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Original Article

# The effects of exercising on an unstable surface on the gait and balance ability of normal adults

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**Abstract.** [Purpose] This study aimed to examine that therapeutic efficacy of an unstable surface on balance and gait ability in normal individuals. [Subjects and Methods] Forty subjects participated in the experiment and were randomly assigned to an experimental group of 20 subjects and a control group of 20 subjects. The experimental group performed balance exercise on an Aero-Step device (Aero-Step XL, TOGU, Prien-Bachham, Germany). The control group performed balance exercise on rigid ground. All subjects performed balance training 30 minutes a day, 5 days a week, for 4 weeks. After the intervention, balance measuring equipment (Good Balance, Metitur, Jyvaskyla, Finland) was used to quantitatively measure balance ability. [Results] Significant differences in post-training gains in the variables of static balance, dynamic balance, and velocity were observed between the experimental group and the control group. [Conclusion] Unstable surface training aimed at improving balance ability is considered to have a positive effect.
**Key words:** Unstable surface, Balance, Adults

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## INTRODUCTION

Balance is important for the entire population, from young adults to elderly individuals, at risk for falls. For the elite athlete, balance deficits may affect performance[1)]. The interaction of central and peripheral elements is essential for maintaining balance. The peripheral element is comprised of the somatosensory system, which provides information on the location of joints and the level of tension, extension, and pain in joints, muscles, ligament, and the vestibular system, which provides information on environmental changes[2)]. The central element integrates information delivered from the peripheral element and controls the location and posture of the trunk so that the are correct. One of the important elements for functioning in daily life is maintenance of symmetrical balance in the human body in standing or sitting postures. Therefore, the loss of balance ability can cause secondary functional disorders due to falls[1)]. Walking is one of the most common forms of human movement, and the human body undergoes a complex process in neurologic and kinetic terms until walking can be performed repeatedly and rhythmically. As this shows, because various elements are involved in walking, an individual exhibits unique gait characteristics according to his/her own functions in the muscular, skeletal, and nervous systems[3)]. Gait is composed of cyclic crossing of the stance leg by the swing leg during the single support phase, and in this phase, the trunk's dynamic balance ability is a highly important factor[4)]. In recent years, balance training using the Aero-Step has been introduced as one of the various interventions for improving balance and gait abilities. The Aero-Step is characterized by elasticity and an unstable surface, as it contains chambers filled with air. In addition, balance exercises using an Aero-Step reduce the impact on lower extremity joints, and the Aero-Step enables performance of various exercises. Moreover, it is a useful exercise tool that can reduce monotonousness and boredom in one's exercise routine[5)]. Balance exercises using an Aero-Step can not only activate the somatosensory, vestibular, and visual systems, which are sensory systems involved in maintaining the body's balance,

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but can also improve the balance ability necessary for maintaining a standing posture. Although various studies have been carried out regarding balance training, studies on balance training using the Aero-Step are limited. Therefore, the purpose of this study was to examine the effects of Aero-Step balance training on the balance and gait abilities of normal individuals.

## SUBJECTS AND METHODS

Forty subjects participated in the experiment and were randomly assigned to an experimental group of 20 subjects and a control group of 20 subjects. The selection criteria for the subjects that participated in the study were as follows: no history of orthopedic surgery in the lower limb, no history of taking any drug due to neurologic problems, and no musculoskeletal system disease. The Research Ethics Committee of Eulji University Hospital approved the study, and all participants provided informed, written consent prior to enrollment in the study. The average ages, heights, and weights were 20.17 ± 1.22 and 21.25 ± 1.36 years old, 172.44 ± 12.03 and 173.15 ± 10.42 cm, and 68.05 ± 9.61 and 65.31 ± 6.62 kg in the experimental and control groups, respectively. Sufficient explanation of this study's intent and the overall purpose was given, and voluntary consent to participation in this study was obtained from all of the subjects. All procedures were reviewed and approved by the Institutional Ethics Committee of Eulji University Hospital. The experimental group performed balance exercise on the Aero-step device (Aero-step XL, TOGU, Prien-Bachham, Germany)[5)]. The control group was performed balance exercise on the rigid ground. All subjects performed balance training 30 minutes a day, 5days a week, for 4weeks. The Aero-Step equipment was used to provide an unstable base during the performance of the exercise program[5)]. The Aero-Step equipment is 51 cm long, 37 cm wide, and 8 cm high. It is composed of a soft rubber and contains two chambers, which are filled with air. In the first phase exercise, the subjects bent the left knee joint at 90° while supporting the body with the right leg, and then they bent the right knee joint at 90° while supporting the body with the left leg. In the second phase, the subjects bent the left knee and hip joints at 90° while supporting the body with the right leg, and then they bent the right knee and hip joints at 90° while supporting the body with the left leg. In the third phase, the subjects walked in place on a supporting surface and maintained a certain gait velocity. While walking in place, they bent the knee and hip joints. In the fourth phase, the subjects stood upright with the feet shoulder-width apart and bent the knee and hip joints at 90°. In the fifth phase, the subject bent and stretched the left hip joint while supporting the body with the right leg, and then they bent and stretched the right hip joint while supporting the body with the left leg. During this exercise, they were required to look straight ahead. Each phase of exercise took five minutes. A three-minute break was provide between phases of exercise. After the intervention, balance measuring equipment (Good Balance, Metitur, Jyvaskyla, Finland) was used to quantitatively measure balance ability. For measurement of balance functions, the subjects were instructed to stand on a triangle platform and maintain a symmetric standing posture with the legs apart at shoulder width. In this case, a visual fixed point was marked in front of the subjects to minimize head movement. The subjects were then ask to place their arms comfortably at the sides of their hip joints, and the COP (center of pressure) was measured for 30 seconds in this standing posture with the eyes open. The COP was measured three times repeatedly, and the average value was calculated. A pedometer (Gait Rite, K634-DB, Epson Inc, America) was used to collect data for temporospatial gait characteristics such as velocity, step length, stride length, single support duration, double support duration, and cadence of the experimental group and the control group. For precise analysis of their gait, the subjects were asked to walk along a 2 m walkway in three sessions, and the average values of the data were used. The subjects lifted their head and looked straight forward and walked barefoot while lightly swinging their upper limbs[6)]. Data analysis was performed using IBM SPSS Statistics version 20.0 (IBM corp., Armonk, NY, USA). The mean and standard deviation (SD) were calculated for each variable. Before the intervention, differences in the general characteristics of the experimental and control groups were compared using independent t-tests and $\chi^2$ tests. Comparisons of variables before and after training within each group were made using paired sample t-tests. Comparisons of pre- and post-test differences in variables between the experimental and control groups were performed using the independent t-test. Intergroup effect sizes were calculated using the Cohen d coefficient[7)]. Statistical analysis was performed at a 95% confidence level, and p values <0.05 were considered statistically significant.

