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Risk factors for lower leg, ankle and foot injuries during basic military training in the Maltese Armed Forces

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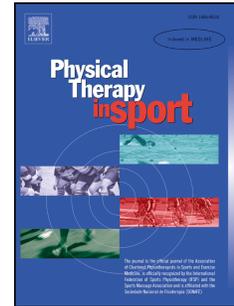
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Project Title:

RISK FACTORS FOR LOWER LEG, ANKLE AND FOOT INJURIES DURING
BASIC MILITARY TRAINING IN THE MALTESE ARMED FORCES

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Abstract

Objectives: Basic military training is physically and psychologically demanding placing recruits at high risk of injury and premature discharge. This study aimed to identify risk factors for lower leg, ankle and foot injury in Maltese military recruits during basic training.

Design: This was a prospective cohort study.

Setting: An armed forces barracks.

Participants: 127 recruits commencing one basic military training course agreed to participate in the study. The cohort comprised 114 males and 13 females with a mean age of 21.7 ± 2.4 years.

Main Outcome Measures: All injuries to the lower leg, ankle and foot were recorded using the Orchard Sports Injury Classification System. Injuries were analysed for associations with fitness scores, smoking status, body mass index and foot type.

Results: A total of 34 (26.2%) recruits sustained at least one injury, with 10 recruits (7.9%) terminating their training prematurely (three due to musculoskeletal injury). Smoking history, body mass index and foot type were not associated with injury risk. Lower fitness levels at the commencement of basic military training compared with fitness levels measured six months prior, were associated with higher injury risk.

Conclusions: Lower fitness at the commencement of basic training was associated with higher injury risk in army recruits. Thus, conditioning

programmes aimed at improving recruit fitness should be considered within an injury prevention strategy.

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Keywords

Basic military training, pre-conditioning, smoking, body mass index, foot type,
recruits

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Introduction

Basic Military Training (BMT) is a psychologically and physically demanding process entailing high intensity training for the purpose of attaining physical standards set by armies (Leggat & Smith, 2007). Despite medical and training advances, injuries sustained to the lower limb during BMT remain common (Jones et al., 2010) and often result in failure to progress through training (Heir & Glomsaker, 1996), trainee wastage (Talcott et al., 1999) and present a considerable financial burden. Auditing recruit characteristics and training outcomes may allow for better recruit selection to reduce BMT morbidity (Thacker et al., 2012).

With specific reference to the military population being studied, musculoskeletal (MSK) injuries have been linked to a number of premature discharges from the Armed Forces of Malta (AFM) within the first few weeks of BMT. In 2013, a dropout rate of 16% was observed during BMT. Although reasons to resign are multifactorial, the most cited reason in this recruitment process (26% of recruits) was inability to cope with training as a consequence of a MSK injury. This represents 4.6% of the total number of recruits in January 2013, slightly higher than Norwegian recruits (2.1%) (Heir & Glomsaker, 1996) and US Air Force (6.2%) (Talcott et al., 1999). In a recent study of BMT related injuries in both infantry and non-infantry unit recruits, a discharge rate of 3.4% was observed with MSK reasons accounting for 43% (Schwartz et al., 2014). Reduction of MSK injuries may follow improvements in the pre-recruitment selection process and BMT modification (Rudzki & Cunningham, 1999).

Lower leg and ankle injuries are amongst the most common injury type identified during BMT in the US military. Compared to the general population, ankle sprain rates are up to five times higher than in the general population (Cameron et al., 2010) accounting for 15% of all reported injuries during predeployment training of British army infantry soldiers (Wilkinson, 2011). These injuries result in considerable duty time-loss (Wilkinson, 2011) and long-term morbidity, with 20-40% of patients at risk of developing chronic ankle instability (Hintermann, 1999).

The repetitive highly intense physical training within short time frames is a significant contributor to the high rate of gradual onset (overuse) injuries (Kaufman et al., 2000). In a study of 18,651 recruits, overuse injuries accounted for 90% of all injuries (Schwartz et al., 2014). This emphasises the need to explore novel methods of decreasing the risk of gradual-onset injuries during BMT.

