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The Influences of the Intensive Ankle Joint Strategy Training on the Muscular Strength and Balancing Ability in the Elderly Women

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발목관절 전략 집중 훈련이 노인여성의 근력과 균형능력에 미치는 영향

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Abstract The purpose of this study was to compare the effects of the intensive ankle joint strategy training on the muscular strength and balancing ability in the elderly women. The subject of this study were 30 elderly women aged from 65 to 80 and randomly assigned to three groups. For 6 weeks, two experimental groups took the training an hour every 3 days of a week. The results that measured the dynamometer, FRT, and SEBT after implementing general lower limbs exercise and the intensive ankle joint strategy training for 6 weeks showed that the changes in the control and experimental group I were not statistically significant while the changes in the experimental group II were statistically significant ($p<.05$). For the prevention of the elderlies from fall and the treatment approaches, it is deemed to be necessary additional studies on the diverse variables through the intensive training of the ankle strategy.

요 약 본 연구는 노인여성들을 대상으로 발목관절 전략 집중 훈련이 근력과 균형능력에 어떠한 영향을 미치는지를 알아보고자 하였다. 연구대상자는 65-80세 사이의 여성노인 30명으로 선정하였다. 대조군(n=10)은 아무런 처치를 하지 않았고, 실험군 I(n=10)은 일반적 하지의 운동만 실시하였다. 실험군 Ⅱ(n=10)는 세라밴드를 이용한 근력운동과 air cushion, unstable board을 이용한 평형운동을 포함한 발목관절 전략 집중 훈련을 실시하였다. 두 실험군은 6주간 주 3회 1시간 훈련을 실시하였다. 6주간 일반적 하지 운동과 발목관절 전략 집중 훈련을 각각 실시한 후 dynamometer, FRT, SEBT를 측정한 결과 대조군과 실험군 I의 변화는 통계학적으로 유의하지 않았지만, 실험군 Ⅱ의 변화는 유의하게 증가하였다($p<.05$). 더불어 노인 낙상 예방 및 치료적 접근에 있어서 발목관절 전략 집중 훈련을 통한 다양한 변인의 추가적인 연구가 필요하다고 생각된다.

Key Words : Ankle joint strategy training, Balancing ability, Muscular strength

1. Introduction

As the average life span of the Korean people becomes 80.08 a little bit above than the average life span of the OECD countries of 78.90, our society is gradually converted to an aging society[1]. Particularly, as the

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average life span of the female population becomes 82.3, which is significantly higher than male population, the health problem in the elderly women is arisen as social issue [2]. Mun et al[3] suggested that there is difference in balancing ability according to the gender, and particularly, the balancing ability is decreased much more in the elderly women. In case of elderly women, they experience symptoms such as the osteoporosis, arthralgia, headache, fatigue, feeling of impotent related to the changes of the rapid decrease of estrogen release in the endocrine system after the menopause[4]. The physical aging causes the lowering of the physical strength and the overall physical functions, and deterioration of functions to control physical balance by the lowering of sight control ability and insecure posture[5].

Balancing is the process to maintain the stability of pose body, the ability to control and maintain the center of gravity for the supporting base surface and exerts the critical influences on the performance of the action such as maintaining of stability in the standing posture, control of the weight load, ambulatory ability[6]. The balancing control is performed through interaction between the joints of the low limbs, and when maintain the balance, it employs several exercise strategies[7]. As the exercise strategies used for lower limbs, there are hip joint strategy using hip joint, ankle joint strategy using ankle muscles and range of motion, the strategy utilizing body rotation, and the squat strategy utilizing comprehensively the ankle joint flexion, knee joint flexion, hip joint flexion[8]. If the range of body shaking is great, the hip joint operates, and if it is small, the ankle joint operates[9].

The ankle joint strategy is generally used when there is small movement in the firm supporting surface, and refers to recovering the upright standing balance through the contraction of the ankle joint muscles at the first place as the strategy of controlling posture[7, 10]. For the approaches to accelerate the ankle strategy, there are the self-initiated sway that makes swaying from forward to back, and left to right without bending body, the recovery of the balance that recovers the balance from the sway of the hip and shoulder caused by the external forces, what makes perform the task required by anticipatory postural control[11]. In addition, the balancing in the elderlies is highly correlated with the muscle strength [12], and the lower limbs muscle strength strengthening exercise can increase the balancing ability significantly[13]. Therefore, to increase the physical stability, the intensive equilibrium training on the ankle joint and the muscle strength training for degraded muscles are required[14].

As the exercises to increase the balancing, there are the exercise using wobble board [15], exercise to keep equilibrium with one leg, the excercise using posturomed [16], and the exercise using air cushion[17]. Particularly, since the exercises performed on the air cushion strengthen the muscles, and show the movement and position of the joint, it is the most effective for proprioceptive sense training[18].

