The influence of high heeled shoes on balance ability and walking in healthy women

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ABSTRACT. [Purpose] The purpose of this study was to investigate the influence of high heeled shoes on balance ability and walking on healthy women. [Subjects and Methods] Thirty healthy female subjects, without orthopedic history of the lower extremity were selected for the present study. The 3 cm, 6 cm, and 9 cm shoes were worn according to the prescribed order to perform a balance and walking test. [Results] Significant difference was shown after the experiment, in comparison of the groups in all variance, and as the result of post hoc test. Time, anterior-posterior length and medial-lateral length of balance variables as well as velocity of walking variables showed a significant increase between 3 cm and 6 cm, 6 cm and 9 cm, 3 cm and 9 cm. In addition, the balance index of the balance variables as well as the step length and single support ratio of the walking variables showed a significant decrease between 3 cm and 6 cm, 6 cm and 9 cm, 3 cm and 9 cm. [Conclusion] It was found that the higher the shoe heel height, the lower the balance and the less the efficiency of walking.

Key words: Balance, Heel heights, Step length

INTRODUCTION

Balance control is the ability to maintain body alignment in gravitational line and to reduce sway of the center of gravity of the body¹). The balance, which is the basis for maintaining the independence of daily life based on all movements, is controlled by the central nervous system based on the information entered through the body senses such as vision, proprioceptive sensation, and vestibular sense²). The ability to maintain a stable balance in static or dynamic situations is a prerequisite for improving function during various daily activities³). People wear shoes when they are outdoors, such as standing or walking, among which women wear high heels to make them look taller or legs look nice⁴). However, generally, when standing or walking on high heels, there is an overall physical change in the body, not only the foot and ankle joint but also the lower extremities and trunk. The resulting physical response also changes the mechanism of balance regulation. These changes reduce the ability to maintain balance during various activities and increase the risk of falls and the musculoskeletal injuries⁵). Although there have been various studies on balance in the past, most studies on the difference in balance ability in unstable support and the effect of the heel height on balance have been limited. According to a previous study, the posture control depends on the somatosensory information transmitted from the foot in contact with the support surface. It is assumed that the higher the heel is, the more somatic sensory information will change⁶). Therefore, the purpose of this study is to investigate the influence of high heeled shoes on balance ability and walking of healthy women.

SUBJECTS AND METHODS

Thirty healthy female subjects, without orthopedic history of the lower extremity were selected for the present study. Their
In this study, we investigated the effect of the 3 cm, 6 cm, and 9 cm heel height on the balance ability of adult women. As a result, it was found that the balancing ability was decreased as the heel increased.

Previous studies have shown that wearing high heels negatively affects the neuromuscular control to maintain balance by impairing the ability to accept and convey proprioietary sensory information and impairs the afferent feedback system. When high heels are worn, the length of the gastrocnemius and soleus is shortened, thereby changing the muscle length–tension relationship and reducing muscle contraction. As a result, the response to the postural fluctuation and the ability to generate the force necessary to control the center of mass are reduced, so that the compensatory action may increase the activity of the plantar flexor muscles. As mentioned above, high heels increase the balance threshold of the foot and ankle joints while maintaining the balance of the body to maintain body balance, divergence of the head position, changes in the level of curvature of the lumbar spine, or bending of the hip and knee joints. So this can lead to various postural deviations.

