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EBP: Final Paper

PICO: For men and women in the military training environment, would use of orthotic devices in combat footwear be better than the use of traditional non-shock absorbing insoles at prevention of overuse injuries.

**Introduction**

Recruits performing basic military training (BMT) or their initial phase of training are at high risk for developing exercise related lower extremity injuries1. Exercise related or overuse injuries occur because of the intense physical nature of BMT with rates in the United States service branches from 14 to 42% in men and 27 to 61% in women1. The high occurrence of training related injuries impacts the military’s manpower, finances, and healthcare system1. The majority of training related injury involves the lower extremity and account for about 20-40% of outpatient clinic visits per month in some US military branches1. The magnitude of injuries in BMT leads to a substantial burden on the healthcare services causing longer waiting periods and short visits1. The development of a lower extremity injury prevention program could provide many benefits including: decreasing direct and indirect costs of injury, loss of training days, prevention of program recycling, and reducing strain on the healthcare system1.

The military has started looking into ways to reduce the amount of injuries acquired during training1. Several intrinsic and extrinsic risk factors for training related injuries have been discovered by the military1. One intrinsic factor of great importance is the trainees’ anatomy specifically the morphology of the foot and leg1. Conditions such as pes planus, pes cavus, genu varum, genu valgum, genu recurvatum, excessive Q angle, and leg length discrepancies have all been proposed as potential risk factors but research supporting such claims is limited1. Military recruits across service branches wear combat boots for many activities including marching, obstacle courses, land navigation, and fighting1. Combat boots have been shown to also be an injury hazard during basic military training2. The combination of these two factors provides a unique opportunity for intervention. The use of orthoses in combat/military boots could reduce the incidence of lower extremity training injuries by possibly controlling abnormal biomechanics caused by lower extremity morphology.

The purpose of this literature review is to outline the current knowledge on orthotic lower extremity injury prevention programs in the military population. The review will help determine if the use of orthoses in combat boots is more effective at preventing lower extremity injuries than the typical non-shock absorbing insoles. The results could potentially aid in the implementation of prophylactic orthotic use in the military as well as help direct future research.

**Research Design**

*Military Environment*

Many investigators around the world have been researching the use of BSO for injury reduction in the military population. The different authors and viewpoints allow for a thorough investigation of the effects of BSO but also pose several difficulties. The environment and specific aspects of physical training are different between countries and even between service branches in the United States3. The investigators of BSO effects on lower extremity injuries have studied almost all branches of services (Army, Air Force, and Navy). Comparison of the exact levels of physical activity could not be explored due to lack of information regarding this topic within most of the literature. The time frame of each country’s BMT or initial training period was also variable. The cadets of the Britannia Royal Naval College had a shorter training period of seven weeks compared to fourteen week training for basic training of Israeli infantry recruits4,5,6,7. Along with differences in training, investigators had discrepancies in recruitment.

*Subjects*

The number of subjects varied greatly between studies in part due to the diversity of research designs and because of variations in military population. Many of the investigations performed were completed with convenience samples of new recruits entering BMT. Investigators whom included an entire cohort of recruits in their research the number of subjects ranged from 102 new recruits in New Zealand, 146 in Denmark, to over 400 in Israel9,8,5,6,7. The investigations with higher recruitment of military personnel typically had better power calculations than those without. Demographic information about the populations was hard to compare due to lack of reporting within the article. The military populations consisted predominately of young male recruits between the ages of eighteen and twenty-eight years old8,5,4,6,7.

*Study Design*

The review of literature on BSO use for reduction of lower extremity injuries during BMT revealed many randomized controlled trials (RCT). Five of eight investigations reviewed met the criteria to be considered an RCT with others being considered quasi-experimental or cohort studies. The level of evidence for the studies reviewed were between levels II and III. Although the majority of investigations were RCT the actually designs for evaluating the effectiveness of BSO were dramatically different. Of the seven intervention studies, four divided all new recruits into groups and provided orthotic intervention to certain groups regardless of foot shape8,5,6,7. Two investigations only included recruits who screened positive for foot abnormalities or potential dysfunction10,4. The last included all new recruits but supplied intervention for only recruits screening positive for foot dysfunction and had an unequal control arm of already serving military personnel9. The wide range of study designs makes the evaluation of BSO use in the military population complex.

**Orthotic Interventions**

*Screening*

The three intervention studies that distributed BSO to only recruits with foot dysfunction or abnormalities had various ways of diagnosing or distinguishing the at risk population9,10,4. The methods of detection all served the purpose of finding recruits thought to susceptible to injury due to the foot shape or mechanics although procedures were vastly different. One study diagnosed recruits with pes planus by static, partial weight bearing foot imprints that were analyzed for arch index11. In almost direct contrast, a pressure plate protocol that analyzed dynamic foot pressures during walking and running was used in another study to classify recruits at low, medium, or high risk for injury4. The third study took a completely different approach and examined foot adaptability9. The screening protocol did not look directly at plantar foot shape but instead evaluated rearfoot posture, postural stability, and forefoot stability9. Based on a point system the recruits were grouped into specific intervention groups: no orthoses, prefabricated orthoses, or custom orthoses9. The dissimilarities of the screening protocols for military recruits in the literature does not allow for equal comparison of the results.

