UNIVERSITEIT VAN PRETORIA
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YUNIBESITHI YA PRETORIA

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

by

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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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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 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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