

**INJURIES SUSTAINED BY FEMALE
INFANTRY TRAINEES DURING
BASIC TRAINING:
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ABSTRACT

Infantry trainees reported approximately 50 exercise-related injuries as a larger-than-expected number of shin-splint injuries, over a 12-week period, during basic training. Of these 13 female infantry trainees, with each of them having sustained a least one pubic stress fracture, sustained a total of 18 stress fractures. The aim of this study was to try and understand the causative factors and the mechanisms by which female infantry trainees interact in order to prevent stress fractures in female infantry trainees in future. Both extrinsic and intrinsic factors were investigated. The potential extrinsic risk factors that were investigated included the training block programme and the physical training programme. The block-training programme shows that intense training was carried out from 08:00 to 16:25 for a period of 12 weeks and that the majority of the 56 periods of drill occurred in the first four weeks of training. Three physical training (PT) periods of 40 minutes were conducted weekly as well as one period weekly at the swimming pool. Additionally mixed training of male and female recruits took place where the female infantry trainee is forced to increase her stride length during drill. The potential intrinsic factors were also investigated. Of these body composition, muscle strength and skeletal alignment were of a concern. The female infantry trainees had a mean %BF of 31.1% as well as a mean waist-hip ratio (0.77) that was lower than the age related mean (0.86). Both the mean quadriceps muscle strength (175n/m-right and 166n/m- left) and the mean hamstring muscle strength (112n/m-right and 109n/m- left) were below the gender related norm (230n/m- quadriceps and 130n/m- hamstrings). In both limbs the Q-angle of the female infantry trainees (Q = 19.92°-right and 17.54°-left) was found to be greater than the acceptable norm (Q = 15°). In conclusion, it is clear that the following four interventions should be revisited to reduce the risk for stress fractures in female infantry trainees: the mixed training of male and female recruits; ensure that short recruits are placed in the front part of the squad during drill; ensure scientifically based PT training programme is

followed and a pre-selection in which potential intrinsic risk factors are assessed.

Key words: Intrinsic risk factors, extrinsic risk factors, pelvic stress fractures, female infantry trainees.

INTRODUCTION

In order to prevent injuries, such as the high incidence of training injuries sustained by female infantry trainees during basic training, the causative factors and the mechanisms by which they interact must be clearly understood. Risk factors for any injury may be classified as intrinsic or extrinsic. Whereas extrinsic factors are characteristics of the environment in which the recruit participates, intrinsic factors are characteristics of the recruits themselves. Injuries occur as a result of various extrinsic and intrinsic factors at a given point in time. Infantry trainees reported approximately 50 exercise-related injuries as well as a larger-than-expected number of shin-splint injuries during basic training. The 13 female Infantry trainees sent to a military hospital sustained a total of 18 stress fractures, with each recruit having sustained a least one pubic stress fracture. Since the precise nature of the kinds of injuries sustained is unclear, only broad guidelines for preventing such a high incidence of training injuries in the future can be given.

However, the precise causes can only be speculative. The following potential extrinsic risk factors for training injuries, especially stress fractures, include:

- a. Physical training:
 - i. Physical fitness
 - ii. Volume of training
 - iii. Pace of training
 - iv. Intensity of training
 - v. Recovery periods
- b. Extrinsic mechanical factors:
 - i. Surface
 - ii. Footwear, insoles and orthotics
 - iii. External loading

Of the factors listed above, the following were available for evaluation.

Training block programme

The following aspects of a training regime may reduce stress fracture development. These interventions include rest periods (Scully & Besterman, 1982), elimination of running and marching on concrete (Greaney, Gerber & Laughlin, 1983), use of running shoes instead of combat boots (Greaney *et al.*, 1983), and reduction of high-impact activity (Scully & Besterman, 1982). These interventions may reduce stress-fracture risk by providing the time for bone micro damage to be repaired and by decreasing the load applied to bone.

The block training programme for basic military training shows that intense training was carried out from 08:00 to 16:25, Mondays to Fridays, and that unit routine was followed on Saturdays and Sundays. The block programme also indicates that three physical training (PT) periods of 40 minutes were held every week as well as one period weekly at the swimming pool. A total of 56 periods of 40 minutes each were dedicated to drill. It appears that most of the drill occurs in the first four weeks of training.

