THE IMPACT ACCELERATION ON THE BILATERAL TIBIA DURING TREADMILL RUNNING

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The purpose of this study was to investigate the changes of the impact acceleration on the left and right tibia during treadmill running for experienced treadmill runners. The bilateral tibial accelerations of 14 subjects were measured during thirty-minutes of running at their preferred speed. Acceleration data was collected every 5 minutes for 30 seconds. There were no significant statistical differences in the peak tibial accelerations during thirty-minutes of treadmill running. The results showed that five subjects had greater right peak tibial accelerations and two subjects had greater left peak tibial accelerations. Experienced treadmill runners seemed to choose their preferred speed at that which they can run for thirty minutes and eventually there was no significant increase in the peak tibial accelerations.

KEYWORDS: bilateral tibial accelerations, experienced treadmill runners, preferred speed

INTRODUCTION: Sports activities have become increasingly popular in modern society as more and more people frequently go jogging or walking in their daily lives. A treadmill is one essential piece of exercise equipment in fitness clubs or in families. 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, etc. 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. With the growing popularity of the treadmill, it may be even more important to perform research on treadmills in the present day.

It has been found that, with increased running time and running distance, the pressure in the sole of the foot was also increased (Verdejo and Mills, 2004). It has also been shown in this study that the long-term usage of shoes will cause structural damage to the sole, which also increases the pressure on the sole of the foot and increases the likelihood of injury. In addition, fatigue after prolonged running may weaken the cushioning effects in the lower body.

Some previous studies found that there is increased stride length, reduced frequency, and raised tibial acceleration in tired runners after long-term running (Derrick et al., 1998; Verbitsky et al., 1998). Higher tibial acceleration may also result in an increased rate of injury. However, the studies above only capture the impact accelerations of the right tibia. The purpose of this study was to investigate the changes of the impact acceleration on the bilateral tibia during treadmill running for experienced treadmill runners.

METHODS: Fifteen experienced treadmill runners were included in this study. However, the data of only fourteen subjects (age: 21.4 ± 2.74; height: 169 ± 7.2 cm; mass: 62.1 ± 9.9 kg) were acquired because the data of one subject was lost. 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 low-weight, three-axes accelerometers (dimensions: 33mm×28mm×19mm, weight: 17grams, range: +50g, sampling rate: 1000Hz) were attached with elastic bandages to the tuberosity of the bilateral tibia of each subject. Only the peak impact accelerations in one direction along the length of the right and left tibia were measured. Because thirty-minutes of exercise is good for improving human fitness, the subjects were asked to run on a treadmill (MAC-7310, Tonic Fitness Technology, Inc, Tainan, Taiwan) for thirty minutes. The subjects

had to reach their preferred speed within 2 minutes after the treadmill was started. Accelerations were measured for the 30 seconds at the beginning of the 2nd, 5th, 10th, 15th, 20th, 25th, and 30th minutes with the Acqknowledge software (BIOPAC Systems, Inc). The data has been normalized by the mean peak impact acceleration of the right tibia measured at the 2nd minute for each subject in order to remove the influences of the different individual speeds and shod conditions on the impact accelerations.
A two-way repeated-measured ANOVA was used to evaluate the differences between the peak impact accelerations of the bilateral tibia under different running times for the experienced treadmill runners with the SPSS version 17.0 statistical software ($\alpha = 0.05$).

RESULTS: The results showed that five subjects had greater right peak tibial accelerations and two subjects had greater left peak tibial accelerations, although no statistically significant differences in the averaged peak accelerations between the right and left tibia were found. Furthermore, the peak tibial acceleration did not significantly change with time (Figure 1). Figure 2 shows that subject 4 had greater right tibial accelerations, while subject 9 had greater left tibial accelerations.

