvis:Area (cm)	68	0.856	0.000
Pair 7	Pre-test Spine:Area (cm) & Post-test Spine:Area (cm)	68	0.773	0.000
Pair 8	Pre-test Total:Area (cm) & Post-test Total:Area (cm)	68	0.899	0.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower			
Pair 1	Pre-test Head:Area (cm) - Post-test Head:Area (cm)	14.456	10.866	1.318	11.826	17.086	10.970	67	0.000
Pair 2	Pre-test Arms:Area (cm) - Post-test Arms:Area (cm)	-2.779	15.170	1.840	-6.451	0.892	-1.511	67	0.136
Pair 3	Pre-test Legs:Area (cm) - Post-test Legs:Area (cm)	-8.382	28.364	3.440	-15.248	-1.517	-2.437	67	0.017
Pair 4	Pre-test Trunk:Area (cm) - Post-test Trunk:Area (cm)	10.574	71.481	8.668	-6.729	27.876	1.220	67	0.227
Pair 5	Pre-test Ribs:Area (cm) - Post-test Ribs:Area (cm)	5.250	44.569	5.405	-5.538	16.038	0.971	67	0.335
Pair 6	Pre-test Pelvis:Area (cm) - Post-test Pelvis:Area (cm)	5.441	20.418	2.476	0.499	10.383	2.197	67	0.031
Pair 7	Pre-test Spine:Area (cm) - Post-test Spine:Area (cm)	-0.029	14.822	1.797	-3.617	3.558	-0.016	67	0.987
Pair 8	Pre-test Total:Area (cm) - Post-test Total:Area (cm)	13.941	91.461	11.091	-8.197	36.080	1.257	67	0.213

T-Test: TEST DIFFERENCES BETWEEN PRE AND POST - BODY COMPOSITION: TISSUE FAT %

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test Left Arm:Tissue (%fat)	30.615	68	8.3123	1.0080
	Post-test Left Arm:Tissue (%fat)	25.263	68	7.2994	0.8852
Pair 2	Pre-test Left Leg:Tissue(%fat)	42.253	68	7.0523	0.8552
	Post-test Left Leg:Tissue(%fat)	40.162	68	6.2097	0.7530
Pair 3	Pre-test Left trunk:Tissue (%fat)	37.00	68	8.837	1.072
	Post-test Left trunk:Tissue (%fat)	30.903	68	7.4108	0.8987
Pair 4	Pre-test Left Total:Tissue (%fat)	37.257	68	7.5809	0.9193
	Post-test Left Total:Tissue (%fat)	33.218	68	6.4812	0.7860
Pair 5	Pre-test Right Arm:Tissue (%fat)	30.655	68	8.3011	1.0067
	Post-test Right Arm:Tissue (%fat)	25.306	68	7.3109	0.8866
Pair 6	Pre-test Right Leg:Tissue(%fat)	42.250	68	7.0432	0.8541
	Post-test Right Leg:Tissue(%fat)	40.128	68	6.2232	0.7547
Pair 7	Pre-test Right trunk:Tissue (%fat)	37.03	68	8.846	1.073
	Post-test Right trunk:Tissue (%fat)	30.907	68	7.4125	0.8989
Pair 8	Pre-test Right Total:Tissue (%fat)	37.240	68	7.6513	0.9279
	Post-test Right Total:Tissue (%fat)	33.08	68	6.466	0.784
Pair 9	Pre-test Arms:Tissue (%fat)	30.628	68	8.3158	1.0084
	Post-test Arms:Tissue (%fat)	25.281	68	7.2953	0.8847
Pair 10	Pre-test Legs:Tissue(%fat)	42.251	68	7.0467	0.8545
	Post-test Legs:Tissue(%fat)	40.141	68	6.2158	0.7538
Pair 11	Pre-test Trunk:Tissue (%fat)	37.02	68	8.840	1.072
	Post-test Trunk:Tissue (%fat)	30.906	68	7.4102	0.8986
Pair 12	Pre-test Total:Tissue (%fat)	37.251	68	7.6162	0.9236
	Post-test Total:Tissue (%fat)	33.144	68	6.4768	0.7854

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre-test Left Arm:Tissue (%fat) & Post-test Left Arm:Tissue (%fat)	68	0.837	0.000
Pair 2	Pre-test Left Leg:Tissue(%fat) & Post-test Left Leg:Tissue(%fat)	68	0.923	0.000
Pair 3	Pre-test Left trunk:Tissue (%fat) & Post-test Left trunk:Tissue (%fat)	68	0.823	0.000
Pair 4	Pre-test Left Total:Tissue (%fat) & Post-test Left Total:Tissue (%fat)	68	0.879	0.000
Pair 5	Pre-test Right Arm:Tissue (%fat) & Post-test Right Arm:Tissue (%fat)	68	0.837	0.000
Pair 6	Pre-test Right Leg:Tissue(%fat) & Post-test Right Leg:Tissue(%fat)	68	0.924	0.000
Pair 7	Pre-test Right trunk:Tissue (%fat) & Post-test Right trunk:Tissue (%fat)	68	0.823	0.000
Pair 8	Pre-test Right Total:Tissue (%fat) & Post-test Right Total:Tissue (%fat)	68	0.875	0.000
Pair 9	Pre-test Arms:Tissue (%fat) & Post-test Arms:Tissue (%fat)	68	0.837	0.000
Pair 10	Pre-test Legs:Tissue(%fat) & Post-test Legs:Tissue(%fat)	68	0.923	0.000
Pair 11	Pre-test Trunk:Tissue (%fat) & Post-test Trunk:Tissue (%fat)	68	0.823	0.000
Pair 12	Pre-test Total:Tissue (%fat) & Post-test Total:Tissue (%fat)	68	0.877	0.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower			
Pair 1	Pre-test Left Arm:Tissue (%fat) - Post-test Left Arm:Tissue (%fat)	5.3515	4.5548	0.5524	4.2490	6.4540	9.688	67	0.000
Pair 2	Pre-test Left Leg:Tissue(%fat) - Post-test Left Leg:Tissue(%fat)	2.0912	2.7292	0.3310	1.4306	2.7518	6.319	67	0.000
Pair 3	Pre-test Left trunk:Tissue (%fat) - Post-test Left trunk:Tissue (%fat)	6.1015	5.0233	0.6092	4.8856	7.3174	10.016	67	0.000
Pair 4	Pre-test Left Total:Tissue (%fat) - Post-test Left Total:Tissue (%fat)	4.0397	3.6257	0.4397	3.1621	4.9173	9.188	67	0.000
Pair 5	Pre-test Right Arm:Tissue (%fat) - Post-test Right Arm:Tissue (%fat)	5.3488	4.5534	0.5522	4.2467	6.4510	9.687	67	0.000
Pair 6	Pre-test Right Leg:Tissue(%fat) - Post-test Right Leg:Tissue(%fat)	2.1221	2.7161	0.3294	1.4646	2.7795	6.443	67	0.000
Pair 7	Pre-test Right trunk:Tissue (%fat) - Post-test Right trunk:Tissue (%fat)	6.1176	5.0201	0.6088	4.9025	7.3328	10.049	67	0.000
Pair 8	Pre-test Right Total:Tissue (%fat) - Post-test Right Total:Tissue (%fat)	4.1632	3.7076	0.4496	3.2658	5.0607	9.260	67	0.000
Pair 9	Pre-test Arms:Tissue (%fat) - Post-test Arms:Tissue (%fat)	5.3471	4.5622	0.5533	4.2428	6.4514	9.665	67	0.000
Pair 10	Pre-test Legs:Tissue(%fat) - Post-test Legs:Tissue(%fat)	2.1103	2.7248	0.3304	1.4508	2.7698	6.387	67	0.000
Pair 11	Pre-test Trunk:Tissue (%fat) - Post-test Trunk:Tissue (%fat)	6.1132	5.0171	0.6084	4.8988	7.3276	10.048	67	0.000
Pair 12	Pre-test Total:Tissue (%fat) - Post-test Total:Tissue (%fat)	4.1074	3.6628	0.4442	3.2208	4.9939	9.247	67	0.000

T-Test: TEST DIFFERENCES BETWEEN PRE AND POST - BODY COMPOSITION: REGION FAT %

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test Left Arm:Region (%fat)	29.212	68	8.1091	0.9834
	Post-test Left Arm:Region (%fat)	24.118	68	7.0543	0.8555
Pair 2	Pre-test Left Leg:Region(%fat)	40.632	68	6.9080	0.8377
	Post-test Left Leg:Region(%fat)	38.637	68	6.0450	0.7331
Pair 3	Pre-test Left trunk:Region (%fat)	35.85	68	8.561	1.038
	Post-test Left trunk:Region (%fat)	29.990	68	7.1459	0.8666
Pair 4	Pre-test Left Total:Region (%fat)	35.713	68	7.3495	0.8913
	Post-test Left Total:Region (%fat)	31.890	68	6.2602	0.7592
Pair 5	Pre-test Right Arm:Region (%fat)	29.17	68	8.079	0.980
	Post-test Right Arm:Region (%fat)	24.119	68	7.0314	0.8527
Pair 6	Pre-test Right Leg:Region(%fat)	40.606	68	6.9083	0.8378
	Post-test Right Leg:Region(%fat)	38.599	68	6.0433	0.7329
Pair 7	Pre-test Right trunk:Region (%fat)	35.89	68	8.564	1.039
	Post-test Right trunk:Region (%fat)	29.966	68	7.1637	0.8687
Pair 8	Pre-test Right Total:Region (%fat)	35.706	68	7.4242	0.9003
	Post-test Right Total:Region (%fat)	31.713	68	6.2170	0.7539
Pair 9	Pre-test Arms:Region (%fat)	29.187	68	8.0975	0.9820
	Post-test Arms:Region (%fat)	24.118	68	7.0473	0.8546
Pair 10	Pre-test Legs:Region(%fat)	40.618	68	6.9157	0.8386
	Post-test Legs:Region(%fat)	38.621	68	6.0485	0.7335
Pair 11	Pre-test Trunk:Region (%fat)	35.86	68	8.567	1.039
	Post-test Trunk:Region (%fat)	29.978	68	7.1554	0.8677
Pair 12	Pre-test Total:Region (%fat)	35.71	68	7.386	0.896
	Post-test Total:Region (%fat)	31.800	68	6.2303	0.7555

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre-test Left Arm:Region (%fat) & Post-test Left Arm:Region (%fat)	68	0.838	0.000
Pair 2	Pre-test Left Leg:Region(%fat) & Post-test Left Leg:Region(%fat)	68	0.922	0.000
Pair 3	Pre-test Left trunk:Region (%fat) & Post-test Left trunk:Region (%fat)	68	0.823	0.000
Pair 4	Pre-test Left Total:Region (%fat) & Post-test Left Total:Region (%fat)	68	0.878	0.000
Pair 5	Pre-test Right Arm:Region (%fat) & Post-test Right Arm:Region (%fat)	68	0.836	0.000
Pair 6	Pre-test Right Leg:Region(%fat) & Post-test Right Leg:Region(%fat)	68	0.922	0.000
Pair 7	Pre-test Right trunk:Region (%fat) & Post-test Right trunk:Region (%fat)	68	0.824	0.000
Pair 8	Pre-test Right Total:Region (%fat) & Post-test Right Total:Region (%fat)	68	0.876	0.000
Pair 9	Pre-test Arms:Region (%fat) & Post-test Arms:Region (%fat)	68	0.837	0.000
Pair 10	Pre-test Legs:Region(%fat) & Post-test Legs:Region(%fat)	68	0.922	0.000
Pair 11	Pre-test Trunk:Region (%fat) & Post-test Trunk:Region (%fat)	68	0.824	0.000
Pair 12	Pre-test Total:Region (%fat) & Post-test Total:Region (%fat)	68	0.877	0.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower			
Pair 1	Pre-test Left Arm:Region (%fat) - Post-test Left Arm:Region (%fat)	5.0941	4.4371	0.5381	4.0201	6.1681	9.467	67	0.000
Pair 2	Pre-test Left Leg:Region(%fat) - Post-test Left Leg:Region(%fat)	1.9956	2.6968	0.3270	1.3428	2.6484	6.102	67	0.000
Pair 3	Pre-test Left trunk:Region (%fat) - Post-test Left trunk:Region (%fat)	5.8603	4.8579	0.5891	4.6844	7.0362	9.948	67	0.000
Pair 4	Pre-test Left Total:Region (%fat) - Post-test Left Total:Region (%fat)	3.8235	3.5192	0.4268	2.9717	4.6754	8.959	67	0.000
Pair 5	Pre-test Right Arm:Region (%fat) - Post-test Right Arm:Region (%fat)	5.0529	4.4466	0.5392	3.9766	6.1293	9.371	67	0.000
Pair 6	Pre-test Right Leg:Region(%fat) - Post-test Right Leg:Region(%fat)	2.0072	2.6899	0.3262	1.3561	2.6583	6.153	67	0.000
Pair 7	Pre-test Right trunk:Region (%fat) - Post-test Right trunk:Region (%fat)	5.9279	4.8510	0.5883	4.7537	7.1021	10.077	67	0.000
Pair 8	Pre-test Right Total:Region (%fat) - Post-test Right Total:Region (%fat)	3.9926	3.5984	0.4364	3.1216	4.8637	9.150	67	0.000
Pair 9	Pre-test Arms:Region (%fat) - Post-test Arms:Region (%fat)	5.0691	4.4444	0.5390	3.9934	6.1449	9.405	67	0.000
Pair 10	Pre-test Legs:Region(%fat) - Post-test Legs:Region(%fat)	1.9971	2.6932	0.3266	1.3452	2.6489	6.115	67	0.000
Pair 11	Pre-test Trunk:Region (%fat) - Post-test Trunk:Region (%fat)	5.8838	4.8581	0.5891	4.7079	7.0597	9.987	67	0.000
Pair 12	Pre-test Total:Region (%fat) - Post-test Total:Region (%fat)	3.9147	3.5565	0.4313	3.0538	4.7756	9.077	67	0.000

T-Test: DIFFERENCES BETWEEN PRE AND POST - BODY COMPOSITION : TISSUE (G)

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Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test Left Arm:Tissue (g)	2,909.13	68	629.903	76.387
	Post-test Left Arm:Tissue (g)	2,915.49	68	568.049	68.886
Pair 2	Pre-test Left Leg:Tissue(g)	11,068.6765	68	1,861.03988	225.68424
	Post-test Left Leg:Tissue(g)	11,370.96	68	1,752.480	212.519
Pair 3	Pre-test Left trunk:Tissue (g)	12,583.0147	68	1,810.57855	219.56490
	Post-test Left trunk:Tissue (g)	12,563.40	68	1,581.548	191.791
Pair 4	Pre-test Left Total:Tissue (g)	28,528.4706	68	4,130.30251	500.87275
	Post-test Left Total:Tissue (g)	28,682.22	68	3,652.925	442.982
Pair 5	Pre-test Right Arm:Tissue (g)	2,747.21	68	533.886	64.743
	Post-test Right Arm:Tissue (g)	2,896.88	68	501.602	60.828
Pair 6	Pre-test Right Leg:Tissue(g)	10,800.2059	68	1,915.44202	232.28146
	Post-test Right Leg:Tissue(g)	11,257.25	68	1,724.534	209.130
Pair 7	Pre-test Right trunk:Tissue (g)	12,660.99	68	1,973.782	239.356
	Post-test Right trunk:Tissue (g)	12,684.59	68	1,684.215	204.241
Pair 8	Pre-test Right Total:Tissue (g)	28,163.99	68	4,239.911	514.165
	Post-test Right Total:Tissue (g)	28,853.41	68	3,697.342	448.369
Pair 9	Pre-test Arms:Tissue (g)	5,656.2794	68	1,128.03877	136.79479
	Post-test Arms:Tissue (g)	5,812.35	68	988.764	119.905
Pair 10	Pre-test Legs:Tissue(g)	21,872.85	68	3,753.196	455.142
	Post-test Legs:Tissue(g)	22,628.18	68	3,431.084	416.080
Pair 11	Pre-test Trunk:Tissue (g)	25,252.7647	68	3,733.76824	452.78591
	Post-test Trunk:Tissue (g)	25,248.10	68	3,178.893	385.497
Pair 12	Pre-test Total:Tissue (g)	56,692.43	68	8,339.678	1,011.335
	Post-test Total:Tissue (g)	57,535.59	68	7,230.803	876.864

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre-test Left Arm:Tissue (g) & Post-test Left Arm:Tissue (g)	68	0.813	0.000
Pair 2	Pre-test Left Leg:Tissue(g) & Post-test Left Leg:Tissue(g)	68	0.884	0.000
Pair 3	Pre-test Left trunk:Tissue (g) & Post-test Left trunk:Tissue (g)	68	0.868	0.000
Pair 4	Pre-test Left Total:Tissue (g) & Post-test Left Total:Tissue (g)	68	0.871	0.000
Pair 5	Pre-test Right Arm:Tissue (g) & Post-test Right Arm:Tissue (g)	68	0.751	0.000
Pair 6	Pre-test Right Leg:Tissue(g) & Post-test Right Leg:Tissue(g)	68	0.886	0.000
Pair 7	Pre-test Right trunk:Tissue (g) & Post-test Right trunk:Tissue (g)	68	0.890	0.000
Pair 8	Pre-test Right Total:Tissue (g) & Post-test Right Total:Tissue (g)	68	0.873	0.000
Pair 9	Pre-test Arms:Tissue (g) & Post-test Arms:Tissue (g)	68	0.811	0.000
Pair 10	Pre-test Legs:Tissue(g) & Post-test Legs:Tissue(g)	68	0.897	0.000
Pair 11	Pre-test Trunk:Tissue (g) & Post-test Trunk:Tissue (g)	68	0.885	0.000
Pair 12	Pre-test Total:Tissue (g) & Post-test Total:Tissue (g)	68	0.883	0.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower			
Pair 1	Pre-test Left Arm:Tissue (g) - Post-test Left Arm:Tissue (g)	-6.353	370.554	44.936	-96.046	83.340	-0.141	67	0.888
Pair 2	Pre-test Left Leg:Tissue(g) - Post-test Left Leg:Tissue(g)	-302.27941	877.33228	106.39217	-514.63907	-89.91976	-2.841	67	0.006
Pair 3	Pre-test Left trunk:Tissue (g) - Post-test Left trunk:Tissue (g)	19.61765	898.58179	108.96905	-197.88548	237.12078	0.180	67	0.858
Pair 4	Pre-test Left Total:Tissue (g) - Post-test Left Total:Tissue (g)	-153.75000	2,033.56788	246.60633	-645.97829	338.47829	-0.623	67	0.535
Pair 5	Pre-test Right Arm:Tissue (g) - Post-test Right Arm:Tissue (g)	-149.676	366.554	44.451	-238.401	-60.951	-3.367	67	0.001
Pair 6	Pre-test Right Leg:Tissue(g) - Post-test Right Leg:Tissue(g)	-457.04412	886.80124	107.54045	-671.69575	-242.39249	-4.250	67	0.000
Pair 7	Pre-test Right trunk:Tissue (g) - Post-test Right trunk:Tissue (g)	-23.603	904.178	109.648	-242.461	195.255	-0.215	67	0.830
Pair 8	Pre-test Right Total:Tissue (g) - Post-test Right Total:Tissue (g)	-689.426	2,068.078	250.791	-1,190.008	-188.845	-2.749	67	0.008
Pair 9	Pre-test Arms:Tissue (g) - Post-test Arms:Tissue (g)	-156.07353	663.66104	80.48072	-316.71372	4.56667	-1.939	67	0.057
Pair 10	Pre-test Legs:Tissue(g) - Post-test Legs:Tissue(g)	-755.324	1,663.890	201.776	-1,158.071	-352.576	-3.743	67	0.000
Pair 11	Pre-test Trunk:Tissue (g) - Post-test Trunk:Tissue (g)	4.66176	1,743.22473	211.39705	-417.28851	426.61204	0.022	67	0.982
Pair 12	Pre-test Total:Tissue (g) - Post-test Total:Tissue (g)	-843.162	3,921.365	475.535	-1,792.334	106.011	-1.773	67	0.081

T-Test DIFFERENCES BETWEEN PRE AND POST: BODY COMPOSITION - FAT(G)

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test Left Arm:Fat (g)	925.69	68	428.440	51.956
	Post-test Left Arm:Fat (g)	757.25	68	330.375	40.064
Pair 2	Pre-test Left Leg:Fat(g)	4,776.46	68	1,528.168	185.318
	Post-test Left Leg:Fat(g)	5,031.38	68	3,319.915	402.599
Pair 3	Pre-test Left trunk:Fat (g)	4,770.16	68	1,693.248	205.336
	Post-test Left trunk:Fat (g)	3,954.04	68	1,310.609	158.935
Pair 4	Pre-test Left Total:Fat (g)	10,858.0279	68	3,561.84859	431.93759
	Post-test Left Total:Fat (g)	9,671.34	68	2,819.161	341.873
Pair 5	Pre-test Right Arm:Fat (g)	868.32	68	373.544	45.299
	Post-test Right Arm:Fat (g)	746.13	68	296.516	35.958
Pair 6	Pre-test Right Leg:Fat(g)	4,619.29	68	1,555.337	188.612
	Post-test Right Leg:Fat(g)	4,582.74	68	1,256.836	152.414
Pair 7	Pre-test Right trunk:Fat (g)	4,809.88	68	1,745.394	211.660
	Post-test Right trunk:Fat (g)	3,995.16	68	1,353.039	164.080
Pair 8	Pre-test Right Total:Fat (g)	10,722.2794	68	3,569.26167	432.83656
	Post-test Right Total:Fat (g)	9,684.50	68	2,812.026	341.008
Pair 9	Pre-test Arms:Fat (g)	1,793.94	68	795.895	96.516
	Post-test Arms:Fat (g)	1,503.41	68	617.136	74.839
Pair 10	Pre-test Legs:Fat(g)	9,439.87	68	3,048.775	369.718
	Post-test Legs:Fat(g)	9,217.06	68	2,543.966	308.501
Pair 11	Pre-test Trunk:Fat (g)	9,579.9118	68	3,429.77753	415.92162
	Post-test Trunk:Fat (g)	7,949.21	68	2,652.892	321.710
Pair 12	Pre-test Total:Fat (g)	21,580.3088	68	7,126.93677	864.26803
	Post-test Total:Fat (g)	19,355.72	68	5,618.609	681.356

