



UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

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

by

PAOLA SILVIA WOOD

Submitted in partial fulfillment of the
requirements of the degree

DOCTOR PHILOSOPHIAE

in the

FACULTY OF HUMANITIES

(DEPARTMENT OF BIKINETICS, SPORT AND LEISURE SCIENCES)

UNIVERSITY OF PRETORIA

AUGUST 2008

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

ACKNOWLEDGEMENTS

It is a privilege to thank the following people and organisations for their contributions in the completion of this study:

Prof. P.E. Krüger, (Department of Biokinetics, Sport and Leisure Sciences), for your valuable advice, support, patience, and above all, belief in my abilities.

Col R.J. (Dolf) Theunissen, for your support, advice and encouragement and for making this study possible.

The South African Defence Force, staff of the JPTSR Training Centre, the Biokinetics Department at 1 Military Hospital and Dougie le Roux, for your support.

All the **participants who volunteered for this study**.

Rina Grant, for your support and assistance; you are an inspiration.

Christine Smit, for the statistical analysis.

Terren Kourkoumelis, for the language editing.

My beloved late father, Enrico Sabini, whose motivation and continuous sacrifices during the course of his lifetime enabled me to earn this degree.

My mother, Bruna Sabini, for your guidance, nurturing and teaching me to persevere and give of my best at all times.

My sister, Emanuela, for all your time spent babysitting, supporting and your friendship; you are the best.

My precious children, Fabio and Alexia, may I be blessed to see you blossom into the great adults I know you will become.

My husband, best friend and companion, Alec, thank you for all your time, dedication, inspiration and unwavering confidence in me.

Finally, to my Heavenly Father, who is my constant strength.

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

- Psalms 119:105

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 referred 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 veranderinge in fisiese merkers te assesser terwyl 'n progressiewe, wetenskaplik ontwerpte Fisiese 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), fisiese fiksheid (gestandaardiseerde militêre fiksheidstoets, isokinetiese bo- en onderbeenkrag, handgrypkrag), 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 Experimentele 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 deelnemers 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 mesomorfkomponeent het toegeneem en 'n afname is in hul % liggaamsvet (LV), asook in die ektomorf- en endomorfkomponeent gevind. Die manlike subjekte se plantaarfleksie en heup eksterne rotasie het afgeneem, terwyl hul dorsifleksie verbeter het. Hul vetvrye liggaamsmassa en mesomorfkomponeent het toegeneem, terwyl hul %LV, ektomorf- en endomorfkomponeent 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.



TABLE OF CONTENTS

DEDICATION.....	ii
ACKNOWLEDGEMENTS	iii
SYNOPSIS	v
SAMEVATTING	viii
TABLE OF CONTENTS.....	xi

LIST OF OF TABLES

.....	xix
-------	-----

LIST OF FIGURES

.....	xxii
-------	------

CHAPTER 1.....	1
----------------	---

INTRODUCTION

.....	1
-------	---

1.1 INTRODUCTION	1
------------------------	---

1.2 INTRINSIC RISK FACTORS	3
----------------------------------	---



1.2.1	Demographic characteristics	3
1.2.2	Anatomic factors	3
1.2.3	Bone characteristics	4
1.2.4	Physical fitness	4
1.2.5	Health risk behaviours	5
1.3	<i>EXTRINSIC RISK FACTORS</i>	6
1.3.1	Type of physical activity	6
1.3.2	Equipment	7
1.3.3	Environment	7
1.4	<i>PROBLEM SETTING</i>	7
1.5	<i>RESEARCH QUESTION</i>	8
1.6	<i>RESEARCH HYPOTHESIS</i>	8
1.7	<i>GOAL OF THE STUDY</i>	9
1.8	<i>OBJECTIVES OF THE STUDY</i>	9
1.8.1	Primary objectives	9
1.8.2	Secondary objective	10
1.9	<i>RESEARCH APPROACH</i>	10
1.9.1	Observation technique	10
1.9.2	Experimentation	10
1.10	<i>RESEARCH DESIGN</i>	11