Na et al[19] suggested that the exercises using air cushion improve the proprioceptive sense, through which it works to promote the contraction of synergist, and to make slow the contraction of antagonist. Heitkamp et al[20] reported that the exercises using air cushion are useful for functional improvement of the muscles around the ankle joint by changing the body to lead the valgus moment to improve the contraction of the muscles around the ankle joint and prevent the fall in the healthy people, too.

The resistance exercise using thera-band, as the exercise to resist against the tension generated by muscles, is a form of exercise to increase the muscular strength and endurance gradually over a period of time[21,22]. Since differently from the training, which controls the loads artificially such dumbbell, barbell, the exercise using thera-band has flexibility, the loads can be applied from all directions of 360°, control the intensity according to the color of the band, position to hold, using bundle of bands and can exercise safely and various ways according to one's muscular strength or physical strength[23].

In regard to the improvement of balancing ability and to prevent the fall in elderly women, the general lower limbs exercises are simply used, but the exercise program using functional strategies of the ankle joint in balancing is rarely found. Therefore, in this study, it was intended to analyze the influences of the intensive ankle joint strategy training on the muscular strength and the balancing ability in the elderly women through the dynamometer, FRT(function reach test), and SEBT(star excursion balance test) after performing intensive ankle joint strategy training using air cushion and elastic band

for elderly women.

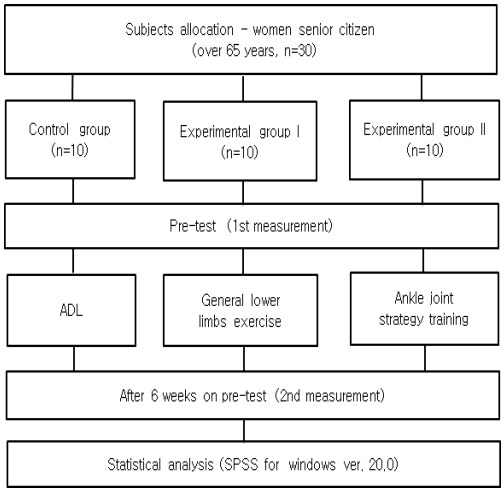
2. Methods

2.1 Subjects

This study was performed during 6 weeks from May to July, 2012 from the 30 elderly women having 65 years or more residing in U city. Sufficient explanation was made to the subjects on the purpose, methods, precautions of this experiment, and written consent to voluntarily participate in this experiment was obtained from them. The subjects were equally and randomly assigned to the control group (only daily life), experimental group I (general lower limbs exercise), and the experimental group II (intensive ankle joint strategy training).

The experimental group I and II performed the exercise 3 times a week, and for the intensity of the exercise, the set and time were increased with three-week interval. The subject persons could manage the daily life independently, did not have any orthopedic disorder and neurological deficiency between lower limbs and the body, and were the elderlies who did not have cardiac disorder, mental disorder, cognitive impairment, visual impairment, and who did not have vertigo while standing on the supporting ground.

2.2 Research Design



[Fig. 1] Frame of study design

In this study, the subject personnel are divided into control group, experimental group I and II, and their muscular strength and the balancing ability were evaluated. To measure the muscular strength of the plantarflexion and dorsiflexion, dynamometer was used, and to measure the balancing ability, the FRT and SEBT were conducted. The intensive ankle joint training and the general limb exercise were performed 3 times a week for 6 weeks. The muscular strength and the balancing ability after the experiment were measured as same way as preliminary tests. The measurement was conducted three times, and the mean values were taken. A design of this study is shown in figure 1.

2.3 Exercise program

For the experimental group I, the general lower limb exercise program was implemented, and for the experimental group II, the ankle joint exercise strategy program (Theraband + unstable board + air cushion exercise) were implemented, and the exercise was lasted 60 minutes each time(Table 1, 2).

To the experimental group I, the lower limbs exercise program for elderly women proposed by Lee [24] was applied after correcting and complementing it. In detail, first, the body was relaxed by performing stretching and free exercises as warming up for 10 minutes, and the resistance and equilibrium exercise were performed as main exercise from the group of big muscles to the group of small muscles in order step by step in order not to fatigue the muscles. And after exercise, to relax the tension in muscles and recover the fatigue, stretching was performed for 10 minutes as cool down. As to the increase the exercise load, the static exercise, which repeats 10 times the set, 5 seconds per set, was performed for initial 3 weeks. After the 4th week, the dynamic exercise, which performs 2 sets and 10 times per set, was performed, and the resting time between each set was 30 seconds.

