BIOMECHANICS OF WALKING IN DIFFERENT SHOES: A COMPARISON BETWEEN OVERGROUND AND TREADMILL TESTING PROTOCOLS

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INTRODUCTION

Typically, the biomechanical assessment of shod locomotion involves repeated movement trials over a force platform placed in the middle of a relatively short runway (e.g. DeWit et al., 2000). Although on-line procedures are usually in place to ensure that velocity and normality of locomotion over trials are consistent and satisfactory it can still be argued that the use of short, discontinuous burts of locomotion may produce movement patterns that are not quite reflective of natural movement behaviour. Alternatively, prolonged and continuous movement kinematics can be obtained using treadmill locomotion. Lafortune et al. (1994) compared overground to treadmill running and found that treadmills reduced impact loading at heel strike due to compliance of the surface but there were no major kinematic modifications of the foot-ankle complex. On the treadmill multiple stride cycles can be captured for averaging purposes and early adaptations to specific footwear conditions can be monitored over a prolonged period. The combination of both these advantages may allow better biomechanical assessment and differentiation of footwear conditions during locomotion. This study compared walking kinematics in two shoe conditions using both an overground (OG) and treadmill (TR) test protocol.

METHODS

Ten healthy young females completed tests of walking biomechanics in two footwear conditions (a flat sandal and a training shoe) using both OG and TR test protocols. OG testing consisted of 5 repeated walking trials at 1.25m/s in each shoe condition across a force platform (Kistler, 9281B), while lower limb kinematics were captured by an 8-camera system at 240Hz (Qualysis, Sweden). The TR protocol involved subjects walking 10 minutes on a treadmill at 1.25m/s whilst 6-camera 500Hz motion was captured at 1, 5 and 9 minutes. 9mm reflective markers were placed on the medial and lateral tibial condyles, proximal and distal shaft of tibia, lateral tibia, medial malleolus, lateral malleolus, posterior, medial and lateral calcaneous and the hallux. A six degrees of freedom model of the shank and heel and was built for analysis of kinematics. Force data and kinematics of the ankle joint at heel strike and toe off were obtained along with the velocity of the heel segment. Results were compared between test methods and shoe conditions using a two-way ANOVA.

RESULTS

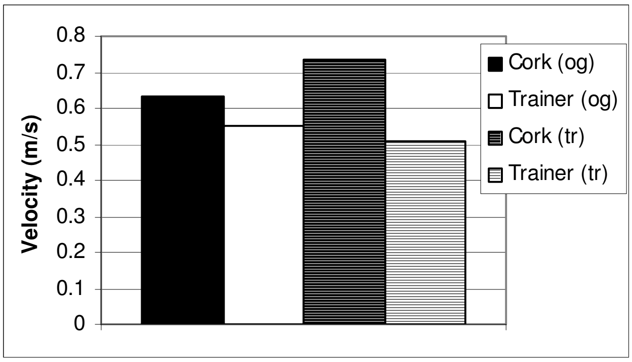
There was a broad similarity in walking kinematics obtained using the OG and TR protocols. Frontal and transverse plane ankle kinematics were in good agreement whilst the sagittal plane kinematics demonstrated some slight differences (Table 1). Ankle angles and heel velocities from the treadmill were compared over time to investigate possible adaptations at heel strike and toe off. There was no significant effect of time in the heel velocity data or in the ankle angle at toe off in all planes of motion. However, the ankle angle data at heel strike did have a significant interaction with time in all three movement planes. The TR data with no time effect was subsequently compared to the OG data. This TR data showed more significant differences in heel velocity at heel strike (figure 1). At heel strike the flat sandal showed no significant heel velocity differences for OG data collection but significant differences for medio-lateral, horizontal and vertical velocity components during the TR protocol. TR There was also a significant difference in the frontal plane ankle angle at toe off for TR data in comparison to non-significant differences in OG data.

Ground reaction force data (Table 2) showed that the peak vertical forces after ground contact and before push off were lower in the trainer compared to the flat sandal ($p<0.05$). This was supplemented by significantly lower peak braking and push-off forces in the trainer.

Table 1. Mean ankle angle kinematics at heel strike for the OG and TM protocols.

	Flat		Trainer	
	OG	TM	OG	TM
Sagittal	-4.97°	-7.16°	-2.43°	-4.29°
Frontal	0.20°	2.09°	0.83°	1.78°
Transverse	-6.13°	-6.64°	-7.41°	-9.02°

a



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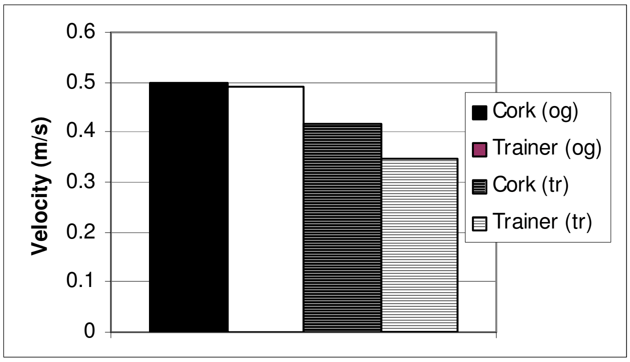

Figure 1. The horizontal (a) and vertical (b) velocity of the heel segment at heel strike for the flat sandal and the trainer during over OG and TR walking.

Table 2. Vertical (V) and anterior-posterior (A.P.) ground reaction force data for each shoe condition.

	Flat		Trainer	
	Mean	SD	Mean	SD
V. Impact	703.33 N	67.35	659.23 N	65.93
V. Push Off	701.41 N	65.45	674.42 N	62.17
A.P. Braking	-805.91 N	9.42	-795.81 N	9.94
A.P. Push Off	163.69 N	24.68	155.04 N	28.28

DISCUSSION AND CONCLUSIONS

The 10-minute TR protocol provided information concerning kinematic adjustment differences between footwear that were not discerned using the OG protocol. The increase in magnitude of the differences between the shoes shows that prolonged data collection can be useful to tease out biomechanical differences in footwear during locomotion. The presence of significant adjustments over time in some of the TR data lend support to the hypothesis that some adaptation to footwear conditions (e.g. kinematics at heel stike) over the 10 minute walk may be present. The OG protocol has the advantage of simultaneous force data collection and GRF variables were clearly able to differentiate between footwear conditions. A combination of OG and TR protocols will allow for the greatest insight into footwear biomechanics with each having their own distinct advantages.

REFERENCES

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