Another area of concern is that mixed training of male and female recruits is currently being undertaken. During drill periods this forces female recruits to increase their stride length as well as their route march speed when marching. Studies (Pope, 1999; Kelly, Jonson, Cohen & Shaffer, 2000) have reported a decrease in pelvic stress fractures by decreasing stride length. Another study found that recruits with pelvic stress fractures were relatively short and reported marching at the back of their training divisions, thus always having to increase their stride length (Devas & Sweetman, 1956).

What is not indicated on the training programme is the surface on which the training took place. Training surface has long been considered to be a contributor to stress fracture development (Steele & Milburn, 1988). Anatomic and biomechanical problems can be accentuated through the use of cambered or uneven surfaces, and ground reaction forces are increased by using less compliant surfaces (Brunker, Bennell & Matheson, 1999). Although there is no data available to specifically assess the relationship between training surface and stress fractures, it may be prudent to minimise the time spent training on hard, uneven surfaces. Finally, the manner in which the training was conducted as well as the activity (e.g. running that took place between periods and during the recruits' 'off-time'), which is part of military culture, is not highlighted.

PT programme

Repetitive mechanical loading that arises from physical training contributes to stress fracture development. However, the contribution of each training component (type, volume, intensity, frequency, and rate of change) to stress fracture risk has

not been elucidated. Training may also influence bone indirectly, through changes in levels of circulating hormones, through effects on soft-tissue composition, and through associations with menstrual disturbances (Bennell, Malcolm & Thomas, 1996).

Physical fitness

It is unclear whether a lack of prior physical activity and poor physical conditioning predispose a person to stress fractures. However, the larger prospective studies tend to suggest that physical fitness is not a predictor of stress fracture risk in people who are undergoing military training (Bennell *et al.*, 1996). Physical Training (PT) presented during Basic Training is clearly outlined in the Organisations PT instruction.

Intrinsic factors

Potential intrinsic risk factors for training injuries, especially stress fractures, include:

- a. Intrinsic mechanical factors:
 - i. Bone-mineral density
 - ii. Bone geometry
 - iii. Skeletal alignment
 - iv. Body size and composition
 (Bennell *et al.*, 1996)

- b. Physiological factors:
 - i. Bone turnover
 - ii. Muscle flexibility and joint range of motion
 - iii. Muscular strength and endurance (Bennell *et al.*, 1996)
- c. Nutritional factors:
 - i. Calcium intake
 - ii. Caloric intake and eating disorders
 - iii. Nutrient deficiencies (Bennell *et al.*, 1996)
- d. Hormonal factors:
 - i. Sex hormones
 - ii. Menarcheal age
 - iii. Other hormones (Bennell *et al.*, 1996)

The difficulty with investigating intrinsic factors is that they are particular to the recruits themselves. In this historical cohort study (Brunker *et al.*, 1999), historical records from the sickbay were used to identify the exposure group. Some of those recruits were contacted to ascertain the presence or outcome of a training injury. The weakness of this design is four-fold, namely:

- i. It is prone to more sources of error (bias and confounding).
- ii. The majority of factors are evaluated/measured only after the injured recruits have already experienced the training injuries.
- iii. There is no control group; thus comparisons can only be made with existing norms for the particular age group and gender.

- iv. Not all the factors are evaluated/measured due to time and financial constraints.

METHODOLOGY

Physical characteristics and diagnoses

Of the estimated 50 training injuries that occurred, only 13 were seen and evaluated at the military hospital. This does not give a clear picture of all the training injuries that occurred during the basic training course. It is useful to gain a better insight into the possible causes of the injuries and possibly narrow down these causes and implement possible corrective steps to reduce the risk of similar injuries in future training.

The physical characteristics and diagnoses of the 13 injured trainees are summarised in Table 1 and the age distribution is illustrated in Figure 1.

RESULTS AND DISCUSSION

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 (Brunker *et al.*, 1999).

Table 1: Physical characteristics and diagnosis.

Ser no.	Gender	Mean age (yrs)	No. of stress #	No. of Pubic stress #	Others
1	All female	20.3	20	18 (10- R; 8- L)	2 (L3; distal tibia)

Table 2: Summary of female infantry trainees' mean body size and composition.

Ser No.	Weight (kg)	Height (cm)	Body fat (%)	Ideal % Body Fat	Waist-Hip ratio	BMI
1	61.4	158.5	31.1	24	0.77	24.51

Table 3: Summary of female infantry trainees mean somatotype.

