Thesis of Master of Science

The Effects of Eight Weeks of Lower Eccentric Exercise Training on Muscle Strength and Function in the Elderly

8주간 하지의 신장성 운동(Eccentric Exercise)이 노인의 근력과 근기능에 미치는 영향

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The Effects of Eight Weeks of Lower Eccentric Exercise Training on Muscle Strength and Function in the Elderly

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Abstract

The Effects of Eight Weeks of Lower Eccentric Exercise Training on Muscle Strength and Function in the Elderly

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Introduction: Sarcopenia, decreased in muscle mass and function related with aging, was known to be accompanied by muscle strength and physical function. We investigated the effects of eccentric exercise on skeletal muscle strength and physical function in the elderly.

Materials and methods: Sixteen healthy older subjects (age, 73.69±2.44; Short Physical Performance Battery (SPPB) score ≥10) underwent 8 weeks of eccentric training with Eccentron (BTE™.Inc.) or conventional resistance training with seated leg press (ENRAF NONIUS) for twice a week. For the eccentric training and conventional training group, participants performed the test of isometric, isokinetic, power via Primus RS (BTE™. Inc.), and body composition. For the measurement of functional capacity, subjects performed specific tests (SPPB, gait speed test, stair-climbing test, and chair-rising test).

Results: Eccentric training significantly improved in muscle function in gait speed (p=0.049) and stair climb test (p=0.046). Also, the eccentric training produced the greatest improvement in 60°/sec isokinetic average peak torque and power test using isotonic at left side of leg (p=0.040), (p=0.005), respectively.

Conclusion: Continuous and regular eccentric exercise program is effective which was to improve the reduction of muscle strength and muscle function that can become noticeable aging. Therefore, these findings suggest that the eccentric exercise training is the one way to improve the prevention of sarcopenia.

Keywords Aging, Eccentric training, Conventional resistance training, muscle functions, muscle strength, Sarcopenia

Student number: 2014-20994

LIST OF ABBREVIATIONS

ETG	Eccentric training group
CTG	Conventional resistance training group
DXA	Dual Energy X-Ray Absorptiometry
SPPB	Short physical performance battery
IPAQ	International physical activity questionnaire
MMSE	Mini mental state examination
GDS	Geriatric depression scale
VMO	Vastus medialis oblique
RF	Rectus femoris
VL	Vastus lateralis
Rt	Right
Lt	Left

Contents

LIST OF TABLES AND FIGURES

LIST OF TABLES

LIST OF FIGURES

I. INTRODUCTION

1. Significance of the study

Korea's population is aging at a faster rate than in any other advanced country in the world. In 2006, the cost of medical expenses incurred by the elderly was 13.2 times higher than it was in 1990. This rate of increase was 8 times higher than that of the medical expenses of the entire population of the country over the same time period. In 2010, the elderly over 70 constituted 11.0% of the population, showing that an aging society is not far away (National Statistical Office, 2010).

Koreans' average life expectancy is 78.6 years old which is quite high among advanced countries. However, Koreans' healthy life expectancy (Disability Adjusted Life Expectancy or DALE), calculated based on the period of survival without disability, is 68.6 years on average, as of 2005. This is about 10-years less than the average life expectancy (National Statistical Office, 2010). It is significantly higher than the usual difference of 5-6 years in other advanced countries, indicating the serious health level of Korean elders. Such a phenomenon not only hinders their independent daily activities due to physical decline and functional disorders but also becomes a problem to the elderly because of worries about treatment and the burden of cost (Ko et al., 2012).

The functions of skeletal muscles, one of the most important elements related to the healthy and well-off life of elders, is most closely related to physical capabilities (Trombetti et al., 2015). The most apparent changes of aging are sarcopenia or muscle atrophy, etc. Sarcopenia is a muscle atrophy due to the age and internal muscle changes in aged skeletal muscles, and is defined as a phenomenon in which 60 to 70-year old elders' muscle amount decreases by about 20~30% compared to young adults and middle-aged people (Frontera et al., 2001).

The muscle atrophy of aging muscles are various elements of functional disorders such as the decrease in muscular strength, flexibility decrease, vulnerability to injuries, delay in functional recovery, etc. (Frontera et al., 2008;

Krivickas et al., 2006). Many chronic degenerative disease such as diabetes, heart disease, arthritis, etc. also indirectly and directly influence muscle aging, i.e. sarcopenia. Young adults also had a similar muscle atrophy as elders after exercise, but study results showed that there is a noticeable decline of recovery for elders (Chakravarthy et al., 2000). Therefore, muscle changes of elders according to injuries and environmental changes appear differently from those of young adults (Payne and Delbono, 2004; Siu et al., 2005).

While the decrease in muscular strength is one of the most typical phenomena of aging, its exact cause is not well-known. One interesting aspect in the decrease in muscular strength due to aging is that the decrease conditions vary depending on the types of muscle contraction. Although the decrease in muscular strength according to aging appears in all kinds of muscle contraction phenomenon, the decrease is much less for eccentric contraction compared to isometric contraction and concentric contraction (Roig et al., 2010). Eccentric strength preservation appears not only in aging muscles but also in damaged or degenerated due to stroke or cerebral palsy, etc. (Clark et al., 2006; Damiano et al., 2001). This is a well-known phenomenon of eccentric strength preservation but its exact cause has not been clarified yet (Roig et al., 2010).

Muscular strength exercise, which is receiving attention as one of the treatment methods of sarcopenia, is a core treatment strategy of sarcopenia and is known as the most effective treatment method for muscle amount and the decrease in muscular strength (Rolland et al., 2011; Peterson et al., 2011). It is well known that body functions and physical capabilities can be improved through muscular strength exercise (Magnione et al., 2010). Because of these reasons, many attempts have continuously been made to prescribe exercise for elders' sarcopenia treatment but most exercise prescriptions so far have only been general muscular strengthening exercise and aerobic exercise (Phu et al., 2015). However, these are basic exercise methods appropriate for normal adults and are not specific for aging nervous system and muscle changes (Behrens et al., 2015). Furthermore, another problem is that it is difficult to provide an adequate exercise treatment to promote functional improvement for elders due to low adaptation level, risk of injuries, and cardiovascular side effects.

In contrast, eccentric contraction has less decrease of muscular strength due to aging compared to isometric and concentric contractions and is thus easy to be applied for elders' muscle strengthening exercise. With regard to this, a study has reported that training related to eccentric contraction can be more effective than concentric contraction when training to increase muscular strength and muscle weight for elders (Roig et al., 2010). Also, eccentric contraction has relatively less heart-lung burden and its exercise movements are functional elements that are commonly used in daily life. Therefore, its advantage is that it can be applied safely for groups such as elders, heart-lung disease patients, and chronic degenerative disease patients, who have high risk burden to have general exercise methods.