Body mass index (BMI) trends in the general population are reflected in the applicants for military enlistment (Hsu et al., 2007). In 2008, 58.5% of the Maltese population were reported to have a BMI exceeding 25kg/m² (NSO, 2010). High BMI scored have been linked to increased sick days, higher financial expenditures (Kyrolainen et al., 2008), medial tibial stress syndrome (Hamstra-Wright et al., 2015) and discharge rates in recruits (Packnett et al., 2011). The degree of association between BMI and body composition is also unclear (Reed et al., 2010) as BMI correlates poorly to lean body mass (Garrido-Chamorro et al., 2009). Nonetheless, BMI remains a simple method of

grading athletes according to their weight (Mei et al., 2002; Mullie et al., 2008; Portal et al., 2010) and is presently recorded in all Maltese military recruits.

Tobacco smoking, has been associated with higher discharge rates (Larsson et al., 2009) and overuse injury rates, compared to non-smokers (Altarac et al., 2000). Of note, despite successful smoking cessation, ex-smokers still maintained a higher injury risk when compared to non-smoking recruits. However, in a study of Chinese male recruits, smoking status did not increase injury risk (Wang et al., 2003). The latter was also confirmed in a separate study (Trone et al., 2014).

Pes planus (flat) and pes cavus (high arched) foot types are recognised as intrinsic risk factors for lower limb injuries, both generally (Buldt et al., 2013) and in military populations (Yates & White, 2004). However, in a more recent and larger study of military recruits, Knapik (2014) failed to identify a reduction in injury rate during BMT following correction of foot arch height. Foot type may be assessed by the Foot Posture Index-6 (FPI-6), which is a valid (Martin et al., 2005), simple static test that allows quantification of foot type with good inter-rater and intra-rater reliability (Cornwall et al., 2008; Morrison & Ferrari, 2009). Symptoms associated with foot and ankle pathology may be quantified using the foot and ankle ability measure (FAAM), which is a validated evaluative self-reporting questionnaire used to assess limitations in activities in daily living (ADL) and sport participation for leg, foot and ankle injuries (Martin et al., 2005). In view of the lack of studies incorporating the use of the FAAM in a military setting, the presented research project will aim to identify the usefulness of FAAM in quantifying disability secondary to BMT.

Whilst a number of risk factors for injury during BMT have been described, specific screening programmes for lower leg, ankle and foot injury risk have never been undertaken in the Armed Forces of Malta. This aim of this project is to explore injury prevention strategies in an attempt to reduce injury risk and premature discharge rates. Associations between previously identified military and general population risk factors and injury types and rates, will be investigated in Maltese Army recruits. The latter findings may result in modifications in the present selection process. Furthermore, by improving the present recruit screening process, optimisation of recruits prior to start of BMT might contribute to reductions in injury risk.

Methods

Participants

All 127 recruits (114 males and 13 females, mean age 21.7 ± 2.4 years) scheduled to undertake one BMT course in 2014 were invited, and consented, to participate in the research project via a letter that was distributed during medical clearance screening undertaken six months prior to commencing BMT.

There were no specific exclusion criteria as applicants unable to undertake BMT secondary to sudden or gradual onset MSK injuries did not satisfy the pre-set medical standards for enlistment in the Maltese Armed Forces and therefore, would have been barred from enlisting at the initial screening stage. Ethical approval was provided by both the Cardiff Metropolitan University, and the University of Malta ethics boards.

Data Collection

Participant age, gender, height, weight and smoking status were recorded during the initial medical screening. The time period between the screening stage (pre-screening tests) and start of BMT (pre-recruitment tests) was six months. Assessments were carried out as follows:

Body Mass Index: BMI was calculated by dividing the weight in kilograms by height in metres squared. The result has been categorised as per recommendations of the Centre for Disease Control and Prevention (CDC), that is, below 18.5kg/m² underweight, between 18.5 kg/m² and 24.9 kg/m² normal, between 25 kg/m² and 29.9 kg/m² overweight and above 30 kg/m² obese (CDC, 2011).

Foot Posture Index: FPI-6 (Redmond et al., 2008) was conducted at the initial assessment as per reference values set by the author (Table 1). Foot types were further grouped into neutral and non-neutral (supinated or pronated) foot types.

Table 1. Scoring of the Foot Posture Index (Redmond et al., 2008)

Score	Foot type
-1 or lower	Supinated
0 to 5	Normal
6 or higher	Pronated

Fitness Level: The total scores obtained from pre-screening fitness tests conducted six months prior to BMT were recorded. These included a one mile running test, the total number of push-ups completed in two minutes and total number of sit-ups in two minutes, each carrying a score of 100. The mode of grading of these tests, inclusive of results required to attain the minimum (50%) and maximum scores (100%) is shown in Table 2. A maximum fitness test score of 300 was therefore possible. Scores attained from fitness tests conducted in the first week of BMT, were also recorded. The latter were referred to as the pre-recruitment fitness tests.