1.11 RESEARCH PROCEDURE AND STRATEGY	11
CHAPTER 2.....	13
LITERATURE REVIEW	
.....	13
2.1 INTRODUCTION	13
2.2 STRESS FRACTURES.....	14
2.2.1 Definition	14
2.2.2 A historical perspective	14
2.2.3 Pathophysiology.....	15
2.3 BONE BIOLOGY	16
2.3.1 Bone structure and gross anatomy.....	16
2.3.2 Microscopic structure of bone	17
2.3.3. Bone loading	19
2.3.4 Bone microarchitecture	24
2.3.5 Bone response to loading.....	24
2.4 EPIDEMIOLOGY OF STRESS FRACTURES	30
2.5 RESEARCH DESIGNS.....	31
2.5.1 Clinical trials	31
2.5.2 Prospective cohort studies	31



2.5.3	Case-control studies.....	32
2.5.4	Case series	32
2.5.5	Cross-sectional studies, or surveys.....	33
2.5.6	'Mixed' study designs	33
2.6	<i>STRESS FRACTURE RATES IN MILITARY POPULATION</i>	33
2.7	<i>SITE DISTRIBUTION OF STRESS FRACTURES IN MILITARY POPULATIONS</i>	38
2.8	<i>RISK FACTORS</i>	40
2.8.1	Intrinsic risk factors.....	42
2.8.2	Extrinsic risk factors	74
2.9	<i>BT PROGRAMME</i>	82
2.9.1	PT within the BT programme.....	82
2.10	<i>STUDY DESIGN</i>	86
2.10.1	Advantages of using the military population	86
2.10.2	Disadvantage with using the military population.....	87
CHAPTER 3.....		88
METHODS AND PROCEDURES		
<hr/>		
.....		88
3.1	<i>INTRODUCTION</i>	88
3.2	<i>RESEARCH APPROACH</i>	89

3.2.1	Observation Technique	89
3.2.2	Experimentation	89
3.3	<i>RESEARCH DESIGN</i>	89
3.4	<i>A 12-WEEK PT PROGRAMME FOR BT</i>	90
3.4.1	Aim of the PT Programme.....	91
3.4.2	Design of the PT Programme.....	92
3.4.3	Quantification (Energy Expenditure) of BT and PT Programme.....	96
3.5	<i>METHODS</i>	96
3.5.1	Participant selection	97
3.5.2	Sample	98
3.5.3	Informed consent	99
3.6	<i>PROCEDURES</i>	99
3.6.1	Ethical approval from the South African Defence Force Ethics Committee	99
3.6.2	Ethical approval from the Medical Faculty of the University of Pretoria	100
3.6.3	Financial approval for Bone Density tests	100
3.6.4	Logistical planning details for Pre-testing procedures	100
3.6	<i>TESTING PROTOCOL</i>	102
3.7.1	Health and Physical Activity Questionnaire	102
3.7.2	Biokinetic evaluation.....	102



3.7.3	Bone density	120
3.7.4	Standard fitness test.....	123
3.8	<i>TWELVE WEEK BT PERIOD</i>	125
3.8.1	BT programme	125
3.8.2	Menstrual history questionnaire	125
3.8	<i>STATISTICAL ANALYSIS</i>	125
3.9.1	Descriptive statistics.....	126
3.9.2	Inferential statistics.....	127
CHAPTER 4	129
RESULTS AND DISCUSSION		
<hr/>		
..... 129		
4.1	<i>PRIMARY OBJECTIVES</i>	129
4.2	<i>SECONDARY OBJECTIVE</i>	129
4.3	<i>STRESS FRACTURES INCIDENCE DURING BT</i>	130
4.3.1	Cohort size	131
4.3.2	Risk	132
4.3.3	Scientifically designed progressive PT Programme	133
4.4	<i>RISK FACTORS RESULTS</i>	133
4.4.1	Intrinsic risk factors.....	133