According to the domestic and overseas research phenomena, problems, and necessity on elderly exercise program, there is a high awareness on the necessity of exercise for sarcopenia treatment and the increase of body functions (Denison et al., 2015). However, the biggest problem is that in most cases, general exercise methods are implemented without considering the unique characteristics of musculoskeletal changes according to sarcopenia. It is difficult to apply exercise intensity known to be safe for normal adults as it is on elders because of their low adaptation level, risk of injuries, and cardiovascular side effects, etc. There is also a difficulty in applying exercise as a treatment method because it many cases it accompanies all kinds of chronic diseases (Levinger et al., 2009).

In aging process, eccentric exercise is known to have less decrease in muscular strength compared to isometric and concentric contractions. Thus, it may be more effective to apply eccentric exercise on training for elders' muscular strength and muscle weight increase instead of isometric and concentric exercises that are commonly applied on healthy adults. In addition, eccentric exercise can generate more strength with lower metabolic requirement and heart-long functions than concentric exercise, so it can be applied relatively safely on patients with declined heart-lung functions (Dufour et al., 2004; Rocha Vieira et al., 2011; Perrey et al., 2001). Therefore, it is considered that eccentric exercise can be applied relatively safely on elders without any burden on cardiovascular side effects. Also, when eccentric exercise is applied on muscular endurance exercise, it is expected that it can be used widely as effective and safe muscular strength and aerobic exercise for the elderly. Moreover, eccentric exercise is expected to be more effective for elders as they carry all kinds of chronic disease such as diabetes, diseases, lung disease, high blood pressure, obesity, etc. However, there are barely any studies that have verified the effects of eccentric exercise by applying it on elders' sarcopenia and there have especially been no studies on the mechanism of such effects (Roig et al., 2009). It is necessary to conduct a study that examines the influence of eccentric exercise on muscle atrophy or sarcopenia through the biomechanical changes of muscles. A study then need to evaluate the improvement of muscular strength and increased effects of body functions by applying eccentric exercise on elderly sarcopenia patients in an actual clinical setting. Considering the worldwide aging trend and entry into super-aging society in the future, this can be an important future assignment to increase the healthy life expectancy of elderly population.

2. Purpose of the study

The purpose of this study is to investigate the effect of eight weeks of eccentric exercise training on muscle strength and functions in elderly people, when compared to conventional resistance exercise training.

3. Research Hypothesis

In order to achieve the purpose of the study, we set the following research hypotheses such as the following.

Research Hypothesis 1: Characteristics

1-1. Eight weeks of eccentric exercise training will improve body composition (using InBody and DXA) more than conventional resistance exercise training.

Research Hypothesis 2: Physical performance

2-1. Eccentric exercise training will increase muscle strength more than conventional resistance exercise training.

2-2. Eccentric exercise training will increase muscle functions (e.g. Gait speed, chair rising and stair climbing) more than conventional resistance exercise training.

4. Limitation

In this study, it has the following limitations.

1) Physiological and psychological factors of the study participants, the motor has not been controlled in the same way.
2) It does not take into account the conditions of personal physical fitness level of the study participants.

II. Literature Review

1. Eccentric Exercise

There are three types of muscle contractions. First, the shortening of muscle length is called concentric contraction. Second, muscle length of the length is called isometric contraction. Third, muscle length which has been lengthened is called eccentric contraction (Close GL et al., 2005). Concentric contraction is when movement is made on the inner track, however, eccentric contraction is when movement is made on the outer track or made by braking (Isner-Horobeti ME., 2013). As mentioned before, the eccentric contraction (Ecc) creates a relatively lot of damage to muscles among the three types of contractions (Newham DJ et al., 1983). Eccentric contractions produce a higher power than concentric contractions (Con) and isometric contractions (Iso) when compared (Westing et al., 1991). But even if the various activities do produce a large force, eccentric contractions show the features according to the low metabolic demand rather than concentric contractions (Gault et al., 2013; Dufour et al., 2004). Most eccentric contraction muscle movements are formed by running and walking downhill (Gault et al., 2013).

The rare to be eccentric contraction induces muscle damage with symptoms of delayed onset muscle soreness (DOMS) (Byrne C et al., 2004). According to some of the eccentric contraction protocol, it causes damage to the more serious and secondary fibers in the elderly when compared to a group of elderly people and young adults (Close et al., 2005; Faulkner et al., 1990). However, this muscle contraction does promote muscle recovery and muscle strength among the elderly (Hameed et al., 2008).

Muscle weakness due to aging is often characterized as displaying differently according to the type of contraction. In other words, a decrease in muscle strength associated with aging is displayed in all kinds of muscle contraction phenomenon (Roig et al., 2010). The muscle strength in eccentric contraction’s is reduced much less than isometric or concentric contractions as shown in the figure below (Roig et al., 2010).

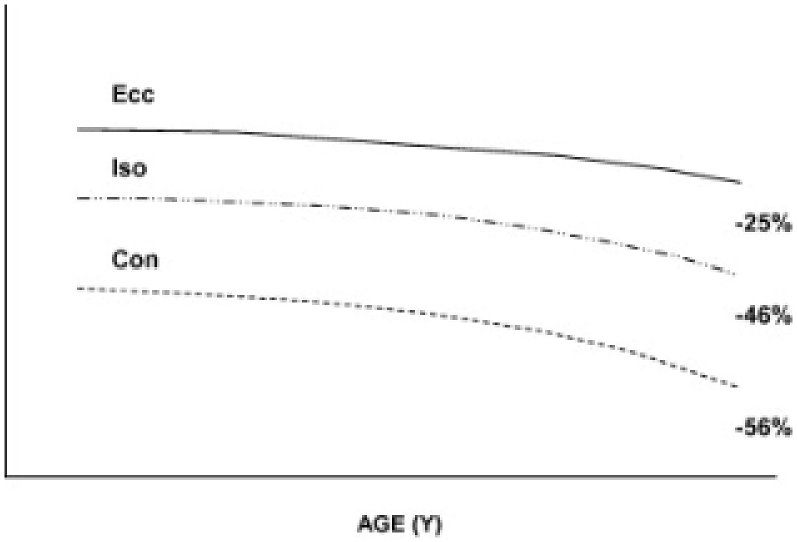

Figure 1. Eccentric Exercise graph – Ecc, Iso, Con

Figure 1. The figure above, it explains that the different type of movement (Ecc, Iso, Con) affect to reducing muscle strength with the procession of aging, Through the figure1, Eccentric contraction is less muscle atrophy than isometric and concentric contraction. (Roig et al., 2010) (X axis: Age, Y axis: Strength)

2. Eccentric Exercise application

Eccentric contraction movement and basic stretching is important in muscle hypertrophy and physical adaptation (LaStayo et al., 2003, 2014; Roig et al., 2008). In a recent study, it introduced eccentric exercise to moderate velocity with high intensity resistance exercise for the elderly. (Granacher et al., 2011). Eccentric actions have a feature related to muscle lengthening during activity. The human body produces a greater force at eccentric contraction when compared to concentric contraction (Enoka, 1996; Jones et al., 1987; Komi et al., 1972; Seliger et al., 1980; Stauber, 1989). The reason that the elderly do eccentric exercises is to increase the muscle mass, muscle strength and reduce the risk of falls (Hortobagyi et al., 1995; LaStayo et al., 2003).