Table 1. Comparison of change in characteristics of the experimental group with values presented as mean (standard deviation) (n=30)

|                      | 3 cm    | 6 cm    | 9 cm    | post-hoc |
|----------------------|---------|---------|---------|----------|
| Balance              |         |         |         |          |
| Time (s)*            | 13.6 ± 6.8 | 19.4 ± 6.7 | 37.6 ± 6.8 | a<b, a<c, b<c |
| Anterior-posterior length (mm) | 1,154.3 ± 638.2 | 1,699.9 ± 871.9 | 4,684.3 ± 857.3 | a<b, a<c, b<c |
| Medial-lateral length (mm)* | 809.3 ± 425.0 | 964.7 ± 408.6 | 2,384.7 ± 425.6 | a<b, a<c, b<c |
| Balance index (scores)* | 85.5 ± 12.1 | 72.2 ± 11.2 | 45.6 ± 14.2 | a>b, a>c, b>c |
| Walking              |         |         |         |          |
| Step length (cm)*    | 55.3 ± 6.5 | 53.2 ± 4.3 | 51.3 ± 5.4 | a>b, a>c, b>c |
| Velocity (m/s)       | 80.3 ± 6.4 | 83.3 ± 5.3 | 90.2 ± 4.6 | a>b, a<c, b<c |
| Single support (%)*  | 42.6 ± 5.3 | 40.7 ± 6.5 | 38.6 ± 4.6 | a>b, a>c, b>c |

*p<0.05.

average age, height, and weight were 21.23 ± 1.31 years old, 164.14 ± 8.23 cm, and 57.26 ± 5.04 kg in experimental and control groups, respectively. Sufficient explanation of this study’s intent and the overall purpose were given, and voluntary consent to participation in this study was obtained from all of the subjects. This study complied with the ethical standards of the Declaration of Helsinki. The 3 cm, 6 cm, and 9 cm shoes were worn according to the prescribed order to perform a balance test. The shoe size was selected by the subject from 235 mm to 250 mm according to the Asian standard size. The subjects measured their balance ability in a noiseless environment so as not to interfere with the measurement in the standing position.

Balance measuring equipment (Good Balance, Metitur, Finland) was used to measure subject’s balance ability. In order to measure the balance function, subjects were instructed to stand on a triangular platform and keep their symmetrical posture with their shoulders wide. The subject’s gaze was fixed at the point in front, minimizing the movement of the head. The subjects opened their eyes and naturally lowered their arms and measured the pressure center for 30 seconds in a standing posture. The mean value was used as data. The lower the score of anterior-posterior and medial-lateral sway means the better the balance ability. The balance index score ranges between 0 and 100, and the higher score means the better balance ability to perform the task.

A pedometer (Gait Rite, K634-DB, Epson Inc., USA) was used to collect data for temporospatial gait characteristics such as velocity, step length and single support ratio. For the gait analysis, the subject was asked to walk three sessions with a 6 m walkway and the average value was used as the data. The subjects were instructed to free walking speed.

One-way ANOVA tests were used to verify the statistical significance in each group, in performances 3 cm, 6 cm, and 9 cm. In addition, a post hoc test was performed, using Fisher’s Least Significance Difference (LSD) test. The statistical significance level was set at α=0.05.

RESULTS

Significant difference was shown after the experiment, in comparison of the groups in all variance (p<0.05), and as the result of post hoc test. Time, anterior-posterior length and medial-lateral length of balance variables as well as velocity of walking variables showed a significant increase between 3 cm and 6 cm, 6 cm and 9 cm, 3 cm and 9 cm (p<0.05). In addition, the balance index of the balance variables as well as the step length and single support ratio of the walking variables showed a significant decrease between 3 cm and 6 cm, 6 cm and 9 cm, 3 cm and 9 cm (p<0.05) (Table 1).

DISCUSSION
this reason, it has been reported that when wearing high heels, body movements in the sagittal plane and coronary plane are increased and sway of the center of gravity is also increased. The results of this study are similar to those of Lord and Bashford and Oh et al., who reported that the higher the shoe heel height, the less the balance control ability.

According to previous studies, when the height of the shoe heel is high, the strides are shortened and the stance phase time is increased compared with the low heel. In another study, it was reported that high heels interfered with the ideal pattern of walking, reducing walking efficiency. These previous studies support our findings. The limitations of this study were fewer subjects and because it is aimed at healthy young women, it cannot be generalized to people with other age or physical problems.

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**Conflict of interest**

None.

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