THE INFLUENCE OF MANUALLY ADJUSTING THE RUNNING SPEED ON THE IMPACT ACCELERATION OF THE TIBIA DURING TREADMILL RUNNING

I Shan Tsai and Hung Ta Chiu

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

The purpose of this study was to investigate the influence of pressing the speed key on the treadmill console to change the running speed on the impact acceleration of the tibia during treadmill running. Twenty-seven subjects were asked to run on the treadmill and increase the speed gradually until their preferred speed within two minutes. Then the subjects were required to adjust their running speed manually every two minutes. The peak impact accelerations of the right and left tibia were measured for 30 seconds at the 2^{nd}, 4^{th}, 6^{th}, 8^{th}, and 10^{th} minutes. The results showed that there are greater peaks of impact acceleration of the tibia when some subjects pressed the speed key on the treadmill console to change their running speed. It is suggested that the position of the speed key of the treadmill be close to the runner.

KEYWORDS: treadmill console, preferred speed, bilateral tibial accelerations

INTRODUCTION: Because of the poor outdoor environments, indoor treadmill exercise is becoming a popular exercise to improve fitness. In previous studies, the treadmill has often been used as the experimental equipment to control conditions, such as speed and surface conditions, and to acquire the data for a continuous time (Verbitsky et. al., 1998; Derek et. al., 2002; White et. al.,2002 and Hardin et. al.,2004). Although the kinematic and kinetic characteristics have been compared between overground and treadmill running, there have been few studies to investigate the characteristics of the specific movements on the treadmill. Therefore, the purpose of this study was to investigate the influence of manual adjustments to the running speed on the impact acceleration of the tibia during treadmill running.

METHODS: Twenty-seven subjects without a history of musculoskeletal injury were recruited for this study. Fifteen subjects (S1-S15) were experienced in treadmill exercise and twelve subjects (S16-S27) were inexperienced. The subjects who had done treadmill exercise at least once a week in the past six months were defined as experienced treadmill runners. The physical characteristics of the subjects are shown in Table1. 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.

Table1

The Physical Characteristics of the Subjects (mean ± SD)

Group	Height (m)	Mass (kg)	Age (years)
Experienced (n=15)	1.69±0.07	62.7±10.0	21.5±2.6
Inexperienced (n=12)	1.72±0.07	63.7±6.0	18.9±0.9
Total (n=27)	1.71±0.07	63.1±8.3	20.3±2.4

At first, the subjects ran on a treadmill (Figure 1, MAG7310, Tonic Fitness Technology, Inc, Tainan, Taiwan) and increased their speed gradually until they reached their preferred speed within two minutes. Then the subjects were required to manually adjust their running speed by pressing the speed key on the console (Figure 1) in order to increasing to 110% of their preferred speed, decreasing back to their preferred speed, then decreasing to 90% of their preferred speed, and finally increasing to their preferred speed every two minutes. Each testing session was finished within ten minutes. Two low-weight, three-axes accelerometers (dimensions: 33mm×28mm×19mm, weight: 17grams, range: $\pm$50g, sampling rate: 1000Hz)

were attached with elastic bandages to the tuberosity of the right and left tibia for each subject. Only the peak impact accelerations in one direction along the length of the right and left tibia were measured for 30 seconds at the beginning of the 2nd (100%), 4th (100%-110%), 6th (110%-100%), 8th (100%-90%) and 10th (90%-100%) minutes. This treadmill speed has a 0.1 km/hr increment every time the speed key is pressed. The subject must press the key continually until the target speed is achieved. The time that the subject took to press the speed key was recorded by an experimenter from the time display on the console.

The data was normalized to the mean peak impact acceleration of the right tibia measured at the 2nd minute for each subject in order to remove the influences of different individual speeds and the influences of the shod conditions on the impact accelerations. Two-way repeated-measures ANOVA was used to evaluate the effects of pressing the speed key and different speed change conditions on the peak impact accelerations of the right tibia for the experienced subjects only. The SPSS version 17.0 statistical software was used (α = 0.05). LSD (Least Significance Difference) method was used to do paired comparisons.

Figure 1: The treadmill used in this study. The circle shows the speed key position.

RESULTS: Nine subjects (six subjects in the experienced group and three subjects in the inexperienced group) in this study performed larger peak impact accelerations on the right or both tibia, but only under some speed change conditions (Table 2). Figure 2 shows the peak impact accelerations of the tibia at the 4th minute for S1 and S4. The region surrounded by the rectangle indicates the duration for which the subjects pressed the key to change running speed. It is obvious that greater peak acceleration appeared as the subjects was pressing the speed key. Statistical analysis was only used to evaluate the effects of pressing the speed key and different speed change conditions on the peak impact accelerations of the right tibia for the experienced subjects because of the greater peak accelerations occurring on the right tibia for the more experienced runners (Table 2). The results showed that significantly larger peak impact accelerations occurred in the duration of the subjects pressing the key on the console to change running speed whether under increasing or decreasing the speed conditions ($p<0.05$). However, the peak accelerations did not differ significantly under different speed conditions after pressing the speed key (Figure 3).

DISCUSSION: In this study, significantly larger peak impact accelerations appeared in the duration of the subjects manually adjusting their running speed by pressing the speed key continuously. The effect of different running speeds on impact acceleration was not significant in this study. Therefore, this indicates that pressing the speed key on the treadmill console to change the running speed perhaps interrupts the running gait and increases the possibility of larger impact accelerations on the tibia. The sudden increase in the impact acceleration perhaps causes lower extremity injuries. However, the mechanism for the influence of manually adjusting the speed movement on the suddenly increased impact acceleration is not clear. Pressing the speed key on the console was a frequent movement during the treadmill exercise. In the future, more kinematic and kinetic analysis should be involved to clarify the relationship between the movement of pressing the speed key and the gait on the treadmill.