As mentioned before, eccentric contraction movements make serious muscle damage because it causes damage to a large number of muscle fibers in the elderly (Hameed et al, 2008). But, this is also has the effect of promoting muscle recovery and muscle strength more and more (Hameed et al, 2008).

Figure 2. Eccentric exercise focused on lower body - (Eccentron ^{TM})

3. Gait speed and balance in elders

Regarding the lower body of muscle weakness, the elderly would experience an increase in the risk of falls or missing the force of movement (Chung-Hoon K et al, 2015). Demographically, falls from movement is the main cause which acts as a large burden on the substantial medical costs in the country of aging (Hill K et al., 1999; Stalenhoef PA et al., 2002). It can be seen in two interactions related to the risk of falls during walking. Falls would be avoided and individuals would feel better balance disorder. During the aging process, that balance recovery capability and neuromuscular function is reduced (Carty CP et al., 2011; Barrett RS et al., 2012; Hisao-Wecksler ET et al., 2007). With the progression of aging, it is possible to increase the risk of falls while reducing the balance and muscle power even if he or she is not frail (Rhonda Orr et al., 2006). To check this test for physical function in the elderly, one would consider measuring gait speed and balance to test overall participants' physical improvement. (Schwenk M et al., 2014).

Figure 3. Gait Speed measurement (Kinect - Korea Institute of device)

5. Conventional Resistance Exercise

Resistance training is characterized by the systematic execution of voluntary muscular contractions against external loads (ACSM 2009). Although this type of exercise is most performed through exercises combining concentric and eccentric muscle actions called conventional resistance exercise or training (Wernborn et al.2007). Among the three type of contractions, concentric contraction is when the quadriceps extend the knee which is commonly used to raise the center of mass, such as when running uphill, jumping, or standing from sitting (Neumann DA, 2011). In particular, the quadriceps pulls the patella upward and laterally, and generates high power through a mechanical advantage from the patella (Neumann DA, 2011). Muscle power declines, which occurs with aging, and is observed faster than others variables, like muscle strength (Metter et al. 1997; Young and Skelton 1994). Per year, the decline in muscle power is 3-4% greater than the rate of decrease in muscle strength (Metter et al. 1997; Young and Skelton 1994). Thus, muscle power is more vulnerable to the aging process. Therefore, exercise to increase muscle power is critical for elderly people through resistance exercise which is conventional resistance exercise (Macaluso and De Vito 2004).

Figure 4. Seated Leg press (EN-Dynamic; ENRAF-NONIUS B.V. Netherlands)

III. Methods

1. Research Participants

Sample size of this study obtained at least the eight people in each group through the G power 3.10 program based on previous study (Vaczi et al., 2014). Previous showed that SSC/ECC groups was significantly different (n =16, p=0.017) in maximal voluntary contraction through healthy elderly (Vaczi et al., 2014). More detailed, the sample size was calculated by ANOVA between factors and the effect size was 0.49 from the previous study. The groups was 4 including pre-eccentric exercise, post-eccentric exercise, pre-conventional resistance exercise, and post-resistance exercise. The number of measurements were 10 such as 4m walk, chair rising test, stair climb test, body characteristic, muscle strength (isometric, isokinetic, isotonic), IPAQ (International Physical Activity Questionnaire), DXA (Dual Energy X-ray Absorptiometry), EMG (Electromyography). By using the G power program, it was measured F test using ANOVA between factors and the significant difference based on 0.05. As a result, the critical F value was 3.49 and total sample size 16 subjects needed. The actual power was 0.8056. This study was recruit 20 subjects and it was considered 20% drop rate. Therefore, the total sample size was 16 subjects.

The subject of the present study was participated who is older than 70 years old and capable to independent walking and daily activities from among the men and women in S city.

Sarcopenia is as the following diagnostic criteria (Sarcopenia in Asia. Consensus report of the Asian Working Group for Sarcopenia, AWGS, 2014). Grip strength criteria for male is under 26kg and female is 18 kg. It is include in Sarcopenia that for both gender's gait speed is less than 0.8m/s. In addition, it is included in the diagnostic criteria which is sarcopenia if each man and woman in the ASM/Ht^2 standards in the result of a DXA measurement with less than 7.0kg/m^2, 5.4kg/m^2, respectively.

Exclusion criteria to recruit research subjects is as follows. First, except patients with coronary artery disease which is a myocardial infarction or symptoms within six months. Second, the person who was wearing a fracture of the upper and lower limbs within six months are excluded. Third, hypertensive patients that have not been well adjusted to more than 150/90mmHg are excluded. Fourth, whether the patient’s neuromuscular disease or people who are taking a drug that can affect the neuromuscular is excluded. Fifth, patients who received hormone therapy are excluded. Sixth, currently, patients with degenerative arthritis symptoms, such as pain and swelling can be seen are excluded. Lastly, people who Mini-mental state examination (MMSE) score come out less than 23 points are excluded.

2. Experimental Design

Research design of this study shown in Figure 5. In this study, divided into two groups of participants were divided into eccentric exercise training group and conventional resistance exercise group. Before the performing an eccentric exercise, pre-test was implemented such as grip strength, 4m walk, chair rising, stair climb, BTE PRIMUS RS and Dual energy X-ray absorptiometry (DXA) and then performed exercise. Before main exercise, carried out stretch exercise for 5 to 10 minutes and then start up with eccentric exercise for 30 minutes with two times per week.