Table 2. Scoring of the pre-screening fitness test. With regards to push-ups and sit-ups, for every added repetition beyond the 50% mark, 1% is added for every repetition. With re: to the run, for every 3 seconds beyond the 50% mark, 1% is added.

Group (points)	Push-ups	Sit-ups	One mile run (seconds)
Males (100)	80	87	360
Males (50)	30	37	510
Females (100)	55	85	468
Females (50)	15	35	618

Foot and Ankle Ability Measure (FAAM): The FAAM was completed by all recruits at the initial screening stage, with the ADL and sport subscales being scored separately. The FAAM was translated into the Maltese language, with

both English and Maltese versions being available. The FAAM was repeated at the end of BMT. The FAAM screening score measured at pre-screening was expressed as a percentage of the the score attained at the end of BMT. The FAAM has been validated in cases of chronic ankle instability (Carcia et al., 2008) with the ADL subscale validated for use in diabetic patients with foot and ankle pathology (Martin et al., 2009). *Injury Data:* Injuries were defined in accordance with the medical attention definition provided by Clarsen and Bahr (2014). These were events, characterised by MSK symptoms (most notably pain) in a body area of interest, that were reported by a recruit to the AFM medical officer, regardless of whether they resulted in time-lost from, or modification of, BMT. Injuries were sub-classified as gradual-onset injuries (developing over a period of time without a single identifiable inciting event), and sudden onset injuries attributable to an instantaneous event (Yang et al, 2012). All participants were reviewed during the course of their BMT and any injuries were categorised according to the injured side (dominant and non-dominant) and body area involved, i.e. lower leg, ankle or foot. Injuries were coded according to the Orchard Sports Injury Classification System (OSICS) (Rae & Orchard, 2007). Recurrences of the same injury in the same body area were not recorded, however different injuries occurring in the same body area, of the same recruit, were recorded. Injuries diagnosed in body areas that do not involve the lower leg, ankle and foot, were still recorded in the recruit's personal medical files, however, these were not included in the analysis.

Data Analysis

Independent Variables: The independent variables and their categorisation are shown in Table 3.

Table 3. Grouping of independent variables

Variable	Variable type	Categories	
Smoking	Categorical	Smoker	Non-smoker
Gender	Categorical	Male	Female
FAAM	Continuous	Not applicable	
BMI	Categorical	Normal/Underweight	Overweight/Obese
Foot type	Categorical	Neutral	Non-neutral
Fitness level	Continuous	Not applicable	

Dependent Variables: Presence or absence of injury denotes the dependant categorical variable in this research. Injuries were sub-grouped into body area (lower leg, ankle and foot) for each side of the body (dominant and non-dominant limb).

Statistical Analysis

Data was analysed using the Statistical Package for the Social Sciences (SPSS) statistics software version 21. All 127 recruits, including prematurely discharged recruits, comprise the final analysed group. In view of the small number of females comprising the group of recruits, no association was made between gender and injury outcomes. Nonetheless, injury risk and injury risk ratio for male and female recruits was calculated. Independent categorical

variables, including smoking status, BMI and foot type, were analysed against injury outcomes using the Chi-square test. The data collected from the fitness tests was non-parametric and therefore, analyses of fitness level, was made using the Mann-Whitney U test. The results from the fitness tests performed during pre-screening were compared to results of the same fitness tests performed six months later at the start of BMT using the Wilcoxon test. Scores from the FAAM questionnaire attained at the pre-screening stage were descriptively compared to scores obtained after BMT, to assess for changes related to injuries sustained during BMT. Results were considered statistically significant when the measured p-value was less than 0.05.

Results

The duration of BMT was 135 days and as there were 127 participants that equals 17145 days of recruit exposure. There were a total of 45 injuries recorded resulting in an incidence of 0.204 injuries/100days BMT. Twelve were gradual onset injuries and 33 injuries were sudden onset. A total of 35 (27.6%) recruits sustained at least one injury to their lower leg, ankle and/or foot during BMT. The risk of injury was 3.1% in females and 2.7% in males, giving a relative risk ratio of 1.15, that is, the risk of injury is 1.15 times higher for female recruits. The number of injuries per body area, and their incidence rates are shown in Tables 4 and 5. The most common injuries per body area were; medial tibial stress syndrome in the leg, ankle lateral ligament sprain in the ankle, and heel fat pad contusion in the foot.