No significant differences in peak accelerations were found for the experienced subjects running at different speeds. This means that the 10% increment or decrement of their preferred speed doesn't change the peak tibial accelerations for the experienced treadmill runners. Only three out of twelve inexperienced subjects had greater peak tibial accelerations during the time when they were pressing the speed key. Therefore, the occurrence of the sudden greater impact acceleration is not related to whether the subject is experienced in treadmill running.

Table2

The Conditions that Significant Greater Peak Acceleration of the Tibia Appeared for the Nine Subjects

Subjects	Speed change conditions (% of the preferred speed)	The tibia where the larger peak accerations appeared
S1	100%-110%	right, left
S1	110%-100%	right, left
S1	100%-90%	right, left
S4	100%-110%	right only
S5	110%-100%	right, left
S11	100%-110%	right only
S12	110%-100%	right, left
S13	100%-90%	right, left
S20	100%-110%	right only
S20	110%-100%	right, left
S21	100%-90%	right only
S26	110%-100%	right, left
S26	90%-100%	right, left

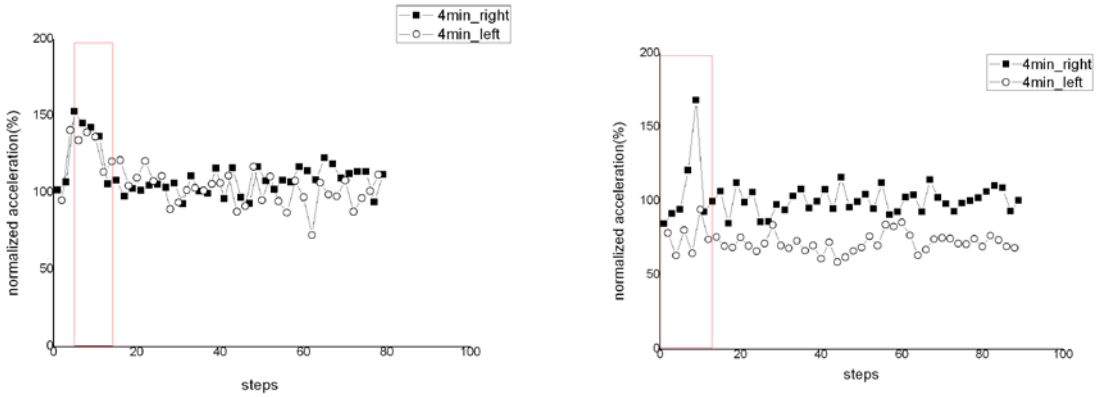

Figure 2: The peak impact acceleration of the tibia at the 4th minute for S1 (left) and S4 (right). The region surrounded by the rectangle indicates the duration for which the subjects pressed the speed key to change running speed.

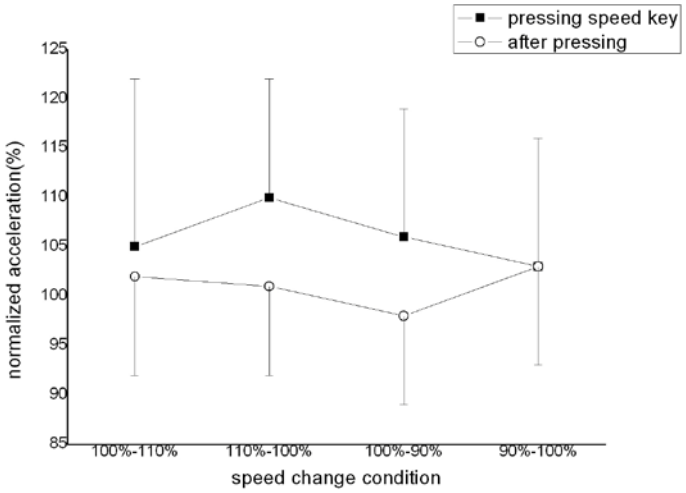

Figure 3: The mean normalized peak impact accelerations of the right tibia under eight different conditions for the experienced subjects.

CONCLUSION: Based on the results of this study, the movement of pressing the speed key seems to affect the gait of the subject during treadmill running. The movement of pressing the speed key is often performed during treadmill exercise. It is suggested that the position of the speed or incline key should be close to the runner. This mechanism should be clarified in future studies and some suggestions for key positions given.

REFERENCE:

Derek, M.R., Brian, K., Maraj, K.V., and Gervais, P. (2002) A kinematic analysis of high-speed treadmill sprinting over a range of velocities. *Medicine & Science In Sports and Exercise,* 34(4), 662-666.

Hardin, E.C., J. Van Den Bogert, and Hamill, J. (2004) Kinematic adaptations duration running : effects of footwear ,surface ,and duration. *Medicine & Science In Sports and Exercise,* 36(5), 838-844.

Verbitsky, O., Mizrahi, J., Voloshin, A., Treiger, J., & Lsakov, E. (1998). Shock transmission and fatigue in human running. *Journal of Applied Biomechanics,* 14, 300-310.

White, S.C., Gilchrist, L.A. and Christina, K. A. (2002) Within-day accommodation effects on vertical reaction forces for treadmill running. *Journal of Applied Biomechanics,* 18, 74-82.

Acknowledgement
The authors would like to thank the MAGTONIC (Tonic Fitness Technology, Inc, Tainan, Taiwan) for providing the funding for this project.