Effects of an Exercise Program Using Aero-step Equipment on the Balance Ability of Normal Adults

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Abstract. [Purpose] This study was conducted to investigate the effects of an exercise program using aero-step exercise equipment on the balance ability of normal adults. [Subjects] Twenty-one normal adults were randomized into a flat floor exercise program group (FEG, n = 7), an aero-step exercise program group (AEG, n = 7), and a control group (CG, n = 7). [Methods] the FEG and AEG performed an exercise program four times a week for 2 weeks, but CG did not receive any treatment. The overall stability index (OSI), anterioposterior stability index (APSI), and mediolateral stability index (MLSI) were measured and compared using a Biodex balance system. [Results] The intragroup comparison revealed significant differences in OSI and APSI of AEG and in MLSI of FEG. [Conclusion] The exercise program using aero-step equipment seems to be effective at improving the balance abilities of OSI and APSI.

Key words: Aero-step, Balance ability, Stability

INTRODUCTION

Balance refers to the adjustment of position in active movements and the maintenance of an appropriate position in response to external stimuli. The maintenance of balance requires normal pressure and an appropriate integration process at the higher center with continuity of the center of gravity within the support plane. The improvement and maintenance of balance is very important, because a decrease in balance increases the frequency of falls and aggravates the physical impairments of patients. Aging brings about anatomical and physiological changes, and such physiological conditions as a loss of perception, dysfunction of the musculoskeletal system, and instability of posture positions, which are connected to balance problems and can lead to serious injuries. In particular, visual acuity, pallesthesia, proprioceptive sense, relative degradation of the lower extremity muscle strength, and delayed response time can all affect balance and cause accidental falls.

Treatment methods for enhancing balance recovery and position adjustment include trunk stabilization exercises, fixed bicycle riding exercises, visual feedback training, and Swiss ball workouts. In recent years, studies have been actively conducted on exercise methods based on motor learning theories for voluntary problem solving with visual, auditory, and biofeedback methods in continuous exercise tasks and conditions. Furthermore, therapeutic approaches on an unstable support plane that requires postural adjustment in changing environmental conditions are being used to treat various health problems including stroke, sports injuries, and falls by the elderly.

Shumway-Cook and Woollacott reported that balance training on an unstable support plane was more effective at improving proprioception of the foot and enhancing the adaptability of balance elements than training on a stable support plane. Exercise on an unstable support plane has very different effects from exercise on a stable support plane and is one of the methods that can potentially change the neuromuscular recruitment pattern. Furthermore, exercise on an unstable support plane increases muscle activity compared to a stable support plane. Accordingly, this study was conducted to investigate the effects of aero-step equipment, which can provide an unstable support plane in any location, enable exercises even in narrow places, and generate various exercise motions, to promote balance ability.

SUBJECTS AND METHODS

The subjects of this study were 21 young adults (male: 9, female: 12) in their 20s who were students of Y University in Chungcheongbukdo. The average age, height, and weight of the flat floor exercise program group (FEG) were 20.86 ± 1.57 years, 170.0 ± 8.46 cm, and 60.64 ± 8.61 kg respectively. The average age, height, and weight of the aero-step exercise program group (AEG) were 20 ± 1.43 years, 166.29 ± 5.22 cm, and 59.34 ± 11.55 kg, respectively. The average age, height, and weight of the control group (CG) were 20.86 ± 0.38 years, 164.71 ± 7.45 cm, and 60.16 ± 5.67 kg, respectively. All of the subjects listened to an explanation about the purpose and exercise method of this study and voluntarily consented to participate in this study in advance. The inclusion criteria for the subjects were no physical defects affecting balance ability, no history of orthopedic or neu...
rologic injuries in the last six months, and no deficiency in visual sense and sense of equilibrium for the maintenance of balance.

Aero-step equipment (Aero-step XL, TOGU, Germany) was used to provide an unstable base during the performance of the exercise program. The size of the aero-step equipment is 51 cm in length, 37 cm in width, and 8 cm in height. It is composed of soft rubber and two spaces, which are filled with air. The aero-step equipment enables exercise in a narrow space and is easy to handle. Due to the nature of the balloons filled with air, it prevents any large shocks to the body. Furthermore, it can avoid the boredom that attends monotonous exercise, because it can generate various exercise motions. Thus, it is an exercise tool that would be useful for the elderly at home.