To the experimental group II, the strategic ankle joint program suggested by Brotzman, Manske[25] and Lee[7] was applied after correcting and complementing it. The efferent contraction and afferent contraction resistance exercise were performed to strengthen the dorsiflexion and plantarflexion muscle of ankle joint. These exercises were composed of resistance exercise and strategic

promotional exercise for total 60 minutes. The resistance exercise was performed in a way that the efferent contract of agonistic muscle was performed in the lowering phase after afferent contraction of the agonistic muscle. The sequence of exercise was performed from dorsiflexion muscle to plantarflexion muscle for each leg alternatively. It has been repeated 3 times when starting every week, and some subject personnel having excellent degree of muscle strength improvement and athletic functions performed by changing number of sets or the color of the band, shortening the length of band, or adjusting repeating times earlier than others considering individual difference. For the strategic promotional exercise, 2 sets of the exercises, which performed standing on unstable board, and the exercises perform on the air cushion for 4 minutes each, and 1st set was performed eyes opened and the 2nd set was performed eyes closed. After the exercise of each set, took 2 minutes for rest sitting on the chair.

2.4 Experimental instruments

2.4.1 Dorsi and plantarflexion muscular strength

The backrest was fixed in order for the subject persons not to be pushed away while they were sitting on the testing bench extending knee joint, maintaining left ankle joint at the neutral top, and the dynamometer (JLW

[Table 1] Ankle joint strategy training program

Level	Component	Item		Time
Warm-up		Stretching		10min
Main exercise	Resistance exercise (Thera-band)	1. Afferent contraction (dorsiflexion) 2. Efferent contraction (dorsiflexion) 3. Afferent contraction (plantarflexion) 4. Efferent contraction (plantarflexion)		20min
	Strategic promotional exercise	Unstable board	1. Stand immobile while maintaining balance 2. Inclines the body front and back, left and right, and directions	20min
		Air cushion	1. Stand immobile while maintaining balance 2. Inclines the body front and back, left and right, and diagonal directions	
Cool-down		Stretching Deep breathing		10min

[Table 2] General lower limb Exercise program

Level	Component	Item		Time
Warm-up		Stretching		10min
Main exercise	Resistance exercise	1-3 week	1. Wall-squat 2. Raising one leg while lying on back 3. Raising heels while standing in place	20min
		4-6 week	1. Wall-squat 2. Leg extension 3. Leg curl	
	Equilibrium exercise	1-3 week	1. Raising hip while lying on back 2. Extending one leg while raising hip and lying on back 3. Raising leg while placing hands on the wall	20min
		4-6 week	1. Extending one leg while raising hip and lying on back 2. Raising one leg while standing alone, 3. Raising hip while lying on back and placing the leg on the gym ball	
Cool-down		Stretching Deep breathing		10min

instruments Inc., CS 200 Dynamometer, USA) was fixed to the test bench after placing the applicator to the plantar surface of the foot tightly to measure maximum isometric contraction. All the subject persons wore the same sneakers, and aligned the joint axis to the axis of the dynamometer. The other leg not being measured was fixed with strap at the thigh forming the knee 90 degree, and the feet was allowed to the supporting board. The measurement was performed 3 times, taking enough resting time between each measurement to prevent the muscular fatigue, and the maximum voluntary isometric contraction was determined by calculating mean value.

2.4.2 Functional reach test(FRT)

Functional reach test, which measures the farthest reachable distance with extended the hands while standing with the supporting part of the leg fixed to the floor, is used to measure the front and back balancing ability. The initial position was to form 90 degree of the shoulder joint flexion, and the final position was the posture of extending the arms as farthest as can maintaining the balance, and the difference of the position of the 3rd metacarpal bone between the initial position and the final position was measured. Mean value was taken as measured value after 3 attempts[26].

2.4.3 Star excursion balance test(SEBT)

To test the dynamic stability of the ankle, SEBT was used as appropriate evaluation having high sensitivity[27]. SEBT measures the distance of extending one leg while standing with the other leg alone, and the test tool has a form drawn with 8 lines in 45 degree of space. The subject person extends the one leg as farthest as she can along the line of each direction maintaining balance while standing with the other leg only at the center. The evaluator measures the distance from the center to the point extended the leg of the subject in cm. The 8 lines are expressed as the anterior, anteriolateral, lateral, posteriolateral, posterior, medial, posteriomedial, and anteriomedial according to direction in clockwise[28].

2.5 Data processing

To analyze the data measured in this study, the descriptive statistics of the mean and standard deviation were calculated using SPSS 20.0 statistical program, and to examine the changes between the training effects and between the groups, one-way ANOVA was conducted. In addition, for the post hoc tests, Tukey's multiple range test was used. and the statistically significant level for the measured values was established to $p<0.05$.

3. Results

3.1 General characteristics of subjects

The participants were divided randomly as control group (n=10), experimental group I, (n=10), experimental group II (n=10). The general characteristics of the research subjects are shown in Table 3.

