ALTERED MIDSOLE GEOMETRY MODULATES REARFOOT KINEMATICS AND MUSCLE ACTIVATION DURING FATIGUE IN RUNNING

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INTRODUCTION

Extensive rearfoot pronation and high impact forces have been linked to overuse injuries. Prospective studies, however, indicate that the occurrence of injuries is not related to the amount of rearfoot movement during ground contact or the impact magnitude at touch-down alone (see Nigg, 2001). Recent publications favour the idea that the musculoskeletal systems responds to mechanical input by specific modulations in muscle activation (Nigg, 2001). Wakeling et al. (2001; 2002) have demonstrated electromyographic differences in response to altered midsole hardness.

The aim of this study was to identify changes in muscle activation and ground contact mechanics provoked by moderate geometric changes of the midsole of a running shoe.

METHODS

Three modifications of a running shoe (Nike) were used in this investigation: neutral (NE), +4° varus (VR) and –4° valgus (VG). Five trained subjects had to perform three typical training runs over 10 km each with a different shoe in a randomized order.
Surface EMG of eight muscles was recorded using differential amplifiers (Biovision, 1000 Hz). A tibial accelerometer was used to identify ground contact. All signals were stored on a portable data logger (Compaq iPaq). Force platform (Bertec™) data were collected at 1200 Hz. Three-dimensional kinematics were recorded using an eight-camera system (Motion Analysis Corp., Eva HiRes with Falcon cameras, 120 Hz). Measuring systems were synchronized via telemetry (Biovision).

Tests were performed on a runway in our laboratory with doors opened on both sides. A running course (900 m) outside the lab was completed 12 times. After each lap three platform crossings were conducted. EMG was collected for three steps per crossing. Running velocity was controlled by a cycle with speed-meter. In the lab, speed was measured via timing gates.
Force platform data and three-dimensional kinematics were used to determine impact peak, knee joint kinematics and net joint torques at the ankle and knee joints (Kersting & Böhm, 1999). EMG amplitudes and integrals were determined in a time window of 150 ms prior to ground contact and the entire step cycle.

ANOVA was used to test differences between conditions. A repeated measures design was applied to compare fatigue conditions after each km of running. A Student-Newman-Keuls test was used for post hoc analysis ($p<.05$).

RESULTS AND DISCUSSION

No significant differences were observed for tibial acceleration or impact forces between shoe models. Maximum pronation was significantly different between the valgus shoe compared to NE and VR. The neutral and varus shoe showed minimal differences. The torques at the subtalar joint showed a similar pattern as the rearfoot movement. A greater torque occurred for the valgus shoe with only minimal differences between NE and VR.The IEMG of the peroneus (PL) and gastrocnemius (GM) are shown in figures 1 and 2 respectively. Values are expressed as percentage of the value obtained during running when using NE.

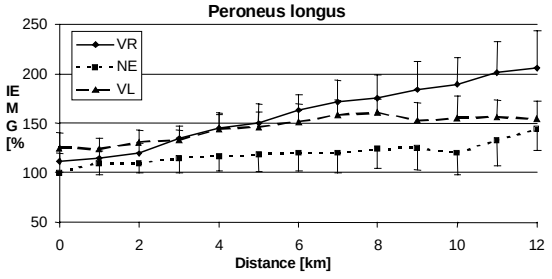

Figure 1: IEMG of PL over one step cycle. Both modified shoes differ significantly from the neutral condition. After 9 km VR shows significantly higher values than NE and VL.

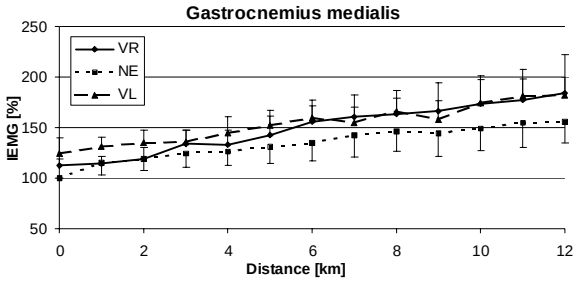

Figure 2: IEMG of GM over one step cycle. Modified shoes show higher but not significantly different values from NE.

SUMMARY

Shoe modifications allow for a change in rearfoot kinematics in a desired direction. Alterations have been observed for net joint loading. During a typical training run distinct changes in muscular activation were observed. Results support reports from recent publications, where similar adaptations for changes in midsole hardness were demonstrated. The method proposed allows the investigation of footwear effects under realistic training conditions.

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