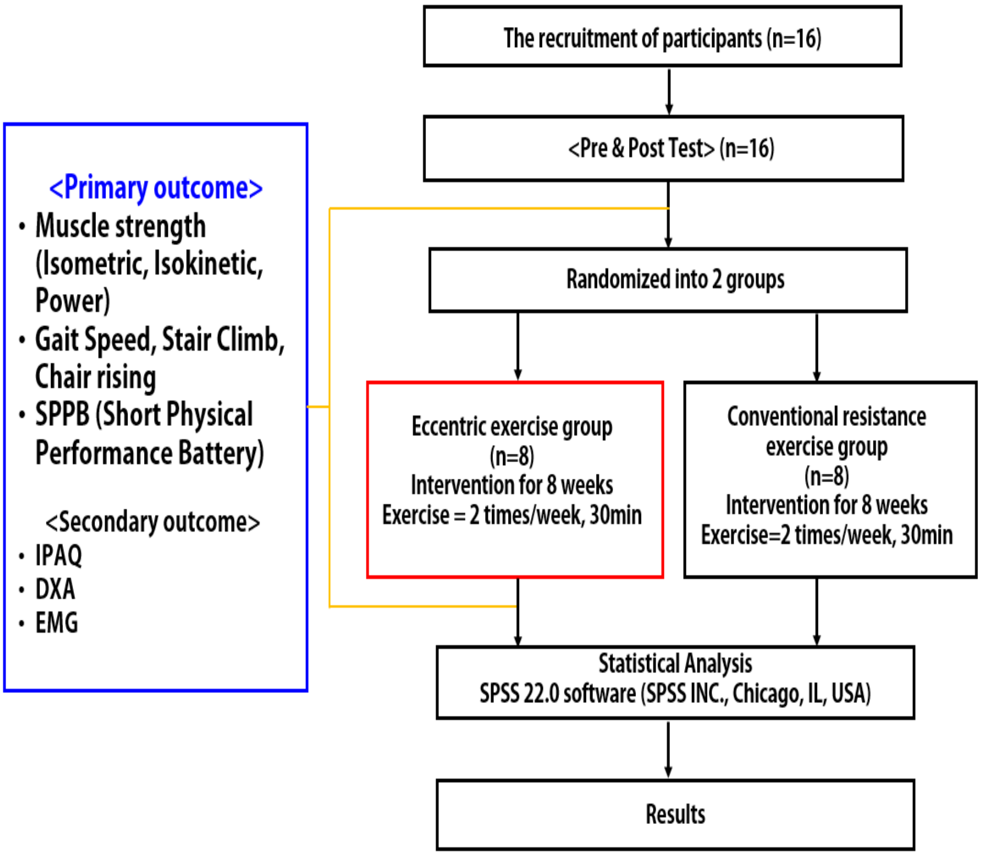

Figure 5. Experimental design

3. Measurement

As a research subject's physical ability and physical method of evaluation of the elderly, this protocol was carried out in the following manner. The primary interviews and questionnaire evaluation conducted physical examination on subjects, such as past medical history, family history and social force survey. Also, Physical evaluations of the subjects were carried out, with interest on the relevant skeletal muscle system, which included movable range of the neurological assessment and the frequency muscle and joint, and on injection therapy history and drug use.

For anthropometric data, the height, weight, Body Mass Index (BMI), and femoral middle portion around the thigh, waist and hip circumferences were measured. Cognitive function was measured by a Mini-Mental State Exam (MMSE). In addition, the Geriatric Depression Scale (GDS) is a screening test developed for the elderly. Assessment of the presence of frailty or pre-frailty was evaluated disease history, questionnaires, and measurement of SPPB and grip strength.

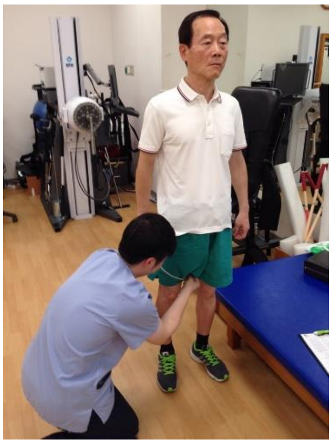

Figure 6. Middle Thigh circumference measurement

The following table shows the diagnostic criteria of frailty. It is possible to diagnose frailty and pre-frailty based on the Cardiovascular Health Study (CHS) frailty index. Frailty is present if applicable to three or more of the following five items are present, and Pre-frailty if one or two of them are present.

Table 1. Frailty diagnosis criteria (Hwang et al., 2010)

Feature of Frailty	Criteria
Shrinking: Weight loss, Sarcopenia	Whether the weight loss of 5kg over the past 1 year
Weakness	Use determine the pilot criteria to measure the grip strength
Poor Endurance; Exhaustion	Use a questionnaire CES-D or Geriatric Depression Scale
Slowness	4m walk test (use SPPB)
Low activity	Use K-PASE or IPAQ

For the evaluation of physical function and disability, it was carried out the following items. Pain related disability, the degree of pain and it due to failure, was carried out using a Brief Pain Inventory: BPI, Korean version. The case of knee and dysfunction of the hip joint used the evaluation of Western Ontario and McMaster Universities (WOMAC) and WOMAC Osteoarthritis Index, Korean version to check the degree of pain, a severe degree in the activities. Also, Activity specific Balance Confidence (ABC) is that a tool to evaluate the confidence to physical activity, it consists of several activities by measuring the degree of confidence for a total of sixteen specific activities, including daily execution of the inner and outer houses cage. After take advantage of the various evaluation questionnaire in the primary, the functional evaluation was measured in secondary through the following items. First of all, Short Physical Performance Battery (SPPB) is a simple tool to assess the physical performance and it is useful in the evaluation method of the physical function of the elderly which is one of the possible to measure with easily. Evaluation item was included walking speed, chair rising test and balance. The assessment method of the walking speed was set second by 4-meter walking. Chair rising test was repeated a sit to stand up five times without using hand. Balance test is try to hold more than 10 seconds with three type of stance which are contain with tandem stance, semi-tandem stance and side-by-side stance.

Stair climbing power test was measured eight stairs with normal speed. It was set by second and tried two times. If subject have difficulty to move on to walking stairs, make them to grab the stairs next to the handle. The beginning of stopwatch was when subject has moved and the completion of test was subject's position of both feet at the end of the stairs. This process is repeated twice.

When the isokinetic and power test measurement, used a constant velocity mechanism (PrimusRS, BTE Inc, Hanover, MD, USA). At 60 degree/sec of angular velocity, subjects were measured in peak torque/body weight and peak power throughout their knee extension. To compare the results between individuals, peak torque is divided by weight ratio.

Figure 7. Isokinetic Peak Torque, EMG (Electromyography) in elderly and Inbody S10 (Inbody CO)

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During body composition analysis, used the DXA which is most accurate for body composition. For measure with fat mass and fat free mass, used DXA (GE, LUNAR prodigy, USA) and Inbody S10 (Inbody CO). While DXA scan, subject were lying down on the examination table until the end of scan from the head to toe. Before measure, subject information is required such as sex, age, height and weight.

4. Eccentron exercise program

1) Exercise program

Exercise program to be applied in this study, is the same as the next of the **Table 2**.

Table 2. Exercise Program

Classification	ETG	CTG
Frequency	2 times/weeks	2 times/weeks
Warm-up (time)	Stretching (5 min)	Stretching (5 min)
Power-Eccentric Exercise	**Eccentron** Session Duration (30min) Speed 23 reps/min (normal)	**Leg Press** Session Duration (30min) 50% of 1RM test via leg press
Cool-down (time)	Stretching (5 min)	Stretching (5 min)
Adaptation Period and exercise Time	1-2 weeks: 10 to 20 min 3-8 weeks: 30 min	1-2 weeks: 10 to 20 min 3-8 weeks: 30 min

ETG; Eccentric training group. CTG; Conventional resistance training group.

1-1. Exercise Period (Duration)

Period of Eccentron exercise program has been ongoing for eight weeks. There is a need for adaptation of the two weeks of the machine.