## RESULTS

No significant differences in the baseline characteristics were observed between the two groups (p>0.05). Forty subjects (experimental group=20, control group=20) completed this experiment. The characteristics of the two groups before and after the intervention are shown in Table 1. The experimental group showed significant increments in the variable of static balance, dynamic balance and velocity compared with the pre-intervention results (p<0.05). In addition, the control group showed significant improvement in static balance and, dynamic balance compared with the pre-intervention results (p<0.05). Significant differences in the post-training gains in the variable of static balance, dynamic balance, and velocity were observed between the experimental group and the control group (p<0.05). The effect sizes for gains in the experimental and control groups were very strong for static balance, dynamic balance, and velocity (effect size=0.94, 1.16, and 0.83, respectively).

**Table 1.** Comparison of change in characteristics of the experimental group and control group with values presented as the mean (standard deviation)

| | EG (n=20) | | CG (n=20) | |
|---|---|---|---|---|
| | Pre | Post | Pre | Post |
| Balance | | | | |
| Static balance (score)[a,b] | 68.5 (7.7) | 83.2 (7.1)* | 72.3 (7.3) | 76.3 (5.3)* |
| Dynamic balance (score)[a,b] | 70.5 (8.2) | 78.6 (5.6)* | 71.1 (5.0) | 74.2 (4.1)* |
| Gait | | | | |
| Step length (cm) | 56.2 (6.2) | 59.2 (5.1) | 53.2 (4.3) | 55.2 (3.2) |
| Velocity[a,b] (m/s) | 85.3 (5.2) | 90.2 (3.2)* | 77.1 (5.2) | 80.2 (4.6) |
| Single support (%) | 41.9 (6.3) | 45.6 (7.2) | 37.3 (5.2) | 38.5 (6.7) |
| Cadence (steps/min) | 98.2 (11.6) | 102.8 (13.9) | 88.3 (12.8) | 90.1 (13.6) |

EG: experimental group; CG: control group.
[a]Significant difference in gains between two groups ($p<0.05$)
[b]Effect size greater than 0.80
*Significant difference from pre-test ($p<0.05$)

## DISCUSSION

Given that the advantage of balance exercises using an Aero-Step is that they can activate not only sensory organs such as the somatosensory, vestibular, and visual systems, but also the central nervous system, these exercises are also effective for brain fitness. In addition, because the Aero-Step is safe and easy to handle, it can be used by the elderly aged 60 or older[8]. This study was performed to learn about the effects of balance exercises using an Aero-Step on the balance and gait of normal individuals. As a result, statistically significant increases were observed in dynamic and static balance abilities and gait velocity. A previous study reported that when poststroke hemiplegic patients performed somatosensory exercises using the proprioceptive senses, statistically significant increases were shown in the balance ability and functional gait indices[9]. This is similar to the results of the present study. Another study reported that when stroke patients performed exercises on an unstable supporting surface, they showed improvements in balance ability and reduction in the risk of falls compared with performing exercises on a stable supporting surface[10]. The mechanism of balance exercises using an Aero-Step can be explained as follows. Somatosensory receptors are largely influenced by the surface. Therefore, balance exercises using Aero-Step as an unstable surface activate tendons, ligaments, and joint receptors. This may be because activation of the somatosensory system by the Aero-Step's unstable surface has positive impacts on improving balance and gait abilities. Reduced balance and gait abilities cause falls. To prevent this, the visual, vestibular, and somatosensory systems should be strengthened[11]. The organs that show the largest distribution of somatosensory receptors in the human body are the hand, foot, and face. Among them, the foot has the largest number of sensory receptors. Therefore, balance exercises using an Aero-Step may be recommended as an exercise method that can develop the somatosensory system effectively.

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