Ser No.	Endo	Meso	Ecto	X value	Y value
1	7.89	4.46	1.06	-6.76	-0.02

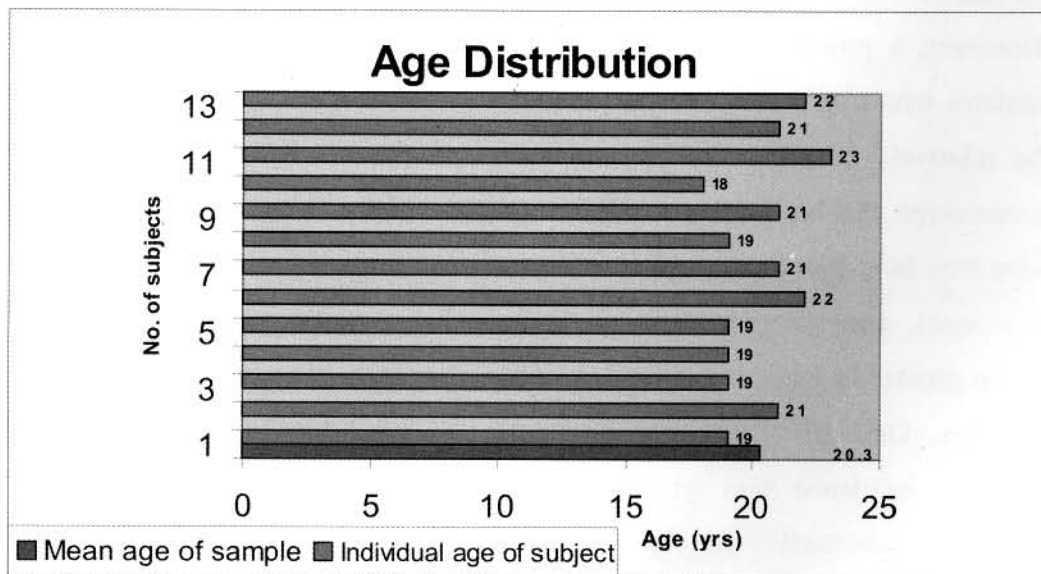


Figure 1: Age distribution of the female infantry trainees with stress fractures.

Body size and composition could also have indirect effects on stress-fracture risk by influencing bone density or menstrual function. A number of potential risk factors related to body size and composition have been reported in stress-fracture literature, including height, weight, body-mass index (BMI), skinfold thickness, total and regional lean mass and fat mass, limb and segment lengths, and body girths and widths (Brunker *et al.*, 1999).

Researchers (Bennell *et al.*, 1996) have failed to find significant differences in height, weight, BMI or fat mass in athletes who developed stress fractures compared to those who did not. However, a possible explanation is that athletes who play a specific sport tend to be relatively homogeneous in terms of somatotype and body composition. Body size may be a risk factor among military personnel, since size variations are likely to be greater in these individuals than in athletes. One study found that stress fracture incidence was greater among smaller individuals (Beck, Ruff & Mourtada, 1996). The researchers surmised that weight packs and other

equipment were carried regardless of the recruits' body weight. It is also possible that the fractured group's lower BMI was indicative of relatively lower muscle mass and/or poorer physical conditioning before training started.

Tables 2 and 3 summarise the body size, composition and somatotype of the female recruits. Figures 2, 3, 4, 5 and 6 illustrate weight distribution, height distribution, mean percent body fat, mean waist-hip ratio and mean BMI in relation to the age-related acceptable norms of the female recruits. A high percent body fat amongst the female infantry trainees is consistent with a study in which the physical fitness levels of recruits entering the U.S. Army in 1998 were compared to those entering in 1978 and 1983 (Sharp, Patton, Knapik, Hauret & Mello, 2002). This study found a greater percentage of body fat in the 1998 recruits. A high percentage of body fat is an indication of poor physical conditioning as well as nutritional status. A lower waist-hip ratio in relation to the norm is of concern in female marine trainees; a narrow pelvis (< 26 cm) was associated with a greater