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre-test Left Arm:Fat (g) & Post-test Left Arm:Fat (g)	68	0.845	0.000
Pair 2	Pre-test Left Leg:Fat(g) & Post-test Left Leg:Fat(g)	68	0.245	0.044
Pair 3	Pre-test Left trunk:Fat (g) & Post-test Left trunk:Fat (g)	68	0.846	0.000
Pair 4	Pre-test Left Total:Fat (g) & Post-test Left Total:Fat (g)	68	0.884	0.000
Pair 5	Pre-test Right Arm:Fat (g) & Post-test Right Arm:Fat (g)	68	0.811	0.000
Pair 6	Pre-test Right Leg:Fat(g) & Post-test Right Leg:Fat(g)	68	0.907	0.000
Pair 7	Pre-test Right trunk:Fat (g) & Post-test Right trunk:Fat (g)	68	0.847	0.000
Pair 8	Pre-test Right Total:Fat (g) & Post-test Right Total:Fat (g)	68	0.881	0.000
Pair 9	Pre-test Arms:Fat (g) & Post-test Arms:Fat (g)	68	0.835	0.000
Pair 10	Pre-test Legs:Fat(g) & Post-test Legs:Fat(g)	68	0.922	0.000
Pair 11	Pre-test Trunk:Fat (g) & Post-test Trunk:Fat (g)	68	0.847	0.000
Pair 12	Pre-test Total:Fat (g) & Post-test Total:Fat (g)	68	0.884	0.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower			
Pair 1	Pre-test Left Arm:Fat (g) - Post-test Left Arm:Fat (g)	168.441	231.578	28.083	112.387	224.495	5.998	67	0.000
Pair 2	Pre-test Left Leg:Fat(g) - Post-test Left Leg:Fat(g)	-254.926	3,297.131	399.836	-1,053.002	543.149	-0.638	67	0.526
Pair 3	Pre-test Left trunk:Fat (g) - Post-test Left trunk:Fat (g)	816.118	911.061	110.482	595.594	1,036.641	7.387	67	0.000
Pair 4	Pre-test Left Total:Fat (g) - Post-test Left Total:Fat (g)	1,186.68971	1,697.46917	205.84837	775.81463	1,597.56478	5.765	67	0.000
Pair 5	Pre-test Right Arm:Fat (g) - Post-test Right Arm:Fat (g)	122.191	218.794	26.533	69.232	175.151	4.605	67	0.000
Pair 6	Pre-test Right Leg:Fat(g) - Post-test Right Leg:Fat(g)	36.559	671.657	81.450	-126.017	199.134	0.449	67	0.655
Pair 7	Pre-test Right trunk:Fat (g) - Post-test Right trunk:Fat (g)	814.721	935.209	113.411	588.352	1,041.089	7.184	67	0.000
Pair 8	Pre-test Right Total:Fat (g) - Post-test Right Total:Fat (g)	1,037.77941	1,718.33182	208.37834	621.85450	1,453.70432	4.980	67	0.000
Pair 9	Pre-test Arms:Fat (g) - Post-test Arms:Fat (g)	290.529	440.361	53.402	183.939	397.119	5.440	67	0.000
Pair 10	Pre-test Legs:Fat(g) - Post-test Legs:Fat(g)	222.809	1,210.428	146.786	-70.177	515.795	1.518	67	0.134
Pair 11	Pre-test Trunk:Fat (g) - Post-test Trunk:Fat (g)	1,630.70588	1,839.17957	223.03328	1,185.52959	2,075.88218	7.311	67	0.000
Pair 12	Pre-test Total:Fat (g) - Post-test Total:Fat (g)	2,224.58824	3,397.11699	411.96095	1,402.31075	3,046.86572	5.400	67	0.000

T-Test: TEST DIFFERENCES BETWEEN PRE AND POST - BODY COMPOSITION: LEAN (G)

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test Left Arm:Lean (g)	1,983.44	68	311.112	37.728
	Post-test Left Arm:Lean (g)	2,158.49	68	356.110	43.185
Pair 2	Pre-test Left Leg:Lean(g)	6,296.19	68	679.156	82.360
	Post-test Left Leg:Lean(g)	6,736.65	68	801.571	97.205
Pair 3	Pre-test Left trunk:Lean (g)	7,812.87	68	826.317	100.206
	Post-test Left trunk:Lean (g)	8,609.41	68	902.177	109.405
Pair 4	Pre-test Left Total:Lean (g)	17,670.4265	68	1,702.33810	206.43882
	Post-test Left Total:Lean (g)	19,010.88	68	1,946.802	236.084
Pair 5	Pre-test Right Arm:Lean (g)	1,878.90	68	295.006	35.775
	Post-test Right Arm:Lean (g)	2,150.78	68	359.969	43.653
Pair 6	Pre-test Right Leg:Lean(g)	6,136.7647	68	715.56107	86.77453
	Post-test Right Leg:Lean(g)	7,471.82	68	6,547.146	793.958
Pair 7	Pre-test Right trunk:Lean (g)	7,859.99	68	911.607	110.549
	Post-test Right trunk:Lean (g)	8,689.47	68	940.528	114.056
Pair 8	Pre-test Right Total:Lean (g)	17,441.7059	68	1,815.47163	220.15827
	Post-test Right Total:Lean (g)	19,168.94	68	1,994.496	241.868
Pair 9	Pre-test Arms:Lean (g)	3,862.29	68	573.933	69.600
	Post-test Arms:Lean (g)	4,308.96	68	647.917	78.571
Pair 10	Pre-test Legs:Lean(g)	12,433.0221	68	1,375.92800	166.85578
	Post-test Legs:Lean(g)	13,411.26	68	1,599.078	193.917
Pair 11	Pre-test Trunk:Lean (g)	15,672.79	68	1,694.808	205.526
	Post-test Trunk:Lean (g)	17,298.87	68	1,768.274	214.435
Pair 12	Pre-test Total:Lean (g)	35,112.16	68	3,480.939	422.126
	Post-test Total:Lean (g)	38,179.76	68	3,821.065	463.372

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre-test Left Arm:Lean (g) & Post-test Left Arm:Lean (g)	68	0.858	0.000
Pair 2	Pre-test Left Leg:Lean(g) & Post-test Left Leg:Lean(g)	68	0.866	0.000
Pair 3	Pre-test Left trunk:Lean (g) & Post-test Left trunk:Lean (g)	68	0.873	0.000
Pair 4	Pre-test Left Total:Lean (g) & Post-test Left Total:Lean (g)	68	0.908	0.000
Pair 5	Pre-test Right Arm:Lean (g) & Post-test Right Arm:Lean (g)	68	0.851	0.000
Pair 6	Pre-test Right Leg:Lean(g) & Post-test Right Leg:Lean(g)	68	0.008	0.948
Pair 7	Pre-test Right trunk:Lean (g) & Post-test Right trunk:Lean (g)	68	0.904	0.000
Pair 8	Pre-test Right Total:Lean (g) & Post-test Right Total:Lean (g)	68	0.910	0.000
Pair 9	Pre-test Arms:Lean (g) & Post-test Arms:Lean (g)	68	0.896	0.000
Pair 10	Pre-test Legs:Lean(g) & Post-test Legs:Lean(g)	68	0.891	0.000
Pair 11	Pre-test Trunk:Lean (g) & Post-test Trunk:Lean (g)	68	0.897	0.000
Pair 12	Pre-test Total:Lean (g) & Post-test Total:Lean (g)	68	0.932	0.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower			
Pair 1	Pre-test Left Arm:Lean (g) - Post-test Left Arm:Lean (g)	-175.044	182.725	22.159	-219.273	-130.815	-7.900	67	0.000
Pair 2	Pre-test Left Leg:Lean(g) - Post-test Left Leg:Lean(g)	-440.456	401.043	48.634	-537.529	-343.383	-9.057	67	0.000
Pair 3	Pre-test Left trunk:Lean (g) - Post-test Left trunk:Lean (g)	-796.544	442.502	53.661	-903.652	-689.436	-14.844	67	0.000
Pair 4	Pre-test Left Total:Lean (g) - Post-test Left Total:Lean (g)	-1,340.45588	819.40054	99.36691	-1,538.79307	-1,142.11870	-13.490	67	0.000
Pair 5	Pre-test Right Arm:Lean (g) - Post-test Right Arm:Lean (g)	-271.882	189.383	22.966	-317.723	-226.042	-11.838	67	0.000
Pair 6	Pre-test Right Leg:Lean(g) - Post-test Right Leg:Lean(g)	-1,335.05882	6,580.39048	797.98956	-2,927.85265	257.73500	-1.673	67	0.099
Pair 7	Pre-test Right trunk:Lean (g) - Post-test Right trunk:Lean (g)	-829.485	406.706	49.320	-927.929	-731.041	-16.818	67	0.000
Pair 8	Pre-test Right Total:Lean (g) - Post-test Right Total:Lean (g)	-1,727.23529	828.03126	100.41354	-1,927.66156	-1,526.80903	-17.201	67	0.000
Pair 9	Pre-test Arms:Lean (g) - Post-test Arms:Lean (g)	-446.662	287.662	34.884	-516.291	-377.033	-12.804	67	0.000
Pair 10	Pre-test Legs:Lean(g) - Post-test Legs:Lean(g)	-978.24265	727.23971	88.19077	-1,154.27216	-802.21313	-11.092	67	0.000
Pair 11	Pre-test Trunk:Lean (g) - Post-test Trunk:Lean (g)	-1,626.074	789.025	95.683	-1,817.058	-1,435.089	-16.994	67	0.000
Pair 12	Pre-test Total:Lean (g) - Post-test Total:Lean (g)	-3,067.603	1,390.083	168.572	-3,404.075	-2,731.131	-18.198	67	0.000

T-Test: TEST DIFFERENCES BETWEEN PRE AND POST - BODY COMPOSITION :BONE MINERAL CONTENT (G) AND TOTAL MASS

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test Left Arm:Bone Mineral Content (g)	140.69	68	21.480	2.605
	Post-test Left Arm:Bone Mineral Content (g)	139.16	68	22.413	2.718
Pair 2	Pre-test Left Leg:Bone Mineral Content(g)	441.93	68	57.470	6.969
	Post-test Left Leg:Bone Mineral Content(g)	447.40	68	59.428	7.207
Pair 3	Pre-test Left trunk:Bone Mineral Content (g)	406.57	68	74.178	8.995
	Post-test Left trunk:Bone Mineral Content (g)	383.96	68	83.884	10.172
Pair 4	Pre-test Left Total:Bone Mineral Content (g)	1,233.96	68	159.143	19.299
	Post-test Left Total:Bone Mineral Content (g)	1,196.56	68	171.751	20.828
Pair 5	Pre-test Right Arm:Bone Mineral Content (g)	141.35	68	21.690	2.630
	Post-test Right Arm:Bone Mineral Content (g)	142.53	68	22.853	2.771
Pair 6	Pre-test Right Leg:Bone Mineral Content(g)	438.72	68	60.954	7.392
	Post-test Right Leg:Bone Mineral Content(g)	447.15	68	63.327	7.680
Pair 7	Pre-test Right trunk:Bone Mineral Content (g)	392.78	68	74.755	9.065
	Post-test Right trunk:Bone Mineral Content (g)	394.91	68	74.695	9.058
Pair 8	Pre-test Right Total:Bone Mineral Content (g)	1,216.51	68	162.316	19.684
	Post-test Right Total:Bone Mineral Content (g)	1,230.38	68	171.780	20.831
Pair 9	Pre-test Arms:Bone Mineral Content (g)	281.97	68	41.987	5.092
	Post-test Arms:Bone Mineral Content (g)	281.81	68	43.590	5.286
Pair 10	Pre-test Legs:Bone Mineral Content(g)	879.49	68	116.892	14.175
	Post-test Legs:Bone Mineral Content(g)	894.49	68	120.616	14.627
Pair 11	Pre-test Trunk:Bone Mineral Content (g)	797.97	68	148.196	17.971
	Post-test Trunk:Bone Mineral Content (g)	778.91	68	150.825	18.290
Pair 12	Pre-test Total:Bone Mineral Content (g)	2,450.59	68	312.907	37.946
	Post-test Total:Bone Mineral Content (g)	2,427.03	68	324.920	39.402
Pair 13	Pre-test Total Mass (Kg)	59.147	68	8.5421	1.0359
	Post-test Total Mass (Kg)	59.963	68	7.4765	0.9067

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre-test Left Arm:Bone Mineral Content (g) & Post-test Left Arm:Bone Mineral Content (g)	68	0.969	0.000
Pair 2	Pre-test Left Leg:Bone Mineral Content(g) & Post-test Left Leg:Bone Mineral Content(g)	68	0.962	0.000
Pair 3	Pre-test Left trunk:Bone Mineral Content (g) & Post-test Left trunk:Bone Mineral Content (g)	68	0.837	0.000
Pair 4	Pre-test Left Total:Bone Mineral Content (g) & Post-test Left Total:Bone Mineral Content (g)	68	0.912	0.000
Pair 5	Pre-test Right Arm:Bone Mineral Content (g) & Post-test Right Arm:Bone Mineral Content (g)	68	0.960	0.000
Pair 6	Pre-test Right Leg:Bone Mineral Content(g) & Post-test Right Leg:Bone Mineral Content(g)	68	0.975	0.000
Pair 7	Pre-test Right trunk:Bone Mineral Content (g) & Post-test Right trunk:Bone Mineral Content (g)	68	0.804	0.000
Pair 8	Pre-test Right Total:Bone Mineral Content (g) & Post-test Right Total:Bone Mineral Content (g)	68	0.896	0.000
Pair 9	Pre-test Arms:Bone Mineral Content (g) & Post-test Arms:Bone Mineral Content (g)	68	0.976	0.000
Pair 10	Pre-test Legs:Bone Mineral Content(g) & Post-test Legs:Bone Mineral Content(g)	68	0.976	0.000
Pair 11	Pre-test Trunk:Bone Mineral Content (g) & Post-test Trunk:Bone Mineral Content (g)	68	0.864	0.000
Pair 12	Pre-test Total:Bone Mineral Content (g) & Post-test Total:Bone Mineral Content (g)	68	0.951	0.000
Pair 13	Pre-test Total Mass (Kg) & Post-test Total Mass (Kg)	68	0.885	0.000

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Paired Samples Test

		Paired Differences							
					95% Confidence Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower	t	df	Sig. (2-tailed)
Pair 1	Pre-test Left Arm:Bone Mineral Content (g) - Post-test Left Arm:Bone Mineral Content (g)	1.529	5.519	0.669	0.193	2.865	2.285	67	0.025
Pair 2	Pre-test Left Leg:Bone Mineral Content(g) - Post-test Left Leg:Bone Mineral Content(g)	-5.471	16.281	1.974	-9.411	-1.530	-2.771	67	0.007
Pair 3	Pre-test Left trunk:Bone Mineral Content (g) - Post-test Left trunk:Bone Mineral Content (g)	22.618	46.012	5.580	11.480	33.755	4.053	67	0.000
Pair 4	Pre-test Left Total:Bone Mineral Content (g) - Post-test Left Total:Bone Mineral Content (g)	37.397	70.505	8.550	20.331	54.463	4.374	67	0.000
Pair 5	Pre-test Right Arm:Bone Mineral Content (g) - Post-test Right Arm:Bone Mineral Content (g)	-1.176	6.383	0.774	-2.722	0.369	-1.520	67	0.133
Pair 6	Pre-test Right Leg:Bone Mineral Content(g) - Post-test Right Leg:Bone Mineral Content(g)	-8.426	14.110	1.711	-11.842	-5.011	-4.925	67	0.000
Pair 7	Pre-test Right trunk:Bone Mineral Content (g) - Post-test Right trunk:Bone Mineral Content (g)	-2.132	46.787	5.674	-13.457	9.192	-0.376	67	0.708
Pair 8	Pre-test Right Total:Bone Mineral Content (g) - Post-test Right Total:Bone Mineral Content (g)	-13.868	76.787	9.312	-32.454	4.719	-1.489	67	0.141
Pair 9	Pre-test Arms:Bone Mineral Content (g) - Post-test Arms:Bone Mineral Content (g)	0.162	9.470	1.148	-2.131	2.454	0.141	67	0.888
Pair 10	Pre-test Legs:Bone Mineral Content(g) - Post-test Legs:Bone Mineral Content(g)	-15.000	26.511	3.215	-21.417	-8.583	-4.666	67	0.000
Pair 11	Pre-test Trunk:Bone Mineral Content (g) - Post-test Trunk:Bone Mineral Content (g)	19.059	77.894	9.446	0.204	37.913	2.018	67	0.048
Pair 12	Pre-test Total:Bone Mineral Content (g) - Post-test Total:Bone Mineral Content (g)	23.559	100.667	12.208	-0.808	47.925	1.930	67	0.058
Pair 13	Pre-test Total Mass (Kg) - Post-test Total Mass (Kg)	-0.8162	3.9720	0.4817	-1.7776	0.1453	-1.694	67	0.095

T-Test: TEST DIFFERENCES BETWEEN PRE AND POST: ANCILLARY HEALTH - AP SPINE: BONE MINERAL DENSITY (G/CM)

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test T12:Bone Mineral Density (g/cm2)	1.4213	25	1.86181	0.37236
	Post-test T12:Bone Mineral Density (g/cm2)	1.0167	25	0.12903	0.02581
Pair 2	Pre-test L1:Bone Mineral Density (g/cm2)	1.1078	68	0.12691	0.01539
	Post-test L1:Bone Mineral Density (g/cm2)	1.0924	68	0.12903	0.01565
Pair 3	Pre-test L2:Bone Mineral Density (g/cm2)	1.1755	68	0.14026	0.01701
	Post-test L2:Bone Mineral Density (g/cm2)	1.1833	68	0.13178	0.01598
Pair 4	Pre-test L3:Bone Mineral Density (g/cm2)	1.2242	68	0.13661	0.01657
	Post-test L3:Bone Mineral Density (g/cm2)	1.2257	68	0.11860	0.01438
Pair 5	Pre-test L4:Bone Mineral Density (g/cm2)	1.1769	68	0.11742	0.01424
	Post-test L4:Bone Mineral Density (g/cm2)	1.1765	68	0.12435	0.01508
Pair 6	Pre-test L1-L2:Bone Mineral Density (g/cm2)	1.1447	68	0.12593	0.01527
	Post-test L1-L2:Bone Mineral Density (g/cm2)	1.1277	68	0.17628	0.02138
Pair 7	Pre-test L1-L3:Bone Mineral Density (g/cm2)	1.1763	68	0.12061	0.01463
	Post-test L1-L3:Bone Mineral Density (g/cm2)	1.1645	68	0.14430	0.01750
Pair 8	Pre-test L1-L4:Bone Mineral Density (g/cm2)	1.1761	68	0.11633	0.01411
	Post-test L1-L4:Bone Mineral Density (g/cm2)	1.1725	68	0.11916	0.01445
Pair 9	Pre-test L2-L3:Bone Mineral Density (g/cm2)	1.2060	68	0.12282	0.01489
	Post-test L2-L3:Bone Mineral Density (g/cm2)	1.2054	68	0.12248	0.01485
Pair 10	Pre-test L2-L4:Bone Mineral Density (g/cm2)	1.1943	68	0.11750	0.01425
	Post-test L2-L4:Bone Mineral Density (g/cm2)	1.1944	68	0.11988	0.01454
Pair 11	Pre-test L3-L4:Bone Mineral Density (g/cm2)	1.2006	68	0.11692	0.01418
	Post-test L3-L4:Bone Mineral Density (g/cm2)	1.1991	68	0.11897	0.01443

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre-test T12:Bone Mineral Density (g/cm2) & Post-test T12:Bone Mineral Density (g/cm2)	25	0.230	0.269
Pair 2	Pre-test L1:Bone Mineral Density (g/cm2) & Post-test L1:Bone Mineral Density (g/cm2)	68	0.962	0.000
Pair 3	Pre-test L2:Bone Mineral Density (g/cm2) & Post-test L2:Bone Mineral Density (g/cm2)	68	0.947	0.000
Pair 4	Pre-test L3:Bone Mineral Density (g/cm2) & Post-test L3:Bone Mineral Density (g/cm2)	68	0.920	0.000
Pair 5	Pre-test L4:Bone Mineral Density (g/cm2) & Post-test L4:Bone Mineral Density (g/cm2)	68	0.962	0.000
Pair 6	Pre-test L1-L2:Bone Mineral Density (g/cm2) & Post-test L1-L2:Bone Mineral Density (g/cm2)	68	0.834	0.000
Pair 7	Pre-test L1-L3:Bone Mineral Density (g/cm2) & Post-test L1-L3:Bone Mineral Density (g/cm2)	68	0.898	0.000
Pair 8	Pre-test L1-L4:Bone Mineral Density (g/cm2) & Post-test L1-L4:Bone Mineral Density (g/cm2)	68	0.981	0.000
Pair 9	Pre-test L2-L3:Bone Mineral Density (g/cm2) & Post-test L2-L3:Bone Mineral Density (g/cm2)	68	0.973	0.000
Pair 10	Pre-test L2-L4:Bone Mineral Density (g/cm2) & Post-test L2-L4:Bone Mineral Density (g/cm2)	68	0.980	0.000
Pair 11	Pre-test L3-L4:Bone Mineral Density (g/cm2) & Post-test L3-L4:Bone Mineral Density (g/cm2)	68	0.976	0.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower			
Pair 1	Pre-test T12:Bone Mineral Density (g/cm2) - Post-test T12:Bone Mineral Density (g/cm2)	0.40460	1.83646	0.36729	-0.35345	1.16265	1.102	24	0.282
Pair 2	Pre-test L1:Bone Mineral Density (g/cm2) - Post-test L1:Bone Mineral Density (g/cm2)	0.01535	0.03528	0.00428	0.00681	0.02389	3.588	67	0.001
Pair 3	Pre-test L2:Bone Mineral Density (g/cm2) - Post-test L2:Bone Mineral Density (g/cm2)	-0.00777	0.04510	0.00547	-0.01869	0.00314	-1.422	67	0.160
Pair 4	Pre-test L3:Bone Mineral Density (g/cm2) - Post-test L3:Bone Mineral Density (g/cm2)	-0.00144	0.05393	0.00654	-0.01449	0.01162	-0.219	67	0.827
Pair 5	Pre-test L4:Bone Mineral Density (g/cm2) - Post-test L4:Bone Mineral Density (g/cm2)	0.00043	0.03417	0.00414	-0.00784	0.00870	0.103	67	0.918
Pair 6	Pre-test L1-L2:Bone Mineral Density (g/cm2) - Post-test L1-L2:Bone Mineral Density (g/cm2)	0.01707	0.09958	0.01208	-0.00703	0.04118	1.414	67	0.162
Pair 7	Pre-test L1-L3:Bone Mineral Density (g/cm2) - Post-test L1-L3:Bone Mineral Density (g/cm2)	0.01181	0.06403	0.00776	-0.00369	0.02731	1.521	67	0.133
Pair 8	Pre-test L1-L4:Bone Mineral Density (g/cm2) - Post-test L1-L4:Bone Mineral Density (g/cm2)	0.00360	0.02298	0.00279	-0.00196	0.00917	1.293	67	0.201
Pair 9	Pre-test L2-L3:Bone Mineral Density (g/cm2) - Post-test L2-L3:Bone Mineral Density (g/cm2)	0.00053	0.02854	0.00346	-0.00638	0.00744	0.153	67	0.879
Pair 10	Pre-test L2-L4:Bone Mineral Density (g/cm2) - Post-test L2-L4:Bone Mineral Density (g/cm2)	-0.00010	0.02369	0.00287	-0.00584	0.00563	-0.036	67	0.972
Pair 11	Pre-test L3-L4:Bone Mineral Density (g/cm2) - Post-test L3-L4:Bone Mineral Density (g/cm2)	0.00141	0.02603	0.00316	-0.00489	0.00771	0.447	67	0.656

