

EFFECT OF RUNNING SHOES ON MECHANICS OF OVERGROUND AND TREADMILL RUNNING

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INTRODUCTION

Recently many people run on treadmill at home or fitness club. Treadmills, providing convenient and controlled environment, are also widely used for research on running shoes. Several researchers compared overground and treadmill running to validate treadmill as an experimental instrument in that simulates overground running. They reported that treadmill run had different running kinematics and impact loading patterns due to motor driven narrower surface and shock attenuating compliant and cushioned deck. However, there has been yet specific running shoes model for treadmill running developed yet, thus most runners on treadmill wear the same running shoes as they do in outdoor. The purpose of this study was to determine if different running shoes on the treadmill could be necessary from that of overground running.

METHODS

Ten male healthy runners experienced at treadmill running participated in this study (mass 74.3 ± 9.3 and height 175.0 ± 4.9 cm). They ran on runway and treadmill at 3.83 ± 0.1 m/s while wearing motion control and cushioning running shoes. A small treadmill, one of most popular model for home-use in Korea, having a running area of 0.4×1.3 m, a maximal speed of 4.5 m/s, and a 1.5 kW motor was used in this study. Kinematic data were collected using a Motion Analysis eight video camera system at 240 Hz. Spherical reflective markers were placed on the shank and shoe for kinematic data collection. Ground reaction force and pressure distribution data under the plantar heel surface of the right foot were collected with a PEDAR pressure insole system with 26 sensors at 360 Hz. Five trials were performed for each condition and mean values were calculated for ground reaction force, pressure, and rearfoot kinematic variables. A within-subject repeated measures two way ANOVA was used to test the running surface and footwear effect ($\alpha = 0.05$).

RESULTS AND DISCUSSION

At initial contact, runners planted their feet in flatter position on the treadmill than overground and in more inverted position with cushioning shoe than motion control shoe (Table 1). This landing style on treadmill may provide more stable locomotion pattern under the intra-stride belt speed variation condition. The less initial inversion with motion control shoes may be due to adjustment of human locomotor system to shoes structure.

Although there was no significant difference in maximum eversion angle, maximum eversion velocity (MEV) was affected by running surfaces and shoes (Table 2). The average value of MEV on treadmill running with cushioning shoe was similar to that during overground running with motion control shoe. Thus, cushioning shoe is appropriate for pronation control during treadmill running. Furthermore, runners on the treadmill showed smaller vertical impact force and loading rate (Table 3). This might be resulted from not only a more flat foot contact but also a spring effect of treadmill. This result indicates that less cushioning shoes could be acceptable for treadmill running. Also, the measurement of loading rate by the pressure insole sensors with higher sampling frequency in this study could be suggested as a validated method when a force plate is not available.

For pressure distribution, there were significant differences under the medial portion of the heel by surfaces and shoes (Figure 1). The absolute reduction of the medial loading and the tendency of a more lateral loading pattern could be applied to for appropriate treadmill running shoe design.

Table 1. Foot motion at heel strike

Shoes \ Surfaces	Shoe sole angle (deg)			Foot inversion angle (deg)		
	Overground	Treadmill	Total	Overground	Treadmill	Total
Cushioning	29.82 ± 3.82	25.74 ± 3.61	27.78 ± 4.18	8.00 ± 2.47	8.53 ± 1.68	8.27 ± 2.07
Motion control	29.59 ± 4.67	26.45 ± 4.25	28.02 ± 4.64	5.51 ± 1.24	6.30 ± 1.96	5.91 ± 1.65
Total	29.72 ± 4.15	* 26.09 ± 3.86		6.76 ± 2.29	7.42 ± 2.11	

* $p < .05$

Table 2. Rearfoot motion

Shoes \ Surfaces	Max eversion angle (deg)			Max eversion velocity (deg/s)		
	Overground	Treadmill	Total	Overground	Treadmill	Total
Cushioning	11.45 ± 3.17	10.72 ± 3.32	11.09 ± 3.18	433.30 ± 85.91	382.72 ± 55.50	408.01 ± 75.02
Motion control	11.12 ± 4.04	10.00 ± 4.16	10.56 ± 4.03	360.20 ± 71.76	327.95 ± 54.06	344.08 ± 64.01
Total	11.28 ± 0.54	10.40 ± 3.68		396.75 ± 85.68 *	355.34 ± 60.27	

