Portuguese Journal of Sport Sciences
11 (Suppl. 2), 2011

THE EFFECT OF CHANGING-SPEED ON THE TOE HEIGHT ON TREADMILL RUNNING

Ya-Han Chang, Pei-Wei Chi and Hung-Ta Chiu

Institute of Physical Education, Health & Leisure Studies, National Cheng Kung University, Tainan, Taiwan

The purpose of this investigation is to observe the differences of foot trajectory when having changing-speed running in treadmill. Subjects running on a treadmill at three different speeds and performing a dynamic data from the mark in toe box and heel counter. The result shows that with increased speed the first peak toe height just after toe-off and toe clearance (TC) increased significantly, and decreased significantly with decreased speed. The result has significant different from walking. In addition, one of four subjects has more obvious foot flat than other subjects. The reason of this phenomenon is still unclear, and we still expect that there will be more studies to establish the treadmill exercise model.

KEY WORDS: the first peak toe height, toe clearance, treadmill, foot trajectory

INTRODUCTION: Running and walking don't take people many special skills, and everyone could do it easily. More and more people frequently go jogging to maintain their health (Derrick, Hamill & Caldwell (1998); Fusco & Cretual, 2008). Due to the running environment is instable at outside, treadmill is one essential piece of exercise equipment in fitness clubs or at home. Furthermore, a treadmill has often been used as auxiliary equipment previously in studies to control the speed of the runner, studies monitoring changes in biomechanical and physiological parameters after long-term running or walking, and studies for the stability or cushion of shoes (Fusco & Cretual, 2008; Hardin, van den Bogert, & Hamill, 2004; Kivi, Maraj, & Gervais, 2002; Verbitsky, Mizrahi, Voloshin, Treiger, & Isakov, 1998; White, Gilchrist, & Christina, 2002). However, a treadmill was rarely considered as the major facility for investigating different model types or for cushioning effects. Such experiments may be useful in improving treadmill functions and developing new models (Guo et al., 2006). With the growing popularity of the treadmill, it may be even more important to perform research on treadmills in the present day.

When running on treadmill, we can usually change the speed and slop. With increased speed, the peak pressure of all regions except the medial forefoot and hallux increased significantly (Ho et al., 2010). For increased speed, the hip and the ankle joints had significantly greater maximum joint extension angles during stance phase and the hip and the knee joints had significantly larger maximum flexion angles in swing phase (Guo et al., 2006). Increased motion during swing phase account for a larger step length and increased motion during stance phase may facilitate the generation of power during forward propulsion as the jogging speed increased (Guo et al., 2006). Base on above results, foot kinematics will change with running condition.

Miller, Feiveson, & Bloomberg (2009) investigated the effects of speed and visual-target distance on toe trajectory, it has been found that, with increasing speed, TC decreased and the peak toe height just before heel strike increased. The peak toe height just after toe-off was significantly changed between the near-target and the far-target task. Otherwise the study also found that the hip and the knee flexion angles had no significantly affected the toe peak after toe-off or TC.

METHODS: Four young men were included in this study. This investigation was approved by the Human Experiment and Ethics Committee of National Cheng Kung University Hospital. The subjects were informed of the experimental risks and signed an informed consent before participation.

Two Visualeyez motion tracking system (VZ4000) with the sampling rate of 200 Hz were positioned on both sides of the treadmill (FUNA-7310, Tonic Fitness Technology, Inc, Tainan, Taiwan) by 2~3 meters to record movements. Active markers were placed along each side of the shoe on the heel counter and the toe box, and those on the same foot were parallel with each other. The kinematics data were collected by the software VZSoft, and analyzed by software VZAnalyzer. Because previous studies had found that the hip and the knee flexion angles didn't affected the foot trajectory ,we use only two makers in toe and heel (Miller et al., 2009). In the present study, we investigate the foot exercise and development the treadmill monitor. So only placed the markers on foot and didn't collected joint ankles.
After 5 minutes warm-up on a treadmill, the subjects were asked to run on a treadmill with different speed for ten minutes. At first, the researcher increased the speed gradually until 10 km/h within 2nd minutes, then increased the speed to 11 km/h within 4th minutes, and 10 km/h within 6th minutes, 9 km/h within 8th minutes, 10 km/h within 10th minutes. Testing session was finished within ten minutes and 25 seconds, and collected data for 30 seconds from 5 seconds before 2nd, 4th, 6th, 8th, 10th minutes.
Take 10 steps from every data. The data was normalized to the mean height of the right toe measured at the 2nd minute for each subject in order to remove the influences of different individual disturb. Compare the pattern of toe trajectory by VZAnalyzer. One-way ANOVA was used to evaluate the effects of different speed change conditions on the first peak toe height just after toe-off and the minimum toe height TC. The SPSS version 17.0 statistical software was used (α = 0.05). LSD (Least Significance Difference) method was used to do Post Hoc Multiple Comparisons.