T-Test: TEST DIFFERENCES PRE AND POST- ANCILLARY HEALTH- AP SPINE: YOUNG ADULT %

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test L1 Young Adult %	98.13	68	10.939	1.327
	Post-test L1 Young Adult %	96.65	68	11.349	1.376
Pair 2	Pre-test L2 Young Adult %	98.31	68	11.011	1.335
	Post-test L2 Young Adult %	98.63	68	11.037	1.338
Pair 3	Pre-test L3 Young Adult %	102.53	68	10.051	1.219
	Post-test L3 Young Adult %	102.18	68	9.899	1.200
Pair 4	Pre-test L4 Young Adult %	97.88	68	10.026	1.216
	Post-test L4 Young Adult %	98.06	68	10.415	1.263
Pair 5	Pre-test L1-L2 Young Adult %	99.59	68	10.966	1.330
	Post-test L1-L2 Young Adult %	99.13	68	11.091	1.345
Pair 6	Pre-test L1-L3 Young Adult %	100.49	68	10.540	1.278
	Post-test L1-L3 Young Adult %	100.07	68	10.426	1.264
Pair 7	Pre-test L1-L4 Young Adult %	99.72	68	9.807	1.189
	Post-test L1-L4 Young Adult %	99.40	68	10.144	1.230
Pair 8	Pre-test L2-L3 Young Adult %	100.46	68	10.234	1.241
	Post-test L2-L3 Young Adult %	100.41	68	10.229	1.240
Pair 9	Pre-test L2-L4 Young Adult %	99.51	68	9.825	1.191
	Post-test L2-L4 Young Adult %	99.53	68	9.983	1.211
Pair 10	Pre-test L3-L4 Young Adult %	100.07	68	9.717	1.178
	Post-test L3-L4 Young Adult %	99.90	68	9.868	1.197

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre-test L1 Young Adult % & Post-test L1 Young Adult %	68	0.963	0.000
Pair 2	Pre-test L2 Young Adult % & Post-test L2 Young Adult %	68	0.953	0.000
Pair 3	Pre-test L3 Young Adult % & Post-test L3 Young Adult %	68	0.964	0.000
Pair 4	Pre-test L4 Young Adult % & Post-test L4 Young Adult %	68	0.963	0.000
Pair 5	Pre-test L1-L2 Young Adult % & Post-test L1-L2 Young Adult %	68	0.973	0.000
Pair 6	Pre-test L1-L3 Young Adult % & Post-test L1-L3 Young Adult %	68	0.976	0.000
Pair 7	Pre-test L1-L4 Young Adult % & Post-test L1-L4 Young Adult %	68	0.979	0.000
Pair 8	Pre-test L2-L3 Young Adult % & Post-test L2-L3 Young Adult %	68	0.973	0.000
Pair 9	Pre-test L2-L4 Young Adult % & Post-test L2-L4 Young Adult %	68	0.981	0.000
Pair 10	Pre-test L3-L4 Young Adult % & Post-test L3-L4 Young Adult %	68	0.975	0.000

Paired Samples Test

		Paired Differences							
					95% Confidence Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower	t	df	Sig. (2-tailed)
Pair 1	Pre-test L1 Young Adult % - Post-test L1 Young Adult %	1.485	3.054	0.370	0.746	2.225	4.010	67	0.000
Pair 2	Pre-test L2 Young Adult % - Post-test L2 Young Adult %	-0.324	3.383	0.410	-1.142	0.495	-0.789	67	0.433
Pair 3	Pre-test L3 Young Adult % - Post-test L3 Young Adult %	0.353	2.686	0.326	-0.297	1.003	1.083	67	0.283
Pair 4	Pre-test L4 Young Adult % - Post-test L4 Young Adult %	-0.176	2.823	0.342	-0.860	0.507	-0.516	67	0.608
Pair 5	Pre-test L1-L2 Young Adult % - Post-test L1-L2 Young Adult %	0.456	2.588	0.314	-0.171	1.082	1.452	67	0.151
Pair 6	Pre-test L1-L3 Young Adult % - Post-test L1-L3 Young Adult %	0.412	2.307	0.280	-0.147	0.970	1.472	67	0.146
Pair 7	Pre-test L1-L4 Young Adult % - Post-test L1-L4 Young Adult %	0.324	2.076	0.252	-0.179	0.826	1.285	67	0.203
Pair 8	Pre-test L2-L3 Young Adult % - Post-test L2-L3 Young Adult %	0.044	2.397	0.291	-0.536	0.624	0.152	67	0.880
Pair 9	Pre-test L2-L4 Young Adult % - Post-test L2-L4 Young Adult %	-0.015	1.958	0.237	-0.489	0.459	-0.062	67	0.951
Pair 10	Pre-test L3-L4 Young Adult % - Post-test L3-L4 Young Adult %	0.176	2.192	0.266	-0.354	0.707	0.664	67	0.509

T-Test: TEST DIFFERENCES PRE AND POST- ANCILLARY HEALTH- AP SPINE: YOUNG ADULT T-SCORE

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test L1 Young Adult T-score	-0.174	68	1.0373	0.1258
	Post-test L1 Young Adult T-score	-0.316	68	1.0778	0.1307
Pair 2	Pre-test L2 Young Adult T-score	-0.169	68	1.1011	0.1335
	Post-test L2 Young Adult T-score	-0.137	68	1.1037	0.1338
Pair 3	Pre-test L3 Young Adult T-score	0.247	68	1.0084	0.1223
	Post-test L3 Young Adult T-score	0.218	68	0.9899	0.1200
Pair 4	Pre-test L4 Young Adult T-score	-0.204	68	0.9903	0.1201
	Post-test L4 Young Adult T-score	-0.194	68	1.0415	0.1263
Pair 5	Pre-test L1-L2 Young Adult T-score	-0.041	68	1.0381	0.1259
	Post-test L1-L2 Young Adult T-score	-0.09	68	1.056	0.128
Pair 6	Pre-test L1-L3 Young Adult T-score	0.053	68	1.0025	0.1216
	Post-test L1-L3 Young Adult T-score	0.012	68	1.0193	0.1236
Pair 7	Pre-test L1-L4 Young Adult T-score	-0.03	68	0.969	0.118
	Post-test L1-L4 Young Adult T-score	-0.057	68	0.9906	0.1201
Pair 8	Pre-test L2-L3 Young Adult T-score	0.046	68	1.0234	0.1241
	Post-test L2-L3 Young Adult T-score	0.041	68	1.0229	0.1240
Pair 9	Pre-test L2-L4 Young Adult T-score	-0.049	68	0.9825	0.1191
	Post-test L2-L4 Young Adult T-score	-0.047	68	0.9983	0.1211
Pair 10	Pre-test L3-L4 Young Adult T-score	0.01	68	0.972	0.118
	Post-test L3-L4 Young Adult T-score	0.02	68	1.028	0.125

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre-test L1 Young Adult T-score & Post-test L1 Young Adult T-score	68	0.963	0.000
Pair 2	Pre-test L2 Young Adult T-score & Post-test L2 Young Adult T-score	68	0.953	0.000
Pair 3	Pre-test L3 Young Adult T-score & Post-test L3 Young Adult T-score	68	0.961	0.000
Pair 4	Pre-test L4 Young Adult T-score & Post-test L4 Young Adult T-score	68	0.965	0.000
Pair 5	Pre-test L1-L2 Young Adult T-score & Post-test L1-L2 Young Adult T-score	68	0.971	0.000
Pair 6	Pre-test L1-L3 Young Adult T-score & Post-test L1-L3 Young Adult T-score	68	0.975	0.000
Pair 7	Pre-test L1-L4 Young Adult T-score & Post-test L1-L4 Young Adult T-score	68	0.981	0.000
Pair 8	Pre-test L2-L3 Young Adult T-score & Post-test L2-L3 Young Adult T-score	68	0.973	0.000
Pair 9	Pre-test L2-L4 Young Adult T-score & Post-test L2-L4 Young Adult T-score	68	0.981	0.000
Pair 10	Pre-test L3-L4 Young Adult T-score & Post-test L3-L4 Young Adult T-score	68	0.942	0.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower			
Pair 1	Pre-test L1 Young Adult T-score - Post-test L1 Young Adult T-score	0.1426	0.2893	0.0351	0.0726	0.2127	4.066	67	0.000
Pair 2	Pre-test L2 Young Adult T-score - Post-test L2 Young Adult T-score	-0.0324	0.3383	0.0410	-0.1142	0.0495	-0.789	67	0.433
Pair 3	Pre-test L3 Young Adult T-score - Post-test L3 Young Adult T-score	0.0294	0.2802	0.0340	-0.0384	0.0972	0.866	67	0.390
Pair 4	Pre-test L4 Young Adult T-score - Post-test L4 Young Adult T-score	-0.0103	0.2733	0.0331	-0.0764	0.0558	-0.311	67	0.757
Pair 5	Pre-test L1-L2 Young Adult T-score - Post-test L1-L2 Young Adult T-score	0.0471	0.2518	0.0305	-0.0139	0.1080	1.541	67	0.128
Pair 6	Pre-test L1-L3 Young Adult T-score - Post-test L1-L3 Young Adult T-score	0.0412	0.2261	0.0274	-0.0135	0.0959	1.502	67	0.138
Pair 7	Pre-test L1-L4 Young Adult T-score - Post-test L1-L4 Young Adult T-score	0.0279	0.1899	0.0230	-0.0180	0.0739	1.213	67	0.229
Pair 8	Pre-test L2-L3 Young Adult T-score - Post-test L2-L3 Young Adult T-score	0.0044	0.2397	0.0291	-0.0536	0.0624	0.152	67	0.880
Pair 9	Pre-test L2-L4 Young Adult T-score - Post-test L2-L4 Young Adult T-score	-0.0015	0.1958	0.0237	-0.0489	0.0459	-0.062	67	0.951
Pair 10	Pre-test L3-L4 Young Adult T-score - Post-test L3-L4 Young Adult T-score	-0.012	0.346	0.042	-0.096	0.072	-0.280	67	0.780

T-Test:TEST DIFFERENCES PRE AND POST- ANCILLARY HEALTH- AP SPINE: AGE MATCHED %

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test L1 Age-matched %	99.72	68	11.434	1.387
	Post-test L1 Age-matched %	98.13	68	11.298	1.370
Pair 2	Pre-test L2 Age-matched %	99.76	68	11.436	1.387
	Post-test L2 Age-matched %	100.01	68	10.900	1.322
Pair 3	Pre-test L3 Age-matched %	103.99	68	10.341	1.254
	Post-test L3 Age-matched %	103.62	68	9.827	1.192
Pair 4	Pre-test L4 Age-matched %	99.35	68	10.157	1.232
	Post-test L4 Age-matched %	99.37	68	10.141	1.230
Pair 5	Pre-test L1-L2 Age-matched %	101.18	68	11.337	1.375
	Post-test L1-L2 Age-matched %	100.53	68	10.986	1.332
Pair 6	Pre-test L1-L3 Age-matched %	102.07	68	10.719	1.300
	Post-test L1-L3 Age-matched %	101.56	68	10.422	1.264
Pair 7	Pre-test L1-L4 Age-matched %	101.18	68	10.232	1.241
	Post-test L1-L4 Age-matched %	100.82	68	10.015	1.214
Pair 8	Pre-test L2-L3 Age-matched %	101.96	68	10.669	1.294
	Post-test L2-L3 Age-matched %	101.93	68	10.119	1.227
Pair 9	Pre-test L2-L4 Age-matched %	100.97	68	10.117	1.227
	Post-test L2-L4 Age-matched %	100.97	68	9.825	1.191
Pair 10	Pre-test L3-L4 Age-matched %	101.49	68	10.081	1.223
	Post-test L3-L4 Age-matched %	101.31	68	9.769	1.185

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre-test L1 Age-matched % & Post-test L1 Age-matched %	68	0.950	0.000
Pair 2	Pre-test L2 Age-matched % & Post-test L2 Age-matched %	68	0.944	0.000
Pair 3	Pre-test L3 Age-matched % & Post-test L3 Age-matched %	68	0.949	0.000
Pair 4	Pre-test L4 Age-matched % & Post-test L4 Age-matched %	68	0.943	0.000
Pair 5	Pre-test L1-L2 Age-matched % & Post-test L1-L2 Age-matched %	68	0.959	0.000
Pair 6	Pre-test L1-L3 Age-matched % & Post-test L1-L3 Age-matched %	68	0.963	0.000
Pair 7	Pre-test L1-L4 Age-matched % & Post-test L1-L4 Age-matched %	68	0.964	0.000
Pair 8	Pre-test L2-L3 Age-matched % & Post-test L2-L3 Age-matched %	68	0.959	0.000
Pair 9	Pre-test L2-L4 Age-matched % & Post-test L2-L4 Age-matched %	68	0.965	0.000
Pair 10	Pre-test L3-L4 Age-matched % & Post-test L3-L4 Age-matched %	68	0.957	0.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower			
Pair 1	Pre-test L1 Age-matched % - Post-test L1 Age-matched %	1.588	3.596	0.436	0.718	2.459	3.642	67	0.001
Pair 2	Pre-test L2 Age-matched % - Post-test L2 Age-matched %	-0.250	3.791	0.460	-1.168	0.668	-0.544	67	0.588
Pair 3	Pre-test L3 Age-matched % - Post-test L3 Age-matched %	0.368	3.246	0.394	-0.418	1.153	0.934	67	0.354
Pair 4	Pre-test L4 Age-matched % - Post-test L4 Age-matched %	-0.015	3.432	0.416	-0.845	0.816	-0.035	67	0.972
Pair 5	Pre-test L1-L2 Age-matched % - Post-test L1-L2 Age-matched %	0.647	3.231	0.392	-0.135	1.429	1.651	67	0.103
Pair 6	Pre-test L1-L3 Age-matched % - Post-test L1-L3 Age-matched %	0.515	2.888	0.350	-0.184	1.214	1.469	67	0.146
Pair 7	Pre-test L1-L4 Age-matched % - Post-test L1-L4 Age-matched %	0.353	2.725	0.330	-0.307	1.013	1.068	67	0.289
Pair 8	Pre-test L2-L3 Age-matched % - Post-test L2-L3 Age-matched %	0.029	3.037	0.368	-0.706	0.765	0.080	67	0.937
Pair 9	Pre-test L2-L4 Age-matched % - Post-test L2-L4 Age-matched %	0.000	2.637	0.320	-0.638	0.638	0.000	67	1.000
Pair 10	Pre-test L3-L4 Age-matched % - Post-test L3-L4 Age-matched %	0.176	2.911	0.353	-0.528	0.881	0.500	67	0.619

T-Test:TEST DIFFERENCES PRE AND POST- ANCILLARY HEALTH- AP SPINE: AGE MATCHED Z-SCORE

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test L1 Age-matched Z-score	-0.031	68	1.0506	0.1274
	Post-test L1 Age-matched Z-score	-0.165	68	1.0336	0.1253
Pair 2	Pre-test L2 Age-matched Z-score	-0.031	68	1.1168	0.1354
	Post-test L2 Age-matched Z-score	0.003	68	1.0699	0.1297
Pair 3	Pre-test L3 Age-matched Z-score	0.379	68	1.0164	0.1233
	Post-test L3 Age-matched Z-score	0.357	68	0.9603	0.1165
Pair 4	Pre-test L4 Age-matched Z-score	-0.08	68	1.005	0.122
	Post-test L4 Age-matched Z-score	-0.056	68	0.9996	0.1212
Pair 5	Pre-test L1-L2 Age-matched Z-score	0.099	68	1.0557	0.1280
	Post-test L1-L2 Age-matched Z-score	0.071	68	1.0346	0.1255
Pair 6	Pre-test L1-L3 Age-matched Z-score	0.185	68	1.0116	0.1227
	Post-test L1-L3 Age-matched Z-score	0.149	68	0.9846	0.1194
Pair 7	Pre-test L1-L4 Age-matched Z-score	0.103	68	0.9862	0.1196
	Post-test L1-L4 Age-matched Z-score	0.088	68	0.9591	0.1163
Pair 8	Pre-test L2-L3 Age-matched Z-score	0.182	68	1.0362	0.1257
	Post-test L2-L3 Age-matched Z-score	0.19	68	0.996	0.121
Pair 9	Pre-test L2-L4 Age-matched Z-score	0.085	68	0.9990	0.1211
	Post-test L2-L4 Age-matched Z-score	0.094	68	0.9706	0.1177
Pair 10	Pre-test L3-L4 Age-matched Z-score	0.140	68	0.9921	0.1203
	Post-test L3-L4 Age-matched Z-score	0.134	68	0.9586	0.1163

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre-test L1 Age-matched Z-score & Post-test L1 Age-matched Z-score	68	0.951	0.000
Pair 2	Pre-test L2 Age-matched Z-score & Post-test L2 Age-matched Z-score	68	0.939	0.000
Pair 3	Pre-test L3 Age-matched Z-score & Post-test L3 Age-matched Z-score	68	0.955	0.000
Pair 4	Pre-test L4 Age-matched Z-score & Post-test L4 Age-matched Z-score	68	0.940	0.000
Pair 5	Pre-test L1-L2 Age-matched Z-score & Post-test L1-L2 Age-matched Z-score	68	0.953	0.000
Pair 6	Pre-test L1-L3 Age-matched Z-score & Post-test L1-L3 Age-matched Z-score	68	0.965	0.000
Pair 7	Pre-test L1-L4 Age-matched Z-score & Post-test L1-L4 Age-matched Z-score	68	0.966	0.000
Pair 8	Pre-test L2-L3 Age-matched Z-score & Post-test L2-L3 Age-matched Z-score	68	0.959	0.000
Pair 9	Pre-test L2-L4 Age-matched Z-score & Post-test L2-L4 Age-matched Z-score	68	0.965	0.000
Pair 10	Pre-test L3-L4 Age-matched Z-score & Post-test L3-L4 Age-matched Z-score	68	0.959	0.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower			
Pair 1	Pre-test L1 Age-matched Z-score - Post-test L1 Age-matched Z-score	0.1338	0.3254	0.0395	0.0551	0.2126	3.392	67	0.001
Pair 2	Pre-test L2 Age-matched Z-score - Post-test L2 Age-matched Z-score	-0.0338	0.3846	0.0466	-0.1269	0.0593	-0.725	67	0.471
Pair 3	Pre-test L3 Age-matched Z-score - Post-test L3 Age-matched Z-score	0.0221	0.3002	0.0364	-0.0506	0.0947	0.606	67	0.547
Pair 4	Pre-test L4 Age-matched Z-score - Post-test L4 Age-matched Z-score	-0.0206	0.3471	0.0421	-0.1046	0.0634	-0.489	67	0.626
Pair 5	Pre-test L1-L2 Age-matched Z-score - Post-test L1-L2 Age-matched Z-score	0.0279	0.3218	0.0390	-0.0499	0.1058	0.716	67	0.476
Pair 6	Pre-test L1-L3 Age-matched Z-score - Post-test L1-L3 Age-matched Z-score	0.0368	0.2637	0.0320	-0.0271	0.1006	1.150	67	0.254
Pair 7	Pre-test L1-L4 Age-matched Z-score - Post-test L1-L4 Age-matched Z-score	0.0147	0.2535	0.0307	-0.0467	0.0761	0.478	67	0.634
Pair 8	Pre-test L2-L3 Age-matched Z-score - Post-test L2-L3 Age-matched Z-score	-0.0029	0.2932	0.0356	-0.0739	0.0680	-0.083	67	0.934
Pair 9	Pre-test L2-L4 Age-matched Z-score - Post-test L2-L4 Age-matched Z-score	-0.0088	0.2636	0.0320	-0.0726	0.0550	-0.276	67	0.783
Pair 10	Pre-test L3-L4 Age-matched Z-score - Post-test L3-L4 Age-matched Z-score	0.0059	0.2823	0.0342	-0.0624	0.0742	0.172	67	0.864

T-Test:TEST DIFFERENCES PRE AND POST- ANCILLARY HEALTH- AP SPINE: BONE MINERAL CONTENT (G)

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test T12:Bone Mineral Content (g)	10.172	25	1.7492	0.3498
	Post-test T12:Bone Mineral Content (g)	9.996	25	1.7794	0.3559
Pair 2	Pre-test L1:Bone Mineral Content (g)	11.622	68	2.0705	0.2511
	Post-test L1:Bone Mineral Content (g)	11.446	68	2.1021	0.2549
Pair 3	Pre-test L2:Bone Mineral Content (g)	13.203	68	2.1686	0.2630
	Post-test L2:Bone Mineral Content (g)	13.326	68	2.1725	0.2635
Pair 4	Pre-test L3:Bone Mineral Content (g)	15.481	68	2.4872	0.3016
	Post-test L3:Bone Mineral Content (g)	15.594	68	2.3806	0.2887
Pair 5	Pre-test L4:Bone Mineral Content (g)	17.037	68	2.6051	0.3159
	Post-test L4:Bone Mineral Content (g)	17.116	68	2.6662	0.3233
Pair 6	Pre-test L1-L2:Bone Mineral Content (g)	24.815	68	4.1208	0.4997
	Post-test L1-L2:Bone Mineral Content (g)	24.772	68	4.1503	0.5033
Pair 7	Pre-test L1-L3:Bone Mineral Content (g)	40.299	68	6.4598	0.7834
	Post-test L1-L3:Bone Mineral Content (g)	40.365	68	6.4002	0.7761
Pair 8	Pre-test L1-L4:Bone Mineral Content (g)	57.343	68	8.7318	1.0589
	Post-test L1-L4:Bone Mineral Content (g)	57.493	68	8.7663	1.0631
Pair 9	Pre-test L2-L3:Bone Mineral Content (g)	28.681	68	4.5845	0.5560
	Post-test L2-L3:Bone Mineral Content (g)	28.918	68	4.4952	0.5451
Pair 10	Pre-test L2-L4:Bone Mineral Content (g)	45.722	68	6.9171	0.8388
	Post-test L2-L4:Bone Mineral Content (g)	46.04	68	6.893	0.836
Pair 11	Pre-test L3-L4:Bone Mineral Content (g)	32.526	68	4.8694	0.5905
	Post-test L3-L4:Bone Mineral Content (g)	32.712	68	4.8393	0.5869