1-2. Exercise Time & Frequency

Warm up and cool down exercise is organized 5 minutes, respectively. For the main exercise is organized with 30 minutes and intensity was carried out twice a week. **Table 3** shows that exercise time and speed during use Eccentron.

Table 3. Eccentric exercise protocol (Eccentron)

Weeks	Speed (rmp)	Time (min)	Target zone
1	**18**	**10 min**	**1st Dosing test**
2	**20**	**20 min**	
3	**23**	**30 min**	
4	**23**	**30 min**	
5	**23**	**30 min**	**2nd Dosing test**
6	**23**	**30 min**	
7	**23**	**30 min**	**3rd Dosing test**
8	**23**	**30 min**	

1-3. Eccentric exercise method

Eccentron, focused on quadriceps and hamstring in a professional machine, is for only eccentric exercise which is figure below. First of all, subject is sit down on the Eccentron, set in accordance with the seat and stride position in the elderly of the foot. Next, entering the personal information with Dosing test and then enter into the main exercise mode in Eccentron.

Figure 8. Eccentron Seat and Stride position, Dosing test, Main monitor view

The above screen, it is possible to watch this screen from beginning of real exercise. In the center top of the screen, it is possible to know the average accuracy of the value for both legs on target, respectively. To obtain accurate values, subject is adjusting until the point is in green target zone by withstand the force in the monitor. Green target zone is made by dosing test with 50% of each subject’s whole power through eccentric contraction. Therefore, it is possible to figure that subject utilize with Eccentron for reduce high risk of falls.

5. Conventional resistance exercise

2-1. Exercise Period (Duration)

The period of conventional resistance exercise is proceeded 8weeks.

2-2. Exercise Time and Intensity

First of all, subjects did dosing test through the Eccentron machine. At this moment, it is possible to get a value of power (Nm) for each subject. The same way as the eccentric exercise, determined exercise intensity value as divide by 50% from 1 RM through PRIMUS RS (BTE^{TM}.Inc.) in each subject. At first, subject needs to sit on the chair and measure subject’s isokinetic. After then, figuring out a value of peak torque from isokinetic machine such as 90.50Nm was measured. The proper value of leg press for this subject was 45.25Nm (50%). As a result of that, it is possible to do same intensity exercise as eccentric group.

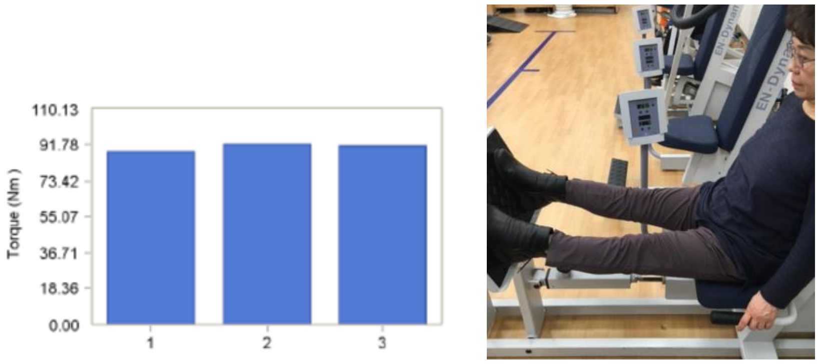

Figure 9. Intensity for conventional resistance exercise

6. Data Analysis

Statistical analysis was performed using the SPSS 22.0 software (SPSS Inc.). Results will be expressed as mean ± SE. Two way ANOVA was performed to exam the difference between groups in body weight, waist and hip circumference, skeletal muscle mass, fat mass, isometric muscle strength, isokinetic muscle strength, gait speed and chair rising test. LSD's post hoc were conducted to determine the existence of mean difference of each group. The level of significance was set at $p<0.05$.

IV. Result

1. Body composition and circumferences

Table 4. Characteristics and body circumferences

	Eccentric Exercise Group (n=8)		Conventional Resistance Exercise Group (n=8)		ANOVA (p-value)
	Pre-test	Post-test	Pre-test	Post-test	
Age	72.38 ± 2.62		75.00 ± 1.41		
Height (cm)	162.745 ± 2.245	162.655 ± 2.209	157.250 ± 8.048	152.170 ± 8.385	0.158
Body weight (kg)	68.338 ± 9.600	67.763 ± 9.123	60.113 ± 7.261	59.625 ± 7.081	0.098
Skeletal muscle mass (kg)	25.712 ± 1.303	25.994 ± 1.225	22.238 ± 1.049	22.463 ± 1.311	0.049
Muscle mass/BW (kg)	0.372 ± 0.016	0.370 ± 0.014	0.365 ± 0.019	0.382 ± 0.017	0.696
BMI (kg/m^2)	26.070 ± 1.374	25.859 ± 1.300	24.150 ± 1.548	23.976 ± 1.464	0.471
Fat (%)	31.400 ± 2.930	31.262 ± 2.413	31.913 ± 3.360	31.225 ± 8.923	0.960
WHR	0.893 ± 0.026	0.914 ± 0.022	0.907 ± 0.030	0.892 ± 0.025	0.624
Body Circumference					
Rt Thigh (cm)	48.188 ± 4.035	49.625 ± 3.861	47.250 ± 2.018	47.875 ± 2.489*	0.229
Lt Thigh (cm)	48.125 ± 4.016	49.750 ± 3.964	47.063 ± 2.111	47.563 ± 2.528*	0.132
Waist (cm)	93.625 ± 9.050	92.438 ± 7.208	88.437 ± 6.316	87.562 ± 6.721	0.459
Hip (cm)	99.563 ± 7.188	98.750 ± 6.541	94.000 ± 3.162	93.000 ± 3.229	0.065

Rt; right, Lt; left, BMI; body mass index

Throughout the 8 weeks of eccentric and conventional resistance program, one volunteers dropped out for personal reasons (e.g., one from conventional resistance exercise program). Therefore, statistical analysis was performed with eight elderly at the Eccentric exercise group (72.38±2.62 years old, 67.76±9.12kg, 162.66±2.21 cm), and eight elderly at the Conventional resistance exercise group (75.0±1.41 years old, 59.63±7.08kg, 157.17±8.39 cm). The Table 4 showed only skeletal muscle mass is significantly improved in both groups. However, there was no significant improvement in other measurement.

1. Physical Activity and Mental State Examination

Table 5. Physical Activity and MMSE-K

	ETG		CTG		ANOVA
	Pre-test	Post-test	Pre-test	Post-test	(p-value)
IPAQ (MET-minutes/weeks)	887.14 ± 93.997	954.24 ± 70.497	800.99 ± 83.592	926.28 ± 88.246	0.814
MMSE-K (score)	28.75 ± 0.463	29.38 ± 0.518	28.88 ± 0.641	29.38 ± 0.518	0.486
GDS (score)	3.38 ± 1.598	2.63 ± 0.916	3.63 ± 1.188	2.63 ± 0.518	0.353

IPAQ; international physical activity questionnaire, MMSE-K; mini mental state examination-Korean, GDS; geriatric depression scale

For the physical activity, IPAQ was calculated according to IPAQ scoring protocol (short forms). The equation of this value was to Total MET-minutes/week = Walk (METs*min*days) + Moderate (METs*min*days) + Vigorous (METs*min*days)

The subject's average amount of physical activity was increased over eight weeks of exercise training. However, Table 5 showed there was no significant difference between ETG and CTG.