3.2 Results of dynamometer measurement

Although the one-way ANOVA results conducted to test the changes in dyna- mometer among the groups according to the period of measuring intensive ankle joint strategy training did not represent the significant difference in all the groups before the experiment, the statistically significant difference was represented in the plantar flexion and dorsiflexion muscle of the experimental group I and II after the experiment($p<.05$). As a post hoc test, Tukey's multiple range test results conducted after 6th week of the experiment showed no statistically significant difference in the experimental group I, but represented the significant increase in the experimental group II ($p<.05$)(Table 4)(Fig. 2)(Fig. 3).

3.3 Results of functional reach test

In the one-way ANOVA results to test the changes in the functional reach test among the groups according to the intensive ankle joint strategy training period, no significant difference were represented in all groups before experiment, but 6 weeks later, the statistically significant difference was represented in the experimental group I and II ($p<.05$). In the results of Tukey's multiple range test conducted for post hoc test after 6 weeks, the significant increase was represented in experimental group II ($p<.05$) while no statistically significant difference was shown in experimental group I (Table 5)(Fig. 4).

[Table 3] Baseline characteristics of subjects

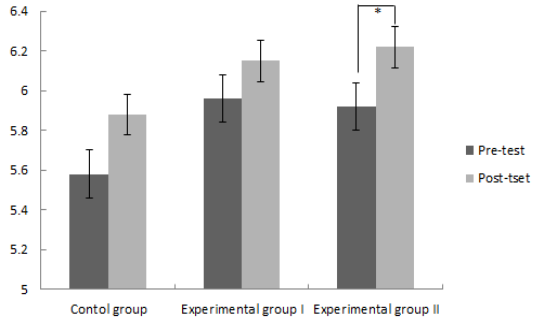
	Control group	Experimental group I	Experimental group II	p
Gender	Female : 10	Female : 10	Female : 10	
Age(yr)	71.88±2.95	70.78±2.90	72.00±2.07	.717
Height(cm)	152.41±4.14	151.90±4.84	150.58±3.92	.891
Weight(Kg)	52.24±5.59	52.33±5.61	52.81±5.93	.982
BMI(Kg/m^2)	22.29±2.77	22.81±3.96	23.39±3.25	.765

All values are shown in means±standard deviation

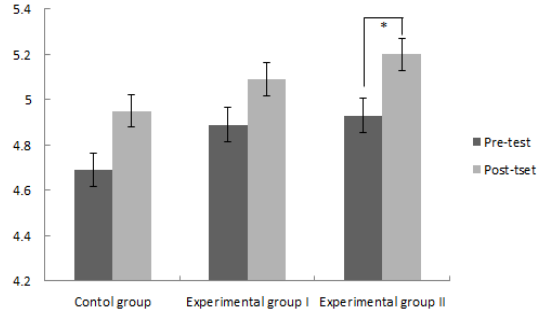
[Table 4] Comparison of pre-test and post-test for dynameter measurement (unit: Kg)

		Control group	Experimental group I	Experimental group II	F	p
Pre-test	Dorsiflexion	5.58±.68	5.96±.17	5.92±.19	1.935	.169
	Plantarflexion	4.69±.33	4.89±.21	4.93±.18	3.665	.150
Post-test	Dorsiflexion	5.88±.28	6.15±.29	6.22±.24†	2.079	.043*
	Plantarflexion	4.95±.19	5.09±.17	5.20±.20†	3.693	.042*

All values are shown in means±standard deviation
Tested by one-way ANOVA(*: p<.05), In the post hoc Tukey's multiple range test, experimental group Ⅰ, group Ⅱ showed significant difference comparing with control group(†: p<.05, †† : p<.01, ††† p<.001)



[Fig. 2] Variation of dorsiflexion muscle

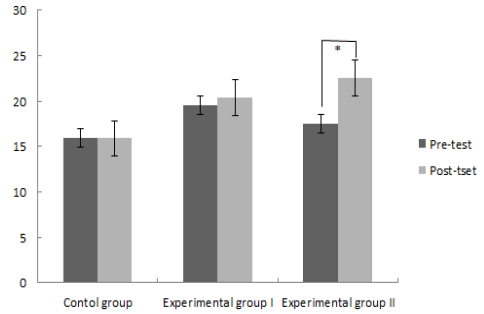


[Fig. 3] Variation of plantarflexion muscle

[Table 5] Comparison of pre-test and post-test for functional reach test (unit: cm)

	Control group	Experimental group I	Experimental group II	F	p
Pre-test	15.97±2.83	19.55±4.65	17.54±5.22	1.356	.279
Post-test	15.89±3.90	20.39±6.47	22.52±4.64†	3.494	.049*