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre-test T12:Bone Mineral Content (g) & Post-test T12:Bone Mineral Content (g)	25	0.969	0.000
Pair 2	Pre-test L1:Bone Mineral Content (g) & Post-test L1:Bone Mineral Content (g)	68	0.984	0.000
Pair 3	Pre-test L2:Bone Mineral Content (g) & Post-test L2:Bone Mineral Content (g)	68	0.966	0.000
Pair 4	Pre-test L3:Bone Mineral Content (g) & Post-test L3:Bone Mineral Content (g)	68	0.969	0.000
Pair 5	Pre-test L4:Bone Mineral Content (g) & Post-test L4:Bone Mineral Content (g)	68	0.974	0.000
Pair 6	Pre-test L1-L2:Bone Mineral Content (g) & Post-test L1-L2:Bone Mineral Content (g)	68	0.983	0.000
Pair 7	Pre-test L1-L3:Bone Mineral Content (g) & Post-test L1-L3:Bone Mineral Content (g)	68	0.983	0.000
Pair 8	Pre-test L1-L4:Bone Mineral Content (g) & Post-test L1-L4:Bone Mineral Content (g)	68	0.987	0.000
Pair 9	Pre-test L2-L3:Bone Mineral Content (g) & Post-test L2-L3:Bone Mineral Content (g)	68	0.977	0.000
Pair 10	Pre-test L2-L4:Bone Mineral Content (g) & Post-test L2-L4:Bone Mineral Content (g)	68	0.985	0.000
Pair 11	Pre-test L3-L4:Bone Mineral Content (g) & Post-test L3-L4:Bone Mineral Content (g)	68	0.983	0.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower			
Pair 1	Pre-test T12:Bone Mineral Content (g) - Post-test T12:Bone Mineral Content (g)	0.1760	0.4371	0.0874	-0.0044	0.3564	2.013	24	0.055
Pair 2	Pre-test L1:Bone Mineral Content (g) - Post-test L1:Bone Mineral Content (g)	0.1765	0.3706	0.0449	0.0868	0.2662	3.927	67	0.000
Pair 3	Pre-test L2:Bone Mineral Content (g) - Post-test L2:Bone Mineral Content (g)	-0.1235	0.5652	0.0685	-0.2603	0.0133	-1.802	67	0.076
Pair 4	Pre-test L3:Bone Mineral Content (g) - Post-test L3:Bone Mineral Content (g)	-0.1132	0.6111	0.0741	-0.2611	0.0347	-1.528	67	0.131
Pair 5	Pre-test L4:Bone Mineral Content (g) - Post-test L4:Bone Mineral Content (g)	-0.0794	0.6093	0.0739	-0.2269	0.0681	-1.075	67	0.286
Pair 6	Pre-test L1-L2:Bone Mineral Content (g) - Post-test L1-L2:Bone Mineral Content (g)	0.0426	0.7601	0.0922	-0.1413	0.2266	0.463	67	0.645
Pair 7	Pre-test L1-L3:Bone Mineral Content (g) - Post-test L1-L3:Bone Mineral Content (g)	-0.0662	1.1761	0.1426	-0.3508	0.2185	-0.464	67	0.644
Pair 8	Pre-test L1-L4:Bone Mineral Content (g) - Post-test L1-L4:Bone Mineral Content (g)	-0.1500	1.3929	0.1689	-0.4872	0.1872	-0.888	67	0.378
Pair 9	Pre-test L2-L3:Bone Mineral Content (g) - Post-test L2-L3:Bone Mineral Content (g)	-0.2368	0.9789	0.1187	-0.4737	0.0002	-1.995	67	0.050
Pair 10	Pre-test L2-L4:Bone Mineral Content (g) - Post-test L2-L4:Bone Mineral Content (g)	-0.3162	1.1965	0.1451	-0.6058	-0.0266	-2.179	67	0.033
Pair 11	Pre-test L3-L4:Bone Mineral Content (g) - Post-test L3-L4:Bone Mineral Content (g)	-0.1853	0.8895	0.1079	-0.4006	0.0300	-1.718	67	0.090

T-Test:TEST DIFFERENCES PRE AND POST- ANCILLARY HEALTH- AP SPINE: AREA (CM)

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test T12:Area (cm)	9.648	25	1.0231	0.2046
	Post-test T12:Area (cm)	9.804	25	1.0426	0.2085
Pair 2	Pre-test L1:Area (cm)	10.434	68	1.1805	0.1432
	Post-test L1:Area (cm)	10.441	68	1.1619	0.1409
Pair 3	Pre-test L2:Area (cm)	11.154	68	1.0658	0.1292
	Post-test L2:Area (cm)	11.231	68	1.0538	0.1278
Pair 4	Pre-test L3:Area (cm)	12.55	68	1.318	0.160
	Post-test L3:Area (cm)	12.701	68	1.2922	0.1567
Pair 5	Pre-test L4:Area (cm)	14.466	68	1.4018	0.1700
	Post-test L4:Area (cm)	14.524	68	1.4126	0.1713
Pair 6	Pre-test L1-L2:Area (cm)	21.28	68	3.160	0.383
	Post-test L1-L2:Area (cm)	21.672	68	2.1160	0.2566
Pair 7	Pre-test L1-L3:Area (cm)	34.132	68	3.3100	0.4014
	Post-test L1-L3:Area (cm)	34.349	68	3.2526	0.3944
Pair 8	Pre-test L1-L4:Area (cm)	48.603	68	4.3809	0.5313
	Post-test L1-L4:Area (cm)	48.878	68	4.3209	0.5240
Pair 9	Pre-test L2-L3:Area (cm)	23.697	68	2.3033	0.2793
	Post-test L2-L3:Area (cm)	23.922	68	2.2524	0.2731
Pair 10	Pre-test L2-L3:Area (cm)	38.162	68	3.3982	0.4121
	Post-test L2-L3:Area (cm)	38.443	68	3.3547	0.4068
Pair 11	Pre-test L3-L4:Area (cm)	27.018	68	2.4382	0.2957
	Post-test L3-L4:Area (cm)	27.216	68	2.4208	0.2936

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre-test T12:Area (cm) & Post-test T12:Area (cm)	25	0.937	0.000
Pair 2	Pre-test L1:Area (cm) & Post-test L1:Area (cm)	68	0.985	0.000
Pair 3	Pre-test L2:Area (cm) & Post-test L2:Area (cm)	68	0.975	0.000
Pair 4	Pre-test L3:Area (cm) & Post-test L3:Area (cm)	68	0.963	0.000
Pair 5	Pre-test L4:Area (cm) & Post-test L4:Area (cm)	68	0.990	0.000
Pair 6	Pre-test L1-L2:Area (cm) & Post-test L1-L2:Area (cm)	68	0.594	0.000
Pair 7	Pre-test L1-L3:Area (cm) & Post-test L1-L3:Area (cm)	68	0.984	0.000
Pair 8	Pre-test L1-L4:Area (cm) & Post-test L1-L4:Area (cm)	68	0.991	0.000
Pair 9	Pre-test L2-L3:Area (cm) & Post-test L2-L3:Area (cm)	68	0.975	0.000
Pair 10	Pre-test L2-L3:Area (cm) & Post-test L2-L3:Area (cm)	68	0.989	0.000
Pair 11	Pre-test L3-L4:Area (cm) & Post-test L3-L4:Area (cm)	68	0.990	0.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower			
Pair 1	Pre-test T12:Area (cm) - Post-test T12:Area (cm)	-0.1560	0.3664	0.0733	-0.3072	-0.0048	-2.129	24	0.044
Pair 2	Pre-test L1:Area (cm) - Post-test L1:Area (cm)	-0.0074	0.2054	0.0249	-0.0571	0.0424	-0.295	67	0.769
Pair 3	Pre-test L2:Area (cm) - Post-test L2:Area (cm)	-0.0765	0.2363	0.0287	-0.1337	-0.0193	-2.668	67	0.010
Pair 4	Pre-test L3:Area (cm) - Post-test L3:Area (cm)	-0.1500	0.3539	0.0429	-0.2357	-0.0643	-3.495	67	0.001
Pair 5	Pre-test L4:Area (cm) - Post-test L4:Area (cm)	-0.0574	0.1980	0.0240	-0.1053	-0.0094	-2.389	67	0.020
Pair 6	Pre-test L1-L2:Area (cm) - Post-test L1-L2:Area (cm)	-0.3965	2.5525	0.3095	-1.0143	0.2214	-1.281	67	0.205
Pair 7	Pre-test L1-L3:Area (cm) - Post-test L1-L3:Area (cm)	-0.2162	0.5889	0.0714	-0.3587	-0.0736	-3.027	67	0.004
Pair 8	Pre-test L1-L4:Area (cm) - Post-test L1-L4:Area (cm)	-0.2750	0.5793	0.0703	-0.4152	-0.1348	-3.914	67	0.000
Pair 9	Pre-test L2-L3:Area (cm) - Post-test L2-L3:Area (cm)	-0.2251	0.5085	0.0617	-0.3482	-0.1021	-3.651	67	0.001
Pair 10	Pre-test L2-L3:Area (cm) - Post-test L2-L3:Area (cm)	-0.2809	0.5100	0.0618	-0.4043	-0.1574	-4.542	67	0.000
Pair 11	Pre-test L3-L4:Area (cm) - Post-test L3-L4:Area (cm)	-0.1985	0.3492	0.0423	-0.2831	-0.1140	-4.688	67	0.000

T-Test:TEST DIFFERENCES PRE AND POST- ANCILLARY HEALTH- AP SPINE: WIDTH (CM)

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test T12:Width (cm)	3.524	25	0.2788	0.0558
	Post-test T12:Width (cm)	3.556	25	0.3042	0.0608
Pair 2	Pre-test L1:Width (cm)	3.519	68	0.2326	0.0282
	Post-test L1:Width (cm)	3.509	68	0.2392	0.0290
Pair 3	Pre-test L2:Width (cm)	3.631	68	0.2364	0.0287
	Post-test L2:Width (cm)	3.644	68	0.2390	0.0290
Pair 4	Pre-test L3:Width (cm)	3.88	68	0.243	0.029
	Post-test L3:Width (cm)	3.92	68	0.250	0.030
Pair 5	Pre-test L4:Width (cm)	4.334	68	0.2899	0.0352
	Post-test L4:Width (cm)	4.353	68	0.2868	0.0348
Pair 6	Pre-test L1-L2:Width (cm)	3.581	68	0.2300	0.0279
	Post-test L1-L2:Width (cm)	3.582	68	0.2324	0.0282
Pair 7	Pre-test L1-L3:Width (cm)	3.675	68	0.2281	0.0277
	Post-test L1-L3:Width (cm)	3.693	68	0.2281	0.0277
Pair 8	Pre-test L1-L4:Width (cm)	3.84	68	0.232	0.028
	Post-test L1-L4:Width (cm)	3.860	68	0.2332	0.0283
Pair 9	Pre-test L2-L3:Width (cm)	3.754	68	0.2262	0.0274
	Post-test L2-L3:Width (cm)	3.784	68	0.2416	0.0293
Pair 10	Pre-test L2-L3:Width (cm)	3.951	68	0.2403	0.0291
	Post-test L2-L3:Width (cm)	3.98	68	0.240	0.029
Pair 11	Pre-test L3-L4:Width (cm)	4.103	68	0.2603	0.0316
	Post-test L3-L4:Width (cm)	4.138	68	0.2693	0.0327

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre-test T12:Width (cm) & Post-test T12:Width (cm)	25	0.873	0.000
Pair 2	Pre-test L1:Width (cm) & Post-test L1:Width (cm)	68	0.952	0.000
Pair 3	Pre-test L2:Width (cm) & Post-test L2:Width (cm)	68	0.950	0.000
Pair 4	Pre-test L3:Width (cm) & Post-test L3:Width (cm)	68	0.941	0.000
Pair 5	Pre-test L4:Width (cm) & Post-test L4:Width (cm)	68	0.948	0.000
Pair 6	Pre-test L1-L2:Width (cm) & Post-test L1-L2:Width (cm)	68	0.968	0.000
Pair 7	Pre-test L1-L3:Width (cm) & Post-test L1-L3:Width (cm)	68	0.969	0.000
Pair 8	Pre-test L1-L4:Width (cm) & Post-test L1-L4:Width (cm)	68	0.969	0.000
Pair 9	Pre-test L2-L3:Width (cm) & Post-test L2-L3:Width (cm)	68	0.958	0.000
Pair 10	Pre-test L2-L3:Width (cm) & Post-test L2-L3:Width (cm)	68	0.960	0.000
Pair 11	Pre-test L3-L4:Width (cm) & Post-test L3-L4:Width (cm)	68	0.937	0.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower			
Pair 1	Pre-test T12:Width (cm) - Post-test T12:Width (cm)	-0.0320	0.1492	0.0298	-0.0936	0.0296	-1.072	24	0.294
Pair 2	Pre-test L1:Width (cm) - Post-test L1:Width (cm)	0.0103	0.0736	0.0089	-0.0075	0.0281	1.154	67	0.253
Pair 3	Pre-test L2:Width (cm) - Post-test L2:Width (cm)	-0.0132	0.0751	0.0091	-0.0314	0.0049	-1.453	67	0.151
Pair 4	Pre-test L3:Width (cm) - Post-test L3:Width (cm)	-0.040	0.085	0.010	-0.060	-0.019	-3.857	67	0.000
Pair 5	Pre-test L4:Width (cm) - Post-test L4:Width (cm)	-0.0191	0.0935	0.0113	-0.0417	0.0035	-1.687	67	0.096
Pair 6	Pre-test L1-L2:Width (cm) - Post-test L1-L2:Width (cm)	-0.0015	0.0586	0.0071	-0.0156	0.0127	-0.207	67	0.837
Pair 7	Pre-test L1-L3:Width (cm) - Post-test L1-L3:Width (cm)	-0.0176	0.0571	0.0069	-0.0315	-0.0038	-2.546	67	0.013
Pair 8	Pre-test L1-L4:Width (cm) - Post-test L1-L4:Width (cm)	-0.0250	0.0583	0.0071	-0.0391	-0.0109	-3.538	67	0.001
Pair 9	Pre-test L2-L3:Width (cm) - Post-test L2-L3:Width (cm)	-0.0294	0.0692	0.0084	-0.0462	-0.0127	-3.503	67	0.001
Pair 10	Pre-test L2-L3:Width (cm) - Post-test L2-L3:Width (cm)	-0.0265	0.0683	0.0083	-0.0430	-0.0099	-3.197	67	0.002
Pair 11	Pre-test L3-L4:Width (cm) - Post-test L3-L4:Width (cm)	-0.0353	0.0943	0.0114	-0.0581	-0.0125	-3.088	67	0.003

T-Test: TEST DIFFERENCES PRE AND POST- ANCILLARY HEALTH- AP SPINE: HEIGHT (CM)

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test T12:Height (cm)	2.7520	25	0.23327	0.04665
	Post-test T12:Height (cm)	2.7648	25	0.21616	0.04323
Pair 2	Pre-test L1:Height (cm)	2.9659	68	0.22337	0.02709
	Post-test L1:Height (cm)	2.9672	68	0.22506	0.02729
Pair 3	Pre-test L2:Height (cm)	3.0691	68	0.16418	0.01991
	Post-test L2:Height (cm)	3.0763	68	0.15412	0.01869
Pair 4	Pre-test L3:Height (cm)	3.2287	68	0.20012	0.02427
	Post-test L3:Height (cm)	3.2371	68	0.19806	0.02402
Pair 5	Pre-test L4:Height (cm)	3.3450	68	0.21834	0.02648
	Post-test L4:Height (cm)	3.3350	68	0.23067	0.02797
Pair 6	Pre-test L1-L2:Height (cm)	6.031	68	0.3515	0.0426
	Post-test L1-L2:Height (cm)	6.0390	68	0.34464	0.04179
Pair 7	Pre-test L1-L3:Height (cm)	9.2581	68	0.49073	0.05951
	Post-test L1-L3:Height (cm)	9.2753	68	0.47619	0.05775
Pair 8	Pre-test L1-L4:Height (cm)	12.6007	68	0.56976	0.06909
	Post-test L1-L4:Height (cm)	12.6082	68	0.57527	0.06976
Pair 9	Pre-test L2-L3:Height (cm)	6.2950	68	0.33126	0.04017
	Post-test L2-L3:Height (cm)	6.2668	68	0.53792	0.06523
Pair 10	Pre-test L2-L3:Height (cm)	9.6372	68	0.42460	0.05149
	Post-test L2-L3:Height (cm)	9.6434	68	0.43014	0.05216
Pair 11	Pre-test L3-L4:Height (cm)	6.5712	68	0.30163	0.03658
	Post-test L3-L4:Height (cm)	6.5696	68	0.31754	0.03851

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre-test T12:Height (cm) & Post-test T12:Height (cm)	25	0.962	0.000
Pair 2	Pre-test L1:Height (cm) & Post-test L1:Height (cm)	68	0.993	0.000
Pair 3	Pre-test L2:Height (cm) & Post-test L2:Height (cm)	68	0.965	0.000
Pair 4	Pre-test L3:Height (cm) & Post-test L3:Height (cm)	68	0.969	0.000
Pair 5	Pre-test L4:Height (cm) & Post-test L4:Height (cm)	68	0.940	0.000
Pair 6	Pre-test L1-L2:Height (cm) & Post-test L1-L2:Height (cm)	68	0.994	0.000
Pair 7	Pre-test L1-L3:Height (cm) & Post-test L1-L3:Height (cm)	68	0.988	0.000
Pair 8	Pre-test L1-L4:Height (cm) & Post-test L1-L4:Height (cm)	68	0.996	0.000
Pair 9	Pre-test L2-L3:Height (cm) & Post-test L2-L3:Height (cm)	68	0.731	0.000
Pair 10	Pre-test L2-L3:Height (cm) & Post-test L2-L3:Height (cm)	68	0.991	0.000
Pair 11	Pre-test L3-L4:Height (cm) & Post-test L3-L4:Height (cm)	68	0.990	0.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower			
Pair 1	Pre-test T12:Height (cm) - Post-test T12:Height (cm)	-0.01280	0.06400	0.01280	-0.03922	0.01362	-1.000	24	0.327
Pair 2	Pre-test L1:Height (cm) - Post-test L1:Height (cm)	-0.00132	0.02687	0.00326	-0.00783	0.00518	-0.406	67	0.686
Pair 3	Pre-test L2:Height (cm) - Post-test L2:Height (cm)	-0.00721	0.04319	0.00524	-0.01766	0.00325	-1.376	67	0.173
Pair 4	Pre-test L3:Height (cm) - Post-test L3:Height (cm)	-0.00838	0.04952	0.00601	-0.02037	0.00360	-1.396	67	0.167
Pair 5	Pre-test L4:Height (cm) - Post-test L4:Height (cm)	0.01000	0.07880	0.00956	-0.00907	0.02907	1.047	67	0.299
Pair 6	Pre-test L1-L2:Height (cm) - Post-test L1-L2:Height (cm)	-0.00750	0.03822	0.00463	-0.01675	0.00175	-1.618	67	0.110
Pair 7	Pre-test L1-L3:Height (cm) - Post-test L1-L3:Height (cm)	-0.01721	0.07740	0.00939	-0.03594	0.00153	-1.833	67	0.071
Pair 8	Pre-test L1-L4:Height (cm) - Post-test L1-L4:Height (cm)	-0.00750	0.05000	0.00606	-0.01960	0.00460	-1.237	67	0.220
Pair 9	Pre-test L2-L3:Height (cm) - Post-test L2-L3:Height (cm)	0.02824	0.37238	0.04516	-0.06190	0.11837	0.625	67	0.534
Pair 10	Pre-test L2-L3:Height (cm) - Post-test L2-L3:Height (cm)	-0.00618	0.05800	0.00703	-0.02022	0.00786	-0.878	67	0.383
Pair 11	Pre-test L3-L4:Height (cm) - Post-test L3-L4:Height (cm)	0.00162	0.04718	0.00572	-0.00980	0.01304	0.283	67	0.778

T-Test:TEST DIFFERENCES PRE AND POST- ANCILLARY HEALTH- AP SPINE: COMPARED TO T-SCORES

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test Compared to Young Adult (t-score)	-1.5024	68	0.90467	0.10971
	Post-test Compared to Young Adult (t-score)	-1.5165	68	0.86051	0.10435
Pair 2	Pre-test Adjust for stature (T-score)	-1.2549	68	0.82417	0.09994
	Post-test Adjust for stature (T-score)	-1.2731	68	0.78437	0.09512

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre-test Compared to Young Adult (t-score) & Post-test Compared to Young Adult (t-score)	68	0.948	0.000
Pair 2	Pre-test Adjust for stature (T-score) & Post-test Adjust for stature (T-score)	68	0.936	0.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Upper	Lower			
Pair 1	Pre-test Compared to Young Adult (t-score) - Post-test Compared to Young Adult (t-score)	0.01412	0.28661	0.03476	-0.05526	0.08349	0.406	67	0.686
Pair 2	Pre-test Adjust for stature (T-score) - Post-test Adjust for stature (T-score)	0.01824	0.28968	0.03513	-0.05188	0.08835	0.519	67	0.605

T-Test:TEST DIFFERENCES PRE AND POST- ANCILLARY HEALTH- LEFT FEMUR: BONE MINERAL DENSITY (G/CM)

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test Neck:Bone Mineral Density (g/cm2)	1.06757	68	0.109205	0.013243
	Post-test Neck:Bone Mineral Density (g/cm2)	1.2144	68	1.19870	0.14536
Pair 2	Pre-test Wards:Bone Mineral Density (g/cm2)	0.9977	68	0.14061	0.01705
	Post-test Wards:Bone Mineral Density (g/cm2)	1.0033	68	0.14224	0.01725
Pair 3	Pre-test Trochanter:Bone Mineral Density (g/cm2)	0.8508	68	0.10679	0.01295
	Post-test Trochanter:Bone Mineral Density (g/cm2)	0.8468	68	0.13068	0.01585
Pair 4	Pre-test Shaft:Bone Mineral Density (g/cm2)	1.3059	68	0.16098	0.01952
	Post-test Shaft:Bone Mineral Density (g/cm2)	1.3151	68	0.16046	0.01946
Pair 5	Pre-test Total:Bone Mineral Density (g/cm2)	1.0885	68	0.12202	0.01480
	Post-test Total:Bone Mineral Density (g/cm2)	1.0956	68	0.12291	0.01490

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre-test Neck:Bone Mineral Density (g/cm2) & Post-test Neck:Bone Mineral Density (g/cm2)	68	0.111	0.367
Pair 2	Pre-test Wards:Bone Mineral Density (g/cm2) & Post-test Wards:Bone Mineral Density (g/cm2)	68	0.977	0.000
Pair 3	Pre-test Trochanter:Bone Mineral Density (g/cm2) & Post-test Trochanter:Bone Mineral Density (g/cm2)	68	0.837	0.000
Pair 4	Pre-test Shaft:Bone Mineral Density (g/cm2) & Post-test Shaft:Bone Mineral Density (g/cm2)	68	0.986	0.000
Pair 5	Pre-test Total:Bone Mineral Density (g/cm2) & Post-test Total:Bone Mineral Density (g/cm2)	68	0.988	0.000