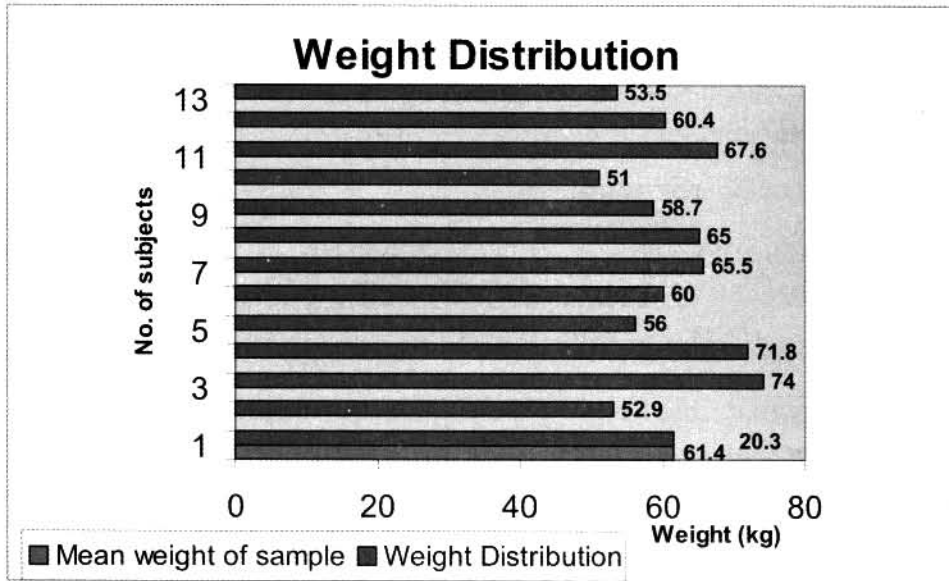


Figure 2: Weight distribution of the female infantry trainees with stress fractures.

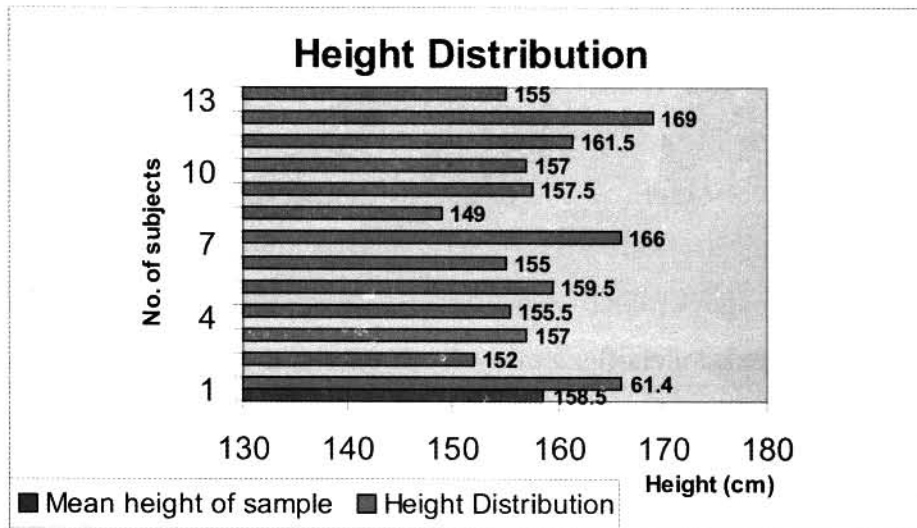


Figure 3: Height distribution of the female infantry trainees with stress fractures.

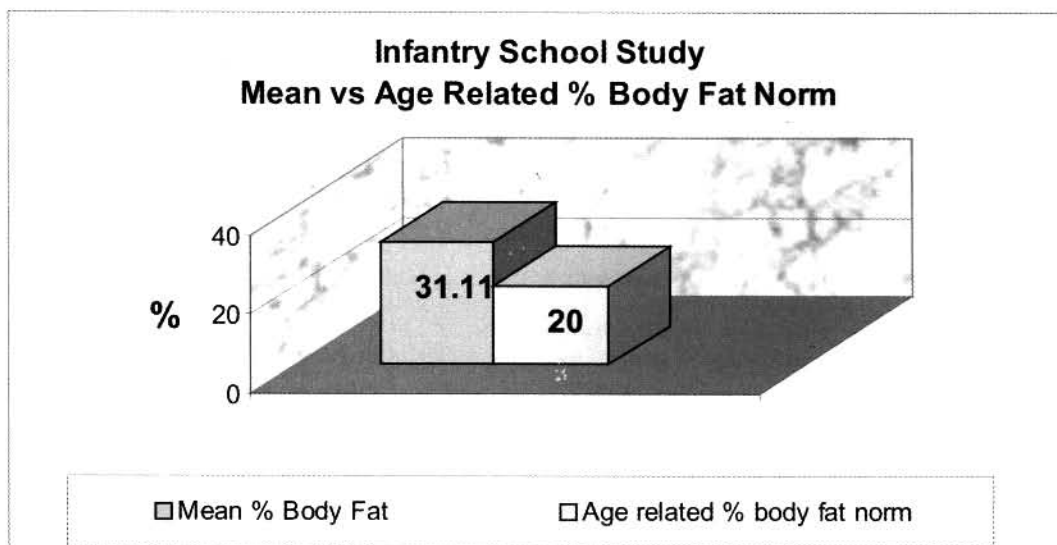


Figure 4: Mean % body fat of the female infantry trainees with stress fractures.

