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Research Article

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# Comparison of the Immediate Effect of Ankle and Hip Joint Thera-band Exercise on the Balance Ability

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**| Abstract |**

**PURPOSE:** This study compared the effect of training ankle joint and hip joint thera-band exercise on balance.

**METHODS:** The participants were divided into two groups of 11 each. Group A performed hip exercise after ankle exercise, and Group B performed ankle exercise after hip exercise. Using a green thera-band, the dorsiflexion and plantarflexion and hip flexion and hip extension were exercised repeatedly for 15 seconds three times with a five-second rest between each set. After the exercise and measurement of one area were complete, the exercise and measurement of the other area were performed at one-day intervals. The balance ability was assessed using a Tetrax and Y-balance test and repeated three times; the best values were taken.

**RESULTS:** In the stability index (ST) of the static balance, the hip joint exercise group (HTG) during the follow-up of normal eye open (NO) revealed notable improvement over the ankle joint exercise group (ATG), and in the follow-up of the normal eye closed (NC), the ATG showed significant improvement over the HTG. In the pillow with eye closed (PC) follow-up, the ATG showed significant improvements over the HTG. At the left (Lt) and Y-balance test (YBT), the ATG showed significant improvements in the follow-up over the HTG ($p < .05$).

**CONCLUSION:** In static balance, the ATG showed significant improvement in the follow-up of NC and PC over the HTG. In the dynamic balance, the Lt. dynamic balance on the non-dominant side in the ATG showed significant improvement in the follow-up over the HTG.

**Key Words:** Ankle, Balance, Hip, Thera-band exercise

## Ⅰ. Introduction

Balance refers to the ability to maintain or control the center of the body with minimal postural sway for a stationary or moving base plane [1]. Balance can be divided into a static balance, in which the central gravity is placed within the support plane without moving, and a dynamic balance, in which the body maintains its posture while moving [2].

Regular participation in resistant exercise is recommended

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because resistance-type exercise can improve muscle strength, muscle mass and bone mass, parallelism, or mobility required for daily life ability [3]. Band-type resistance exercise stimulates the intrinsic sense of the water-soluble areas of the joints and muscles, transmitting information on the joint location and movement to the cerebrum to maintain a correct posture. There is less impact during exercise, even when performing movements within various joints [4]. Thera-band exercise can activate the necessary muscles as much as possible through resistance exercise [5] for the following reasons: the range of resistance varies according to the length, color, and grip of the band; the intensity of motion can be easily adjusted; transportation and cost are relatively low [6].

Humans require a hip strategy and ankle strategy to maintain physical stability and harmonious movement during standing [7]. An ankle strategy is an important component for maintaining a controlled position [8].

Song [9] reported that an eight-week thera band resistance exercise has a positive effect on the balance and walking of stroke patients, Yu et al. [10] stated that resistance exercise using a five-week thera band could improve the static and dynamic balance of the elderly. Gribble [11] reported significant improvement in the front plane posture control for six weeks of thera band exercise. Kim [12] observed significant improvement in the front plane posture control after six weeks of thera band exercise. Dashti et al. [13] showed that six weeks of thera band training for elderly women was more effective in dynamic balance than Pilates training. Pelin et al. [14] reported that the six-week thera band exercise program effectively stabilized the core and improved balance. Lee et al. [15] showed that the six-week campaign to strengthen the thera band improved the balance ability of raising one leg with the eyes open. In this way, various exercise experiments using a thera band are being performed on stroke patients, the elderly, and women at home and abroad. On the other hand, the ankle and hip joints belong to lower extremities or interbody exercise studies, and comprehensive movements have been studied, but studies on each independent movement are insufficient. Therefore, this study examined the immediate effect of the ankle joint and hip joint thera band exercise on balance.

## Ⅱ. Methods

### 1. Participants

This study was conducted on 22 healthy college students in Asan, South Chungcheong. The subjects had no injury to ankle and knee joints or a history of such after the pre-test, and all subjects who provided prior consent participated in the study. The subjects were blinded to the group and experimented with a crossover study. This study was conducted with the approval of the Institutional Review Board (IRB) of Sun-moon University (SM-202103-015-2).

A consent form was signed after the subjects were explained the purpose of the experiment and the methods used. The height and weight were measured using an automatic BMI-measuring tadiometer (BSM 370, Korea, 2011) before starting the experiment. The physical characteristics of the participants were similar (Table 1). The number of samples in the study was calculated using the sample count program G*Power3.1.9.2. (Table 2). The total number of samples required was 20. Hence, 22 people were recruited considering potential dropouts.