Paired Samples Test

		Paired Differences							
					95% Confidence Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower	t	df	Sig. (2-tailed)
Pair 1	Pre-test Neck:Bone Mineral Density (g/cm2) - Post-test Neck:Bone Mineral Density (g/cm2)	-0.146853	1.191528	0.144494	-0.435264	0.141558	-1.016	67	0.313
Pair 2	Pre-test Wards:Bone Mineral Density (g/cm2) - Post-test Wards:Bone Mineral Density (g/cm2)	-0.00562	0.03045	0.00369	-0.01299	0.00175	-1.522	67	0.133
Pair 3	Pre-test Trochanter:Bone Mineral Density (g/cm2) - Post-test Trochanter:Bone Mineral Density (g/cm2)	0.00396	0.07150	0.00867	-0.01335	0.02126	0.456	67	0.650
Pair 4	Pre-test Shaft:Bone Mineral Density (g/cm2) - Post-test Shaft:Bone Mineral Density (g/cm2)	-0.00926	0.02672	0.00324	-0.01573	-0.00280	-2.859	67	0.006
Pair 5	Pre-test Total:Bone Mineral Density (g/cm2) - Post-test Total:Bone Mineral Density (g/cm2)	-0.00709	0.01896	0.00230	-0.01168	-0.00250	-3.082	67	0.003

T-Test:TEST DIFFERENCES PRE AND POST- ANCILLARY HEALTH- LEFT FEMUR: YOUNG ADULT %

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test Neck Young Adult %	102.81	68	10.592	1.284
	Post-test Neck Young Adult %	103.13	68	10.946	1.327
Pair 2	Pre-test Wards Young Adult %	109.72	68	15.493	1.879
	Post-test Wards Young Adult %	110.29	68	15.641	1.897
Pair 3	Pre-test Trochanter Young Adult %	100.01	68	12.575	1.525
	Post-test Trochanter Young Adult %	100.50	68	13.003	1.577
Pair 4	Pre-test Total Young Adult %	108.00	68	12.060	1.462
	Post-test Total Young Adult %	108.69	68	12.190	1.478

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre-test Neck Young Adult % & Post-test Neck Young Adult %	68	0.967	0.000
Pair 2	Pre-test Wards Young Adult % & Post-test Wards Young Adult %	68	0.977	0.000
Pair 3	Pre-test Trochanter Young Adult % & Post-test Trochanter Young Adult %	68	0.978	0.000
Pair 4	Pre-test Total Young Adult % & Post-test Total Young Adult %	68	0.987	0.000

Paired Samples Test

		Paired Differences							
					95% Confidence Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower	t	df	Sig. (2-tailed)
Pair 1	Pre-test Neck Young Adult % - Post-test Neck Young Adult %	-0.324	2.778	0.337	-0.996	0.349	-0.961	67	0.340
Pair 2	Pre-test Wards Young Adult % - Post-test Wards Young Adult %	-0.574	3.365	0.408	-1.388	0.241	-1.406	67	0.164
Pair 3	Pre-test Trochanter Young Adult % - Post-test Trochanter Young Adult %	-0.485	2.745	0.333	-1.150	0.179	-1.458	67	0.150
Pair 4	Pre-test Total Young Adult % - Post-test Total Young Adult %	-0.691	1.957	0.237	-1.165	-0.218	-2.913	67	0.005

T-Test:TEST DIFFERENCES PRE AND POST- ANCILLARY HEALTH- LEFT FEMUR: YOUNG ADULT T-SCORE

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test Neck Young Adult T-score	0.251	68	0.9158	0.1111
	Post-test Neck Young Adult T-score	0.263	68	0.9370	0.1136
Pair 2	Pre-test Wards Young Adult T-score	0.668	68	1.0804	0.1310
	Post-test Wards Young Adult T-score	0.722	68	1.0942	0.1327
Pair 3	Pre-test Trochanter Young Adult T-score	-0.006	68	1.0796	0.1309
	Post-test Trochanter Young Adult T-score	0.049	68	1.1202	0.1358
Pair 4	Pre-test Total Young Adult T-score	0.674	68	0.9934	0.1205
	Post-test Total Young Adult T-score	0.718	68	1.0098	0.1225

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre-test Neck Young Adult T-score & Post-test Neck Young Adult T-score	68	0.965	0.000
Pair 2	Pre-test Wards Young Adult T-score & Post-test Wards Young Adult T-score	68	0.976	0.000
Pair 3	Pre-test Trochanter Young Adult T-score & Post-test Trochanter Young Adult T-score	68	0.975	0.000
Pair 4	Pre-test Total Young Adult T-score & Post-test Total Young Adult T-score	68	0.989	0.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower			
Pair 1	Pre-test Neck Young Adult T-score - Post-test Neck Young Adult T-score	-0.0119	0.2475	0.0300	-0.0718	0.0480	-0.397	67	0.693
Pair 2	Pre-test Wards Young Adult T-score - Post-test Wards Young Adult T-score	-0.0544	0.2378	0.0288	-0.1120	0.0031	-1.887	67	0.064
Pair 3	Pre-test Trochanter Young Adult T-score - Post-test Trochanter Young Adult T-score	-0.0544	0.2470	0.0300	-0.1142	0.0054	-1.816	67	0.074
Pair 4	Pre-test Total Young Adult T-score - Post-test Total Young Adult T-score	-0.0441	0.1520	0.0184	-0.0809	-0.0073	-2.394	67	0.019

TEST DIFFERENCES PRE AND POST- ANCILLARY HEALTH- LEFT FEMUR: AGE-MATCHED %

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test Neck Age-matched %	102.42	67	10.452	1.277
	Post-test Neck Age-matched %	101.20	67	16.478	2.013
Pair 2	Pre-test Wards Age-matched %	106.67	67	15.235	1.861
	Post-test Wards Age-matched %	107.28	67	14.925	1.823
Pair 3	Pre-test Trochanter Age-matched %	100.54	67	12.507	1.528
	Post-test Trochanter Age-matched %	100.96	67	12.856	1.571
Pair 4	Pre-test Total Age-matched %	108.43	67	12.085	1.476
	Post-test Total Age-matched %	109.15	67	12.052	1.472

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre-test Neck Age-matched % & Post-test Neck Age-matched %	67	0.663	0.000
Pair 2	Pre-test Wards Age-matched % & Post-test Wards Age-matched %	67	0.970	0.000
Pair 3	Pre-test Trochanter Age-matched % & Post-test Trochanter Age-matched %	67	0.974	0.000
Pair 4	Pre-test Total Age-matched % & Post-test Total Age-matched %	67	0.984	0.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower			
Pair 1	Pre-test Neck Age-matched % - Post-test Neck Age-matched %	1.222	12.340	1.508	-1.788	4.232	0.811	66	0.420
Pair 2	Pre-test Wards Age-matched % - Post-test Wards Age-matched %	-0.612	3.729	0.456	-1.522	0.298	-1.343	66	0.184
Pair 3	Pre-test Trochanter Age-matched % - Post-test Trochanter Age-matched %	-0.418	2.929	0.358	-1.132	0.297	-1.168	66	0.247
Pair 4	Pre-test Total Age-matched % - Post-test Total Age-matched %	-0.716	2.173	0.265	-1.246	-0.186	-2.699	66	0.009

T-Test:TEST DIFFERENCES PRE AND POST- ANCILLARY HEALTH- LEFT FEMUR: AGE-MATCHED Z-SCORE

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test Neck Age-matched Z-score	0.207	67	0.9144	0.1117
	Post-test Neck Age-matched Z-score	0.231	67	0.9328	0.1140
Pair 2	Pre-test Wards Age-matched Z-score	0.470	67	1.0905	0.1332
	Post-test Wards Age-matched Z-score	0.52	67	1.073	0.131
Pair 3	Pre-test Trochanter Age-matched Z-score	0.040	67	1.0559	0.1290
	Post-test Trochanter Age-matched Z-score	0.079	67	1.0877	0.1329
Pair 4	Pre-test Total Age-matched Z-score	0.691	67	0.9882	0.1207
	Post-test Total Age-matched Z-score	0.745	67	0.9834	0.1201

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre-test Neck Age-matched Z-score & Post-test Neck Age-matched Z-score	67	0.961	0.000
Pair 2	Pre-test Wards Age-matched Z-score & Post-test Wards Age-matched Z-score	67	0.970	0.000
Pair 3	Pre-test Trochanter Age-matched Z-score & Post-test Trochanter Age-matched Z-score	67	0.975	0.000
Pair 4	Pre-test Total Age-matched Z-score & Post-test Total Age-matched Z-score	67	0.984	0.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower			
Pair 1	Pre-test Neck Age-matched Z-score - Post-test Neck Age-matched Z-score	-0.0239	0.2583	0.0316	-0.0869	0.0391	-0.757	66	0.452
Pair 2	Pre-test Wards Age-matched Z-score - Post-test Wards Age-matched Z-score	-0.0493	0.2671	0.0326	-0.1144	0.0159	-1.510	66	0.136
Pair 3	Pre-test Trochanter Age-matched Z-score - Post-test Trochanter Age-matched Z-score	-0.0388	0.2418	0.0295	-0.0978	0.0202	-1.314	66	0.194
Pair 4	Pre-test Total Age-matched Z-score - Post-test Total Age-matched Z-score	-0.0537	0.1744	0.0213	-0.0963	-0.0112	-2.522	66	0.014

T-Test:TEST DIFFERENCES PRE AND POST- ANCILLARY HEALTH- LEFT FEMUR: BONE MINERAL CONTENT (G)

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test Neck:Bone Mineral Content (g)	4.851	68	0.5535	0.0671
	Post-test Neck:Bone Mineral Content (g)	4.891	68	0.5748	0.0697
Pair 2	Pre-test Wards:Bone Mineral Content (g)	2.297	68	0.4246	0.0515
	Post-test Wards:Bone Mineral Content (g)	2.347	68	0.4376	0.0531
Pair 3	Pre-test Trochanter:Bone Mineral Content (g)	9.646	68	1.9366	0.2348
	Post-test Trochanter:Bone Mineral Content (g)	10.006	68	4.3737	0.5304
Pair 4	Pre-test Shaft:Bone Mineral Content (g)	16.70	68	1.953	0.237
	Post-test Shaft:Bone Mineral Content (g)	17.263	68	3.6369	0.4410
Pair 5	Pre-test Total:Bone Mineral Content (g)	31.199	68	4.1432	0.5024
	Post-test Total:Bone Mineral Content (g)	31.369	68	4.2357	0.5137

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre-test Neck:Bone Mineral Content (g) & Post-test Neck:Bone Mineral Content (g)	68	0.974	0.000
Pair 2	Pre-test Wards:Bone Mineral Content (g) & Post-test Wards:Bone Mineral Content (g)	68	0.968	0.000
Pair 3	Pre-test Trochanter:Bone Mineral Content (g) & Post-test Trochanter:Bone Mineral Content (g)	68	0.716	0.000
Pair 4	Pre-test Shaft:Bone Mineral Content (g) & Post-test Shaft:Bone Mineral Content (g)	68	0.413	0.000
Pair 5	Pre-test Total:Bone Mineral Content (g) & Post-test Total:Bone Mineral Content (g)	68	0.987	0.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower			
Pair 1	Pre-test Neck:Bone Mineral Content (g) - Post-test Neck:Bone Mineral Content (g)	-0.0393	0.1308	0.0159	-0.0709	-0.0076	-2.476	67	0.016
Pair 2	Pre-test Wards:Bone Mineral Content (g) - Post-test Wards:Bone Mineral Content (g)	-0.0500	0.1100	0.0133	-0.0766	-0.0234	-3.750	67	0.000
Pair 3	Pre-test Trochanter:Bone Mineral Content (g) - Post-test Trochanter:Bone Mineral Content (g)	-0.3603	3.2791	0.3976	-1.1540	0.4334	-0.906	67	0.368
Pair 4	Pre-test Shaft:Bone Mineral Content (g) - Post-test Shaft:Bone Mineral Content (g)	-0.5603	3.3437	0.4055	-1.3696	0.2491	-1.382	67	0.172
Pair 5	Pre-test Total:Bone Mineral Content (g) - Post-test Total:Bone Mineral Content (g)	-0.1706	0.6763	0.0820	-0.3343	-0.0069	-2.080	67	0.041

T-Test:TEST DIFFERENCES PRE AND POST- ANCILLARY HEALTH- LEFT FEMUR: AREA (CM)

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test Neck:Area (cm)	4.544	68	0.2964	0.0359
	Post-test Neck:Area (cm)	4.525	68	0.6006	0.0728
Pair 2	Pre-test Wards:Area (cm)	2.30	68	0.298	0.036
	Post-test Wards:Area (cm)	2.34	68	0.327	0.040
Pair 3	Pre-test Trochanter:Area (cm)	11.288	68	1.4249	0.1728
	Post-test Trochanter:Area (cm)	11.176	68	1.4333	0.1738
Pair 4	Pre-test Shaft:Area (cm)	12.815	68	0.6421	0.0779
	Post-test Shaft:Area (cm)	12.850	68	0.6713	0.0814
Pair 5	Pre-test Total:Area (cm)	28.654	68	1.8757	0.2275
	Post-test Total:Area (cm)	28.612	68	1.9383	0.2351

Paired Samples Correlations

	N	Correlation	Sig.

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Pair 1	Pre-test Neck:Area (cm) & Post-test Neck:Area (cm)	68	0.595	0.000
Pair 2	Pre-test Wards:Area (cm) & Post-test Wards:Area (cm)	68	0.954	0.000
Pair 3	Pre-test Trochanter:Area (cm) & Post-test Trochanter:Area (cm)	68	0.953	0.000
Pair 4	Pre-test Shaft:Area (cm) & Post-test Shaft:Area (cm)	68	0.920	0.000
Pair 5	Pre-test Total:Area (cm) & Post-test Total:Area (cm)	68	0.982	0.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower			
Pair 1	Pre-test Neck:Area (cm) - Post-test Neck:Area (cm)	0.0191	0.4866	0.0590	-0.0987	0.1369	0.324	67	0.747
Pair 2	Pre-test Wards:Area (cm) - Post-test Wards:Area (cm)	-0.037	0.099	0.012	-0.061	-0.013	-3.059	67	0.003
Pair 3	Pre-test Trochanter:Area (cm) - Post-test Trochanter:Area (cm)	0.1118	0.4369	0.0530	0.0060	0.2175	2.109	67	0.039
Pair 4	Pre-test Shaft:Area (cm) - Post-test Shaft:Area (cm)	-0.0353	0.2642	0.0320	-0.0992	0.0286	-1.102	67	0.275
Pair 5	Pre-test Total:Area (cm) - Post-test Total:Area (cm)	0.0426	0.3662	0.0444	-0.0460	0.1313	0.960	67	0.340

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COPY DISK APPENDIX F: DESCRIOTIVE STATISTICS OF MENSTRUAL HISTORY QUESTIONNAIRE

Frequencies of Health questionnaire

Table 1: Pre:History of Osteoporosis in family

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	3	3.6	3.7	3.7
	No	79	95.2	96.3	100.0
	Total	82	98.8	100.0	
Missing	System	1	1.2		
Total		83	100.0		

Table 2: Pre:Diagnosed or treated for Low bone density

		Frequency	Percent
Missing	System	83	100.0

Table 3: Pre:Diagnosed or treated for Scoliolis

		Frequency	Percent
Missing	System	83	100.0

Table 4: Pre:Diagnosed or treated for Anorexia Nervosa

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	1	1.2	100.0	100.0
Missing	System	82	98.8		
Total		83	100.0		

Table 5: Pre:Diagnosed or treated for Bulimia Nervosa

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	1	1.2	100.0	100.0
Missing	System	82	98.8		
Total		83	100.0		

COPY DISK APPENDIX F: DESCRIOTIVE STATISTICS OF MENSTRUAL HISTORY QUESTIONNAIRE

Table 6: Pre:Suffered stress fracture

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	6	7.2	7.3	7.3
	No	76	91.6	92.7	100.0
	Total	82	98.8	100.0	
Missing	System	1	1.2		
Total		83	100.0		

Table 7: Pre:Had a menstrual period

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	82	98.8	100.0	100.0
Missing	System	1	1.2		
Total		83	100.0		

Table 8: Pre:Age of first menstrual period

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	11	5	6.0	6.1	6.1
	12	6	7.2	7.3	13.4
	13	21	25.3	25.6	39.0
	14	24	28.9	29.3	68.3
	15	15	18.1	18.3	86.6
	16	7	8.4	8.5	95.1
	17	1	1.2	1.2	96.3
	18	2	2.4	2.4	98.8
	19	1	1.2	1.2	100.0
	Total	82	98.8	100.0	
Missing	System	1	1.2		
Total		83	100.0		

Table 9: Pre:Last menstrual period (Year)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2003	1	1.2	1.2	1.2
	2004	1	1.2	1.2	2.4
	2005	1	1.2	1.2	3.7
	2006	78	94.0	95.1	98.8
	5006	1	1.2	1.2	100.0
	Total	82	98.8	100.0	
Missing	System	1	1.2		
Total		83	100.0		

COPY DISK APPENDIX F: DESCRIOTIVE STATISTICS OF MENSTRUAL HISTORY QUESTIONNAIRE

Table 10: Pre:Regularity of menstrual cycle

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very regular (within 3 day)	58	69.9	70.7	70.7
	Somewhat irregular (4-10 day variation)	16	19.3	19.5	90.2
	Very irregular (variation greater than 10 days)	8	9.6	9.8	100.0
	Total	82	98.8	100.0	
Missing	System	1	1.2		
Total		83	100.0		

Table 11: Pre:Changes in menstrual period during basic training

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	66	79.5	80.5	80.5
	No	16	19.3	19.5	100.0
	Total	82	98.8	100.0	
Missing	System	1	1.2		
Total		83	100.0		

Table 12: Pre:Nature of change in menstrual period during basic training

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Longer	3	3.6	4.5	4.5
	Shorter	41	49.4	61.2	65.7
	Absent	23	27.7	34.3	100.0
	Total	67	80.7	100.0	
Missing	System	16	19.3		
Total		83	100.0		

Table 13: Pre:Without menstrual period for 3 or more months

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	10	12.0	12.2	12.2
	No	72	86.7	87.8	100.0
	Total	82	98.8	100.0	
Missing	System	1	1.2		
Total		83	100.0		

COPY DISK APPENDIX F: DESCRIOTIVE STATISTICS OF MENSTRUAL HISTORY QUESTIONNAIRE

Table 14: Pre:Currently using birth control pills or hormones

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	11	13.3	13.4	13.4
	No	71	85.5	86.6	100.0
	Total	82	98.8	100.0	
Missing	System	1	1.2		
Total		83	100.0		

Table 15: Post:Suffered stress fracture

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	1.2	1.3	1.3
	2	79	95.2	98.8	100.0
	Total	80	96.4	100.0	
Missing	System	3	3.6		
Total		83	100.0		

Table 16: Post:Regularity of menstrual cycle

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very regular (within 3 day)	54	65.1	67.5	67.5
	Somewhat irregular (4-10 day variation)	13	15.7	16.3	83.8
	Very irregular (variation greater than 10 days)	13	15.7	16.3	100.0
	Total	80	96.4	100.0	
Missing	System	3	3.6		
Total		83	100.0		

Table 17: Post:Changes in menstrual period during basic training

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	53	63.9	66.3	66.3
	No	27	32.5	33.8	100.0
	Total	80	96.4	100.0	
Missing	System	3	3.6		
Total		83	100.0		

COPY DISK APPENDIX F: DESCRIOTIVE STATISTICS OF MENSTRUAL HISTORY QUESTIONNAIRE

Table 18: Post:Nature of change in menstrual period during basic training

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Longer	9	10.8	14.1	14.1
	Shorter	36	43.4	56.3	70.3
	Absent	19	22.9	29.7	100.0
	Total	64	77.1	100.0	
Missing	System	19	22.9		
Total		83	100.0		

Table 19: Post:Without menstrual period for 3 or more months

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	11	13.3	13.8	13.8
	No	69	83.1	86.3	100.0
	Total	80	96.4	100.0	
Missing	System	3	3.6		
Total		83	100.0		

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Non Parametric Tests: Results for Males - Testing differences within groups across time.

Descriptive Statistics

GROUP		N	Mean	Std. Deviation	Minimum	Maximum
Experimental	AF1TOT: 2.4 km total time	97	10.5266	1.02987	9.11	14.03
	BF1TOT: 2.4 km total time	97	9.2743	0.76597	8.07	11.48
	CF1TOT: 2.4 km total time	97	9.2067	0.59345	8.20	11.06
Control	AF1TOT: 2.4 km total time	66	8.6283	0.94862	7.20	11.14
	BF1TOT: 2.4 km total time	66	9.0300	0.66109	7.54	11.35
	CF1TOT: 2.4 km total time	66	9.0045	0.61759	8.10	10.53

Friedman Test

Ranks

GROUP		Mean Rank
Experimental	AF1TOT: 2.4 km total time	2.95
	BF1TOT: 2.4 km total time	1.54
	CF1TOT: 2.4 km total time	1.51
Control	AF1TOT: 2.4 km total time	1.39
	BF1TOT: 2.4 km total time	2.38
	CF1TOT: 2.4 km total time	2.23

Test Statistics(a)

Experimental	N	97
	Chi-Square	132.642
	df	2
	Asymp. Sig.	0.000
Control	N	66
	Chi-Square	38.252
	df	2
	Asymp. Sig.	0.000

a. Friedman Test

NPar Tests

Descriptive Statistics

GROUP		N	Mean	Std. Deviation	Minimum	Maximum
Experimental	AF2: 2.4 km - Points	97	749.86	152.529	0	936
	BF2: 2.4 km - Points	97	898.64	88.265	624	1,008
	CF2: 2.4 km - Points	97	909.40	70.765	624	1,008
Control	AF2: 2.4 km - Points	66	955.09	84.931	696	1,008
	BF2: 2.4 km - Points	66	927.45	68.330	648	1,008
	CF2: 2.4 km - Points	66	932.18	64.579	732	1,008

Friedman Test

Ranks

GROUP		Mean Rank
Experimental	AF2: 2.4 km - Points	1.05
	BF2: 2.4 km - Points	2.46
	CF2: 2.4 km - Points	2.48
Control	AF2: 2.4 km - Points	2.45
	BF2: 2.4 km - Points	1.67
	CF2: 2.4 km - Points	1.89

Test Statistics(a)

Experimental	N	97
	Chi-Square	135.085
	df	2
	Asymp. Sig.	0.000
Control	N	66
	Chi-Square	26.613
	df	2
	Asymp. Sig.	0.000

a. Friedman Test

NPar Tests

Descriptive Statistics

GROUP		N	Mean	Std. Deviation	Minimum	Maximum
Experimental	AF4: Push-ups - Amount	96	31.45	8.970	5	50
	BF4: Push-ups - Amount	96	53.65	10.903	5	78
	CF4: Push-ups - Amount	96	60.25	11.134	30	97
Control	AF4: Push-ups - Amount	66	39.20	12.917	9	79
	BF4: Push-ups - Amount	66	47.52	11.957	28	100
	CF4: Push-ups - Amount	66	53.52	11.501	32	100

Friedman Test

Ranks

GROUP		Mean Rank
Experimental	AF4: Push-ups - Amount	1.03
	BF4: Push-ups - Amount	2.28
	CF4: Push-ups - Amount	2.69
Control	AF4: Push-ups - Amount	1.36
	BF4: Push-ups - Amount	2.08
	CF4: Push-ups - Amount	2.56

Test Statistics(a)