risk of stress fracture (Winfred, Bracker, Moore & Johnson, 1997). Stress-fracture incidences in women who had a narrow pelvis were 14%, compared to 4% in women who had a wider pelvis. An explanation for this finding is unclear, as a wider pelvis has typically been attributed to increased biomechanical stresses through an increase in the Q angle.

Muscle flexibility and joint range of motion

Flexibility of muscles and joints may directly influence stress-fracture risk by way of altering the forces applied to the bone. Numerous variables have been assessed, including range of rear foot inversion-eversion, ankle dorsiflexion-plantarflexion, knee flexion-extension, and hip rotation-extension, together with length of calf, hamstring, quadriceps, hip adductors and hip flexor muscles (Brunker *et al.*, 1999). Of the variables, only range of hip external rotation and range of dorsiflexion have been associated with stress-fracture development (Giladi, Milgrom, Simkin & Danon, 1991). The difficulty in assessing the role of muscle and joint flexibility in

stress fracture may be related to the imprecise measurement methods often used.

With the 13 female infantry trainees, the standard sit-and-reach flexibility test was performed. This test gives an indication of hamstring and lower-back flexibility and is often used as an indicator of overall flexibility in mass screening. The recruits do not appear to have a general problem with their flexibility as they are not far from the age-related acceptable norm as indicated in Figure 7.

Muscular strength and endurance

Skeletal muscle attenuates and dissipates forces applied to bone (Meyer, Salzman & Albright, 1993). During running, each foot strikes the ground approximately 500 times per kilometre. Each heel strike generates vertical ground-reaction forces that vary from two to five times body weight. The forces can be considerably higher: up to twelve times body weight during jumping and landing activities (Brunker *et al.*, 1999).

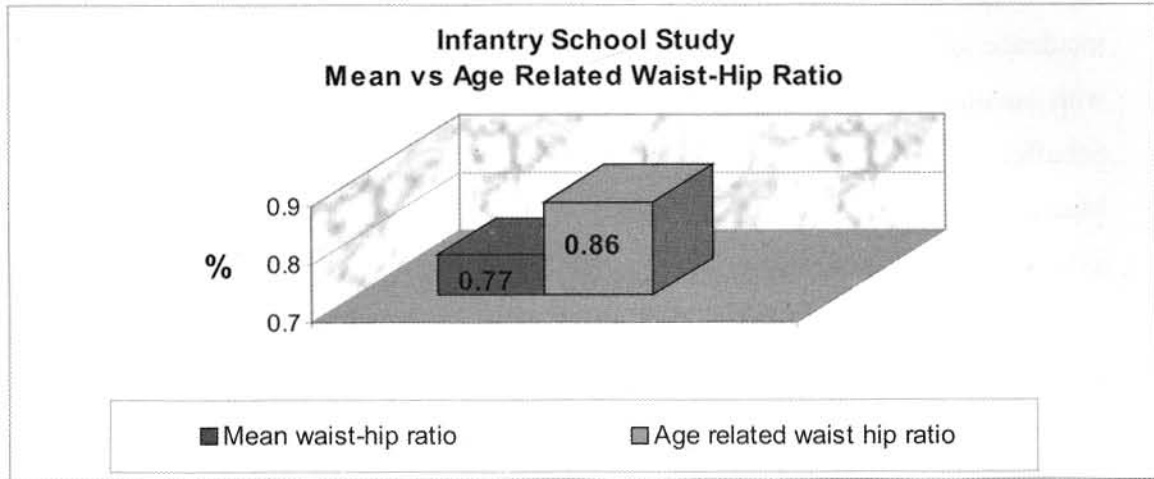


Figure 5: Mean waist-hip ratio of the female infantry trainees with stress fractures.