### 2. Design

Before the experiment, the ball was placed on the floor, and the leg kicking the ball was identified as the dominant side to apply motion to the non-dominant side [16]. The distance between the ball and the target was set at 2M.

Table 1. General Characteristics of the Participants (N = 22)

| Variable | | Participants (n = 22) |
|---|---|---|
| Age (years) | | 23.43 ± 2.56 |
| Gender | Male | 11(50%) |
| | Female | 11(50%) |
| Height (cm) | | 168.09 ± 7.97 |
| Weight (kg) | | 65.46 ± 12.08 |

Table 2. Determining the Sample Size

| | Participants (n = 22) |
|---|---|
| Test family | F tests, ANOVA: Repeated measures, within factors |
| Type of power analysis | A priori: compute required sample size - given α, power, and effect size |
| Effect size | .2784735 |
| α err prob | .05 |
| Power (1- B err probe) | .8 |
| Number of groups | 2 |
| Number of measurements | 3 |
| Corr among rep measures | .75 |

Warm-up exercises were performed for five minutes before starting exercise to prevent injury. This study was a crossover design. The participants were divided into two groups of 11 each. Group A performed hip exercise after ankle exercise, and Group B performed ankle exercise after hip exercise. Dorsiflexion and plantarflexion and hip flexion and hip extension movement were performed using a green thera band. The interval between exercises was one day to prevent the first applied interventions from affecting the following interventions. After exercise, a cool-down exercise was performed by stretching for five minutes to prevent injury. The static and dynamic balance abilities were measured before and immediately after exercise and five minutes after exercise using Tetrax and Y-balance. The overall research design was the same as Fig. 1(Fig. 1).

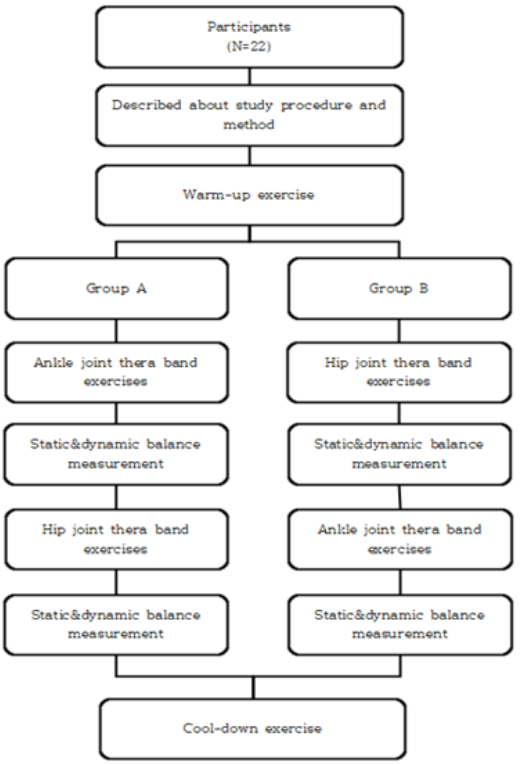


Fig. 1. Experiment protocol flow chart.

### 3. Measurement Equipment

#### 1) TETRAX

The TETRAX system analyzed the patient's balance and measured the target's dynamic posture control. Tetrax is a tool for evaluating the postural sways by weight changes loaded on four points (two wheels and two toes) by installing independent force platforms on the left and right wheels and toe, respectively. After taking off their shoes, the subjects placed their feet on a power plate and stood in a comfortable position. The subjects were asked to keep their arms on both sides and keep their eyes focused on the front, and limit their movements to the maximum extent possible during the examination. The evaluation was started after one exercise set to stabilize the posture before the examination [17]. Normal eye open (NO), normal eye closed (NC), pillow with eye open (PO), pillow with eye closed (PC) were measured to assess the static balance (Fig. 2). Thirty-two seconds were needed for each posture, and data were taken before and after each exercise and

Fig. 2. Tetrax.

Fig. 3. Y-balance test.

after rest. In preparation for falls during the examination, the examiner waited around the subjects and observed them. The stability index (ST) was used for evaluation, and the static balancing capacity increased with decreasing ST value.

2) Y-balance Test

Dynamic posture control was evaluated using the Y-Balance test (YBT). The data were measured in cm, where the subject stretched and balanced in three directions:

$$\frac{(\text{Anterior} + \text{Posteromedial} + \text{Posterolateral})}{(\text{Leg length}*3)} * 100$$

Fig. 4. Formula for calculating the YBT.

posteromedial (PM), Posterolateral (PL), and 135° away from the center of the Y-balance board to both sides in terms of the anterior (Fig. 3). Both the right and left sides were measured three times in each direction, with the highest measurement recorded. The measurement was regarded as a failure and measured again if the supporting foot left the ground, an extended foot was used for balance, or the foot failed to return to the starting position after stretching [18]. For each exercise, the measurements were taken before and after exercise. The length of the subjects' legs was measured, and the composite score was calculated according to the formula below (Fig. 4).