Experimental	N	96
	Chi-Square	144.568
	df	2
	Asymp. Sig.	0.000
Control	N	66
	Chi-Square	51.084
	df	2
	Asymp. Sig.	0.000

a. Friedman Test

NPar Tests

Descriptive Statistics

GROUP		N	Mean	Std. Deviation	Minimum	Maximum
Experimental	AF5: Push-ups - Points	97	416.11	230.007	0	720
	BF5: Push-ups - Points	97	760.42	138.585	0	1,008
	CF5: Push-ups - Points	97	834.80	115.047	540	1,008
Control	AF5: Push-ups - Points	66	548.73	237.835	0	1,008
	BF5: Push-ups - Points	66	686.77	120.371	456	1,008
	CF5: Push-ups - Points	66	757.06	119.060	504	1,008

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Friedman Test

Ranks

GROUP		Mean Rank
Experimental	AF5: Push-ups - Points	1.03
	BF5: Push-ups - Points	2.28
	CF5: Push-ups - Points	2.69
Control	AF5: Push-ups - Points	1.39
	BF5: Push-ups - Points	2.05
	CF5: Push-ups - Points	2.56

Test Statistics(a)

Experimental	N	97
	Chi-Square	148.047
	df	2
	Asymp. Sig.	0.000
Control	N	66
	Chi-Square	48.538
	df	2
	Asymp. Sig.	0.000

a. Friedman Test

NPar Tests

Descriptive Statistics

GROUP		N	Mean	Std. Deviation	Minimum	Maximum
Experimental	AF7: Sit-ups - Amount	97	34.45	10.071	12	70
	BF7: Sit-ups - Amount	97	65.46	13.683	39	110
	CF7: Sit-ups - Amount	97	65.47	14.312	22	102
Control	AF7: Sit-ups - Amount	67	44.81	12.157	3	74
	BF7: Sit-ups - Amount	67	59.55	13.954	34	106
	CF7: Sit-ups - Amount	67	72.58	15.099	30	110

Friedman Test

Ranks

GROUP		Mean Rank
Experimental	AF7: Sit-ups - Amount	1.01
	BF7: Sit-ups - Amount	2.55
	CF7: Sit-ups - Amount	2.45
Control	AF7: Sit-ups - Amount	1.20
	BF7: Sit-ups - Amount	2.02
	CF7: Sit-ups - Amount	2.78

Test Statistics(a)

Experimental	N	97
	Chi-Square	146.355
	df	2
	Asymp. Sig.	0.000
Control	N	67
	Chi-Square	83.737
	df	2
	Asymp. Sig.	0.000

a. Friedman Test

NPar Tests

Descriptive Statistics

GROUP		N	Mean	Std. Deviation	Minimum	Maximum
Experimental	AF8: Sit-ups - Points	97	187.84	244.371	0	750
	BF8: Sit-ups - Points	97	704.18	129.945	440	1,000
	CF8: Sit-ups - Points	97	695.88	147.788	0	1,000
Control	AF8: Sit-ups - Points	67	418.81	243.482	0	790
	BF8: Sit-ups - Points	67	639.70	155.290	0	1,000
	CF8: Sit-ups - Points	67	766.12	161.245	0	1,000

Friedman Test

Ranks

GROUP		Mean Rank
Experimental	AF8: Sit-ups - Points	1.01
	BF8: Sit-ups - Points	2.57
	CF8: Sit-ups - Points	2.43
Control	AF8: Sit-ups - Points	1.19
	BF8: Sit-ups - Points	2.03
	CF8: Sit-ups - Points	2.78

Test Statistics(a)

Experimental	N	97
	Chi-Square	146.836
	df	2
	Asymp. Sig.	0.000
Control	N	67
	Chi-Square	86.826
	df	2
	Asymp. Sig.	0.000

a. Friedman Test

NPar Tests

Descriptive Statistics

GROUP		N	Mean	Std. Deviation	Minimum	Maximum
Experimental	AF10: Shuttle Run - Time (Seconds)	96	55.42	3.588	47	69
	BF10: Shuttle Run - Time (Seconds)	96	48.70	3.662	42	68
	CF10: Shuttle Run - Time (Seconds)	96	53.00	3.092	44	60
Control	AF10: Shuttle Run - Time (Seconds)	67	51.16	4.144	44	64
	BF10: Shuttle Run - Time (Seconds)	67	49.22	3.089	44	58
	CF10: Shuttle Run - Time (Seconds)	67	48.09	4.217	40	64

Friedman Test

Ranks

GROUP		Mean Rank
Experimental	AF10: Shuttle Run - Time (Seconds)	2.72
	BF10: Shuttle Run - Time (Seconds)	1.11
	CF10: Shuttle Run - Time (Seconds)	2.16
Control	AF10: Shuttle Run - Time (Seconds)	2.46
	BF10: Shuttle Run - Time (Seconds)	1.92
	CF10: Shuttle Run - Time (Seconds)	1.63

Test Statistics(a)

Experimental	N	96
	Chi-Square	134.011
	df	2
	Asymp. Sig.	0.000
Control	N	67
	Chi-Square	26.759
	df	2
	Asymp. Sig.	0.000

a. Friedman Test

NPar Tests

Descriptive Statistics

GROUP		N	Mean	Std. Deviation	Minimum	Maximum
Experimental	AF11: Shuttle Run - Points	96	709.75	113.650	0	925
	BF11: Shuttle Run - Points	96	882.52	82.965	625	1,000
	CF11: Shuttle Run - Points	96	776.10	79.281	600	1,000
Control	AF11: Shuttle Run - Points	67	829.48	98.370	600	1,000
	BF11: Shuttle Run - Points	67	869.61	76.557	650	1,000
	CF11: Shuttle Run - Points	67	898.21	82.548	700	1,008

Friedman Test

Ranks

GROUP		Mean Rank
Experimental	AF11: Shuttle Run - Points	1.28
	BF11: Shuttle Run - Points	2.86
	CF11: Shuttle Run - Points	1.86
Control	AF11: Shuttle Run - Points	1.60
	BF11: Shuttle Run - Points	2.06
	CF11: Shuttle Run - Points	2.34

Test Statistics(a)

Experimental	N	96
	Chi-Square	126.679
	df	2
	Asymp. Sig.	0.000
Control	N	67
	Chi-Square	21.145
	df	2
	Asymp. Sig.	0.000

a. Friedman Test

NPar Tests

Descriptive Statistics

GROUP		N	Mean	Std. Deviation	Minimum	Maximum
Experimental	AF13TOT: 4km walk total time	96	30.1206	1.49453	27.47	34.00
	BF13TOT: 4 km walk total time	96	26.6372	1.56049	23.01	31.00
	CF13TOT: 4 km walk total time	96	27.3798	1.68051	24.04	32.41
Control	AF13TOT: 4km walk total time	67	29.3425	2.97031	24.02	39.52
	BF13TOT: 4 km walk total time	67	27.7045	2.07396	23.51	36.46
	CF13TOT: 4 km walk total time	67	26.9316	2.38942	22.03	37.43

Friedman Test

Ranks

GROUP		Mean Rank
Experimental	AF13TOT: 4km walk total time	2.93
	BF13TOT: 4 km walk total time	1.33
	CF13TOT: 4 km walk total time	1.74
Control	AF13TOT: 4km walk total time	2.74
	BF13TOT: 4 km walk total time	1.96
	CF13TOT: 4 km walk total time	1.30

Test Statistics(a)

Experimental	N	96
	Chi-Square	131.688
	df	2
	Asymp. Sig.	0.000
Control	N	67
	Chi-Square	69.895
	df	2
	Asymp. Sig.	0.000

a. Friedman Test

NPar Tests

Descriptive Statistics

GROUP		N	Mean	Std. Deviation	Minimum	Maximum
Experimental	AF14: 4km walk - Points	96	496.65	289.432	0	864
	BF14: 4km walk - Points	96	916.63	127.833	480	1,008
	CF14: 4km walk - Points	96	861.13	182.004	0	1,008
Control	AF14: 4km walk - Points	67	625.16	357.297	0	1,008
	BF14: 4km walk - Points	67	834.45	188.864	0	1,008
	CF14: 4km walk - Points	67	887.78	157.808	420	1,008

Friedman Test

Ranks

GROUP		Mean Rank
Experimental	AF14: 4km walk - Points	1.06
	BF14: 4km walk - Points	2.63
	CF14: 4km walk - Points	2.31
Control	AF14: 4km walk - Points	1.32
	BF14: 4km walk - Points	2.12
	CF14: 4km walk - Points	2.56

Test Statistics(a)

Experimental	N	96
	Chi-Square	140.730
	df	2
	Asymp. Sig.	0.000
Control	N	67
	Chi-Square	62.388
	df	2
	Asymp. Sig.	0.000

a. Friedman Test

NPar Tests

Descriptive Statistics

GROUP		N	Mean	Std. Deviation	Minimum	Maximum
Experimental	AF 16: Total Points	97	2,564.37	660.592	0	3,864
	BF 16: Total Points	97	4,156.73	337.508	3,162	4,841
	CF 16: Total Points	97	4,062.63	380.527	2,863	4,949
Control	AF 16: Total Points	67	3,377.63	554.282	1,958	4,618
	BF 16: Total Points	67	3,947.06	338.080	2,816	4,479
	CF 16: Total Points	67	4,237.55	381.527	3,310	4,924

Friedman Test

Ranks

GROUP		Mean Rank
Experimental	AF 16: Total Points	1.00
	BF 16: Total Points	2.62
	CF 16: Total Points	2.38
Control	AF 16: Total Points	1.13
	BF 16: Total Points	2.03
	CF 16: Total Points	2.84

Test Statistics(a)

Experimental	N	97
	Chi-Square	148.227
	df	2
	Asymp. Sig.	0.000
Control	N	67
	Chi-Square	97.075
	df	2
	Asymp. Sig.	0.000

a. Friedman Test

Non Parametric Tests: Results for Females - Testing differences within groups across time.

Descriptive Statistics

GROUP		N	Mean	Std. Deviation	Minimum	Maximum
Experimental	AF1TOT: 2.4 km total time	57	16.5888	1.81044	13.07	20.15
	BF1TOT: 2.4 km total time	57	13.4561	2.23174	1.51	17.12
	CF1TOT: 2.4 km total time	57	13.1746	1.28041	10.27	16.08
Control	AF1TOT: 2.4 km total time	81	13.2319	2.41771	7.26	19.30
	BF1TOT: 2.4 km total time	81	13.2651	2.00226	8.12	17.00
	CF1TOT: 2.4 km total time	81	12.5195	1.61466	8.39	15.50

Friedman Test

Ranks

GROUP		Mean Rank
Experimental	AF1TOT: 2.4 km total time	2.98
	BF1TOT: 2.4 km total time	1.70
	CF1TOT: 2.4 km total time	1.32
Control	AF1TOT: 2.4 km total time	2.17
	BF1TOT: 2.4 km total time	2.38
	CF1TOT: 2.4 km total time	1.44

Test Statistics(a)

Experimental	N	57
	Chi-Square	86.772
	df	2
	Asymp. Sig.	0.000
Control	N	81
	Chi-Square	39.284
	df	2
	Asymp. Sig.	0.000

a. Friedman Test

NPar Tests

Descriptive Statistics

GROUP		N	Mean	Std. Deviation	Minimum	Maximum
Experimental	AF2: 2.4 km - Points	57	184.42	278.584	0	768
	BF2: 2.4 km - Points	57	634.11	271.072	0	1,008
	CF2: 2.4 km - Points	57	729.89	174.960	0	1,008
Control	AF2: 2.4 km - Points	81	688.73	311.471	0	1,008
	BF2: 2.4 km - Points	81	668.74	309.800	0	1,008
	CF2: 2.4 km - Points	81	806.17	163.224	444	1,008

Friedman Test

Ranks

GROUP		Mean Rank
Experimental	AF2: 2.4 km - Points	1.09
	BF2: 2.4 km - Points	2.25
	CF2: 2.4 km - Points	2.66
Control	AF2: 2.4 km - Points	1.77
	BF2: 2.4 km - Points	1.65
	CF2: 2.4 km - Points	2.58

Test Statistics(a)

Experimental	N	57
	Chi-Square	79.641
	df	2
	Asymp. Sig.	0.000
Control	N	81
	Chi-Square	48.609
	df	2
	Asymp. Sig.	0.000

a. Friedman Test

NPar Tests

Descriptive Statistics

GROUP		N	Mean	Std. Deviation	Minimum	Maximum
Experimental	AF4: Push-ups - Amount	57	32.79	10.057	13	55
	BF4: Push-ups - Amount	57	58.35	14.645	32	110
	CF4: Push-ups - Amount	57	58.33	12.586	34	98
Control	AF4: Push-ups - Amount	84	43.08	13.433	8	86
	BF4: Push-ups - Amount	84	56.88	14.432	30	104
	CF4: Push-ups - Amount	84	59.08	12.856	27	110

Friedman Test

Ranks

GROUP		Mean Rank
Experimental	AF4: Push-ups - Amount	1.07
	BF4: Push-ups - Amount	2.45
	CF4: Push-ups - Amount	2.48
Control	AF4: Push-ups - Amount	1.28
	BF4: Push-ups - Amount	2.27
	CF4: Push-ups - Amount	2.45

Test Statistics(a)

Experimental	N	57
	Chi-Square	74.942
	df	2
	Asymp. Sig.	0.000
Control	N	84
	Chi-Square	68.840
	df	2
	Asymp. Sig.	0.000

a. Friedman Test

NPar Tests

Descriptive Statistics

GROUP		N	Mean	Std. Deviation	Minimum	Maximum
Experimental	AF5: Push-ups - Points	57	559.53	188.991	0	852
	BF5: Push-ups - Points	57	854.21	162.921	66	1,008
	CF5: Push-ups - Points	57	868.63	116.228	600	1,008
Control	AF5: Push-ups - Points	84	698.10	161.172	0	1,008
	BF5: Push-ups - Points	84	848.74	122.441	552	1,008
	CF5: Push-ups - Points	84	868.71	145.045	108	1,008

Friedman Test

Ranks

GROUP		Mean Rank
Experimental	AF5: Push-ups - Points	1.07
	BF5: Push-ups - Points	2.40
	CF5: Push-ups - Points	2.53
Control	AF5: Push-ups - Points	1.27
	BF5: Push-ups - Points	2.28
	CF5: Push-ups - Points	2.45

Test Statistics(a)

Experimental	N	57
	Chi-Square	77.761
	df	2
	Asymp. Sig.	0.000
Control	N	84
	Chi-Square	70.773
	df	2
	Asymp. Sig.	0.000

a. Friedman Test

NPar Tests

Descriptive Statistics

GROUP		N	Mean	Std. Deviation	Minimum	Maximum
Experimental	AF7: Sit-ups - Amount	56	24.43	10.009	4	52
	BF7: Sit-ups - Amount	56	49.38	14.884	13	91
	CF7: Sit-ups - Amount	56	86.30	161.587	19	790
Control	AF7: Sit-ups - Amount	84	28.48	14.678	1	70
	BF7: Sit-ups - Amount	84	45.32	19.322	6	100
	CF7: Sit-ups - Amount	84	56.49	18.464	0	106

Friedman Test

Ranks

GROUP		Mean Rank
Experimental	AF7: Sit-ups - Amount	1.03
	BF7: Sit-ups - Amount	2.50
	CF7: Sit-ups - Amount	2.47
Control	AF7: Sit-ups - Amount	1.08
	BF7: Sit-ups - Amount	2.06
	CF7: Sit-ups - Amount	2.86

Test Statistics(a)

Experimental	N	56
	Chi-Square	81.397
	df	2
	Asymp. Sig.	0.000
Control	N	84
	Chi-Square	136.663
	df	2
	Asymp. Sig.	0.000

a. Friedman Test

NPar Tests

Descriptive Statistics

GROUP		N	Mean	Std. Deviation	Minimum	Maximum
Experimental	AF8: Sit-ups - Points	57	339.12	290.026	0	810
	BF8: Sit-ups - Points	57	749.44	187.638	0	1,008
	CF8: Sit-ups - Points	57	757.89	152.535	0	1,000
Control	AF8: Sit-ups - Points	84	401.67	318.879	0	990
	BF8: Sit-ups - Points	84	682.95	264.749	0	1,008
	CF8: Sit-ups - Points	84	823.57	166.246	0	1,000

Friedman Test

Ranks

GROUP		Mean Rank
Experimental	AF8: Sit-ups - Points	1.06
	BF8: Sit-ups - Points	2.46
	CF8: Sit-ups - Points	2.48
Control	AF8: Sit-ups - Points	1.10
	BF8: Sit-ups - Points	2.05
	CF8: Sit-ups - Points	2.85

Test Statistics(a)

Experimental	N	57
	Chi-Square	78.798
	df	2
	Asymp. Sig.	0.000
Control	N	84
	Chi-Square	138.827
	df	2
	Asymp. Sig.	0.000

a. Friedman Test

NPar Tests

Descriptive Statistics

GROUP		N	Mean	Std. Deviation	Minimum	Maximum
Experimental	AF10: Shuttle Run - Time (Seconds)	56	67.52	8.097	51	85
	BF10: Shuttle Run - Time (Seconds)	56	61.09	5.866	48	75
	CF10: Shuttle Run - Time (Seconds)	56	64.71	5.717	57	81
Control	AF10: Shuttle Run - Time (Seconds)	79	63.09	6.697	48	78
	BF10: Shuttle Run - Time (Seconds)	79	63.33	7.595	49	89
	CF10: Shuttle Run - Time (Seconds)	79	59.87	6.128	47	75

Friedman Test

Ranks

GROUP		Mean Rank
Experimental	AF10: Shuttle Run - Time (Seconds)	2.38
	BF10: Shuttle Run - Time (Seconds)	1.44
	CF10: Shuttle Run - Time (Seconds)	2.19
Control	AF10: Shuttle Run - Time (Seconds)	2.23
	BF10: Shuttle Run - Time (Seconds)	2.25
	CF10: Shuttle Run - Time (Seconds)	1.51

Test Statistics(a)

Experimental	N	56
	Chi-Square	29.261
	df	2
	Asymp. Sig.	0.000
Control	N	79
	Chi-Square	29.561
	df	2
	Asymp. Sig.	0.000

a. Friedman Test

NPar Tests

Descriptive Statistics

GROUP		N	Mean	Std. Deviation	Minimum	Maximum
Experimental	AF11: Shuttle Run - Points	57	618.86	271.375	0	1,000
	BF11: Shuttle Run - Points	57	800.44	170.116	0	1,000
	CF11: Shuttle Run - Points	57	716.84	201.852	0	925
Control	AF11: Shuttle Run - Points	79	755.92	170.978	0	1,008
	BF11: Shuttle Run - Points	79	744.62	214.897	0	1,000
	CF11: Shuttle Run - Points	79	845.89	129.683	475	1,000

Friedman Test

Ranks

GROUP		Mean Rank
Experimental	AF11: Shuttle Run - Points	1.62
	BF11: Shuttle Run - Points	2.50
	CF11: Shuttle Run - Points	1.88
Control	AF11: Shuttle Run - Points	1.82
	BF11: Shuttle Run - Points	1.69
	CF11: Shuttle Run - Points	2.49

Test Statistics(a)

Experimental	N	57
	Chi-Square	24.972
	df	2
	Asymp. Sig.	0.000
Control	N	79
	Chi-Square	30.791
	df	2
	Asymp. Sig.	0.000

a. Friedman Test

NPar Tests

Descriptive Statistics

GROUP		N	Mean	Std. Deviation	Minimum	Maximum
Experimental	AF13TOT: 4km walk total time	54	35.5761	1.88052	32.03	40.01
	BF13TOT: 4 km walk total time	54	31.7022	1.99451	28.06	37.19
	CF13TOT: 4 km walk total time	54	31.4956	2.10385	28.08	36.51
Control	AF13TOT: 4km walk total time	80	33.7566	2.27485	25.16	37.20
	BF13TOT: 4 km walk total time	80	32.1289	2.09264	27.18	41.48
	CF13TOT: 4 km walk total time	80	30.7080	1.92933	26.15	37.17

Friedman Test

Ranks

GROUP		Mean Rank
Experimental	AF13TOT: 4km walk total time	3.00
	BF13TOT: 4 km walk total time	1.54
	CF13TOT: 4 km walk total time	1.46
Control	AF13TOT: 4km walk total time	2.83
	BF13TOT: 4 km walk total time	1.99
	CF13TOT: 4 km walk total time	1.19

Test Statistics(a)

Experimental	N	54
	Chi-Square	81.148
	df	2
	Asymp. Sig.	0.000
Control	N	80
	Chi-Square	107.275
	df	2
	Asymp. Sig.	0.000

a. Friedman Test

NPar Tests

Descriptive Statistics

GROUP		N	Mean	Std. Deviation	Minimum	Maximum
Experimental	AF14: 4km walk - Points	57	390.74	344.338	0	960
	BF14: 4km walk - Points	57	867.37	269.540	0	1,008
	CF14: 4km walk - Points	57	874.11	229.829	0	1,008
Control	AF14: 4km walk - Points	80	678.70	272.561	0	1,008
	BF14: 4km walk - Points	80	880.95	139.848	552	1,008
	CF14: 4km walk - Points	80	943.16	142.813	0	1,008

Friedman Test

Ranks

GROUP		Mean Rank
Experimental	AF14: 4km walk - Points	1.06
	BF14: 4km walk - Points	2.46
	CF14: 4km walk - Points	2.47
Control	AF14: 4km walk - Points	1.28
	BF14: 4km walk - Points	2.12
	CF14: 4km walk - Points	2.60

Test Statistics(a)

Experimental	N	57
	Chi-Square	85.870
	df	2
	Asymp. Sig.	0.000
Control	N	80
	Chi-Square	90.845
	df	2
	Asymp. Sig.	0.000

a. Friedman Test

NPar Tests

Descriptive Statistics

GROUP		N	Mean	Std. Deviation	Minimum	Maximum
Experimental	AF 16: Total Points	57	2,096.11	908.659	0	4,054
	BF 16: Total Points	57	3,917.28	656.619	1,967	4,984
	CF 16: Total Points	57	3,937.14	614.307	1,950	4,839
Control	AF 16: Total Points	84	3,172.40	894.291	953	4,624
	BF 16: Total Points	84	3,814.76	731.678	1,428	4,843
	CF 16: Total Points	84	4,269.35	842.788	1,604	9,356

Friedman Test

Ranks

GROUP		Mean Rank
Experimental	AF 16: Total Points	1.02
	BF 16: Total Points	2.44
	CF 16: Total Points	2.54
Control	AF 16: Total Points	1.12
	BF 16: Total Points	2.05
	CF 16: Total Points	2.83

Test Statistics(a)

Experimental	N	57
	Chi-Square	82.842
	df	2
	Asymp. Sig.	0.000
Control	N	84
	Chi-Square	123.714
	df	2
	Asymp. Sig.	0.000

a. Friedman Test

T-Tests for Males to test differences between the experimental and control group at each measurement