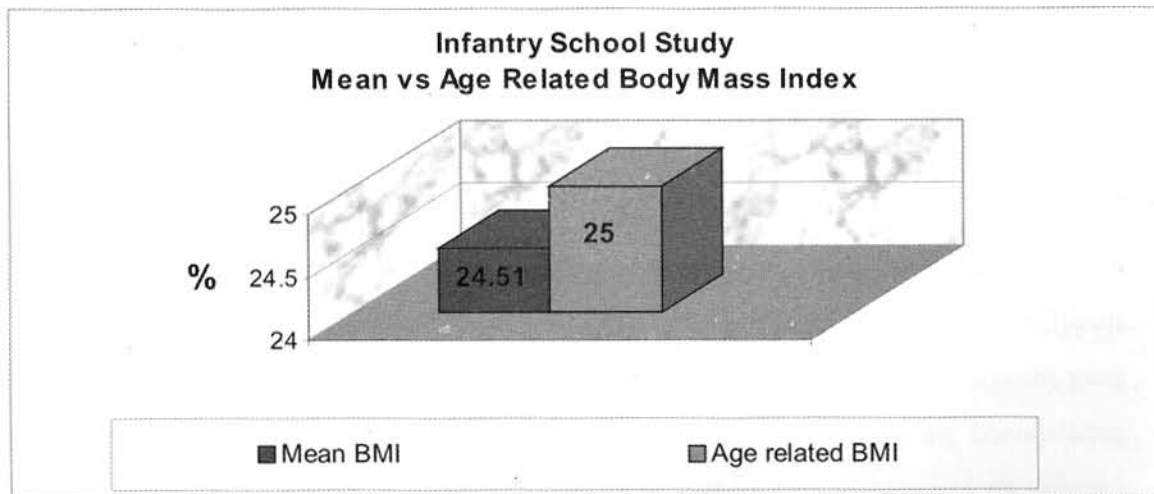


Figure 6: Mean body mass index (BMI) of the female infantry trainees with stress fractures.

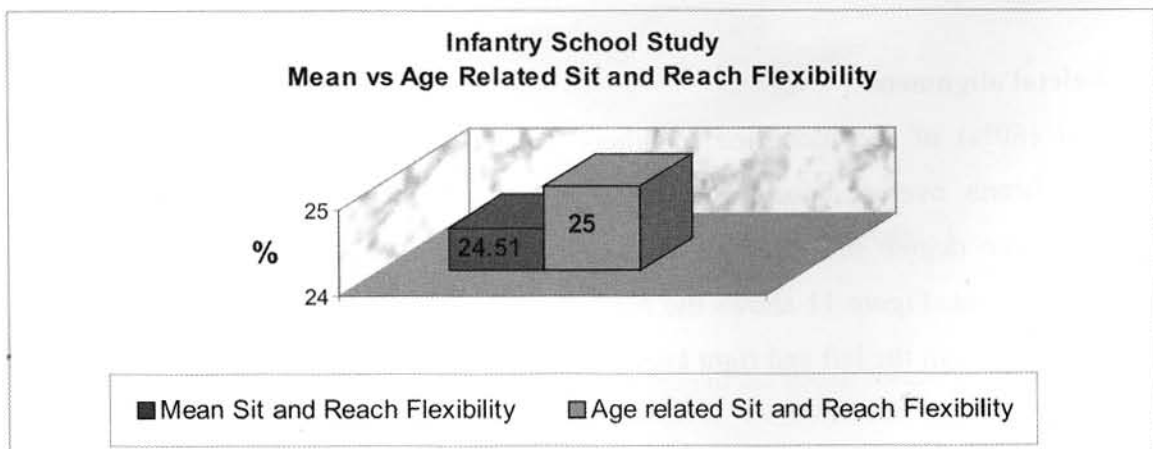


Figure 7: Mean sit-and-reach flexibility of the female infantry trainees with stress fractures.

One study found that there was a greater incidence of stress fractures in recruits with smaller thigh muscles (Beck, Ruff, Schaffer & Betsinger, 2000). Measurement of muscle size can be indicative of that muscle's ability to generate force. Male recruits who had a larger calf circumference developed significantly fewer femoral and tibial stress fractures (Brunker *et al.*, 1999).

The 13 female infantry trainees underwent isokinetic evaluations of the quadriceps and hamstring muscles at the military hospital. Figures 8, 9 and 10 clearly illustrate that the recruits' leg strength was poor, although the quadriceps/hamstring ratio was fine. The poor muscle strength could therefore have predisposed them to stress fractures by causing an increase in or a redistribution of stress to the bone (Rudski & Cunningham, 1999).