4. Exercise Program

1) Ankle Dorsiflexion Exercise [19]

A green thera band was tied to a bedpost, and the participant extended their legs and their side legs and bent and fixed their non-exercising legs. A thera band was placed on the back of the participant's foot, bent the back of the foot, and held it for 15 seconds. The exercise was performed three times with a five-second rest between each set (Fig. 5).

2) Ankle plantarflexion Exercise [19]

The participant worked out in a straightened, sedentary position, with the non-exercising lateral leg bent and fixed and the exercising lateral leg in a straight position. The participant hung a green thera band on the soles of his feet while exercising, grabbed it from the participant's knee position, and extended it to the pelvis for resistance. With the thera band stretched, the participant bent the soles for 15 seconds. The exercise was performed three times with a five-second rest between each set (Fig. 5).

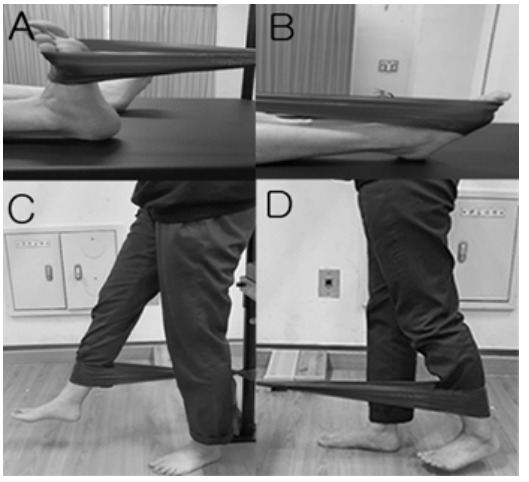


Fig. 5. Thera band exercise
A : Dorsi flexion, B : Plantar flexion, C : Hip Flexion, D : Hip Extension.

3) Hip Flexion Exercise [20]

A green thera band was tied to a bedpost, and the participant placed a thera band on the front of the ankle of the exercise and stood up straight away. Immediately after, the participant bent their hips with their knees stretched out. The hip flexion was performed three times for 15 seconds each with a five-second rest between each set (Fig. 5).

4) Hip Extension Exercise [20]

A green thera band was tied to a bedpost, and the participant placed a thera band on the front of the ankle of the exercise and stood up straight away. Immediately after, the participant bent their hips with their knees stretched out. The hip flexion was performed three times for 15 seconds each with a five-second rest between each set (Fig. 5).

### 5. Statistical Analyses

All statistical analyses used the SPSS statistical software(version 20.0; IBM) program to calculate the mean and standard deviation for each metric. After the normality test, the intergroup comparison was conducted using an independent t-test, and for each exercise, repeated measures of ANOVA was performed for a comparison of the balance changes between before and after exercise. This was followed by a posterior analysis with Fisher's LSD. All significance levels for statistical analysis were set to $p < .05$.

## Ⅲ. Results

### 1. Changes in the Ability to Balance over Time in Each Group

Table 3 lists the changes in the balance capacity of the ankle joint exercise group (ATG) and hip joint exercise group (HTG) over time. Significant differences in subjects' dynamic and static balancing capacity changes were noted ($p < .05$).

### 2. Changes in Balance

An analysis of NO showed a change in the figure over time in the ankle joint training, but the change was not significant. In hip joint training, significant differences were observed between the groups immediately after training and after rest ($p < .05$). An analysis of NC showed significant differences between the groups immediately after training and after resting in ankle joint training ($p < .05$), and statistically significant differences immediately after training and after resting in hip joint training ($p < .05$). A significant difference was observed immediately after training and after rest during hip joint training in a PC ($p < .05$). In PO, there was a significant difference immediately after training and after rest ($p < .05$). Significant differences in Lt. during the Y-balance test were observed between the groups immediately after training and after resting in ankle joint training ($p < .05$). In addition, significant differences were noted immediately after training and after resting during hip joint training ($p < .05$). During the Rt. Y-balance test, there was a change in ankle joint training over time, but the change was not