Group Statistics

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
AF1TOT: 2.4 km total time	Experimental	99	10.5449	1.06317	0.10685
	Control	70	8.7186	1.24598	0.14892
AF2: 2.4 km - Points	Experimental	99	743.31	169.089	16.994
	Control	70	941.31	141.096	16.864
AF4: Push-ups - Amount	Experimental	100	31.31	8.867	0.887
	Control	69	39.16	12.813	1.542
AF5: Push-ups - Points	Experimental	100	413.83	230.738	23.074
	Control	69	550.09	234.055	28.177
AF7: Sit-ups - Amount	Experimental	100	34.53	10.037	1.004
	Control	70	44.61	12.186	1.457
AF8: Sit-ups - Points	Experimental	100	187.60	244.690	24.469
	Control	70	409.71	249.585	29.831
AF10: Shuttle Run - Time (Seconds)	Experimental	99	55.51	3.592	0.361
	Control	70	51.61	4.867	0.582
AF11: Shuttle Run - Points	Experimental	99	707.69	112.982	11.355
	Control	70	813.57	140.630	16.809
AF13TOT: 4km walk total time	Experimental	100	30.2499	1.65378	0.16538
	Control	70	29.4636	3.02298	0.36131
AF14: 4km walk - Points	Experimental	100	481.70	296.032	29.603
	Control	70	608.66	365.094	43.637
AF 16: Total Points	Experimental	100	2,535.73	696.118	69.612
	Control	70	3,322.91	641.258	76.645

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Upper	Lower
AF1TOT: 2.4 km total time	Equal variances assumed	0.119	0.731	10.239	167	0.000	1.82638	0.17838	1.47421	2.17854
	Equal variances not assumed			9.964	133.432	0.000	1.82638	0.18329	1.46385	2.18891
AF2: 2.4 km - Points	Equal variances assumed	1.939	0.166	-8.018	167	0.000	-198.001	24.693	-246.752	-149.250
	Equal variances not assumed			-8.270	162.387	0.000	-198.001	23.942	-245.278	-150.724
AF4: Push-ups - Amount	Equal variances assumed	5.573	0.019	-4.709	167	0.000	-7.849	1.667	-11.140	-4.558
	Equal variances not assumed			-4.412	111.968	0.000	-7.849	1.779	-11.375	-4.324
AF5: Push-ups - Points	Equal variances assumed	0.490	0.485	-3.751	167	0.000	-136.257	36.323	-207.969	-64.545
	Equal variances not assumed			-3.741	144.993	0.000	-136.257	36.419	-208.238	-64.276
AF7: Sit-ups - Amount	Equal variances assumed	1.547	0.215	-5.898	168	0.000	-10.084	1.710	-13.459	-6.709
	Equal variances not assumed			-5.701	129.704	0.000	-10.084	1.769	-13.584	-6.585
AF8: Sit-ups - Points	Equal variances assumed	3.829	0.052	-5.777	168	0.000	-222.114	38.447	-298.016	-146.212
	Equal variances not assumed			-5.757	146.775	0.000	-222.114	38.583	-298.364	-145.865
AF10: Shuttle Run - Time (Seconds)	Equal variances assumed	2.466	0.118	5.980	167	0.000	3.891	0.651	2.606	5.175
	Equal variances not assumed			5.683	119.872	0.000	3.891	0.685	2.535	5.246
AF11: Shuttle Run - Points	Equal variances assumed	0.768	0.382	-5.418	167	0.000	-105.885	19.543	-144.469	-67.300
	Equal variances not assumed			-5.220	127.634	0.000	-105.885	20.285	-146.022	-65.747
AF13TOT: 4km walk total time	Equal variances assumed	22.454	0.000	2.178	168	0.031	0.78633	0.36096	0.07373	1.49893
	Equal variances not assumed			1.979	97.943	0.051	0.78633	0.39736	-0.00223	1.57489
AF14: 4km walk - Points	Equal variances assumed	3.369	0.068	-2.498	168	0.013	-126.957	50.830	-227.305	-26.609
	Equal variances not assumed			-2.408	128.200	0.017	-126.957	52.731	-231.293	-22.622
AF 16: Total Points	Equal variances assumed	0.285	0.594	-7.493	168	0.000	-787.184	105.055	-994.583	-579.786
	Equal variances not assumed			-7.603	155.866	0.000	-787.184	103.539	-991.704	-582.664

T-Test

Group Statistics

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
BF1TOT: 2.4 km total time	Experimental	97	9.2743	0.76597	0.07777
	Control	69	9.0272	0.65892	0.07932
BF2: 2.4 km - Points	Experimental	97	898.64	88.265	8.962
	Control	69	927.33	68.127	8.201
BF4: Push-ups - Amount	Experimental	96	53.65	10.903	1.113
	Control	68	47.54	12.118	1.470
BF5: Push-ups - Points	Experimental	97	760.42	138.585	14.071
	Control	68	687.22	123.425	14.967
BF7: Sit-ups - Amount	Experimental	97	65.46	13.683	1.389
	Control	69	59.48	13.758	1.656
BF8: Sit-ups - Points	Experimental	97	704.18	129.945	13.194
	Control	69	639.13	153.064	18.427
BF10: Shuttle Run - Time (Seconds)	Experimental	97	48.69	3.644	0.370
	Control	69	49.36	3.167	0.381
BF11: Shuttle Run - Points	Experimental	97	882.70	82.551	8.382
	Control	69	866.14	78.554	9.457
BF13TOT: 4 km walk total time	Experimental	97	26.6943	1.65121	0.16766
	Control	69	27.7051	2.04515	0.24621
BF14: 4km walk - Points	Experimental	97	907.18	157.585	16.000
	Control	69	835.13	186.453	22.446
BF 16: Total Points	Experimental	97	4,156.73	337.508	34.269
	Control	69	3,943.14	339.576	40.880

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Upper	Lower
BF1TOT: 2.4 km total time	Equal variances assumed	1.441	0.232	2.168	164	0.032	0.24708	0.11394	0.02210	0.47207
	Equal variances not assumed			2.224	158.091	0.028	0.24708	0.11109	0.02767	0.46649
BF2: 2.4 km - Points	Equal variances assumed	5.870	0.016	-2.263	164	0.025	-28.694	12.682	-53.735	-3.653
	Equal variances not assumed			-2.362	162.864	0.019	-28.694	12.148	-52.683	-4.706
BF4: Push-ups - Amount	Equal variances assumed	0.237	0.627	3.371	162	0.001	6.102	1.810	2.527	9.677
	Equal variances not assumed			3.310	134.647	0.001	6.102	1.843	2.456	9.747
BF5: Push-ups - Points	Equal variances assumed	0.032	0.857	3.491	163	0.001	73.202	20.967	31.801	114.603
	Equal variances not assumed			3.563	153.878	0.000	73.202	20.543	32.619	113.785
BF7: Sit-ups - Amount	Equal variances assumed	0.147	0.702	2.771	164	0.006	5.986	2.160	1.721	10.250
	Equal variances not assumed			2.769	146.118	0.006	5.986	2.162	1.713	10.258
BF8: Sit-ups - Points	Equal variances assumed	0.069	0.793	2.950	164	0.004	65.045	22.047	21.512	108.578
	Equal variances not assumed			2.870	131.176	0.005	65.045	22.663	20.212	109.878
BF10: Shuttle Run - Time (Seconds)	Equal variances assumed	0.000	0.983	-1.235	164	0.219	-0.672	0.544	-1.746	0.403
	Equal variances not assumed			-1.264	157.468	0.208	-0.672	0.531	-1.721	0.378
BF11: Shuttle Run - Points	Equal variances assumed	0.001	0.970	1.299	164	0.196	16.556	12.743	-8.606	41.718
	Equal variances not assumed			1.310	150.857	0.192	16.556	12.637	-8.412	41.524
BF13TOT: 4 km walk total time	Equal variances assumed	1.197	0.276	-3.517	164	0.001	-1.01074	0.28740	-1.57822	-0.44327
	Equal variances not assumed			-3.393	126.429	0.001	-1.01074	0.29787	-1.60020	-0.42129
BF14: 4km walk - Points	Equal variances assumed	1.937	0.166	2.689	164	0.008	72.045	26.796	19.135	124.955
	Equal variances not assumed			2.614	130.750	0.010	72.045	27.565	17.513	126.577
BF 16: Total Points	Equal variances assumed	0.001	0.980	4.008	164	0.000	213.587	53.288	108.368	318.806
	Equal variances not assumed			4.004	146.059	0.000	213.587	53.343	108.162	319.012

T-Test

Group Statistics

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
CF1TOT: 2.4 km total time	Experimental	99	9.2244	0.61662	0.06197
	Control	67	9.0663	0.79429	0.09704
CF2: 2.4 km - Points	Experimental	99	907.64	72.962	7.333
	Control	67	925.07	86.554	10.574
CF4: Push-ups - Amount	Experimental	99	60.06	11.073	1.113
	Control	68	53.56	11.331	1.374
CF5: Push-ups - Points	Experimental	99	834.55	113.910	11.448
	Control	68	757.74	117.334	14.229
CF7: Sit-ups - Amount	Experimental	99	65.36	14.186	1.426
	Control	68	72.40	15.063	1.827
CF8: Sit-ups - Points	Experimental	99	694.95	146.415	14.715
	Control	68	764.41	160.655	19.482
CF10: Shuttle Run - Time (Seconds)	Experimental	98	53.06	3.089	0.312
	Control	68	48.18	4.246	0.515
CF11: Shuttle Run - Points	Experimental	99	766.73	110.764	11.132
	Control	68	896.03	83.878	10.172
CF13TOT: 4 km walk total time	Experimental	98	27.4152	1.73329	0.17509
	Control	68	26.9684	2.39080	0.28993
CF14: 4km walk - Points	Experimental	98	853.84	200.638	20.268
	Control	68	884.07	159.574	19.351
CF 16: Total Points	Experimental	99	4,051.22	394.420	39.641
	Control	68	4,223.35	396.359	48.066

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Upper	Lower
CF1TOT: 2.4 km total time	Equal variances assumed	2.209	0.139	1.442	164	0.151	0.15818	0.10973	-0.05849	0.37484
	Equal variances not assumed			1.374	117.638	0.172	0.15818	0.11514	-0.06984	0.38619
CF2: 2.4 km - Points	Equal variances assumed	0.752	0.387	-1.400	164	0.163	-17.438	12.452	-42.026	7.149
	Equal variances not assumed			-1.355	125.237	0.178	-17.438	12.868	-42.905	8.029
CF4: Push-ups - Amount	Equal variances assumed	0.041	0.840	3.693	165	0.000	6.502	1.761	3.025	9.978
	Equal variances not assumed			3.677	141.960	0.000	6.502	1.768	3.006	9.997
CF5: Push-ups - Points	Equal variances assumed	0.095	0.759	4.229	165	0.000	76.810	18.162	40.950	112.670
	Equal variances not assumed			4.206	141.332	0.000	76.810	18.263	40.707	112.913
CF7: Sit-ups - Amount	Equal variances assumed	0.307	0.580	-3.069	165	0.003	-7.033	2.291	-11.558	-2.509
	Equal variances not assumed			-3.035	138.389	0.003	-7.033	2.317	-11.615	-2.452
CF8: Sit-ups - Points	Equal variances assumed	0.471	0.494	-2.895	165	0.004	-69.462	23.997	-116.843	-22.082
	Equal variances not assumed			-2.845	135.175	0.005	-69.462	24.415	-117.747	-21.177
CF10: Shuttle Run - Time (Seconds)	Equal variances assumed	5.179	0.024	8.581	164	0.000	4.885	0.569	3.761	6.009
	Equal variances not assumed			8.113	114.578	0.000	4.885	0.602	3.692	6.077
CF11: Shuttle Run - Points	Equal variances assumed	0.001	0.978	-8.151	165	0.000	-129.302	15.863	-160.623	-97.982
	Equal variances not assumed			-8.575	163.377	0.000	-129.302	15.079	-159.078	-99.526
CF13TOT: 4 km walk total time	Equal variances assumed	6.574	0.011	1.396	164	0.165	0.44682	0.32005	-0.18513	1.07877
	Equal variances not assumed			1.319	114.282	0.190	0.44682	0.33869	-0.22411	1.11775
CF14: 4km walk - Points	Equal variances assumed	0.006	0.937	-1.036	164	0.302	-30.237	29.193	-87.880	27.406
	Equal variances not assumed			-1.079	160.890	0.282	-30.237	28.022	-85.575	25.102
CF 16: Total Points	Equal variances assumed	0.781	0.378	-2.765	165	0.006	-172.131	62.246	-295.032	-49.229
	Equal variances not assumed			-2.763	143.691	0.006	-172.131	62.303	-295.280	-48.981

T-Tests for Females to test differences between the experimental and control group at each measurement

Group Statistics

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
AF1TOT: 2.4 km total time	Experimental	83	17.0681	2.00993	0.22062
	Control	111	13.3303	2.26077	0.21458
AF2: 2.4 km - Points	Experimental	83	139.47	252.793	27.748
	Control	111	679.32	302.369	28.700
AF4: Push-ups - Amount	Experimental	83	31.30	10.340	1.135
	Control	113	41.58	13.012	1.224
AF5: Push-ups - Points	Experimental	83	532.88	204.490	22.446
	Control	113	679.08	166.410	15.655
AF7: Sit-ups - Amount	Experimental	83	22.78	9.884	1.085
	Control	113	28.75	14.890	1.401
AF8: Sit-ups - Points	Experimental	83	282.05	294.911	32.371
	Control	113	414.34	317.189	29.839
AF10: Shuttle Run - Time (Seconds)	Experimental	82	68.99	8.934	0.987
	Control	111	63.62	6.776	0.643
AF11: Shuttle Run - Points	Experimental	82	561.28	319.629	35.297
	Control	111	744.22	190.999	18.129
AF13TOT: 4km walk total time	Experimental	83	35.8424	1.99406	0.21888
	Control	112	33.8987	2.27053	0.21454
AF14: 4km walk - Points	Experimental	83	356.77	347.340	38.126
	Control	112	659.21	273.628	25.855
AF 16: Total Points	Experimental	83	1,869.30	954.283	104.746
	Control	113	3,145.82	874.245	82.242

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Upper	Lower
AF1TOT: 2.4 km total time	Equal variances assumed	0.737	0.392	11.941	192	0.000	3.73780	0.31304	3.12037	4.35523
	Equal variances not assumed			12.145	186.267	0.000	3.73780	0.30776	3.13065	4.34495
AF2: 2.4 km - Points	Equal variances assumed	0.798	0.373	-13.180	192	0.000	-539.854	40.960	-620.643	-459.066
	Equal variances not assumed			-13.523	189.566	0.000	-539.854	39.920	-618.599	-461.110
AF4: Push-ups - Amount	Equal variances assumed	2.271	0.133	-5.950	194	0.000	-10.283	1.728	-13.692	-6.874
	Equal variances not assumed			-6.160	192.761	0.000	-10.283	1.669	-13.575	-6.990
AF5: Push-ups - Points	Equal variances assumed	1.205	0.274	-5.512	194	0.000	-146.200	26.523	-198.510	-93.890
	Equal variances not assumed			-5.342	154.424	0.000	-146.200	27.366	-200.259	-92.141
AF7: Sit-ups - Amount	Equal variances assumed	10.146	0.002	-3.173	194	0.002	-5.969	1.881	-9.679	-2.259
	Equal variances not assumed			-3.369	192.204	0.001	-5.969	1.772	-9.464	-2.475
AF8: Sit-ups - Points	Equal variances assumed	0.149	0.700	-2.971	194	0.003	-132.288	44.520	-220.094	-44.482
	Equal variances not assumed			-3.005	183.535	0.003	-132.288	44.025	-219.148	-45.428
AF10: Shuttle Run - Time (Seconds)	Equal variances assumed	11.928	0.001	4.746	191	0.000	5.366	1.131	3.136	7.596
	Equal variances not assumed			4.557	145.163	0.000	5.366	1.178	3.039	7.694
AF11: Shuttle Run - Points	Equal variances assumed	24.016	0.000	-4.953	191	0.000	-182.936	36.935	-255.788	-110.083
	Equal variances not assumed			-4.610	123.065	0.000	-182.936	39.680	-261.480	-104.391
AF13TOT: 4km walk total time	Equal variances assumed	1.244	0.266	6.221	193	0.000	1.94375	0.31246	1.32747	2.56003
	Equal variances not assumed			6.342	187.442	0.000	1.94375	0.30649	1.33914	2.54836
AF14: 4km walk - Points	Equal variances assumed	26.971	0.000	-6.799	193	0.000	-302.443	44.481	-390.174	-214.713
	Equal variances not assumed			-6.565	151.151	0.000	-302.443	46.066	-393.459	-211.427
AF 16: Total Points	Equal variances assumed	1.401	0.238	-9.715	194	0.000	-1,276.522	131.396	-1,535.670	-1,017.373
	Equal variances not assumed			-9.585	167.624	0.000	-1,276.522	133.175	-1,539.438	-1,013.606

T-Test

Group Statistics

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
BF1TOT: 2.4 km total time	Experimental	62	13.6421	2.27301	0.28867
	Control	98	13.5413	2.17374	0.21958
BF2: 2.4 km - Points	Experimental	62	602.90	293.848	37.319
	Control	98	639.80	316.870	32.009
BF4: Push-ups - Amount	Experimental	62	57.94	14.364	1.824
	Control	100	55.49	14.138	1.414
BF5: Push-ups - Points	Experimental	62	851.71	158.977	20.190
	Control	100	836.18	124.769	12.477
BF7: Sit-ups - Amount	Experimental	61	48.57	14.710	1.883
	Control	100	45.12	18.987	1.899
BF8: Sit-ups - Points	Experimental	62	744.16	182.391	23.164
	Control	100	679.98	266.676	26.668
BF10: Shuttle Run - Time (Seconds)	Experimental	61	61.67	6.115	0.783
	Control	100	63.76	7.850	0.785
BF11: Shuttle Run - Points	Experimental	62	787.90	172.062	21.852
	Control	100	733.50	226.642	22.664
BF13TOT: 4 km walk total time	Experimental	59	31.7251	2.00523	0.26106
	Control	100	32.3861	2.24050	0.22405
BF14: 4km walk - Points	Experimental	62	850.26	285.024	36.198
	Control	100	849.96	186.232	18.623
BF 16: Total Points	Experimental	62	3,847.71	698.922	88.763
	Control	100	3,732.33	792.672	79.267

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Upper	Lower
BF1TOT: 2.4 km total time	Equal variances assumed	1.397	0.239	0.281	158	0.779	0.10077	0.35905	-0.60838	0.80992
	Equal variances not assumed			0.278	125.573	0.782	0.10077	0.36269	-0.61702	0.81856
BF2: 2.4 km - Points	Equal variances assumed	0.530	0.468	-0.738	158	0.462	-36.893	50.011	-135.669	61.883
	Equal variances not assumed			-0.750	137.103	0.454	-36.893	49.166	-134.113	60.328
BF4: Push-ups - Amount	Equal variances assumed	0.210	0.648	1.064	160	0.289	2.445	2.299	-2.096	6.986
	Equal variances not assumed			1.060	127.864	0.291	2.445	2.308	-2.121	7.012
BF5: Push-ups - Points	Equal variances assumed	1.164	0.282	0.692	160	0.490	15.530	22.438	-28.783	59.842
	Equal variances not assumed			0.654	106.882	0.514	15.530	23.734	-31.521	62.581
BF7: Sit-ups - Amount	Equal variances assumed	4.404	0.037	1.215	159	0.226	3.454	2.842	-2.160	9.068
	Equal variances not assumed			1.291	150.018	0.199	3.454	2.674	-1.830	8.738
BF8: Sit-ups - Points	Equal variances assumed	5.660	0.019	1.668	160	0.097	64.181	38.486	-11.824	140.187

	Equal variances not assumed			1.817	158.402	0.071	64.181	35.323	-5.584	133.946
BF10: Shuttle Run - Time (Seconds)	Equal variances assumed	1.592	0.209	-1.774	159	0.078	-2.088	1.177	-4.412	0.236
	Equal variances not assumed			-1.883	149.625	0.062	-2.088	1.109	-4.279	0.103
BF11: Shuttle Run - Points	Equal variances assumed	1.470	0.227	1.622	160	0.107	54.403	33.547	-11.848	120.655
	Equal variances not assumed			1.728	153.429	0.086	54.403	31.483	-7.793	116.599
BF13TOT: 4 km walk total time	Equal variances assumed	1.506	0.222	-1.867	157	0.064	-0.66102	0.35403	-1.36029	0.03826
	Equal variances not assumed			-1.921	132.723	0.057	-0.66102	0.34402	-1.34149	0.01946
BF14: 4km walk - Points	Equal variances assumed	3.704	0.056	0.008	160	0.994	0.298	37.013	-72.800	73.396
	Equal variances not assumed			0.007	93.528	0.994	0.298	40.708	-80.534	81.130
BF 16: Total Points	Equal variances assumed	1.394	0.240	0.941	160	0.348	115.380	122.575	-126.694	357.453
	Equal variances not assumed			0.970	141.600	0.334	115.380	119.005	-119.876	350.636

T-Test

Group Statistics

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
CF1TOT: 2.4 km total time	Experimental	75	13.3892	1.38815	0.16029
	Control	105	12.6163	1.60410	0.15654
CF2: 2.4 km - Points	Experimental	75	691.59	220.321	25.440
	Control	105	793.89	175.764	17.153
CF4: Push-ups - Amount	Experimental	75	56.32	13.690	1.581
	Control	108	59.47	14.048	1.352
CF5: Push-ups - Points	Experimental	75	846.72	132.548	15.305
	Control	108	869.89	141.240	13.591
CF7: Sit-ups - Amount	Experimental	75	93.95	175.566	20.273
	Control	108	56.44	18.701	1.800
CF8: Sit-ups - Points	Experimental	75	750.40	144.909	16.733
	Control	108	828.43	162.539	15.640
CF10: Shuttle Run - Time (Seconds)	Experimental	75	65.08	5.990	0.692
	Control	105	60.38	6.363	0.621
CF11: Shuttle Run - Points	Experimental	75	701.80	219.397	25.334
	Control	105	827.86	154.123	15.041
CF13TOT: 4 km walk total time	Experimental	73	31.8353	2.24719	0.26301
	Control	104	30.7729	2.09817	0.20574
CF14: 4km walk - Points	Experimental	75	837.12	260.623	30.094
	Control	104	941.51	140.987	13.825
CF 16: Total Points	Experimental	75	3,819.85	660.949	76.320
	Control	108	4,232.44	804.743	77.436

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Upper	Lower
CF1TOT: 2.4 km total time	Equal variances assumed	1.537	0.217	3.368	178	0.001	0.77291	0.22951	0.32001	1.22582
	Equal variances not assumed			3.450	171.482	0.001	0.77291	0.22405	0.33066	1.21517
CF2: 2.4 km - Points	Equal variances assumed	0.953	0.330	-3.461	178	0.001	-102.299	29.561	-160.633	-43.965
	Equal variances not assumed			-3.334	136.500	0.001	-102.299	30.683	-162.974	-41.624
CF4: Push-ups - Amount	Equal variances assumed	0.004	0.949	-1.508	181	0.133	-3.152	2.090	-7.276	0.971
	Equal variances not assumed			-1.516	161.919	0.132	-3.152	2.080	-7.260	0.955
CF5: Push-ups - Points	Equal variances assumed	0.010	0.921	-1.119	181	0.265	-23.169	20.705	-64.024	17.686
	Equal variances not assumed			-1.132	165.531	0.259	-23.169	20.469	-63.582	17.244
CF7: Sit-ups - Amount	Equal variances assumed	24.099	0.000	2.205	181	0.029	37.502	17.011	3.937	71.068
	Equal variances not assumed			1.843	75.168	0.069	37.502	20.352	-3.040	78.045
CF8: Sit-ups - Points	Equal variances assumed	3.450	0.065	-3.337	181	0.001	-78.026	23.384	-124.166	-31.886
	Equal variances not assumed			-3.407	170.032	0.001	-78.026	22.904	-123.239	-32.813
CF10: Shuttle Run - Time (Seconds)	Equal variances assumed	0.855	0.356	5.004	178	0.000	4.699	0.939	2.846	6.552
	Equal variances not assumed			5.055	165.057	0.000	4.699	0.930	2.864	6.534
CF11: Shuttle Run - Points	Equal variances assumed	2.146	0.145	-4.529	178	0.000	-126.057	27.832	-180.980	-71.134
	Equal variances not assumed			-4.279	124.368	0.000	-126.057	29.462	-184.370	-67.745
CF13TOT: 4 km walk total time	Equal variances assumed	1.547	0.215	3.220	175	0.002	1.06246	0.32992	0.41133	1.71359
	Equal variances not assumed			3.182	148.267	0.002	1.06246	0.33392	0.40259	1.72232
CF14: 4km walk - Points	Equal variances assumed	21.925	0.000	-3.447	177	0.001	-104.390	30.284	-164.154	-44.625
	Equal variances not assumed			-3.152	105.164	0.002	-104.390	33.118	-170.055	-38.724
CF 16: Total Points	Equal variances assumed	0.000	0.982	-3.663	181	0.000	-412.591	112.626	-634.819	-190.363
	Equal variances not assumed			-3.795	175.878	0.000	-412.591	108.725	-627.165	-198.018

APPENDIX G - Crosstabulations to determine whether there is a relationship between group membership (experimental vsl

Crosstabulations between group membership and fitness tests' pass or fail rates for
Pre-test A

GROUP * AF3: 2.4 km - Pass/fail

Crosstab

			AF3: 2.4 km - Pass/fail		
			Pass	Fail	Total
GROUP	Experimental	Count	101	81	182
		% within GROUP	55.5%	44.5%	100.0%
		% within AF3: 2.4 km - Pass/fail	40.4%	71.1%	50.0%
		% of Total	27.7%	22.3%	50.0%
	Control	Count	149	33	182
		% within GROUP	81.9%	18.1%	100.0%
		% within AF3: 2.4 km - Pass/fail	59.6%	28.9%	50.0%
		% of Total	40.9%	9.1%	50.0%
Total		Count	250	114	364
		% within GROUP	68.7%	31.3%	100.0%
		% within AF3: 2.4 km - Pass/fail	100.0%	100.0%	100.0%
		% of Total	68.7%	31.3%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	29.427(b)	1	0.000		
Continuity Correction(a)	28.213	1	0.000		
Likelihood Ratio	30.128	1	0.000		
Fisher's Exact Test				0.000	0.000
Linear-by-Linear Association	29.346	1	0.000		
N of Valid Cases	364				

a. Computed only for a 2x2 table

b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 57.00.