The subjects of this study were randomized into three groups. The FEG performed the exercise program on a hard, flat surface. The AEG performed the exercise program with the aero-step equipment, which has an unstable support surface. The CG did not receive any treatment.

Both FEG and AEG performed the exercise program in four 30-min sessions per week for 2 weeks. The subjects repeated the motions of step 1 to step 6 in each session, and took a rest for 3 minutes between each step. All the exercise programs were performed in the standing position. In step 1, subjects crossed their hands in front of their chest and put them on both their shoulders. When ready, they closed their eyes, and stood for 6 seconds on their toes, and then for 6 seconds on their heels. In step 2, while bending their shoulders at 45 degrees and keeping their elbows spread, they turned their upper body to the right and left. Then, they raised the toes and heels of their feet. In step 3, the motion was identical to step 2, but it was performed while holding subject a 2 kg weight in both hands. In step 4, both hands were crossed in front of the chest and put on both shoulders. Subjects supported their weight on one leg and maintained the position for 6 seconds, before returning to the original position. Then, they supported their weight on the other leg. In step 5, with both arms crossed, the shoulders flexed at 45 degrees and the elbows extended, subjects bent their knee and hip joints for 6 seconds before returning to the original position. In step 6, with both arms crossed in front of their chest and the hands placed on both shoulders, subjects balanced on one foot alternately.

To collect clinical data related to balance, the Bodex Balance System (Bodex medical systems Inc, USA) was used. The subjects stood with their hands on their shoulders on a round foothold, which could be moved in all directions at an angle of up to 20 degrees according to the movement of weight. While gazing at a cursor (point) at the center of a circle on a computer monitor, they were asked to maintain their eyes on the cursor (point) at the center of a circle without taking their feet off the foothold when the foothold was inclined. The positions of their feet on the foothold were adjusted so that the line of gravity of the body passing through the ankle joint and the line indicated on the foothold met at a right angle. The distance between both feet was kept at four inches in all measurements. The stability level of the foothold ranges from level 8, which is the highest, to level 1, which is the lowest. In this study, levels 1 to 6 were set and the averages of two measurements were used. For the overall stability index (OSI), anteroposterior stability index (APSI), and mediolateral stability index (MLSI), a higher value of the balance index indicates a lower level of balance.

For statistical analysis of the balance ability within each group, the paired t-test was performed. SPSS 12.0 for Windows was used for statistical analysis with a significance level α of 0.05.

RESULTS

The intragroup comparison revealed significant differences in OSI and APSI of AEG, and in MLSI of FEG (p < 0.05). However, there were no significant differences in OSI, APSI, and MLSI in CG (p > 0.05) (Table 1).

DISCUSSION

The improvement of balance ability has been researched as a highly important clinical issue for many years. The methods of research for balance recovery and functional improvement include lateral weight movement training, visual feedback training, task-oriented training, and trunk stabilization exercise using proprioceptive neuromuscular facilitation (PNF). In recent years, studies have been actively conducted of exercise methods based on motor learning theories for voluntary problem solving with visual, auditory, and biofeedback methods in continuous exercise tasks and conditions. In this study, the effects of an exercise program using an aero-step device on balance ability were investigated.

Katz-Leurer et al.3 trained stroke patients using static bicycle riding exercises. Kim4 reported that a trunk stabilization exercise using PNF elicited functional movement control and brought about positive reactions in balance and position adjustment in hemiplegic patients. Lee et al.5 used a balance ability exercise therapy system to treat post-stroke patients with acute hemiplegia, and Lee6 improved the balance and movement abilities of stroke patients using

| Table 1. The within group comparison of OSI, APSI, and MLSI (unit: score) |
|-----------------------------------------------|
| Index | Group | Before | After |
|-------|-------|--------|-------|
| OSI   | FEG   | 2.8±0.8| 2.2±0.9|
| AEG   | 3.3±1.0| 2.2±1.3|
|       | **   | 3.0±0.9| 2.9±0.9|
| APSI  | FEG   | 2.4±1.4| 2.1±1.8|
| AEG   | 2.6±1.1| 1.5±1.08|
|       | 2.2±0.7| 2.1±0.6|
|       | **   | 1.9±0.6| 1.3±0.5|
| MLSI  | AEG   | 1.4±0.6| 1.3±0.5|
|       | 1.6±0.7| 1.7±0.6|

OSI: overall stability index, APSI: anteroposterior stability index, MLSI: mediolateral stability index, FEG: flat floor exercise program group, AEG: aero-step exercise program group, CG: control group. #: Mean±SD, *: Paired t test, **: p<0.05, ***: p<0.01.
a balance pad with an unstable support plane. In this study, a balance program was performed on an unstable support plane with aero-step equipment, which is easily movable to any place, can be used by many persons, and is not limited by location.