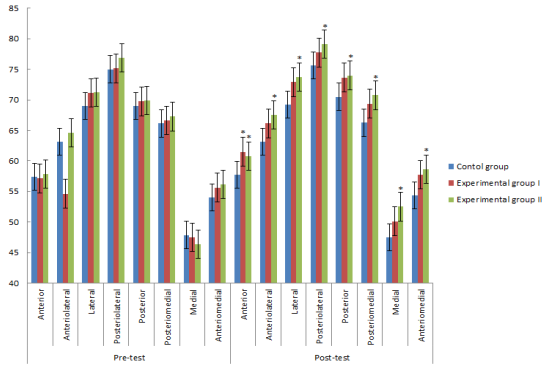
All values are shown in means±standard deviation
Tested by one-way ANOVA(*: p<.05), In the post hoc Tukey's multiple range test, experimental group Ⅰ, group Ⅱ showed significant difference comparing with control group(†: p<.05, †† : p<.01, ††† p<.001)



[Fig. 4] Variation of functional reach test

3.4 Results of star excursion balance test

In the one-way ANOVA conducted to test the changes in SEBT among the groups by the intensive ankle joint strategy training period, the statistical significant difference was represented in the experimental group I and II after 6 weeks ($p<.05$), while no significant difference was represented in all groups before experiment. In the results of Tukey's multiple range test conducted for the post hoc test, the experimental group I represented the significant increase in the anterior direction only, and the experimental group II represented the significant increase in all directions ($p<.05$)(Table 6)(Fig. 5).



[Fig. 5] Variation of star excursion balance test

[Table 6] Comparison of pre-test and post-test for star excursion balance test (unit: cm)

		Control group	Experimental group I	Experimental group II	F	p
Pre-test	Anterior	57.38±2.67	57.13±2.90	57.88±2.90	.146	.865
	Anteriolateral	63.13±3.52	64.63±2.07	64.63±2.56	6.000	.474
	Lateral	69.00±4.72	71.13±3.48	71.25±2.71	.919	.414
	Posteriolateral	75.00±3.38	75.13±5.22	76.88±3.31	.531	.596
	Posterior	69.00±3.38	69.75±3.96	69.88±4.58	.112	.895
	Posteriomedial	66.13±2.36	66.63±2.50	67.25±3.20	.346	.711
	Medial	47.88±2.90	47.50±3.16	46.38±3.38	.490	.619
	Anteriomedial	54.00±2.73	55.63±2.83	56.13±2.90	3.494	.309
Post-test	Anterior	57.75±2.60	61.50±2.20†	60.75±2.12†	5.854	.010*
	Anteriolateral	63.13±2.70	66.13±3.40	67.50±3.51†	3.862	.037*
	Lateral	69.25±3.99	72.88±2.59	73.75±2.71†	4.557	.023*
	Posteriolateral	75.63±2.83	77.75±2.31	79.13±2.03†	4.273	.028*
	Posterior	70.50±2.14	73.63±2.50	74.00±2.83†	4.704	.021*
	Posteriomedial	66.25±3.85	69.38±2.00	70.75±2.76†	4.832	.019*
	Medial	47.50±4.44	50.13±2.80	52.50±3.59†	3.715	.042*
	Anteriomedial	54.38±3.62	57.75±3.85	58.63±2.13†	3.723	.041*

All values are shown in means±standard deviation
Tested by one-way ANOVA(*: $p<.05$), In the post hoc Tukey's multiple range test, experimental group Ⅰ, group Ⅱ showed significant difference comparing with control group(†: $p<.05$, †† : $p<.01$, ††† $p<.001$)

4. Discussion

The fall is the most serious problem threatening the health of elderlies, and the major reasons of the fall are caused by physical aging such as decrease of the femoral muscle strength, the decrease of functional range of ankle joint, damage to the athletics capability, changes in scala vestibuli, deficiency of balance[29]. Balance control refers to the ability to control the body in space, and the most commonly used is the ankle joint strategy[7]. For the ankle strategy, the proper range of motion and the muscular strength are required[10], and for the pelvic limb, typically the centripetal and eccentrical muscular activities are required functionally[30]. In addition, the capability to perform functional tasks such as locomotion, is deeply related to the muscular weakness of the dorsiflexor and plantarflexor[31]. However, the balance recover- ing ability using ankle joint strategy in the elderlies is decreased, and the maximum muscular strength and the responding time to generate the muscular strength is delayed[32].

Judge et al[33] reported that the deterioration of muscular strength in elderlies affects the balance, and to overcome the unstability in posture, the improvement of muscular strength is required. The study of Lee[10], which suggested that the reduction of balancing ability by the aging occurs by the deterioration of muscular strength of lower limbs, reported that there is correlation between the equilibrium and the muscular strength of lower limbs, and the Kim[21] reported that the balancing ability was significantly improved after performing the exercise to increase knee muscular strength using theraband for the 20 elderlies during 5 weeks. Considering the results of preceding researches, the muscular strength can be considered to improve the balancing ability.