GROUP * AF6: Push-ups - Pass/fail

Crosstab

			AF6: Push-ups - Pass/fail		Total
			Pass	Fail	
GROUP	Experimental	Count	63	120	183
		% within GROUP	34.4%	65.6%	100.0%
		% within AF6: Push-ups - Pass/fail	34.2%	66.3%	50.1%
		% of Total	17.3%	32.9%	50.1%
	Control	Count	121	61	182
		% within GROUP	66.5%	33.5%	100.0%
		% within AF6: Push-ups - Pass/fail	65.8%	33.7%	49.9%
		% of Total	33.2%	16.7%	49.9%
Total		Count	184	181	365
		% within GROUP	50.4%	49.6%	100.0%
		% within AF6: Push-ups - Pass/fail	100.0%	100.0%	100.0%
		% of Total	50.4%	49.6%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	37.512(b)	1	0.000		
Continuity Correction(a)	36.241	1	0.000		
Likelihood Ratio	38.183	1	0.000		
Fisher's Exact Test				0.000	0.000
Linear-by-Linear Association	37.409	1	0.000		
N of Valid Cases	365				

a. Computed only for a 2x2 table

b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 90.25.

GROUP * AF9: Sit-ups - Pass/fail

Crosstab

			AF9: Sit-ups - Pass/fail		Total
			Pass	Fail	
GROUP	Experimental	Count	19	164	183
		% within GROUP	10.4%	89.6%	100.0%
		% within AF9: Sit-ups - Pass/fail	27.1%	55.4%	50.0%
		% of Total	5.2%	44.8%	50.0%
	Control	Count	51	132	183
		% within GROUP	27.9%	72.1%	100.0%
		% within AF9: Sit-ups - Pass/fail	72.9%	44.6%	50.0%
		% of Total	13.9%	36.1%	50.0%
Total		Count	70	296	366
		% within GROUP	19.1%	80.9%	100.0%
		% within AF9: Sit-ups - Pass/fail	100.0%	100.0%	100.0%
		% of Total	19.1%	80.9%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	18.088(b)	1	0.000		
Continuity Correction(a)	16.975	1	0.000		
Likelihood Ratio	18.652	1	0.000		
Fisher's Exact Test				0.000	0.000
Linear-by-Linear Association	18.039	1	0.000		
N of Valid Cases	366				

a. Computed only for a 2x2 table

b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 35.00.

GROUP * AF12:Shuttle Run - Pass/fail

Crosstab

			AF12:Shuttle Run - Pass/fail		Total
			Pass	Fail	
GROUP	Experimental	Count	143	38	181
		% within GROUP	79.0%	21.0%	100.0%
		% within AF12:Shuttle Run - Pass/fail	46.4%	70.4%	50.0%
		% of Total	39.5%	10.5%	50.0%
	Control	Count	165	16	181
		% within GROUP	91.2%	8.8%	100.0%
		% within AF12:Shuttle Run - Pass/fail	53.6%	29.6%	50.0%
		% of Total	45.6%	4.4%	50.0%
Total		Count	308	54	362
		% within GROUP	85.1%	14.9%	100.0%
		% within AF12:Shuttle Run - Pass/fail	100.0%	100.0%	100.0%
		% of Total	85.1%	14.9%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	10.534(b)	1	0.001		
Continuity Correction(a)	9.598	1	0.002		
Likelihood Ratio	10.802	1	0.001		
Fisher's Exact Test				0.002	0.001
Linear-by-Linear Association	10.505	1	0.001		
N of Valid Cases	362				

a. Computed only for a 2x2 table

b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 27.00.

GROUP * AF15: 4km walk - Pass/fail

Crosstab

			AF15: 4km walk - Pass/fail		Total
			Pass	Fail	
GROUP	Experimental	Count	81	102	183
		% within GROUP	44.3%	55.7%	100.0%
		% within AF15: 4km walk - Pass/fail	41.5%	59.6%	50.0%
		% of Total	22.1%	27.9%	50.0%
	Control	Count	114	69	183
		% within GROUP	62.3%	37.7%	100.0%
		% within AF15: 4km walk - Pass/fail	58.5%	40.4%	50.0%
		% of Total	31.1%	18.9%	50.0%
Total		Count	195	171	366
		% within GROUP	53.3%	46.7%	100.0%
		% within AF15: 4km walk - Pass/fail	100.0%	100.0%	100.0%
		% of Total	53.3%	46.7%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	11.953(b)	1	0.001		
Continuity Correction(a)	11.240	1	0.001		
Likelihood Ratio	12.020	1	0.001		
Fisher's Exact Test				0.001	0.000
Linear-by-Linear Association	11.920	1	0.001		
N of Valid Cases	366				

a. Computed only for a 2x2 table

b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 85.50.

GROUP * AF17: Total Pass/Fail

Crosstab

			AF17: Total Pass/Fail		Total
			Pass	Fail	
GROUP	Experimental	Count	37	146	183
		% within GROUP	20.2%	79.8%	100.0%
		% within AF17: Total Pass/Fail	24.2%	68.5%	50.0%
		% of Total	10.1%	39.9%	50.0%
	Control	Count	116	67	183
		% within GROUP	63.4%	36.6%	100.0%
		% within AF17: Total Pass/Fail	75.8%	31.5%	50.0%
		% of Total	31.7%	18.3%	50.0%
Total		Count	153	213	366
		% within GROUP	41.8%	58.2%	100.0%
		% within AF17: Total Pass/Fail	100.0%	100.0%	100.0%
		% of Total	41.8%	58.2%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	70.091(b)	1	0.000		
Continuity Correction(a)	68.328	1	0.000		
Likelihood Ratio	72.842	1	0.000		
Fisher's Exact Test				0.000	0.000
Linear-by-Linear Association	69.900	1	0.000		
N of Valid Cases	366				

a. Computed only for a 2x2 table

b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 76.50.

Crosstabulations between group membership and fitness tests' pass or fail rates for Post-test B

GROUP * BF3: 2.4 km - Pass/fail

Crosstab

			BF3: 2.4 km - Pass/fail		Total
			Pass	Fail	
GROUP	Experimental	Count	140	19	159
		% within GROUP	88.1%	11.9%	100.0%
		% within BF3: 2.4 km - Pass/fail	50.5%	36.5%	48.3%
		% of Total	42.6%	5.8%	48.3%
	Control	Count	137	33	170
		% within GROUP	80.6%	19.4%	100.0%
		% within BF3: 2.4 km - Pass/fail	49.5%	63.5%	51.7%
		% of Total	41.6%	10.0%	51.7%
Total		Count	277	52	329
		% within GROUP	84.2%	15.8%	100.0%
		% within BF3: 2.4 km - Pass/fail	100.0%	100.0%	100.0%
		% of Total	84.2%	15.8%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	3.438(b)	1	0.064		
Continuity Correction(a)	2.900	1	0.089		
Likelihood Ratio	3.481	1	0.062		
Fisher's Exact Test				0.071	0.044
Linear-by-Linear Association	3.427	1	0.064		
N of Valid Cases	329				

a. Computed only for a 2x2 table

b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 25.13.

GROUP * BF6: Push-ups - Pass/fail

Crosstab

			BF6: Push-ups - Pass/fail		Total
			Pass	Fail	
GROUP	Experimental	Count	155	4	159
		% within GROUP	97.5%	2.5%	100.0%
		% within BF6: Push-ups - Pass/fail	49.8%	20.0%	48.0%
		% of Total	46.8%	1.2%	48.0%
	Control	Count	156	16	172
		% within GROUP	90.7%	9.3%	100.0%
		% within BF6: Push-ups - Pass/fail	50.2%	80.0%	52.0%
		% of Total	47.1%	4.8%	52.0%
Total		Count	311	20	331
		% within GROUP	94.0%	6.0%	100.0%
		% within BF6: Push-ups - Pass/fail	100.0%	100.0%	100.0%
		% of Total	94.0%	6.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	6.703(b)	1	0.010		
Continuity Correction(a)	5.561	1	0.018		
Likelihood Ratio	7.202	1	0.007		
Fisher's Exact Test				0.011	0.008
Linear-by-Linear Association	6.683	1	0.010		
N of Valid Cases	331				

a. Computed only for a 2x2 table

b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 9.61.

GROUP * BF9: Sit-ups - Pass/fail

Crosstab

			BF9: Sit-ups - Pass/fail		Total
			Pass	Fail	
GROUP	Experimental	Count	135	24	159
		% within GROUP	84.9%	15.1%	100.0%
		% within BF9: Sit-ups - Pass/fail	52.1%	32.9%	47.9%
		% of Total	40.7%	7.2%	47.9%
	Control	Count	124	49	173
		% within GROUP	71.7%	28.3%	100.0%
		% within BF9: Sit-ups - Pass/fail	47.9%	67.1%	52.1%
		% of Total	37.3%	14.8%	52.1%
Total		Count	259	73	332
		% within GROUP	78.0%	22.0%	100.0%
		% within BF9: Sit-ups - Pass/fail	100.0%	100.0%	100.0%
		% of Total	78.0%	22.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	8.453(b)	1	0.004		
Continuity Correction(a)	7.700	1	0.006		
Likelihood Ratio	8.614	1	0.003		
Fisher's Exact Test				0.005	0.003
Linear-by-Linear Association	8.428	1	0.004		
N of Valid Cases	332				

a. Computed only for a 2x2 table

b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 34.96.

GROUP * BF12:Shuttle Run - Pass/fail

Crosstab

			BF12:Shuttle Run - Pass/fail		Total
			Pass	Fail	
GROUP	Experimental	Count	153	6	159
		% within GROUP	96.2%	3.8%	100.0%
		% within BF12:Shuttle Run - Pass/fail	49.0%	33.3%	48.2%
		% of Total	46.4%	1.8%	48.2%
	Control	Count	159	12	171
		% within GROUP	93.0%	7.0%	100.0%
		% within BF12:Shuttle Run - Pass/fail	51.0%	66.7%	51.8%
		% of Total	48.2%	3.6%	51.8%
Total		Count	312	18	330
		% within GROUP	94.5%	5.5%	100.0%
		% within BF12:Shuttle Run - Pass/fail	100.0%	100.0%	100.0%
		% of Total	94.5%	5.5%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	1.681(b)	1	0.195		
Continuity Correction(a)	1.111	1	0.292		
Likelihood Ratio	1.718	1	0.190		
Fisher's Exact Test				0.231	0.146
Linear-by-Linear Association	1.676	1	0.195		
N of Valid Cases	330				

a. Computed only for a 2x2 table
b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.67.

GROUP * BF12:4 km Run - Pass/fail

Crosstab

			BF15: 4km walk - Pass/fail		Total
			Pass	Fail	
GROUP	Experimental	Count	151	8	159
		% within GROUP	95.0%	5.0%	100.0%
		% within BF15: 4km walk - Pass/fail	49.2%	33.3%	48.0%
		% of Total	45.6%	2.4%	48.0%
	Control	Count	156	16	172
		% within GROUP	90.7%	9.3%	100.0%
		% within BF15: 4km walk - Pass/fail	50.8%	66.7%	52.0%
		% of Total	47.1%	4.8%	52.0%
Total		Count	307	24	331
		% within GROUP	92.7%	7.3%	100.0%
		% within BF15: 4km walk - Pass/fail	100.0%	100.0%	100.0%
		% of Total	92.7%	7.3%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	2.241(b)	1	0.134		
Continuity Correction(a)	1.651	1	0.199		
Likelihood Ratio	2.289	1	0.130		
Fisher's Exact Test				0.144	0.099
Linear-by-Linear Association	2.234	1	0.135		
N of Valid Cases	331				

a. Computed only for a 2x2 table
b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 11.53.

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GROUP * BF17: Total Pass/Fail

Crosstab

			BF17: Total Pass/Fail		Total
			Pass	Fail	
GROUP	Experimental	Count	151	8	159
		% within GROUP	95.0%	5.0%	100.0%
		% within BF17: Total Pass/Fail	50.0%	26.7%	47.9%
		% of Total	45.5%	2.4%	47.9%
	Control	Count	151	22	173
		% within GROUP	87.3%	12.7%	100.0%
		% within BF17: Total Pass/Fail	50.0%	73.3%	52.1%
		% of Total	45.5%	6.6%	52.1%
Total		Count	302	30	332
		% within GROUP	91.0%	9.0%	100.0%
		% within BF17: Total Pass/Fail	100.0%	100.0%	100.0%
		% of Total	91.0%	9.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	5.954(b)	1	0.015		
Continuity Correction(a)	5.055	1	0.025		
Likelihood Ratio	6.203	1	0.013		
Fisher's Exact Test				0.020	0.011
Linear-by-Linear Association	5.936	1	0.015		
N of Valid Cases	332				

a. Computed only for a 2x2 table

b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 14.37.

Crosstabulations between group membership and fitness tests' pass or fail rates for Post-test C

GROUP * CF3: 2.4 km - Pass/fail

Crosstab

			CF3: 2.4 km - Pass/fail		Total
			Pass	Fail	
GROUP	Experimental	Count	157	17	174
		% within GROUP	90.2%	9.8%	100.0%
		% within CF3: 2.4 km - Pass/fail	49.8%	53.1%	50.1%
		% of Total	45.2%	4.9%	50.1%
	Control	Count	158	15	173
		% within GROUP	91.3%	8.7%	100.0%
		% within CF3: 2.4 km - Pass/fail	50.2%	46.9%	49.9%
		% of Total	45.5%	4.3%	49.9%
Total		Count	315	32	347
		% within GROUP	90.8%	9.2%	100.0%
		% within CF3: 2.4 km - Pass/fail	100.0%	100.0%	100.0%
		% of Total	90.8%	9.2%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.125(b)	1	0.723		
Continuity Correction(a)	0.028	1	0.866		
Likelihood Ratio	0.125	1	0.723		
Fisher's Exact Test				0.853	0.433
Linear-by-Linear Association	0.125	1	0.724		
N of Valid Cases	347				

a. Computed only for a 2x2 table

b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 15.95.

GROUP * CF6: Push-ups - Pass/fail

Crosstab

			CF6: Push-ups - Pass/fail		Total
			Pass	Fail	
GROUP	Experimental	Count	171	3	174
		% within GROUP	98.3%	1.7%	100.0%
		% within CF6: Push-ups - Pass/fail	49.7%	42.9%	49.6%
		% of Total	48.7%	0.9%	49.6%
	Control	Count	173	4	177
		% within GROUP	97.7%	2.3%	100.0%
		% within CF6: Push-ups - Pass/fail	50.3%	57.1%	50.4%
		% of Total	49.3%	1.1%	50.4%
Total		Count	344	7	351
		% within GROUP	98.0%	2.0%	100.0%
		% within CF6: Push-ups - Pass/fail	100.0%	100.0%	100.0%
		% of Total	98.0%	2.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.129(b)	1	0.720		
Continuity Correction(a)	0.000	1	1.000		
Likelihood Ratio	0.129	1	0.719		
Fisher's Exact Test				1.000	0.509
Linear-by-Linear Association	0.128	1	0.720		
N of Valid Cases	351				

a. Computed only for a 2x2 table

b. 2 cells (50.0%) have expected count less than 5. The minimum expected count is 3.47.

GROUP * CF9: Sit-ups - Pass/fail

Crosstab

			CF9: Sit-ups - Pass/fail		Total
			Pass	Fail	
GROUP	Experimental	Count	157	17	174
		% within GROUP	90.2%	9.8%	100.0%
		% within CF9: Sit-ups - Pass/fail	48.9%	56.7%	49.6%
		% of Total	44.7%	4.8%	49.6%
	Control	Count	164	13	177
		% within GROUP	92.7%	7.3%	100.0%
		% within CF9: Sit-ups - Pass/fail	51.1%	43.3%	50.4%
		% of Total	46.7%	3.7%	50.4%
Total		Count	321	30	351
		% within GROUP	91.5%	8.5%	100.0%
		% within CF9: Sit-ups - Pass/fail	100.0%	100.0%	100.0%
		% of Total	91.5%	8.5%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.660(b)	1	0.416		
Continuity Correction(a)	0.387	1	0.534		
Likelihood Ratio	0.662	1	0.416		
Fisher's Exact Test				0.450	0.267
Linear-by-Linear Association	0.659	1	0.417		
N of Valid Cases	351				

a. Computed only for a 2x2 table

b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 14.87.

GROUP * CF12:Shuttle Run - Pass/fail

Crosstab

			CF12:Shuttle Run - Pass/fail		Total
			Pass	Fail	
GROUP	Experimental	Count	160	14	174
		% within GROUP	92.0%	8.0%	100.0%
		% within CF12:Shuttle Run - Pass/fail	48.6%	73.7%	50.0%
		% of Total	46.0%	4.0%	50.0%
	Control	Count	169	5	174
		% within GROUP	97.1%	2.9%	100.0%
		% within CF12:Shuttle Run - Pass/fail	51.4%	26.3%	50.0%
		% of Total	48.6%	1.4%	50.0%
Total		Count	329	19	348
		% within GROUP	94.5%	5.5%	100.0%
		% within CF12:Shuttle Run - Pass/fail	100.0%	100.0%	100.0%
		% of Total	94.5%	5.5%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	4.509(b)	1	0.034		
Continuity Correction(a)	3.563	1	0.059		
Likelihood Ratio	4.685	1	0.030		
Fisher's Exact Test				0.056	0.028
Linear-by-Linear Association	4.496	1	0.034		
N of Valid Cases	348				

a. Computed only for a 2x2 table

b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 9.50.

GROUP * CF15: 4km walk - Pass/fail

Crosstab

			CF15: 4km walk - Pass/fail		Total
			Pass	Fail	
GROUP	Experimental	Count	154	19	173
		% within GROUP	89.0%	11.0%	100.0%
		% within CF15: 4km walk - Pass/fail	47.8%	79.2%	50.0%
		% of Total	44.5%	5.5%	50.0%
	Control	Count	168	5	173
		% within GROUP	97.1%	2.9%	100.0%
		% within CF15: 4km walk - Pass/fail	52.2%	20.8%	50.0%
		% of Total	48.6%	1.4%	50.0%
Total		Count	322	24	346
		% within GROUP	93.1%	6.9%	100.0%
		% within CF15: 4km walk - Pass/fail	100.0%	100.0%	100.0%
		% of Total	93.1%	6.9%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	8.775(b)	1	0.003		
Continuity Correction(a)	7.567	1	0.006		
Likelihood Ratio	9.316	1	0.002		
Fisher's Exact Test				0.005	0.002
Linear-by-Linear Association	8.750	1	0.003		
N of Valid Cases	346				

a. Computed only for a 2x2 table

b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 12.00.

GROUP * CF17: Total Pass/Fail

Crosstab

			CF17: Total Pass/Fail		Total
			Pass	Fail	
GROUP	Experimental	Count	161	13	174
		% within GROUP	92.5%	7.5%	100.0%
		% within CF17: Total Pass/Fail	48.5%	68.4%	49.6%
		% of Total	45.9%	3.7%	49.6%
	Control	Count	171	6	177
		% within GROUP	96.6%	3.4%	100.0%
		% within CF17: Total Pass/Fail	51.5%	31.6%	50.4%
		% of Total	48.7%	1.7%	50.4%
Total		Count	332	19	351
		% within GROUP	94.6%	5.4%	100.0%
		% within CF17: Total Pass/Fail	100.0%	100.0%	100.0%
		% of Total	94.6%	5.4%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	2.855(b)	1	0.091		
Continuity Correction(a)	2.113	1	0.146		
Likelihood Ratio	2.916	1	0.088		
Fisher's Exact Test				0.103	0.072
Linear-by-Linear Association	2.847	1	0.092		
N of Valid Cases	351				

a. Computed only for a 2x2 table

b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 9.42.