Lee\(^7\) performed a study of 36 elderly patients over 60 and reported that the aero-step exercise significantly improved cardiopulmonary endurance, systemic flexibility, shoulder flexibility, confidence in balance, multi-directional body twist, and balance tests, and reported that aero-step exercising was more effective for the improvement of physical strength than weight training. Oh\(^8\) conducted Swiss ball and aero-step exercises with elderly subjects aged over 70, and reported that while both exercises significantly increased static balance, the Swiss ball exercise group improved static balance on a stable surface and the aero-step exercise group improved static balance on an unstable surface. Park and Yoon\(^9\) measured elderly subjects aged 65 or older for 8 weeks and reported that aero-step exercise significantly increased the muscle strengths of the abdomen, the back, and the lower extremities, and that the increased muscle strength of the lower extremities improved the static and dynamic balance abilities of the elderly, which in turn decreased the risk of falls due to unstable walking. Bae et al.\(^10\) conducted exercises for 40 elderly subjects aged 65 or older for 8 weeks and reported that the aero-step program group showed external ear and the knee joint alignment closer to the central line of gravity in the sagittal plane than the control group; and in the coronal plane, the differences in ASIS, indicating the positions of the bilateral acromion processes and the pelvis, decreased suggesting that proprioceptive exercises using aero-step can improve the muscular competency along with the proprioceptive sense as well as the postural alignment of the elderly. Kim and Yoon\(^1\) conducted an experiment with elderly women subjects for eight weeks, and reported the group which used the aero-step program significantly increased their abdominal and leg muscle strengths. Chang et al.\(^12\) conducted an experiment with normal adult subjects in their 20s for six weeks, and reported the activities of the right multifidus and the left external abdominal oblique muscles of those in the stabilization exercise group that used an aero-step were higher than those in the stabilization exercise group that used an unstable support. Park\(^13\) conducted a 12-week experiment with patients who had been diagnosed with stroke, and reported the exercise group that used an aero-step improved their overall balance, anteroposterior balance, and external and internal balance relative to the exercise group that used flat ground.

The intragroup comparison of the present study showed significant differences in OSI and APSI of AEG, and MLSI of FEG, but no significant differences were found in OSI, APSI, and MLSI in CG. In AEG, anteroposterior sway was elicited by steps 1 to 3 of the exercise program, and dorsi-flexion and plantarflexion of the ankle joint stimulated the Golgi tendon organs and muscle spindles following joint movement, increasing muscle activity and muscle competency due to an instant reaction to this. Therefore, AEG, which used an unstable support plane, received greater stimulation of proprioceptors and more smooth stimulation of the mechanoreceptors in the plantar skin and ankle joint than FEG, which used a stable support plane. Thus, it seems that the activities of the muscles involved in dorsi-flexion and plantarflexion of the ankle joint and the muscles involved in flexion and extension of the knee and hip joints were enhanced and the balance ability of APSI increased. FEG, which used a stable support plane, showed a significant difference in MLSI. It seems that mediolateral sway was elicited by steps 4 to 6 of the exercise program, and postural balance was maintained at the hip joint and trunk rather than at the ankle, which improved the balance ability of MLSI. As shown by the results of this study, the plantar skin sense plays an important part in postural adjustment and balance. It seems that aero-step equipment, which has an unstable support surface, more effectively stimulates the plantar skin receptors and the joint receptors of the ankle during performance of proprioceptive stimulation exercises than standing upright on a hard ground.

This study had some limitations. First, the number of subjects was small. Second, it is difficult to generalize the results because the subjects were young adults from the Chungcheongbukdo region of South Korea. Third, long-term effects were not evaluated because this study was conducted for a short period of 2 weeks. Fourth, sufficient evidentiary materials were not presented because a previous study of aero-step has not been conducted in South Korea, and it was difficult to find international papers. Fifth and last, objective data were insufficient because the muscle activities of the lower extremities that affect balance were not measured. Future studies should develop a program for the elderly exposed to falls using aero-step equipment with an unstable support plane and investigate its effects on balance ability and muscle activity.

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