Table 3. Static and Dynamic Balance Means and Standard Deviation Values According to Time

| Method of Exercise | | Time | | | | |
|---|---|---|---|---|---|---|
| | | Pre | Post | Follow-up | F | p |
| §NO (%) | †ATG | 15.15 ± 3.8 | 16.5 ± 3.5 | 12.48 ± 2.41 | 16.532 | .067 |
| | ‡HTG | 14.27 ± 2.94 | 16.45 ± 4.06 | 13.03 ± 3.4 | 28.219 | .041[a] |
| ‖NC (%) | ATG | 12.48 ± 2.41 | 11.35 ± 3.85 | 9.7 ± 3.79 | 26.843 | .038[a] |
| | HTG | 19.31 ± 2.71 | 18.93 ± 3.15 | 15.31 ± 1.03 | 31.776 | .031[a] |
| ¶PO (%) | ATG | 21.35 ± 3.93 | 21.45 ± 3.15 | 21.35 ± 3.93 | 13.547 | .506 |
| | HTG | 21 ± 4.18 | 23.13 ± 4.1 | 18.19 ± 4.18 | 67.24 | .000[a] |
| **PC (%) | ATG | 27.2 ± 3.6 | 27.75 ± 3.69 | 27.2 ± 3.6 | 9.153 | .653 |
| | HTG | 27.77 ± 4.89 | 24.04 ± 5.05 | 20.77 ± 4.89 | 29.581 | .000[a] |
| ††Lt. YBT (cm) | ATG | 101.55 ± 7.91 | 102.02 ± 12.36 | 113.03 ± 10.96 | 46.231 | .001[a] |
| | HTG | 101.66 ± 6.71 | 104.89 ± 11.21 | 108.87 ± 11.48 | 31.564 | .239 |
| ‡‡Rt. YBT (cm) | ATG | 98.61 ± 11.01 | 101.03 ± 11.43 | 106.64 ± 7.94 | 17.064 | .147 |
| | HTG | 100.46 ± 7.67 | 104.86 ± 10.39 | 106.4 ± 11.56 | 19.215 | .108 |

*Values are expressed as the mean ± standard deviation.

†ATG, Ankle Training Group; ‡HTG, Hip Training Group;

§NO, Normal Eye Open; ‖NC, Normal Eye Close ;

¶PO, Pillow with eye Open; **PC, Pillow with eye Close.

††Lt.YBT Left side Y-Balance Test; ‡‡Rt.YBT Right side Y-Balance Test

significant. There was also a change over time in hip joint training, but the change was not significant (Table 3).

### 3. Comparison of Balance Ability in Each Group

The differences in balance capacity between the ankle joint exercise group and hip joint exercise group and time are as follows (Table 4). The group and timing interactions were 17.48 ± 2.41. The hip joint exercise group measured 13.03 ± 3.4. The follow-up of the ankle joint exercise group in NC and the hip joint exercise group measured 15.31 ± 1.03. The follow-up measurements of the ankle joint and hip joint exercise groups on the PC were 27.2 ± 3.6 and 20.77 ± 4.89, respectively. The Y-balance test results showed a significant difference in the follow-up measurements with 113.03 ± 10.93, and the hip joint exercise group showed 108.87 ± 11.48.

## Ⅳ. Discussion

Balance is the ability to move or maintain posture without falling while supporting weight [21]. A relationship between damage to balance ability and lower extremity muscle strength in elderly falls was reported [22]. Increasing the instability of the ankle joint due to weakening of the muscle strength of the tibialis anterior and gastrocnemius muscles leads to functional instability, which results in over-compensation for hip and interbody movements, limiting the efficient mechanical balance response [23]. In the recovery of the balance according to posture fluctuations, the balance is maintained upright using both strategies, such as ankle strain or hip strain [24]. Therefore, this study attempted to find more effective training methods to improve the balance by comparing the ankle joint thera band exercise and hip joint thera band