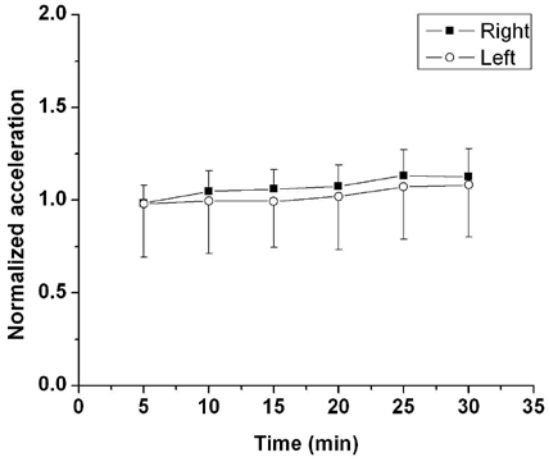

Figure 1. Mean normalized peak accelerations in 30 minutes for all subjects. There were no significant differences between the right and left tibia under different running time conditions.

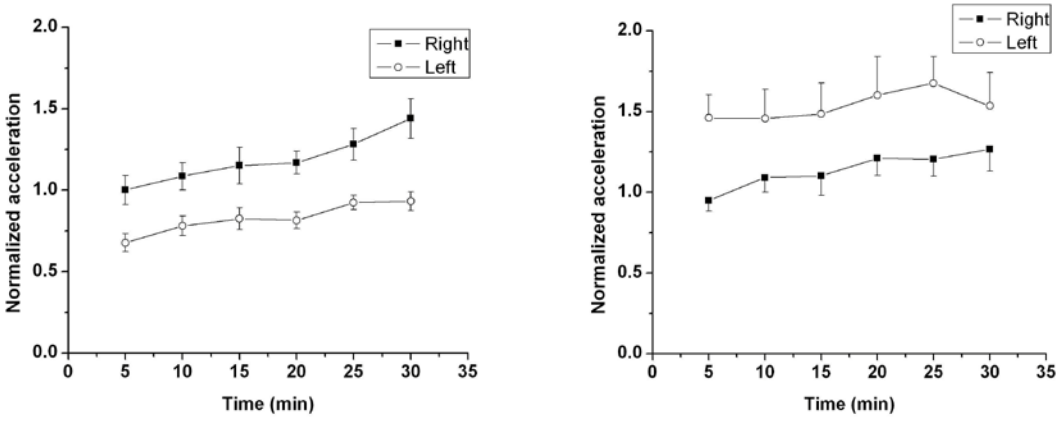

Figure 2. Mean normalized peak accelerations in 30 minutes for subject 4 and subject 9.

DISCUSSION: In the study of Verbitsky et al. (1998), 22 participants ran on a treadmill with the same shoes. The speed was increased every 30 seconds by 0.22 m/s from 1 m/s until the participant's anaerobic threshold (AT) was reached. After 30 minutes the End-tidal carbon dioxide pressure (PETCO2) test was employed to identify the subjects' fatigue level. The accelerometers were attached to the tibial tuberosity in order to collect 30 impact accelerations at intervals of 5 minutes. The peak acceleration was found to increase when fatigue occurred after 30 minutes (Verbitsky et al., 1998). The researchers postulated a significant relation between the results and the causes of running injuries. On the contrary, in this present study, the peak value did not increase with time. The experienced treadmill runners seemed to choose their preferred speed at that which they could run for thirty minutes and eventually there was no significant increase in the peak tibial accelerations.
Although there were no significant differences in the averaged peak accelerations between the right and left tibia, seven out of the fourteen subjects in this study had different impact accelerations between their right and left tibias. This means that the different running patterns of the subjects on the treadmill cause different impact accelerations to be performed on the bilateral tibia. Therefore, the bilateral tibial accelerations were suggested that they be captured under treadmill running to identify whether the maximum impact acceleration perhaps occurred in the right or left tibia.

CONCLUSION: Based on the results, there was no significant statistical difference between the peak tibial accelerations during thirty-minutes of treadmill running. The experienced treadmill runners seemed to be used to doing thirty-minutes of running to improve their fitness. Therefore, there were no increases on impact accelerations after thirty-minutes of running at their preferred speeds. The different bilateral tibial accelerations were found in half of the subjects in this study. In the research for investigating the cushioning of the treadmill's surface, a bilateral tibial acceleration measurement should be carried out to capture the real maximum impact acceleration on the right or left tibia.

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