*Fabrication*

Biomechanical shoe orthoses can be made in orthotic labs or on location by an orthotist or qualified professional. The fitting or molding techniques for custom orthoses are as variable as the methods by which they are produced. The use of orthotic laboratory companies was rarely consistent across the literature. Several intervention investigations completed in Israel as well as an additional laboratory study maintained the same production companies but were analyzing different outcome variables5,12,7. The variety of orthotic labs and orthotic types allowed for a great variability in the fitting of orthoses. Orthoses were molded by controlled pronation, subtalar neutral positioning casts, or subtalar neutral positioning with partial weight bearing into foam8,5,12,6,7. The final product was then made by the laboratory company (send in casts, impressions, or pressure plate analysis), an orthotist, or cam mill machine8,10,5,4,12,6,7. The wide range of fitting and production of orthoses in the literature causes discrepancies between investigations and might account for differences in results. The employment of diverse orthotic laboratories and fitting methods was driven by the use of different types of orthoses.

*Type*

A combination of orthotic types was used in the literature for investigating orthotic intervention for the prevention of lower extremity injuries in the military population. The application of different orthotic types helped establish evidence to which type was most effective at reducing injury incidence rates. The literature included custom semi-rigid, custom soft, prefabricated semi-rigid, and/or soft prefabricated orthoses. Investigations contained one or more of these types of orthoses and most had a control group that did not receive orthotic intervention (either no equipment given or a non-supportive/shock-absorbing shoe insert) 8,10,5,4,12,6,7. The variety of combinations of orthotic types, along with previous differences in screening and fabrication, make assembling a unified conclusion from the data convoluted.

**Outcome Measurements and Results**

*Outcome Measures*

All intervention studies found during the literature reviewed incorporated the incidence of lower extremity and/or back injuries as part of their outcome measurement battery although again there were many disparities between investigations. One investigation included only injury incidence data on low back injury5. Another calculated only the incidence rates of stress fractures in the basic military training population7. Whereas others included specific problems of the lower extremity including anterior knee pain, Iliotibial band syndrome, patellofemoral pain syndrome, medial tibial stress syndrome, chronic exertional compartment syndrome, Achilles tendinopathy, or plantar fasciitis4. The investigations varied on injury surveillance, self-report measures or electronic medical records, and how they reported lower extremity injury, specific conditions or general. One problem in comparing the incidence of overuse or lower extremity injury between the investigations is the operational definition of training injury. Investigations had different requirements for reporting lower extremity injury; ranging from simple diagnosis of an injury to requiring at least three days off of duty due to injury9,10. Other outcome measures that appeared multiple times in the literature review were: number of off duty days, completion of training in orthoses, and comfort scores8,5,6,7. The frequencies of outcome measurements were contingent on basic military training periods and methods of outcome investigation (self-report questionnaires, physical evaluation, or electronic medical records).

*Results*

Non-significant Results

The literature provides inconclusive evidence for the use of biomechanical shoe orthoses for prevention/reduction of lower extremity and back injuries during basic military training. Only two investigations demonstrated no statistical benefit for using biomechanical shoe orthoses10,5. The first investigation had limited power due to extremely small sample size10. The results indicated a positive yet non-significant trend towards reduced pain and injury and increased foot health for military recruits with flat feet who were compliant with wearing the orthoses10. A well developed and performed investigation for determining the effect of various biomechanical shoe orthoses on the incidence of weight bearing induced back pain also yield no significant results5. The per protocol analysis revealed that soft biomechanical orthoses compared to no orthoses might demonstrate different results if examined exclusively5.

Incidence of Lower Extremity Injury

Three investigations demonstrated reduced prevalence of lower extremity injuries during basic military training with the use of either soft or semi-rigid biomechanical shoe orthoses8,9,4. The investigations varied in the strength of their results based on statistical analysis. Of the investigations that established significant findings, one had a statistically significant intention-to-treat analysis, one a significant pre-protocol analysis, and the other did not properly report4,9,8. The results of various analysis protocols could have differed due to sample size, type of orthoses, and/or injury surveillance. One investigation, along with reduced lower extremity injury, also reported a decreased incidence of back pain related problems8.

Incidence of Stress Factures

Biomechanical shoe orthoses have also shown to reduce the incidence of lower extremity stress fractures and shin splints8,9,7. Both soft and semi-rigid custom biomechanical shoe orthoses appear to reduce the risk of stress fractures and shin splints8,9,7. Differences in effectiveness between soft and semi-rigid orthoses are presently unclear7. In one investigation soft custom biomechanical shoe orthoses displayed a lower incidence of stress fractures compared to the semi-rigid orthoses during but results were not statistically significant7. Further insight on the topic was presented in a laboratory study examining tibial strain rates and various types of footwear and biomechanical shoe orthoses12. Both soft and semi-rigid biomechanical shoe orthoses may reduce tibial stress fractures secondary to diminished peak to peak strain rates during walking with military boots12. Soft orthoses also demonstrate decreased tension and compression strain rates during walking whereas semi-rigid do not12. Semi-rigid orthoses also appear to have potential adverse affects during running with military boots, increased strain rates, therefore the use soft orthoses more highly indicated for this population12.