4.4.2	Extrinsic risk factors	232
4.5	<i>STUDY DESIGN</i>	239
CHAPTER 5.....		241
CONCLUSIONS AND RECOMMENDATIONS		
.....		241
5.1	<i>RECOMMENDATIONS AND FUTURE RESEARCH</i>	251
5.1.1	Study design	251
5.1.2	Intrinsic risk factors.....	251
5.1.3	Extrinsic risk factors	252
5.2	<i>RESEARCH LIMITATIONS</i>	253
BIBLIOGRAPHY		255
APPENDIX A		A-1
<i>INFORMED CONSENT FORM</i>		A-1
APPENDIX B		B-1
<i>GENERAL ACTIVITY AND HEALTH INFORMATION QUESTIONNAIRE</i>		B-1
APPENDIX C		C-1
<i>MENSTRUAL HISTORY QUESTIONNAIRE</i>		C-1

CONTENT OF COPY DISK

COPY DISK APPENDIX A: Basic Training block programme



COPY DISK APPENDIX B: Physical Training Programme

COPY DISK APPENDIX C: Physical Training Instructors Manual

COPY DISK APPENDIX D: Biokinetic variables descriptive statistics

COPY DISK APPENDIX E: Bone density descriptive statistics

COPY DISK APPENDIX F: Descriptive statistics of Menstrual History
Questionnaire

COPY DISK APPENDIX G: Standardised Fitness Test descriptive statistics

LIST OF OF TABLES

Table 2.1	Bone's moment of inertia properties (Brukner et al., 1999).....	23
Table 2.2	Phases of bone remodelling	26
Table 2.3	Incidence of stress fracture rate in military studies undergoing BT.	35
Table 2.4	Site distribution, expressed in percentage, of stress fractures incurred by military recruits undergoing BT.....	38
Table 2.5	Studies that have investigated the association between foot morphology and stress fractures.....	49
Table 3.1	Application of training principles to develop muscular strength and muscular endurance based on fitness goals.....	95
Table 3.2	Detailed outline of practical programme followed to complete testing of all variables.....	101
Table 3.3	Acceptable levels for hip to waist ratio	113
Table 3.4	Foot type categorisation based on footprint.....	116
Table 3.5	Ratings for Handgrip strength test (Heyward, 2002).....	120
Table 4.1	Chronological age of the participants in years	134
Table 4.2	Sex of the participants	135
Table 4.3	Race of the participants	136

Table 4.4	Classification of foot type (left).....	138
Table 4.5	Classification of foot type (right).....	138
Table 4.6	Leg-length discrepancy expressed in percentage of occurrence ..	141
Table 4.7	Bone status of participant T-scores according to the WHO guidelines.....	145
Table 4.8	History of fracture	147
Table 4.9	Activity levels of the participants	160
Table 4.10	Kind of sport the participants participated in	160
Table 4.11	Isokinetic strength changes that occurred in the male participants during 12 weeks of BT.....	183
Table 4.12	Isokinetic strength changes that occurred in female participants during 12 weeks of BT.....	187
Table 4.13	Relationship between group membership and pass rate at the Pre- test (Measurement A).....	195
Table 4.14	Relationship between group membership and pass rate at the first Post-test (Measurement B).....	197
Table 4.15	Relationship between group membership and pass rate at the last Post-test (measurement C)	198
Table 4.16	Means and standard deviations of selected anthropometric characteristics at the start of BT	204

Table 4.17	Dual-energy X-ray absorptiometry assessed changes of regional body composition, of the female participants over 12 weeks of BT.....	214
Table 4.18	Regularity of menstrual cycle	224
Table 4.19	Nature of changes in menstrual period during BT	226
Table 4.20	Chronological age of menarche onset in female cohort undergoing 12 weeks of BT	227
Table 4.21	Previous history of the incidence and area of injury prior to the start of BT	232
Table 4.22	Mean energy expenditure for male and female participants during 12 weeks of BT	234

LIST OF FIGURES

Figure:2.1	Hypothetical mechanism for progression of fatigue failure in bone	29
Figure 2.2	Pathogenesis of a stress fracture (Bennell & Brukner, 2005)	30
Figure 2.3	Average % stress fracture incidence during BT 1977-2007	37
Figure 2.4	Identified intrinsic and extrinsic risk factors within the stress fracture literature	41
Figure 2.5	Factors that can influence the risk of stress fractures	42
Figure 4.1	Changes in the Q angle after 12 weeks of BT.....	139
Figure 4.2	Changes in leg-length after 12 weeks of BT	140
Figure 4.3	Bone density classification according to the WHO guidelines ...	143
Figure 4.4	Changes in Total Body - Area (cm ²) after 12 weeks of BT in female participants	150
Figure 4.5	Changes in AP Spine - Area (cm ²) after 12 weeks of BT in female participants	151
Figure 4.6	Changes in Left Femur - Area (cm ²) after 12 weeks of BT in female participants	151

