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The effect of obstacle gait training on the plantar pressure and contact time of elderly women

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ABSTRACT

Objective: The aim of the present study was to examine the effect of gait training using obstacle on the plantar pressure and contact time in elderly women.
Methods: A total of 24 elderly women who were residing in communities in D city, South Korea aged 79.9 ± 2.2, 154.5 ± 7.6 cm in height, and 56.2 ± 5.2 kg in weight participated in this study. The participants conducted obstacle gait training for 8 weeks and foot contact time and foot pressure right before and after crossing the obstacle were measured for 3 times: before the intervention, at the 4 weeks, and 8 weeks using F-scan (Tekscan, USA).
Results: The results show that foot contact time did not decrease right before crossing the obstacle but decreased right after crossing the obstacle ($p < 0.05$). Foot pressure moved from the end of the frontal foot to the midfoot (MF) and heel (HL) right before crossing the obstacle ($p < 0.05$). Foot pressure increased in lesser toe (LT) right after crossing the obstacle ($p < 0.05$).
Conclusion: These results indicate proper weight distribution in feet, increased foot stability due to increased muscle power and flexibility, and improved strategy to cope with the obstacle. The obstacle gait training may be helpful to the elderly who would either fear for or limit outdoor activities due to the risk of falls based on the result of this study.

1. Introduction

Generally, instant instability increases during gait because people put weight on one side of the leg and they move their bodies to maintain center of gravity (COG) within base of support (BOS) to reduce such instability. Controlling COG is called balance control and it is generally performed in feet (Błaszczyk & Michalski, 2006; Jian, Winter, Ishac, & Gilchrist, 1993; Maki & McIlroy, 1999). In order to perform foot functions such as absorbing shocks and balance control properly, arch support mechanism of feet should work properly and COG should be evenly distributed across the feet from HL to toe (Redmond, Landorf, & Keenan, 2009; Winter, 1995).

However, people experience functional changes and hypoesthesia in foot as they get old with overall decline in functional ability such as a decrease in muscle power and flexibility (Eils et al., 2002). In addition, such a decrease in foot function affects weight bearing causing uneven weight distribution across feet, which leads to a decrease in COG range in feet and balance control (Eils et al., 2002; Kim, Nam, & Yong, 2014). Because of decreased balance ability, even a low height obstacle such as sidewalk bricks, which can be seen frequently outdoors, increases the risk of falls in elderly people when they are not a problem for regular adults at all and fear for falling limits outdoor activity of the elderly causing a decrease in quality of life (Lord, Sherrington, Menz, & Close, 2007). In order to prevent this problem, assessments for fall prediction using obstacle gait for the elderly (Means, 1996; Weerdesteyn et al., 2006) and obstacle trainings for the elderly are conducted (Lamoureux, Sparrow, Murphy, & Newton, 2003; Yamada et al., 2012). In particular, indoor gait training using obstacles are widely conducted because it is safer than outdoor trainings and can reduce the risk of falls through adaptation to obstacles (Lamoureux et al., 2003; Yamada et al., 2012).

The purpose of this study was to analyze whether gait training using an obstacle induces a decrease in the risk of falls through an improvement in the deterioration in elderly foot function by examining plantar pressure and contact time.

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2. Methods

2.1. Participants

This study was conducted with 24 elderly women living in communities in D city, Korea. The selection criteria for the subjects were as follows: (1) at least 65 years old; (2) no falls within the last year; (3) ability to walk independently for more than 10 m without ambulatory assistive aids or an assistant; and (4) no disease that might affect conducting the test. Those who had visual impairment, hearing damage, nervous system or vestibular organ problems, or who were unable to understand the nature of the experiment were excluded. Information on the study and written informed consent according to the ethical standards of the Declaration of Helsinki were provided to all subjects prior to their participation, and all agreed to participate in the project (Table 1).

2.2. Obstacle gait training

The subjects took enough rest in chairs before conducting the test and were instructed to walk and pass an obstacle placed in the middle of the 5 m path. They crossed the obstacle with frequently used dominant foot as a leading foot and walked at a comfortable and normal pace. Muscle strength and posture control ability in the elderly decrease as they get old causing a decrease in maximum gait speed (Bohannon, 1997). Faster gait controlled artificially in the elderly increases risk of falls because of irregular and inconsistent movements (Kerrigan, Todd, Della Croce, Lipsitz, & Collins, 1998). The subjects were not forced to walk faster than their original gait speed in their daily living to reduce risk of falls and perform consistent movement. Each session was composed of two times of gait exercises followed by 20 s rest and the subjects performed 12 sessions, 3 times per week for 8 weeks.

