The Effect of Load Carriage and Lower Extremity Strength on Plantar Pressures Obtained in the Barefoot Condition

Pletcher ER, Bansbach HM, Nagai T, Abt JP: Neuromuscular Research Laboratory, University of Pittsburgh, Pittsburgh, PA

Context: The foot offers primary support and flexibility for appropriate force transfer during dynamic activities. It is important to diagnose any foot problems early for injury prevention. Plantar pressure measurements provide information on foot and ankle function during gait and weight bearing activity. Abnormalities in these areas due to additional weight (military gear, equipment intensive sports) or lack of muscular support may predispose an individual for injury. Objective: The primary purpose of this study was to establish if the addition of external load affects plantar pressure distribution in the barefoot condition. The secondary purpose was to determine if isometric hip and ankle strength affects plantar pressure distribution. Design: Cross-sectional. Setting: Research laboratory. Participants: Twenty-five physically active men (n=10) and women (n=15) between 18 and 40 years of age (age: 24.6 ± 4.8yrs, height: 171.0 ± 9.8cm, mass: 69.9 ± 11.9kg) participated in this study. Participants were excluded if they had a current unresolved lower extremity injury or previous ankle surgery. Interventions: Bilateral isometric hip and ankle strength were measured. Participants were asked to walk barefoot across the emed®-x platform (Novel GmbH, Munich, Germany) in an unloaded and loaded (9.5kg weighted vest) condition. Main Outcome Measures: Isometric strength was recorded as percent of body weight (%BW). The Novel Database Medical software package was used to obtain geometric variables (foot progression angle, subarch angle and arch index) and average maximum force as a percent of body weight (MF%BW) and peak pressure (PP) for select regions of each foot. An alpha level of 0.05 was set a priori as a significance level for all statistical analyses. For changes in plantar pressure variables between an unloaded and loaded condition, a paired t-test calculation or Wilcoxon signed-rank test was used. To determine if there was a correlation present between foot or hip strength and changes in plantar pressure, a Pearson Correlation Coefficient or Spearman’s Rank Correlation Coefficients were used. Results: Significant differences were found in the majority of geometric variables and plantar pressures between the unloaded and loaded condition, a paired t-test calculation or Wilcoxon signed-rank test was used. To determine if there was a correlation present between foot or hip strength and changes in plantar pressure, a Pearson Correlation Coefficient or Spearman’s Rank Correlation Coefficients were used. Results: Significant differences were found in the majority of geometric variables and plantar pressures between the unloaded and loaded conditions. Significant negative correlations were found between changes in unloaded and loaded plantar pressures of right MF%BW of the second toe (p=0.016), total contact time (p=0.013), total maximum force (p=0.011) and right foot evertor strength. No significant correlations were found within the left side. Conclusion: Changes in plantar pressure have been shown to contribute to lower extremity injury. Significant correlations suggest that increasing ankle evertor strength may offset some of the changes in plantar pressure due to external load. Early intervention utilizing an ankle strengthening program may help diminish the negative effects of carrying additional load and prevent future injury. Future research can examine the effects of heavier load carriage after fatigue on changes in plantar pressure.