Table 4. Number and percentage of injuries according to body area

Body area	Number of recruits who sustained at least one injury (%)	Total number of injuries (%)	Incidence per 100 days
Lower leg	10 (7.8)	16 (12.6)	0.06
Ankle	11 (8.7)	12 (9.4)	0.06
Foot	16 (12.4)	17 (13.4)	0.09

Table 5. Number of injuries according to body area and limbs involved

Body area	Number of at least one injury (%)	Total number of injuries (%)	Incidence per 100 days
Dominant lower leg	9 (7.1)	10 (7.8)	0.05
Dominant ankle	6 (4.7)	6 (4.7)	0.04
Dominant foot	9 (7.1)	10 (12.4)	0.05
Non-dominant lower leg	5 (3.9)	6 (4.7)	0.03
Non-dominant ankle	6 (4.7)	6 (4.7)	0.04
Non-dominant foot	7 (5.5)	7 (5.5)	0.04

Premature discharge

One hundred and seventeen recruits (92%) completed BMT with 10 (nine males and one female) recruits (8%) terminating their training prematurely. Personal or unspecified reasons (40%) and knee injuries (20%) accounting for over half of the withdrawals. Only one recruit was discharged for failing to attain the

required standard. Injury was the cause of discharge in three recruits although only one was in one of the three body areas included in the study.

Smoking

The presence (n = 35, 27.6%) or absence (n = 92, 72.4%) of a smoking history was not associated to injury risk during BMT ($X^2(l) = 0.025$, $p = 0.875$).

Body Mass Index

Pre-recruitment BMI scores were not associated with injury risk during BMT ($X^2(l) = 0.724$, $p = 0.395$). The mean BMI score for all the recruits was 24.8kg/m².

Foot type

Dominant limb foot type was not associated with injury to either dominant ($X^2(l) = 0.155$, $p = 0.694$) or non-dominant limb ($X^2(l) = 1.851$, $p = 0.174$). Nor was dominant foot type associated with presence of absence of injury in either limb ($X^2(l) = 1.875$, $p = 0.171$). Non-dominant foot type was not associated with injury to either dominant ($X^2(l) = 0.262$, $p = 0.609$) or non-dominant limb ($X^2(l) = 2.992$, p -value = 0.084). Nor was non-dominant foot type associated with injury in either limb ($X^2(l) = 0.007$, $p = 0.934$).

Fitness scores

The screening stage fitness tests scores were higher than those conducted immediately prior to start of BMT ($T = -9.105$, $p < 0.000$). The screening stage fitness tests scores were not associated with injury risk during BMT ($U = 1371$,

$p = 0.198$). Immediate pre-BMT fitness test scores were associated with injury risk during BMT ($U = 1226$, $p = 0.039$).

Foot and ankle ability measure

The mean percentages of the FAAM ADL subscales measured before and after BMT, were 99.9% and 99.5% respectively. The mean percentages of the FAAM sports subscales measured before and after BMT were 99.6% and 98.7% respectively.

Discussion

This project aimed to improve Maltese military recruit injury prevention strategies through the investigation of risk factors for lower leg, ankle and foot injuries. Of the four risk factors studied, only recruit fitness levels were associated with injury risk. The latter is a modifiable risk factor that could be addressed in future recruitment processes. With reference to body areas of interest, the foot was the most frequently injured, differing from the results of audit work conducted by Jones (2010), in which the lower leg and ankle were the most commonly injured areas during BMT. Gradual onset injuries of the lower leg, particularly medial tibial stress syndrome, were the most common injury type in this study, concordant with rates observed in foreign armies (Kaufman et al., 2000, Schwartz et al., 2014). Therefore, recommendations for training modification in an attempt to reduce gradual onset injuries should be considered for future BMT in the studied population (Kaufman et al., 2000; Wyss et al., 2014).. Such modifications may include gradual running distance increments and night rest to reduce injury risk (Wyss et al., 2014).