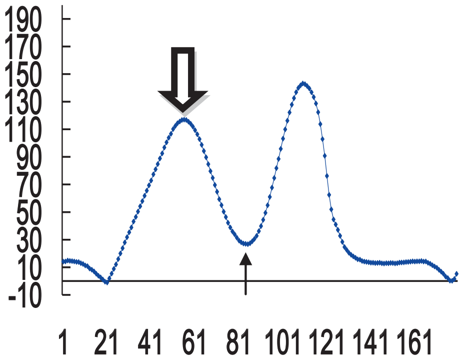


Figure 1: The height of toe in a gait recycle. ⇩ Present the first peak ↑ Present TC. The ordinate axis show the height of toe in millimeter. The cross axis show the time in millisecond.

RESULTS AND DISCUSSION: The patterns of toe trajectory show that with increased speed, the first peak toe height just after toe-off and TC increased significantly ($P < 0.05$), and decreased significantly ($P < 0.05$) with decreased speed. The results of the present study were different that found by Miller, Feiveson & Bloomberg (2009), the reason may be that subjects probably alter the duration time of double float phase and changed the step length to adapt the treadmill speed when they were running. Walking has no double float phase, so they have to change frequency or duration time of swing phase to adapt the treadmill speed.
Additionally, the toe and the heel markers of the three subjects were parallel with each other in a transient time during running (foot flat, FF). Only one of subjects has obvious FF. The other three subjects who have transient FF which may cause by heel-toe running and the other subject who has obvious FF may use his toes to touch the treadmill more, leadding the FF longer.

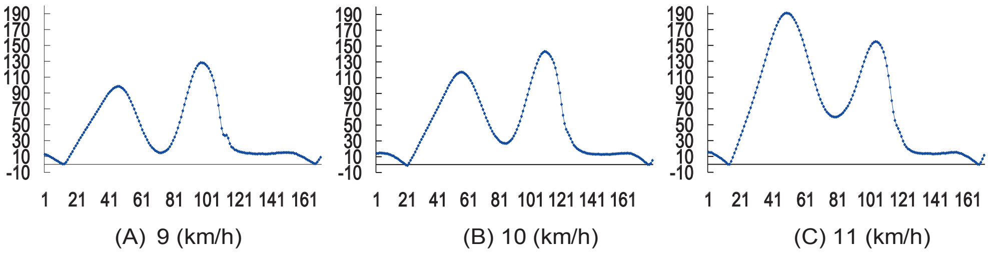
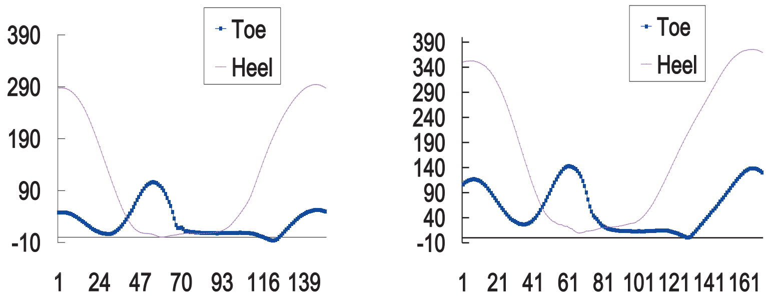
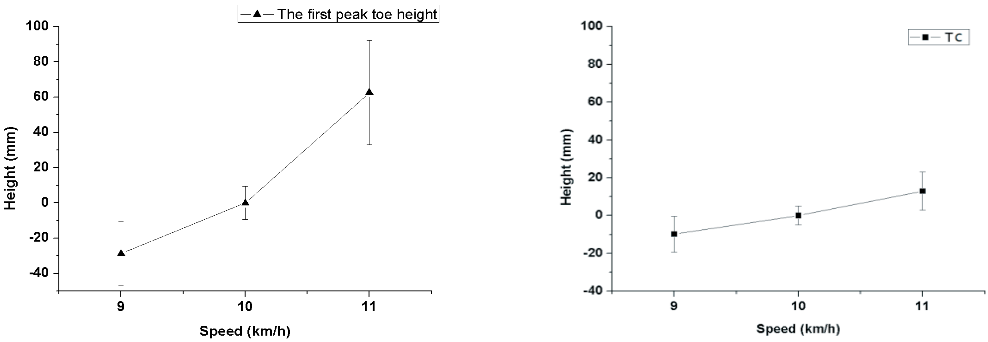