In this study, the plantarflexion and dorsiflexion muscular strength were measured using dynamometer [34], which can evaluate the muscular strength clinically easy and quickly. After the experiment, the statistically significant difference was represented in the plantarflexion and dorsiflexion muscle in the experimental group I and II ($p<.05$). And in the post hoc test, the experimental group I did not represent any significant difference, but the experimental group II represented the significant increase ($p<.05$). This means that the intensive ankle joint strategy training is much effective for strengthening the lower limb muscular strength than general lower limbs exercises.

The air cushion exercise used in the intensive ankle joint strategy training is the exercise to maintain the balance on the dome type circular board, and there have been reports that it has effects to strengthen the muscular strength around the ankle joint, and to reduce time to contract the calf muscle[35]. Na et al[19] measured the difference of the time starting the contraction of anterior tibial and long peroneal muscle using electro- myogram, and the results showed that the contraction delay time was improved both in the persons having functional instability in ankle and the healthy persons. Considering that significant improvements of the functional stability were made in the most of researches using air cushion exercise, it was judged that the air cushion exercise has significant effects for both static and dynamic stability of the ankle joint strategy.

Regarding to equilibrium, the functional reach test is important to measure the response of the balance correction[36], and has a close relationship with balancing ability, which is not to get out from the center, and flexibility of the ankle joint [3]. Duncan et al[26] revealed that the functional reach test has high reliability by studying the relevancy of the functional reach test, reliability of test and re-test, and the reliability among the observers from the 128 healthy persons, and reported that it has correlation with the age. In addition, Shurtleff et al[36] suggested that the functional reach test value is varied by the exercise, and the changes in the balancing ability can be measured sensitively[37,38]. After the experiment, the statistically significant differences was represented in the experimental group I and II ($p<.05$), and in the post hoc test, the experimental group I did not represent the significant difference, but the experimental group II represented the significant increase ($p<.05$). The improvement of the functional reach test represented in this study is consistent with the results of preceding studies that the improvement in the functional reach test may reflect the improvement of the ability to control the front and back direction, which works predo- minantly in the ankle joint strategy[39].

As a test method to examine the effects on the

stability of the ankle joint, SEBT test was adopted because it is suggested as a method to test the stability of ankle joint effectively with the comprehensive method to test the muscular strength around the ankle joint and proprioceptive function[40]. Kim et al[26] reported that the results of SEBT test conducted after intensive ankle joint strategy training for 6 weeks showed significant increase in most of directions, and the intensive ankle joint training has positive each direction in the experimental group II than experimental group I ($p<.05$), and were consistent with the results of the preceding researches. Kim et al[28] reported that the exercise on the unstable circular board would increase the functional stability of the ankle joint, and the Han et al[17] reported that the significant changes in the balancing ability effects on the improvement of functional stability of the ankle joint together with Romberg test results. The results of this study also observed significant increase in were represented by the strengthening of the muscles around the ankle joint.

So, it was observed that the intensive ankle joint strategy training is much effective for improving the balancing ability improvement than general lower limb exercise.

However, since the results of this study was obtained by evaluating the effects of balancing improvement by the experimental movements, it has restrictions to evaluate the complex balance control such as fall, dynamic balancing ability, hip joint strategy. In addition, the variables for the differences in the conditions of muscular strength by the ages of the research subjects in this study. And it is hard to assert if the exercise effect is sustained because the period of performing exercise was short. So, the author expects that future study would develop efficient intensive ankle joint strategy training to improve the balancing ability in elderlies and to contribute to the stable and effective prevention of the fall by complementing and correcting the limitations of this study.

5. Conclusion

In the results of dynamometer, FRT, SEBT conducted after the general lower limbs exercise and the intensive ankle joint strategy training for 6 weeks, the changes in the experimental group I were not statistically significant, and the changes in the experimental group II were increased significantly ($p<.05$).

To sum up the aforementioned results, the better results in the muscular strength and balancing were presented comparing with other two groups by including resistance exercises using theraband and the intensive training of the strategy using unstable board and air cushion when implementing the ankle exercise program for female elderlies. As such, for the follow-up studies, it is deemed to be necessary to study on the exercise program to fit the individual characteristics by adding diverse tools and methods used for ankle.

References

[1] National Statistical Office, "The life of a woman who looks to 2010 statistics", Korea Development Institute, Economic Information Center, 2010.

[2] H. Y. So, S. H. Ahn, R. Y. Song, H. L. Kim, "Relationships among obesity, bone mineral density, and cardiovascular risks in post- menopausal women", *Korean J Women Health Nurs,* Vol. 16, No. 3, pp. 224-233, 2010, Article(CrossRefLink)

[3] J. H. Mun, J. S. Og, U. Y. Park, "The effect of 12 week exercise program on muscle fitness, flexibility and balance in the fall down female elderly", Sports Science, Vol. 13, No. 1, pp. 77- 86, 2004.