Skeletal alignment

Most (80%) of the identified members with chronic overuse injuries are women with some degree of lower-leg skeletal misalignment. Figure 11 shows the mean Q-angle of both the left and right knee. In

both limbs the Q-angle of the female infantry trainees was found to be greater than the acceptable norm. Cowan *et al.* (1996) found that trainees who had a Q angle of more than 15° had a relative risk of stress fracture that was 5.4 times that of recruits who had an angle smaller than 15°. Literature has identified other possible alignment features, which suggests these features play a role in stress fracture development that was not measured. These include:

- a. Foot type
- b. Leg-length discrepancy

Research has failed to find an association between biomechanical features and stress fractures in cohort studies, although this does not rule out the importance of these features in recruits (Brunker *et al.*, 1999). Until the contribution of biomechanical abnormalities to stress-fracture risk is clarified through scientific research, correction of the abnormalities should be attempted.

CONCLUSION

Although overuse injuries and fatigue fractures are not unusual in military personnel, those of the pubic ramus are rare (Lee & Lee, 2005).

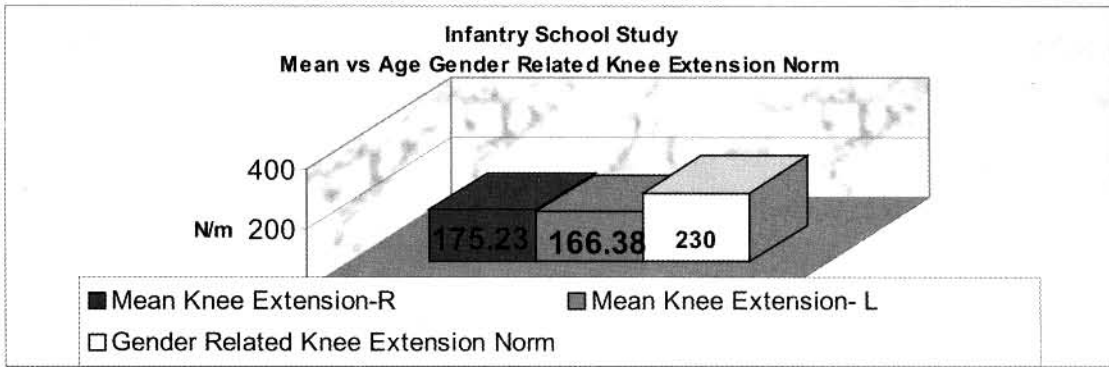


Figure 8: Mean quadriceps muscle strength of the female infantry trainees with stress fractures.

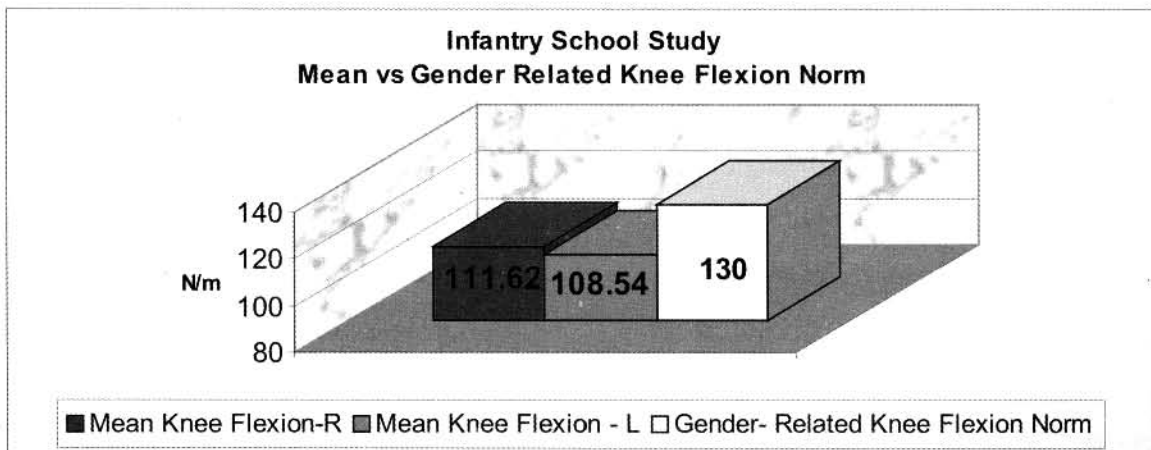


Figure 9: Mean hamstring muscle strength of the female infantry trainees with stress fractures.