Figure 4.7	Changes in Total Bone Density T-scores and Z-scores after 12 weeks of BT in female participants	152
Figure 4.8	Changes in AP Spine T-scores after 12 weeks of BT in female participants	153
Figure 4.9	Changes in AP Spine Z - scores after 12 weeks of BT in female participants	153
Figure 4.10	Changes in Left Femur T - scores after 12 weeks of BT in female participants.	154
Figure 4.11	Changes in Left Femur Z - scores after 12 weeks of BT in female participants	155
Figure 4.12	Statistically significant changes in BMC after 12 weeks of BT in female participants	156
Figure 4.13	Differences (within males) in the EG and CGs in the time taken to complete the 2.4 km run	164
Figure 4.14	Differences (within females) in the EG and CG in the time taken to complete the 2.4 km run	165
Figure 4.15	Differences (within males) in the EG and CG in the time taken to complete the 4km walk	166
Figure 4.16	Differences (within females) in the EG and CG in the time taken to complete the 4 km walk	167
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.....	168

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	170
Figure 4.19	Differences (within males) in the EG and CG in the number of push-ups completed in two minutes	173
Figure 4.20	Differences (within females) in the EG and CG in the number of push-ups completed in two minutes	174
Figure 4.21	Differences (within males) in the EG and CG on the number of sit-ups completed in 2 minutes.....	175
Figure 4.22	Differences (within females) in the EG and CG on the number of sit-ups completed in 2 minutes.....	176
Figure 4.23	Differences in the amount of sit-ups and push-ups performed by male participants in the EG and CG	178
Figure 4.24	Differences in the amount of sit-ups and push-ups performed by female participants in the EG and CG	179
Figure 4.25	Differences in isometric handgrip strength between the EG and CG in male participants during 12 weeks of BT	180
Figure 4.26	Differences in isometric handgrip strength of female participants between the EG and CG during 12 weeks of BT.....	181
Figure 4.27	Changes in male participants' isokinetic knee extension/ flexion and ankle plantar/dorsi flexion relative peak torque during 12 weeks of BT.....	185

Figure 4.28	Changes in male participants' isokinetic knee extension/ flexion and ankle plantar/dorsi flexion absolute peak torque during 12 weeks of BT.....	186
Figure 4.29	Changes in female participants' isokinetic knee extension/ flexion and ankle plantar/dorsi flexion relative peak torque during 12 weeks of BT.....	189
Figure 4.30	Changes in female participants' isokinetic knee extension/ flexion and ankle plantar/dorsi flexion absolute peak torque during 12 weeks of BT.....	190
Figure 4.31	Differences (within males) in the EG and CG on the time taken to complete the 10 x 22m shuttle run test.....	191
Figure 4.32	Differences (within females) in the EG and CG on the time taken to complete the 10 x 22m shuttle run test.....	192
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 ...	193
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..	194
Figure 4.35	Changes in flexibility measurements of male participants during 12 weeks of BT (ankle plantarflexion, dorsiflexion and hip external rotation)	201
Figure 4.36	Changes in flexibility measurements of female participants during 12 weeks of BT (ankle plantarflexion, dorsiflexion and hip external rotation)	202

Figure 4.37	Changes in anthropometric measurements of male participants during 12 weeks of BT.....	207
Figure 4.38	Changes in anthropometric measurements of female participants during 12 weeks of BT.....	210
Figure 4.39:	Dimensional representation of the somatotype changes in the male and female participants during 12 weeks of BT.....	212
Figure 4.40	Dual-energy X-ray absorptiometry assessed changes in body mass (kg), of female participants over 12 weeks of BT.....	215
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)	216
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).....	219
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).....	220
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).....	221
Figure 4.45	Changes in resting blood pressure measurements of male and female participants during 12 weeks of BT.....	222