Concordant with the results of previous studies, the risk factor associated with injury in this study was fitness level (Knapik et al., 2001; Knapik et al., 2006). Of note, was the considerable drop in fitness test results in the six months between the pre-screening and pre-recruitment stages. The difference between the scores follows the presumption that recruits, after passing their initial pre-screening physical test, did not maintain fitness training and therefore became de-conditioned. This was despite being advised by the military medical officers at the pre-screening stage to maintain their participation in physical training. The study emphasises the need to prevent physical de-conditioning in recruits.

This could be attained by initiatives such as; offering fitness training programmes in the lead up to BMT, and repeating physical testing in the interim between pre-screening and the start of BMT. Knapik (2006) suggests referring recruits who fail the pre-screening test for a fitness assessment programme, where they undertake physical training until they pass their fitness test. Only then would they be allowed to start their BMT. The investigator reported that this intervention reduced injury risk and attrition from BMT. The same could be considered in the Maltese Armed Forces. As an incentive aimed at improving participation in pre-BMT physical training, recruits could be informed in advance that failing the fitness test at the start of BMT may result in the recruit being excluded from enlisting.

With reference to other risk factors, BMI was not associated with injury risk, however, other tests that may correlate better than BMI to body fat percentages such as skin fold measurement and electrical bio-impedance testing, (Mei et al., 2002, Mullie et al., 2008, Portal et al., 2010) should be considered for future

studies, possibly allowing direct associations to be made between body fat percentage and lean muscle mass, to injury risk (Jacobson et al., 2003). Of note, the study has evaluated injury to three (albeit the most commonly involved) anatomical areas and therefore, the association of BMI to the injury occurrence, irrespective of anatomical area, needs to be considered prior to recommending that BMI is of limited use in the military setting.

Scoring of foot type with the FPI-6 was of limited use as, non-neutral foot types were not significantly associated with injury risk. This study therefore does not recommend the introduction of the FPI-6 for screening of military recruits. As with body fat estimation, equipment to measure dynamic plantar pressures, which would better reflect the foot-ground reaction forces than static tests (Zammit et al., 2010), are presently unavailable within the Armed Forces of Malta. Furthermore, despite existent evidence linking non-neutral foot type to gradual onset injury (Yates & White, 2004) , no associations were made between gradual onset injury occurrence and foot type. Further studies in the wider Maltese military population employing other methods of assessing plantar pressures, should be considered.

The FAAM was measured at two stages and in both instances, high scores were obtained. Therefore, in this setting, the FAAM was of limited use. A further possible limitation of the FAAM in this setting would include the reluctance of recruits to admit their limitations in ADL and in sports performance, for fear of being excluded from duty, training or sports participation. Since this study did not assess FAAM at the end of BMT for recruits who were prematurely discharged secondary to MSK injuries, future studies might consider measuring

FAAM score at the time of discharge and allow comparisons to pre-BMT scores. Of note, although the FAAM was available both in English and Maltese, there has been to date no validation of a Maltese version of the FAAM. Further work in this regard is required.

Potential limitations of the medical-attention injury definition is that recruits with symptoms in the body areas of interest may not necessarily consulted the AFM medical officer for review, resulting in underreporting of injuries. With reference to foot type as a risk factor, undisclosed use of insoles by recruits could have potentially altered foot-ground interactions in a way that alters injury risk. As regards the use of the FAAM, despite both English and Maltese versions being made available to recruits, the FAAM in the Maltese language was not validated. Under reporting of smoking habits at the screening stage could have introduced bias in investigating smoking history. On the other hand, over-reporting of smoking habits could result from recruits opting to stop smoking upon starting their BMT. However, with reference to over reporting, if the latter was the case, as described by Altarac (2000) smoking cessation should still have been associated with a higher risk of injury. The association of a positive smoking history to injury risk was however not made in this project.

Conclusion

This study evaluated possible risk factors for lower leg, ankle and foot injury during BMT in the Armed Forces of Malta with the aim of improving selection of recruits and where possible, improving their biophysical profile prior to the start of training. The results raise the importance of educating recruits on the

importance of pre-conditioning, and programming BMT so that gradual onset injury risk is managed without compromising recruits' military development. Suggestions into how the latter could be achieved have been listed in the respective sections.

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Highlights:

- Basic military training is both psychologically and physically demanding
- Factors have been linked with increased injury risk during military training
- Foot type, body mass index and smoking unaltered leg, ankle and foot injury risk
- Lower pre-enlistment fitness scores were associated with increased injury risk
- Strategies for pre-enlistment physical conditioning are encouraged to reduce injury