The maximum score of the MMSE is 30 points. Results are divided into two categories, normal (up to 24) and cognitive impairment (23 or lower).

The subject's average MMSE score was increased over eight weeks of exercise training. However, there was no significant difference between ETG and CTG.

To the count of Geriatric depression scale, it is divided into three categories that normal (0 to 9 point), mild depressives (10 to 19) and severe depressives (20 to 30).

The subject’s average GDS score is decreased over eight weeks of exercise training. However, there was no significance difference between ETG and CTG.

3 Muscle Fatigue (Surface EMG)

Table 6. Muscle Fatigue (Surface EMG)

	ETG		CTG		ANOVA
	Pre-test	Post-test	Pre-test	Post-test	(p-value)
Rt Muscle Fatigue (VMO)	75.194 ± 8.974	76.463 ± 10.697	90.958 ± 19.922	90.212 ± 14.486	0.170
Rt Muscle Fatigue (RF)	79.441 ± 6.136	72.185 ± 8.185*	82.449 ± 8.751	84.454 ± 7.487	0.037
Rt Muscle Fatigue (VL)	80.027 ± 14.051	81.504 ± 14.549	92.609 ± 6.353	88.516 ± 5.798	0.312
Lt Muscle Fatigue (VMO)	73.044 ± 11.393	69.182 ± 6.536	76.695 ± 8.376	81.883 ± 13.905	0.127
Lt Muscle Fatigue (RF)	74.794 ± 8.633	66.931 ± 9.313*	86.153 ± 11.589	86.397 ± 15.967	0.048
Lt Muscle Fatigue (VL)	76.445 ± 10.388	78.641 ± 15.908	84.718 ± 7.585	84.290 ± 8.116	0.464

Rt; right, Lt; left, VMO: vastus medialis oblique, RF; rectus femoris, VL; vastus lateralis

The table 6 showed muscle fatigue using surface EMG (Electromyography). There was significantly improved in right rectus femoris (RF) and left rectus femoris (RF) in ETG and CTG. However, vastus medialis (VMO) and vastus lateralis (VL) was not difference in two groups.

4 Grip Strength

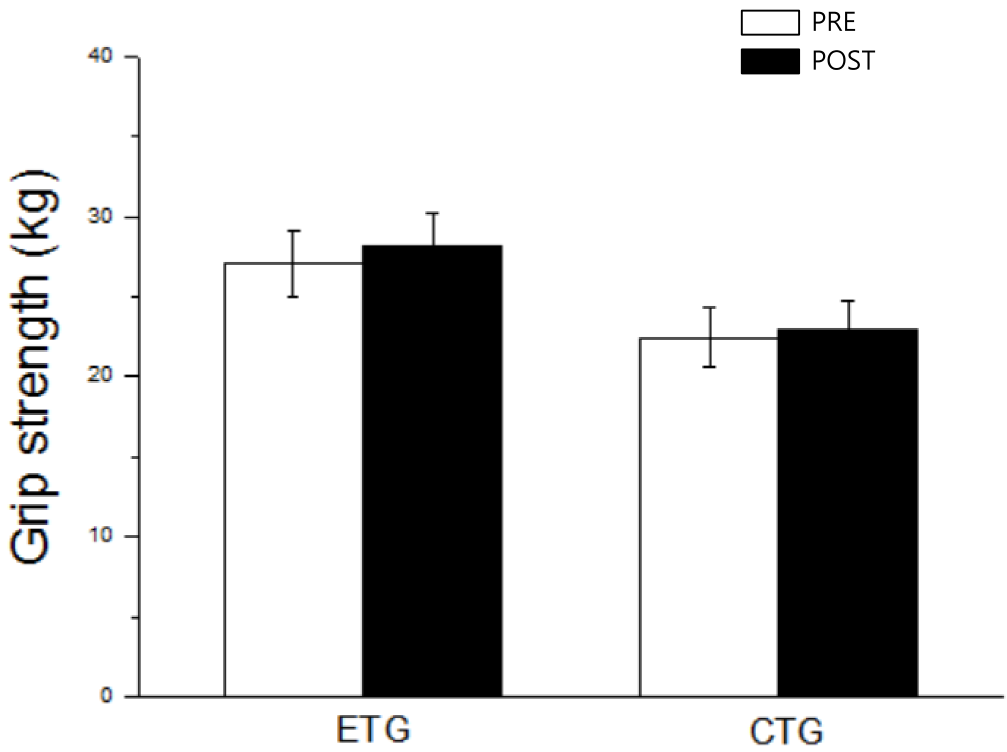

Figure 10. Relative grip strength of ETG (eccentric training group), CTG (conventional resistance training group).

For grip strength, the value of grip strength measured at before and after 8 weeks of exercise training, respectively. The result showed no significant improvement in grip strength in both groups (PRE ETG vs. POST ETG, 27.052±2.052 vs. 28.202±2.003 and PRE CTG vs. POST CTG, 22.423±1.864 vs. 22.967±1.763). In addition, there was no significant difference in ETG and CTG.