[4] O. M. Kim, Y. S. Lee, "The climacteric symptoms and quality of life in climacteric women according to hormone replacement therapy", *Korean J Women Health Nurs,* Vol. 7, No. 4, pp. 642-656, 2001.

[5] G. C. Gauchard, P. Gangloff, C. Jeandel, P. P. Perrin, "Influence of regular proprioceptive and bioenergetic physical activities on balance control in elderly women", J Gerontol A Biol Sci Med Sci, Vol. 58. No. 9, pp. 846-850, 2003, Article(CrossRefLink)

[6] H. K. Shin, B. I. Chung, "The effect of functional strengthening exercise on standing balance in a child with cerebral palsy", Journal of the Korean Academy of University Trained Physical Therapists, Vol. 8, No. 3, pp. 97-105, 2001.

[7] J. W. Lee, "Effect of ankle exercise on improvement of balance in elderly with impaired balance", Doctoral Thesis, Yonsei University, 2007.

[8] J. S. Park, O. Y. Kwon, H. S. Choi, T. H. Kim, "Effects of the movement strategies on functional forward reach in standing", Journal of the Korean Academy of University Trained Physical Therapists, Vol. 7, No. 1, pp. 46-54, 2000.

[9] C. F. Runge, C. L. Shupert, F. B. Horak, F. E. Zajac, "Ankle and hip postural strategies defined by joint torques", Gait Posture, Vol. 10, No. 2, pp. 161-170, 1999, Article(CrossRefLink)

[10] F. B. Horak, C. L. Shupert, A. Mirka, "Components of postural dyscontrol in the elderly: a review", Neurobiol Aging, Vol. 10, No. 6, pp. 727-738, 1989, Article(CrossRefLink)

[11] A. Shumway-Cook, M. H. Wollacott, Motor contol: Theory and practical applications. 1st ed. Baltimore: Williams & Willkins, 1995.

[12] H. J. Lee, C. H. Yi, E. Y. Yoo, "Correlations Among the Berg Balance Scale, Gait Parameters, and Falling in the Elderly", Journal of Korean Academy of University Trained Physical Therapists", Vol. 9, No. 3, pp. 47-65, 2002.

[13] I. H. Lee, S. G. Moon, B. K. Lee, J. W. Lee, I. S. Kim, "The Effects of progressive resistive exercise and aqua exercise program on lower extremity muscle strength and balance in elderly Women", Journal of the Korean Academy of Clinical Electrophysiology, Vol. 2, No. 1, pp. 19-37, 2004.

[14] K. Delbaere, J. Bourgois, N. Van Den Noortgate, G. Vanderstraeten, T. Willems, D. Cambier, "A home-based multidimensional exercise program reduced physical impairment and fear of falling", Acta Clin Belg, Vol. 61, No. 6, pp. 340-350, 2006.

[15] R. A. Adedoyin, M. O. Olaogum, K. Omotayo, O. A. Olawale, M. O. Egwu, "Effects of wobble board training on weight distribution on the lower extremities of sedentary subjects", Technol Health Care, Vol. 16, No. 4, pp. 247- 253, 2008.

[16] O. Muller, M. Günther, I. Krauss, T. Horstmann, "Physical characterization of the therapeutic device posturomed as a measuring device - presentation of a procedure to characterize balancing ability", Biomed Tech, Vol. 49, No. 3, pp. 56-60, 2004, Article(CrossRefLink)

[17] S. W. Han, M. J. Kwon, Y. W. Chae, Y. W. Baek, H. B. Jeong, K. T. Kim, J. R. Yoon, "Electromyographic analysis of ankle muscles according to unstable platforms", Journal of Coaching Development, Vol. 8, No. 2, pp. 231- 239, 2006.

[18] B. L. Riemann, S. M. Lephart, "The sensorimotor system, part Ⅱ: The role of proprioception in motor control and functional joint stability", J Athl Train, Vol. 37, No. 1, pp. 80-84, 2002.

[19] Y. M. Na, J. H. Moon, Y. J. Seong, H. J. Lee, H. S. Lee, E. S. Eo, "The effects of ankle disk training in functional ankle instability", J Korean Society Sports Med, Vol. 17, No. 2, pp. 406-412, 1999.

[20] H. C. Heitkamp, T. Horstmann, F. Mayer, J. Weller, H. H. Dickhuth, "Gain in strength and muscular balance after balance training", Int J Sports Med, Vol. 22, No. 4, pp. 285-290, 2001, Article(CrossRefLink)

[21] Patterson RM, Stegink Jansen CW, Hogan HA, Nassif MD. "Material properties of Thera-Band Tubing", Phys Ther, Vol. 81, No. 8, pp. 1437- 1445, 2001.

