Biomechanical Risk Factors for Lower Extremity Stress Fracture

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Objectives: Stress fracture injuries disproportionately affect athletes and military service members and little is known about the modifiable biomechanical risk factors associated with these injuries. The purpose of this study was to prospectively examine the association between neuromuscular and biomechanical factors upon entry to military service and the subsequent incidence of lower-extremity stress fracture injury during four years of follow-up.
Methods: We analyzed data from the JUMP-ACL cohort, an existing prospective cohort study of military cadets. JUMP-ACL conducted detailed motion analysis during a jump landing task at the initiation of each subject's military career. We limited our analyses to the class years 2009-2013 (i.e., subjects who completed baseline testing in 2005-2008). There were 1895 subjects available for analysis. Fifty-two subjects reported a history of stress fracture at baseline and were excluded from further analysis leaving 1843 subjects. Incident lower extremity-stress fracture cases were identified through the Defense Medical Surveillance System and the Cadet Injury and Illness Tracking System during the follow-up period. The electronic medical records of each potential incident case were reviewed and each case was confirmed by an adjudication committee consisting of two sports medicine fellowship trained orthopaedic surgeons. The primary outcome of interest was the incidence rate of lower-extremity stress fracture during the follow-up period. The association between incident stress fracture and sagittal, frontal, and transverse plane hip and knee kinematics during the jump-landing task were examined at initial contact (IC), 15%(T15), 50%(T50), 85%(T85) and 100%(T100) of stance phase. Descriptive plots of all biomechanical variables along with 95% confidence intervals (CI) were generated during the stance phase of the jump landing task. Univariate and multivariable Poisson regression models were used to estimate the association between baseline biomechanical factors and the incidence rate of lower-extremity stress fracture during follow-up.
Results: Overall, 94 (5.1%, 95%CI: 4.14, 6.21) subjects sustained an incident stress fracture during the follow-up period. The incidence rate for stress fracture injuries among females was nearly three times greater when compared to males (IRR=2.86, 95%CI: 1.88, 4.34, p<0.001). Compared to those with greater than 5° of knee valgus, subjects with neutral or varus knee alignment experienced incidence rates for stress fracture that were 43%-53% lower at IC (IRR=0.57, 95%CI: 0.29, 1.11, p=0.10), T50 (IRR=0.47, 95%CI=0.23, 1.00, p=0.05), and T85 (IRR=0.53, 95%CI: 0.29, 0.98, p=0.04). Subjects with greater than 5° of internal knee rotation exhibited rates for stress fracture that were 2-4 times higher at T15 (IRR=2.31, 95%CI: 1.01, 5.27, p=0.05), T50 (IRR=3.98, 95%CI: 0.99, 16.00, p=0.05), and T85 (IRR=2.31, 95%CI: 0.86, 6.23, p=0.10), when compared to those with neutral or external knee rotation alignment.
Conclusion: Several potentially modifiable biomechanical factors at the time of entry into military service appear to be associated with the subsequent rate of stress fracture. It is possible that injury prevention programs targeted to address these biomechanical movement patterns may reduce the risk of stress fracture injury in athletes and military service members.

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