5 Gait speed

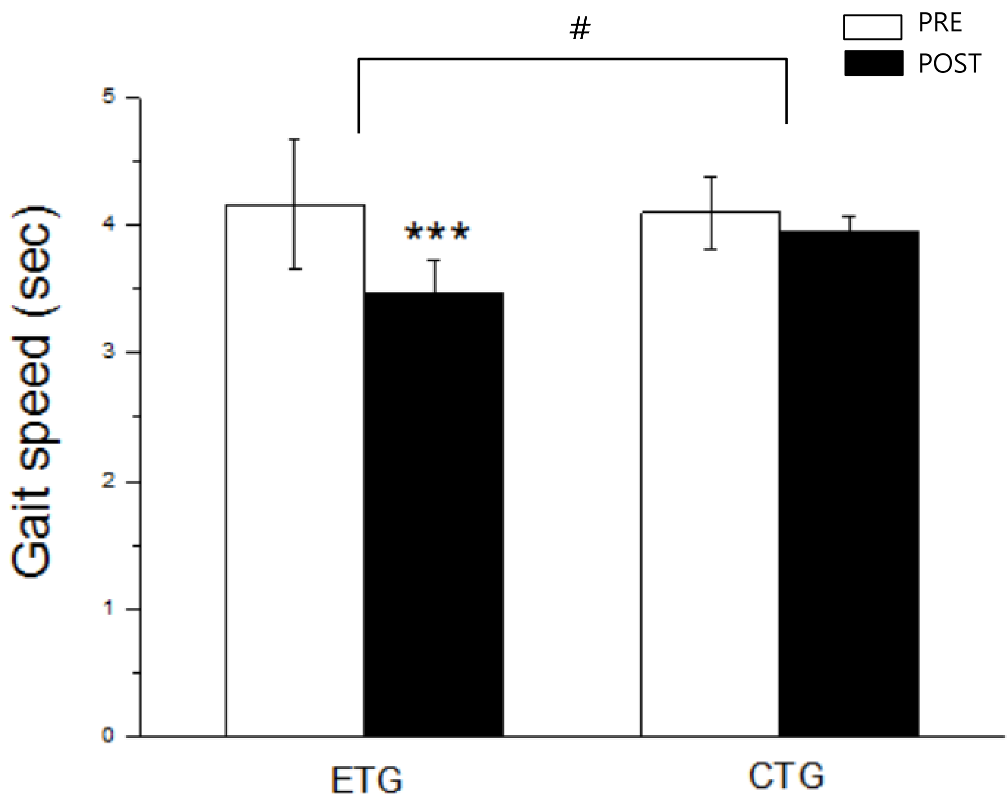

Figure 11. Relative Gait speed of ETG (eccentric training group) and CTG (conventional resistance training group). **; vs. PRE, #; vs. CTG

For gait speed, both group's gait speed used with Kinect program to measure. There were significantly decreased in eccentric training group compared to pre-test (PRE vs. POST, 4.164±0.509 vs. 3.465±0.266, $p<0.01$). However, there was no significant between pre and post test in conventional training group (PRE vs. POST, 4.098±0.289 vs. 3.945±0.125). In addition, There was significant difference between ETG group and CTG group.

6 Chair rising test

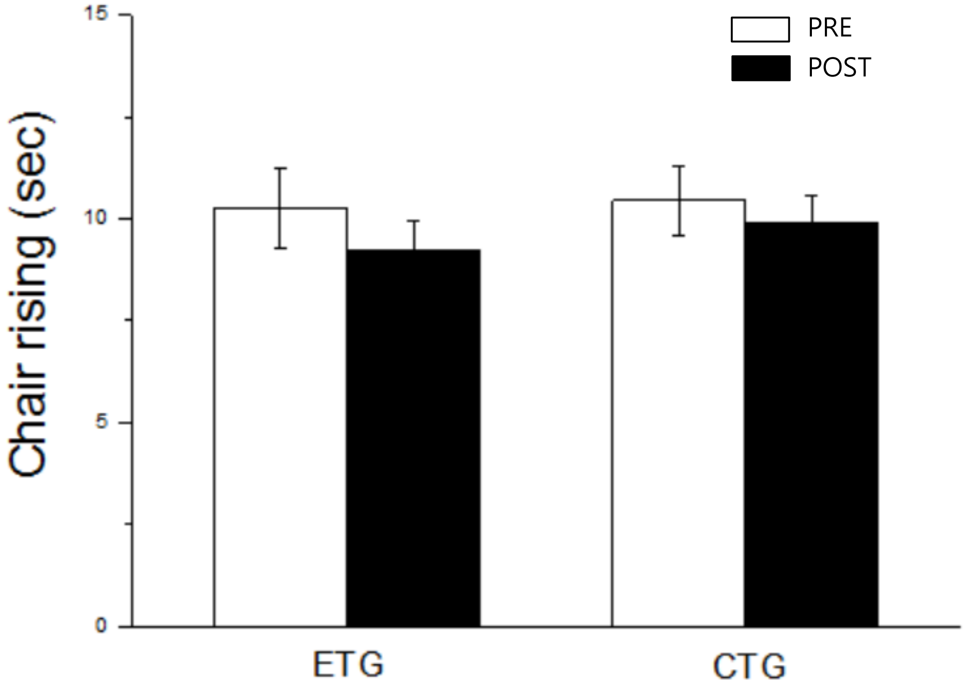

Figure 12. Chair rising test in ETG (eccentric training group) and CTG (conventional resistance training group).

By result of chair rising, it was measured in regular chair which height is 46cm from the bottom. The result of chair rising test showed there was decreased in pre and post ETG and CTG. (PRE ETG vs. POST ETG, 10.254±0.957 vs. 9.232±0.719, $p<0.05$) In addition, there was no significance difference in ETG and CTG.

7 Stair climb test

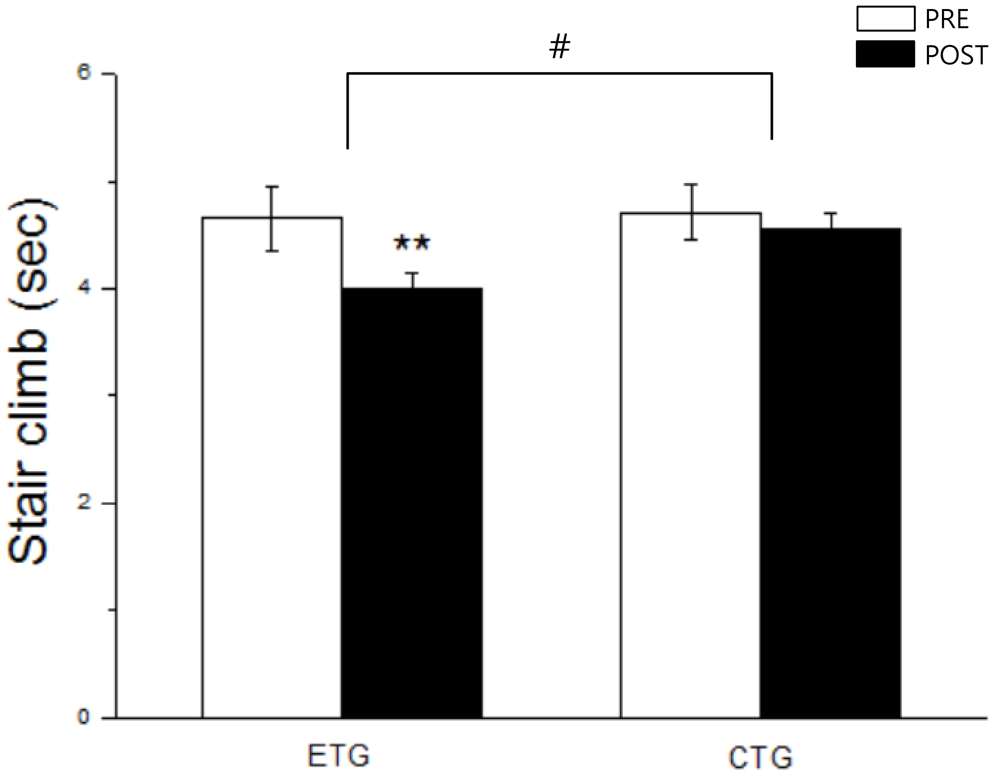

Figure 13. Relative Stair climb test in ETG (eccentric training group) and CTG (conventional resistance training group). **; vs. PRE, #; ETG vs. CTG