* p < .05

Table 3. Impact loading

Shoes \ Surfaces	Max vertical impact force (body weight)			Max loading rate (body weight/s)		
	Overground	Treadmill	Total	Overground	Treadmill	Total
Cushioning	1.63 ± 0.26	1.31 ± 0.22	1.47 ± 0.29	87.79 ± 24.52	68.54 ± 16.24	78.16 ± 22.52
Motion control	1.68 ± 0.16	1.37 ± 0.21	1.53 ± 0.25	90.23 ± 19.56	72.83 ± 15.20	81.53 ± 19.25
Total	1.66 ± 0.21	1.34 ± 0.21 *		89.01 ± 21.63	70.68 ± 15.47 *	

* p < .05

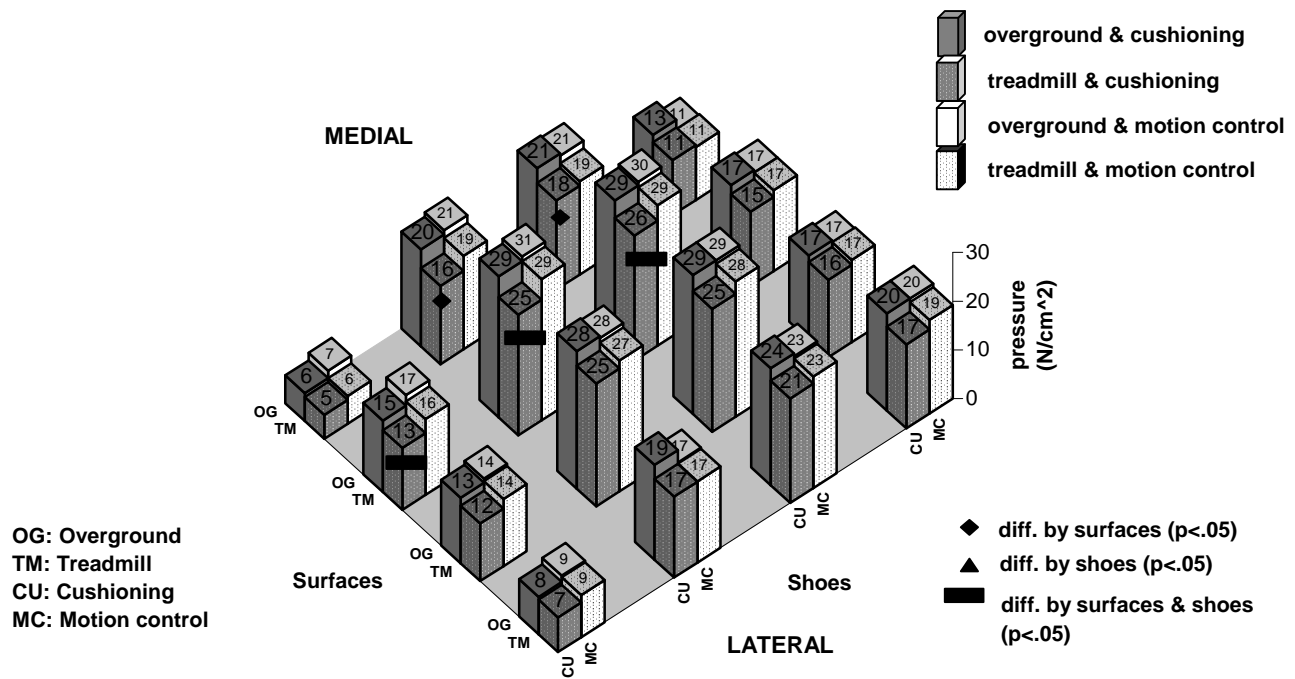


Figure 1. Average in-shoe plantar pressure by surfaces and shoes

REFERENCES

Lafortune, M. A., E. M. Hennig, and T. Milani (1994). Comparison of treadmill and overground running, *Proc. 8th Conf. Canadian Society for Biomechanics, Calgary*: 90-91.

Nigg, B. M., R. W. De Boer, and V. Fisher (1995). A kinematic comparison of overground and treadmill running, *Med.Sci SportsExe*, 27, 98-105.