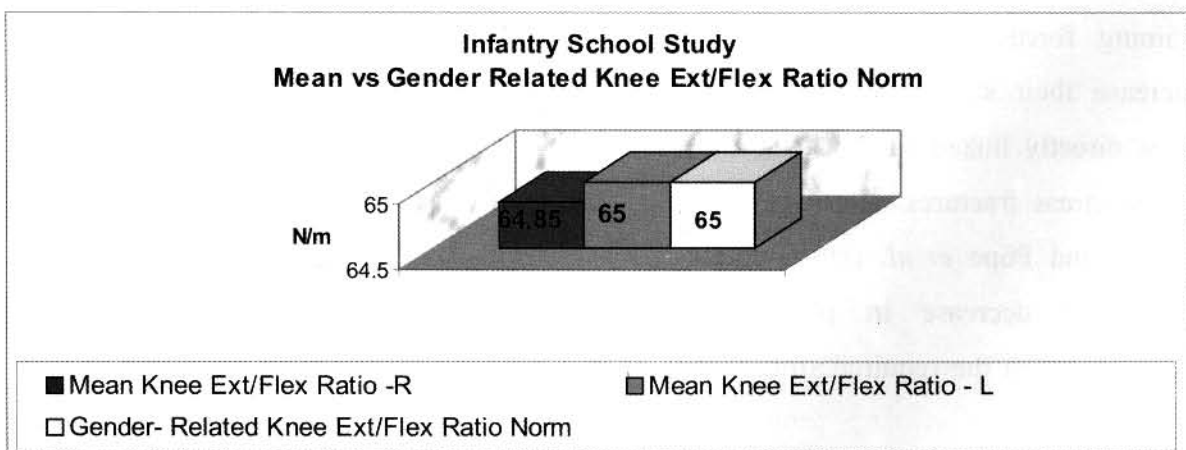


Figure 10: Mean quadriceps/hamstring muscle-strength ratio of the female infantry trainees with stress fractures.

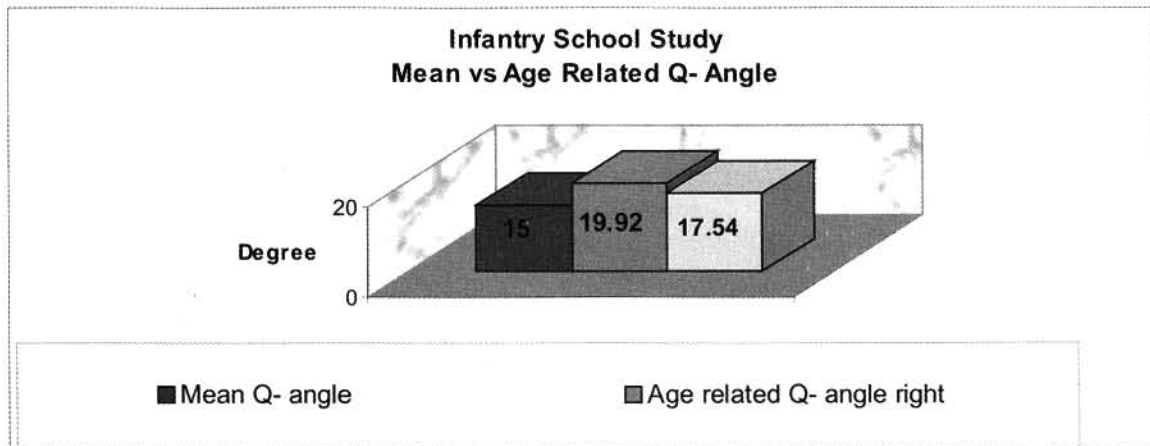


Figure 11: Mean Q angle of the female infantry trainees with stress fractures.

What is worrying is that of the 13 female infantry trainees evaluated at the military hospital, 18 pubic ramus stress fractures were diagnosed. Five of the 13 were diagnosed with bi-lateral inferior pubic ramus stress fractures, whilst 12 of the 18 were found to be inferior pubic stress fractures. Studies (Hill, Charterji, Chambers & Keeling, 1996; Pope, 1999; Kelly *et al.*, 2000) have found that mixed training forces the female recruits to increase their stride length, which has been directly linked to the incidence of pelvic stress fractures. Both Hill *et al.* (1996) and Pope *et al.* (1999) found a significant decrease in pelvic stress fractures when the required stride length was reduced.

This report indicates that four clear interventions regarding training should be revisited, namely:

- a. The mixed training of male and female recruits
- b. Ensuring that short recruits are placed in the front part of the squad during drill

- c. An evaluation of exactly what PT training is done and by whom
- d. Evaluating and monitoring the manner in which training is conducted during the recruits' 'off-time' and in between periods.

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