Table 4. Comparison of Balance Ability between the Two Groups

| | | †ATG | ‡HTG | t | p |
|---|---|---|---|---|---|
| §NO (%) | Pre | 15.15 ± 3.8 | 14.27 ± 2.94 | 4.503 | .621 |
| | Post | 16.5 ± 3.5 | 16.45 ± 4.06 | 2.83 | .960 |
| | Follow-up | 12.48 ± 2.41 | 13.03 ± 3.4 | 8.068 | .035** |
| ‖NC (%) | Pre | 19.35 ± 3.85 | 19.31 ± 2.71 | 3.541 | .767 |
| | Post | 19.7 ± 3.79 | 18.93 ± 3.15 | -11.26 | .052 |
| | Follow-up | 17.48 ± 2.56 | 15.31 ± 1.03 | 15.402 | .000** |
| ¶PO (%) | Pre | 21.35 ± 3.93 | 21 ± 4.18 | -2.669 | .787 |
| | Post | 21.45 ± 3.15 | 23.13 ± 4.1 | -8.546 | .147 |
| | Follow-up | 21.35 ± 3.93 | 18.19 ± 4.18 | -13.484 | .783 |
| **PC (%) | Pre | 27.2 ± 3.6 | 27.77 ± 4.89 | 6.564 | .682 |
| | Post | 27.75 ± 3.69 | 24.04 ± 5.05 | 14.961 | .430 |
| | Follow-up | 27.2 ± 3.6 | 20.77 ± 4.89 | 21.835 | .000** |
| ††Lt. YBT (cm) | Pre | 101.55 ± 7.91 | 101.66 ± 6.71 | 5.126 | .963 |
| | Post | 102.02 ± 12.36 | 104.89 ± 11.21 | 3.684 | .432 |
| | Follow-up | 113.03 ± 10.96 | 108.87 ± 11.48 | 9.13 | .0443** |
| ‡‡Rt. YBT (cm) | Pre | 98.61 ± 11.01 | 100.46 ± 7.67 | 7.654 | .521 |
| | Post | 101.03 ± 11.43 | 104.86 ± 10.39 | -1.862 | .268 |
| | Follow-up | 106.64 ± 7.94 | 106.4 ± 11.56 | 8.502 | .946 |

†ATG, Ankle Training Group; ‡HTG, Hip Training Group;

§NO, Normal Eye Open; ‖NC, Normal Eye Close ;

¶PO, Pillow with eye Open; **PC, Pillow with eye Close.

††Lt.YBT Left side Y-Balance Test; ‡‡Rt.YBT Right side Y-Balance Test

exercise to college students in their 20 s.

Han SW. et al. evaluated 24 elderly women for eight weeks mediated with a sera band and a Swiss ball to improve the functional arm length from 11.01 ± 4.08 cm to 13.68 ± 4.11 cm [25]. Therefore, in this study, exercise was performed using a thera band.

The results of this study revealed significant differences in the dynamic and static balance capabilities in the follow-up to both ankle and hip joints. According to previous studies, Ribeiro F et al. reported that the functional arm stretch test is closely related to a significant increase in foot flexor muscle strength and that the chair posture of yoga and jogging of aerobic exercise among virtual reality exercise programs are used as the sole flexor muscles that significantly improved functional arm stretch length [26]. In this study, reinforcement exercise of the sole flexor had a positive effect on improving the dynamic balance ability. The results of this experiment, in which the HTG group showed a significant improvement over the ATG group in the follow-up of NO, were similar to a previous study [27] in that the eight-week femoral reinforcement training of Dawn Askelton et al. produced a 9-55% improvement in balance ability.

Jang MJ. et al. reported statistically significant differences in both static and dynamic equilibrium between the time points within the ankle joint elastic resistance exercise

group, and the result that the central dynamic was minimized [28]. Studies have shown that ankle flexion and hip flexion are strong predictors that can improve the balance control ability measured using the Y-balance test. Among them, the flexion muscle can be an effective variable for balance control ability [29]. ROM promotion through ankle flexor training was appropriately correlated with the forward normalization reach of SEBT [30], which was similar to the results of previous studies. These studies are consistent with the results of the ATG showing more significant improvement than the HTG group in the follow-up of NC, PC, and Lt.YBT, which are the experimental results of this paper. Therefore, both the non-right ankle and hip joint thera band exercise immediately improves the dynamic and static balance capabilities, of which ankle joint exercise has a more significant effect.

This study has the following limitations. First, this study was limited to young and healthy college students in a specific area, and the sample was small. Second, a study on the long-term effect of the intervention is needed because the immediate effect of the reinforcement training immediately before, immediately after, and after five minutes of rest was studied. Third, it is difficult to generalize and interpret the study results because the exercise effects in homes and other facilities other than this laboratory are not considered. Fourth, the effect of exercise may have changed because compensation measures were not controlled.

## Ⅴ. Conclusion

For college students in their 20s, the ST of Tetrax and the composite score of the Y-balance kit were measured before thera band exercise, after thera band exercise, and after rest by performing thera band exercise on the ankle and hip joints. This study examined how the thera band exercise of the ankle and hip joints affects the dynamic and static balance. The results showed that in the follow-up, NO was high in the HTG and NC, PC, and Lt. YBT were high in the ATG. Therefore, performing ankle joint thera band exercise for dynamic balance improvement and hip joint thera band exercise for static balance improvement may be effective.

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