Figure 2: (A)(B)(C) are the toe height at three speeds. The first peak toe height increased with treadmill speeds. The ordinate axis show the height of toe in millimeter. The cross axis show the time in millisecond.



(A) (B)

Figure 3: The toe and the heel markers of the three subjects were parallel with each other in a transient time during running (FF). Only one subject (A) has obvious FF and the other three subjects(B) have FF in a transient time.



(A) (B)

Figure 4: The two figures show the standard deviation of (A) the first peak toe height and (B) TC changed with treadmill speed.

CONCLUSION: Previous studies about toe trajectory were investigated in walking gait. The studies in the present show that the gait which people run on the treadmill with different speed is different from walking. The first peak toe height just after toe-off and TC was changed with speed, and the duration time divergence of FF, the reasons of all this phenomenon above are still unclear. We expect there will be more studies to establish the treadmill exercise model.

REFERENCES:

Derrick, T., Hamill, J., & Caldwell, G. (1998). Energy absorption of impacts during running at various stride lengths. *Medicine & Science in Sports & Exercise,30*(1), 128.

Fusco, N., & Cretual, A. (2008). Instantaneous treadmill speed determination usingsubject's kinematic data. *Gait Posture, 28*(4), 663-667.

Guo, L., Su, F., Yang, C., Wang, S., Chang, J., Wu, W. et al. (2006). Effects of Speed and Incline on Lower Extremity Kinematics during Treadmill Jogging in Healthy Subjects. *Biomedical Engineering Application Basis and communications 18*(2), 73

Hardin, E. C. , van den Bogert, A. J., & Hamill, J. (2004). Kinematic adaptations25during running: effects of footwear, surface, and duration. *Med Sci SportsExerc, 36*(5), 838-844.

Ho, I., Hou, Y., Yang, C., Wu, W., Chen, S., & Guo, L. (2010). Comparison of plantar pressure distribution between different speed and incline during treadmill jogging. *Journal of Sports Science and Medicine, 9*, 154-160.

Kivi, D. M., Maraj, B. K., & Gervais, P. (2002). A kinematic analysis of high-speed treadmill sprinting over a range of velocities. *Med Sci Sports Exerc, 34*(4),662-666.

Miller, C. A., Feiveson, A. H., & Bloomberg, J. J. (2009). Effects of speed and visual-target distance on toe trajectory during the swing phase of treadmill walking. *J Appl Biomech, 25*(1), 32-42.

Thompson, P. D., Buchner, D., Pina, I. L., Balady, G. J., Williams, M. A., Marcus, B. H., et al. (2003). Exercise and physical activity in the prevention and treatment of atherosclerotic cardiovascular disease: a statement from the Council on Clinical Cardiology.

Verbitsky, O., Mizrahi, J., Voloshin, A., Treiger, J., & Isakov, E. (1998). Shock transmission and fatigue in human running. *Journal of Applied Biomechanics,14*, 300-311.

White, S., Gilchrist, L., & Christina, K. (2002). Within-Day Accommodation Effects on Vertical Reaction Forces for Treadmill Running. Journal of Applied Biomechanics*, 18*, 1.