The obstacle was a 2 cm × 1 cm and 1 m length wooden stick and both ends were placed on top of two boxes which are set at a height of 11 cm. Therefore, the total height of the obstacle was 12 cm which is similar to that of sidewalk bricks. The stick was not fixed on the boxes to ensure subjects' safety and the test was conducted in an indoor lab for the subjects to avoid falling. Gait training using obstacle was applied under physical therapists' supervision, and any subject who felt fatigue had enough rest while the training and then restarted it.

2.3. Measuring plantar pressure

F-scan (Tekscan, USA), a resistance pressure sensor, was placed in the subjects' shoes in the form of an insole to measure plantar pressure during the test. The planter side of the foot, the measurement point for foot pressure, was divided into 7 parts, the HL, MF, MFF (medial forefoot), CFF (central forefoot), lateral forefoot (LFF), medial toe (MT), and LT (Fig. 1). Plantar pressure and contact time were measured before the test and at 4 and 8 weeks of the test (Ahroni, Boyko, & Forsberg, 1998; Menz & Morris, 2006). They were measured right before crossing the obstacle and right after crossing the obstacle. Body weight of each subject was entered in F scan for calibration in a standing position prior to foot pressure measurement. The foot pressure right before crossing the obstacle indicates that of the foot which works as a trailing foot, and the foot pressure right after crossing the obstacle indicates that of the foot which works as a leading foot. 'Trailing foot' was defined as the leg before passing the body which trails the body and 'leading foot' as the leg already passed the body which leads the body in this study. Trailing foot is the foot that starts to create forward momentum. Leading foot shows HL-strike force just after crossing the obstacle and the amount of decrease in anterior momentum while the elderly are crossing the obstacle. All the measurements were described as mean value ± standard deviation.

Table 1
General characteristics of subjects.

Age (year)	79.9 ± 2.2[a]
Height (cm)	154.5 ± 7.6
Weight (kg)	56.2 ± 5.2

[a] Mean ± SD.

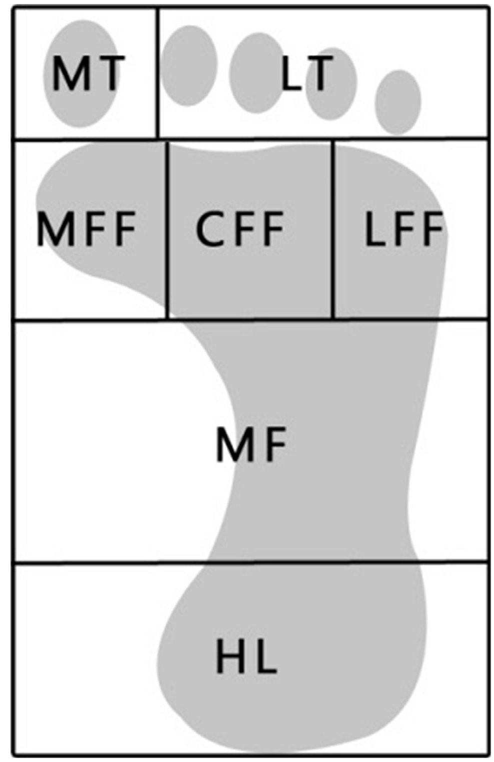

Fig. 1. Measuring areas of foot pressure. MT: medial toe; LT: lesser toe; MFF: medial forefoot; CFF: central forefoot; LFF: lateral forefoot; MF: midfoot; HL: heel.

2.4. Statistical analysis

This study used SPSS for Windows (version 20.0) to analyze the data. Repeated Measure ANOVA was used to examine the changes in contact time and plantar pressure according to intervention period. The least significant difference (LSD) was used to analyze post-HOC. The statistical significance level was set to $\alpha = 0.05$.

3. Results

In plantar contact time, there was no significant result before crossing the obstacle while there was a significant decrease after crossing the obstacle between the 4th and 8th weeks ($p < 0.05$, Table 2).

Foot pressure according to intervention period right before crossing the obstacle significantly decreased between before the gait and the 4th weeks of the gait, and between before the gait and the 8th weeks of the gait in the MT and MFF, and significantly increased between before the gait and the 4th weeks of the gait, and between before the gait and the 8th weeks of the gait in the MF and HL ($p < 0.05$, Table 3).

Foot pressure according to intervention period right after crossing the obstacle significantly increased between 4th and the 8th weeks of the gait, and between before the gait and the 8th weeks of the gait in the LT, and significantly decreased between