USING INSTRUMENTED INSOLES TO MONITOR ADAPTATIONS IN LOWER LIMB LOADING DURING RUNNING IN LOAD-CARRYING SOLDIERS

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Summary

The present study compared force platform and instrumented insole-derived lower limb loading in soldiers during jogging, while carrying a back pack and unloaded. It is suggested that the insoles were able to capture key characteristics of both the impact and compressive loading phases of ground contact and could potentially be used to monitor cumulative loading.

Introduction

Soldiers can be medically downgraded due to musculoskeletal injuries (MSKI's) which often occur in the lower limbs. They are attributed to overloading and recent work has begun to examine cumulative loading during fatigue and load carriage [1, 2]. Our initial work aims to unobtrusively monitor loading in the field directly at the foot-boot interface loads using instrumented insoles. Emphasis is placed on both the initial heel impact [3] and the subsequent compressive loading. This pilot study examined insole sensor measurements in comparison to simultaneous, gold standard force platform measures during controlled loaded and unloaded jogging on a force-measuring treadmill.

Methods

19 healthy soldiers ran for one-minute at 3.0 ms^{-1} on a treadmill (Treadmetrix, U.S.A), while carrying a 20kg military back pack, and also while unloaded. Ground reaction forces (GRF's) were monitored during the last 30 seconds of each run at 1500Hz. A pair of commercial insoles (Sportscentia), each with 9 Force Sensitive Resistors (FSRs) and an Inertial Measurement Unit (IMU) with additional high-g accelerometer (460Hz), were inserted into their standard army boots (AKU's). GRF and insole data curves were monitored and averaged over multiple foot contacts.

Vertical GRF and summed FSR data were compared during impact and compressive loading phases. Impact loading was also monitored using peak resultant foot deceleration and foot landing velocity (4).

Preliminary Results and Discussion

Group mean ground contact durations were similar for force platform and insoles measures, and increased by 0.02sec with load carriage (0.31 (S.D 0.01) sec for unloaded and 0.33 (0.01) for loaded). This agreed with previous work [e.g. 1, 2] and reflected increased loading during mid-stance through to push-off (see figure 1). This shift in loading has implications for foot and lower limb injury (5).

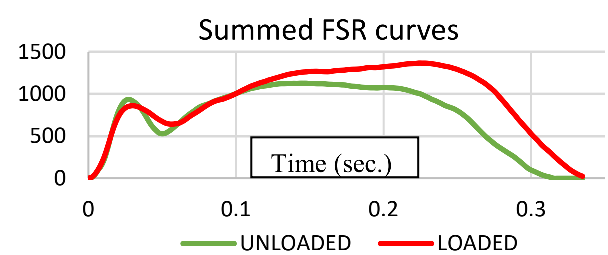

Figure 1: Averaged summed insole FSR profiles during jogging.

Average impact GRF and summed FSR curves were not modified by the loading condition. Similarly, group mean resultant foot velocities at ground contact (with load 1.34m/s (0.06) versus unloaded 1.27 (0.05)) and peak resultant foot acceleration soon after contact (with load 17.1g (3.0) versus unloaded 17.3g (2.1)), were not significantly different. Using heavier loads and other forms of locomotion (e.g. marching), and fatigue [2] will confirm these observations and might have implications for examining the risk of specific MSKI's during load carriage [1]. We also hope to utilize deep learning approaches that will help us predict both GRF measures in the field using insole data inputs and the corresponding loading of the tibia.

Conclusions

Instrumented insole data captured the changes in both compressive loading and impact loading of the soldiers while jogging with load. Insole-based measures of large changes in impact loading remain to be explored.

References

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