Completion of Training and Comfort Scores

Completion of training and comfort scores for biomechanical shoe orthoses were consistent across the literature5,6,7. Military recruits assigned to soft custom biomechanical shoe orthoses were more likely to complete basic military training in their assigned orthoses compared to custom semi-rigid orthoses5. In several investigations soft biomechanical shoe orthoses also had significantly better comfort scores than semi-rigid orthoses and non-supportive/non-shock absorbing insoles6,7. One well designed investigation examined comfort scores for custom soft and semi-rigid biomechanical shoe orthoses and soft and semi-rigid prefabricated orthoses6. The soft orthoses were developed by the same orthotic company and the semi-rigid were made by another6. The soft custom biomechanical orthoses had the highest comfort scores for military personnel completing basic training6.

Summary

Biomechanical shoe orthoses appear to reduce general lower extremity injury and stress fractures in military recruits undergoing basic training. The use of orthoses for prevention or reduction of back pain and injury remains uncertain. Of various orthotic interventions, soft biomechanical orthoses have the highest rate of completion of training and best overall comfort scores. Therefore the use of soft orthoses should be considered for lower extremity injury prevention in the military population.

**Limitations of Current Literature**

*Methodology*

The literature examining the effectiveness of biomechanical shoe orthoses at injury reduction in the military population is diverse and presently inconclusive. Several investigations have demonstrated the ability of orthoses to reduce incidence of lower extremity injuries in the military population but the exact methods of screening, system of disbursement, fabrication technique, and type of orthoses has not been determined. Many of the investigations were limited by original sample size and high dropout rates8,9,10. Dropout rates were most significantly affected by orthoses comfort and fit6.

*Cost*

Only one investigation performed a cost to prevent analysis to determine the feasibility of implementing a shoe orthoses program8. The investigators decided that biomechanical shoe orthoses, although significantly reduced general and specific lower extremity problems, was not economically feasible8. The investigators found the cost to prevent one injury was reasonable but the cost to prevent one off duty day was not8. A flaw in the cost to prevent analysis included not accounting for healthcare savings from less medical visits. Further insight and more in-depth analysis of program cost are needed.

*Generalization*

The significant results obtained in several of the investigations may not be able to be generalized to other services or civilians. The positive effects on injury reduction seen in college naval cadets might not be seen in infantry recruits due to differences in early training4. Likewise, the specific training of military recruits, including marching in boots and with weighted packs, is unique to the military environment. Therefore results of investigations on biomechanical shoe orthoses may not crossover to the civilian realm.

**Recommendations for Future Research**

One set of investigators have done a decent job of maintaining several study variables constant over a number of investigations5,12,6,7. The consistency of the military recruits and training, the distribution of orthoses, and the use of only a few orthoses companies allow the results of the investigations to be compared and build on one another. Research needs to be geared in such a direction in order for true deductions and conclusions to be drawn from the literature. Future research needs to narrow the parameters being studied at one time and perform follow-up investigations to elaborate on particular significant or trending findings.

**Clinical Practice**

*Programs*

The feasibility of broad implementation of biomechanical shoe orthoses for military recruits entering basic training is unclear. Based on the current literature, a generalized program that supplies a soft custom biomechanical orthoses appears to be most effective. The most widely used method of soft custom orthoses fabrication is subtalar neutral positioning with casts or foam impressions. Impressions and casting are quick, less expensive ways to produce custom orthoses than method as such pressure plate analysis. The recruits should be given a wear schedule in order to improve adaptation and comfort. After accommodation, the recruit should be instructed to wear orthoses in their military boots at all times.

*Individuals*

Physical therapist working within the military environment should consider using biomechanical shoe orthoses for their at risk patients. Recruits with abnormalities in foot shape or function are at a higher risk for lower extremity injury9,10. The literature suggests that at risk recruits that wear custom biomechanical shoe orthoses are less likely to sustain an injury9,10. Physical therapists should attempt to address foot shape and lower extremity alignment issues prophylacticly when possible; during a visit for another problem or early on in the patient’s treatment. Physical therapists should be able to screen for dysfunction and alignment based on their knowledge of the anatomy and biomechanics. The fabrication of orthoses can be decided on by the physical therapist.

**Conclusion**

Military recruits are at high risk for lower extremity injuries during the initial phase of basic training due to the intense physical demand. The incidence of exercise related lower extremity injuries leads to an overuse of the military healthcare system, increased military costs due to provision of medical services, and diminished level of manpower with off duty days and program recycling1. Evidence on biomechanical shoe orthoses is limited but has shown the potential for lower extremity injury reduction compared to no orthoses or non-shock absorbing insoles in the military population. The best means for disbursement and fabrication of orthoses has yet to be determined. Future research should be conducted to narrow confounding variable and establish an effective prophylactic program of biomechanical shoe orthoses for the military population.

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