[22] R. S. P. Mazzeo, W. J. Cavan, M. Evans, "Position stand on exercise and physical activity for older adults", Med Sci Sport Exer, Vol. 30, No. 6, pp. 992-1008, 2008, Article(CrossRefLink)

[23] H. G. Kim, "The effect of knee muscle power strengthening using thera band on the balance control ability in the elderly", Master Thesis, Dangook University, 2003.

[24] S. J. Lee, "The effect of 8 week lower exercise program on proprioception and balance of female elderly", Master Thesis, Kookmin university, 2008.

[25] S. B. Brotzman, R. C. Manske, "Clinical orthopaedic rehabilitation(3rd Ed.)". Philadelphia: Mosby, 322-333, 2011.

[26] P. W. Duncan, D. K. Weiner, J. Chandler, S, Studenski, "Functional reach; a new clinical measure of balance", J Gerontol, Vol. 45, No. 6, pp. 192-197, 1990, Article(CrossRefLink)

[27] P. A. Gribble, J. Hertel, C. R. Denegar, W. E. Buckley, "The effects of fatigue and chronic ankle instability on dynamic postural control", J Athl Train, Vol. 39, No. 4, pp. 321-329, 2004.

[28] Y. S. Kim, S. Y. Park, H. J. Kang, M. H. Seok, J. W. Oh, "The effect of the disk training and the combined training on functional stability of ankles", Sports Science, Vol. 13, No. 1, pp. 113-124, 2004.

[29] S. J. Hwang, S. Y. Lee, "Effects of balance control and functional activities during gym ball exercises in elderly people", Journal of the Korean Academy of University Trained Physical Therapists, Vol. 11, No. 3, pp. 25-32, 2004.

[30] T. W. Kaminski, D. H. Perrin, B. M. Gansneder, "Eversion strength analysis of uninjuried and

functionally unstable ankles", J Athl Train, Vol. 34, No. 3, pp. 239-245, 1999.

[31] A. Lamontagne, F. Malouin, C. L. Richards, F. Dumas, "Mechanisms of disturbed motor control in ankle weakness during gait after stroke", Gait Posture, Vol. 15, No. 3, pp. 244-255, 2002, Article(CrossRefLink)

[32] D. C. Mackey, S. N. Robinovitch, "Postural steadiness during quiet stance dose not associate with ability to recover balance in older women", Clin Biomech, Vol. 20, No. 8, pp. 776- 783, 2005, Article(CrossRefLink)

[33] J. O. Judge, C. Lindsey, M. Underwood, D. Winsemius, "Balance improvement in older women: effects of exercise training", Phys Ther, Vol. 73, No. 4, pp. 254-262, 1993.

[34] K. M. Lee, S. H. Han, J. W. Kang, "The effects of measuring posture in evaluation of hip girdle strength", Korean Society of Sports Medicine, Vol. 18, No. 2, pp. 290-295, 2000.

[35] P. Sheth, B. Yu, E. R. Laskowski, K. N. An, "Ankle disk training influences reaction times of selected muscles in a stimulated ankle sprain", Am J Sports Mede, Vol. 25, No. 4, pp. 538-543, 1997, Article(CrossRefLink)

[36] T. L. Shurtleff, J. W. Standeven, J. R. Engsberg, "Changes in dynamic trunk/head stability and functional reach after hippotherapy", Arch Phys Med Rehabil, Vol. 90, No. 7, pp. 1185-1195, 2009, Article(CrossRefLink)

[37] A. J. Campbell, M. C. Robertson, M. M. Gardner, R. N. Norton, D. M. Buchner. "Psychotropic medication withdrawal and a home-based exercise program to prevent falls: A randomized, controlled trial", J Am Geriatr Soc, Vol. 47, No. 7, pp. 850-853, 1999.

[38] K. Hauer, B. Rost, K. Rutchle, H. Opitz, N. Specht, P. Bartsch, P. Oster, G. Schlicrf. "Exercise training for rehabilitation and secondary prevention of falls in geriatric patients with a history of injurious falls", J Am Geriatr Soc, Vol. 49, No. 1, pp. 10-20, 2001, Article(CrossRefLink)

[39] D. A. Winter, A. E. Patla, F. Prince, M. Ishac, K. Gielo-Perczak, "Stiffness control of balance in quiet standing", J Neurophysiol, Vol. 80, No. 3, pp. 1211-1221, 1998.

[40] L. C. Olmsted, C. R. Carcia, J. Hertel, S. J. Shultz, "Efficacy of the star excursion balance

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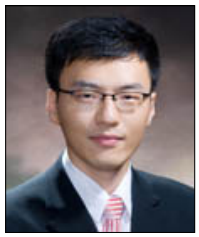

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