Correlation Between Treadmill Acceleration and Plantar Pressure during Running

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INTRODUCTION
Running is one of the most widespread and highly unconstrained sport activities which can take place in a wide variety of environments: indoors or outdoors; on a track or over rough terrain; up hills, on level ground or down hills; in the heat of summer or the cold of winter; during daylight hours or nighttime conditions. Impact force peaks reach approximately 1.5-2.5 body weights, whereas impact acceleration peaks are approximately 8 g. Impacts contribute to injury under the more stressful circumstances, such as anatomical anomalies, high mileage or large increases in mileage, short recovery time between workouts, substantial downhill or hard-surface running, or running while the body is fatigued (Derrick et al., 2002). Therefore, this study investigates the relationship between ground reaction force, peak plantar pressure, and peak treadmill accelerations during various running speed.

MATERIALS AND METHODS

Subjects
Eight active college students (age 21±0.8 yrs; mass 62.5±9.8 kg; height 169.9±7.4 cm) were volunteers from the university student body. All subjects were right leg dominant as established by their preferred kicking leg. All subjects reported no history of orthopedic injury.

F-Scan Insole System
The F-Scan Mobile in-shoe pressure measurement system (Tekscan, Boston, MA) was used to collect foot pressure data during running. All subjects wore standard laboratory socks and shoes provided by the investigators. Calibration was performed prior to taking the foot scan of each subject according to the method recommended by the F-Scan manufacturer.

Accelerometer Sensor Node
A custom-built dual axis accelerometer (MAX2312G/M, MEMSIC, Inc, USA) was attached in the middle of the treadmill running board (figure 1) and was synchronized activated by connecting them to an external electronic pulse with the F-Scan Mobil. The accelerometer sensor node used measures accelerations only in the vertical direction and the speed of acceleration data acquisition was set to 500 Hz (matching the F-Scan Mobil system).

DISCUSSION
The purpose of this study was to examine the relationship between treadmill accelerations and plantar pressures during running. The results of this study show that PPP and PTA increase with increasing running speed. It also demonstrated the peak treadmill accelerations (PTA) and heel peak plantar pressures (PPP) increased linearly as running speed increased and there have a strong correlation between PPP and PTA during treadmill running. During foot-ground contact, the closed cell structure of the heel pad serves to attenuate the impact. The peak immediately following loading response, decelerative peak, has been shown to linearly increase in magnitude as speed increases up to 4.0 m/s (Keller et al., 1996). Therefore, the linear increase in peak plantar pressure at the heel at faster speeds seems associated with the speed-vertical ground reaction force relationship. During a typical heel-toe running cycle the foot impacts the ground and causes a very rapid increase in the vertical ground reaction force that reaches a maximum after heel contact. This impact force accelerates a portion of the lower extremity so that there is also a strong correlation between PPP and PTA during running exercise.

CONCLUSION
This study demonstrated onboard treadmill accelerometer could be used to determine the PPP and PTA during running exercise. The significant correlation that exists between the PTA and PPP during running landing could provide a valuable tool for measuring injury potential during running landing. Additional research is needed to determine the role of joint contact angles and landing technique on PPP and PTA during running. Moreover, the onset of fatigue has to be considered, because it is likely to affect the stiffness of landing and therefore the impact forces.

RESULTS
Table 1 reports the PTA and PPP measurements with standard deviations at each speed. The PTA and PPP were smallest at the 3 and 4 miles per hour running speed (<0.05), but greatest at the speeds over 7 miles per hour (p<0.05). In addition, there was a strong (average r2=0.75) and significant (p<0.05) correlation between PTA and PPP for all eight subjects (figure 3).

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