For Stair climb test, it was measured in 8 stairs which height was 17.5cm each before and after exercise training. The result showed significant improvement in pre and post ETG. (PRE vs. POST, 4.655±0.298 vs. 3.989±0.149, $p<0.01$) Also, there was significant difference in ETG and CTG. (ETG vs. CTG, 3.989±0.149 vs. 4.564±0.138, $p<0.01$)

8 Right knee Isometric

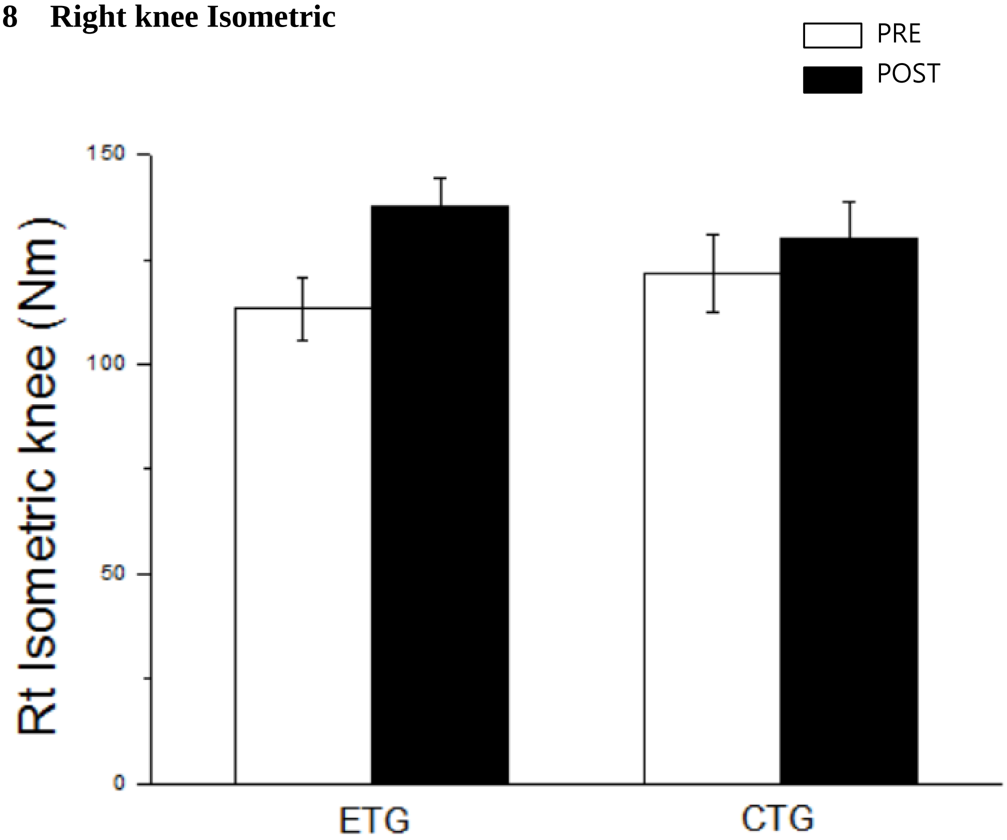

Figure 14. Right Isometric knee in ETG (eccentric training group), CTG (conventional resistance training group).

By the result of right side isometric knee, it was measure with BTE PRIMUS RS (BTE^{TM}. Inc.) before and after 8 weeks of exercise. The results showed increased at right knee isometric in eccentric training group and conventional resistance exercise group. (PRE ETG vs. POST ETG, 113.173±7.493 vs. 137.663±6.782, and PRE CTG vs. POST CTG, 121.790±9.245 vs. 130.087±8.703) In addition, there was no significant difference in ETG and CTG.

9 Left knee Isometric

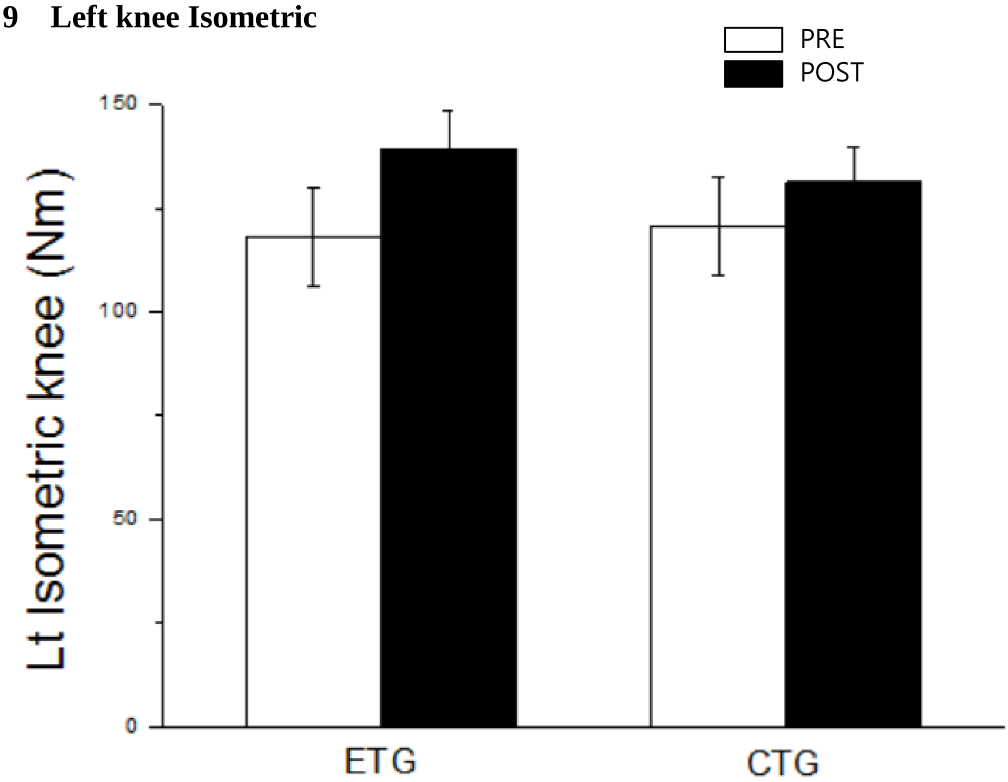

Figure 15. Left Isometric knee in ETG (eccentric training group), CTG (conventional resistance training group).

By the result of left side isometric knee, it was measure with BTE PRIMUS RS (BTE™. Inc.) before and after 8 weeks of exercise. The results showed increased at left knee isometric in eccentric training group and conventional resistance exercise group. (PRE ETG vs. POST ETG, 118.052±12.065 vs. 139.342±9.127, $p<0.01$ and PRE CTG vs. POST CTG, 120.611±11.953 vs. 131.333±8.585) In addition, there was no significant difference in ETG and CTG.

10 Right knee Isokinetic

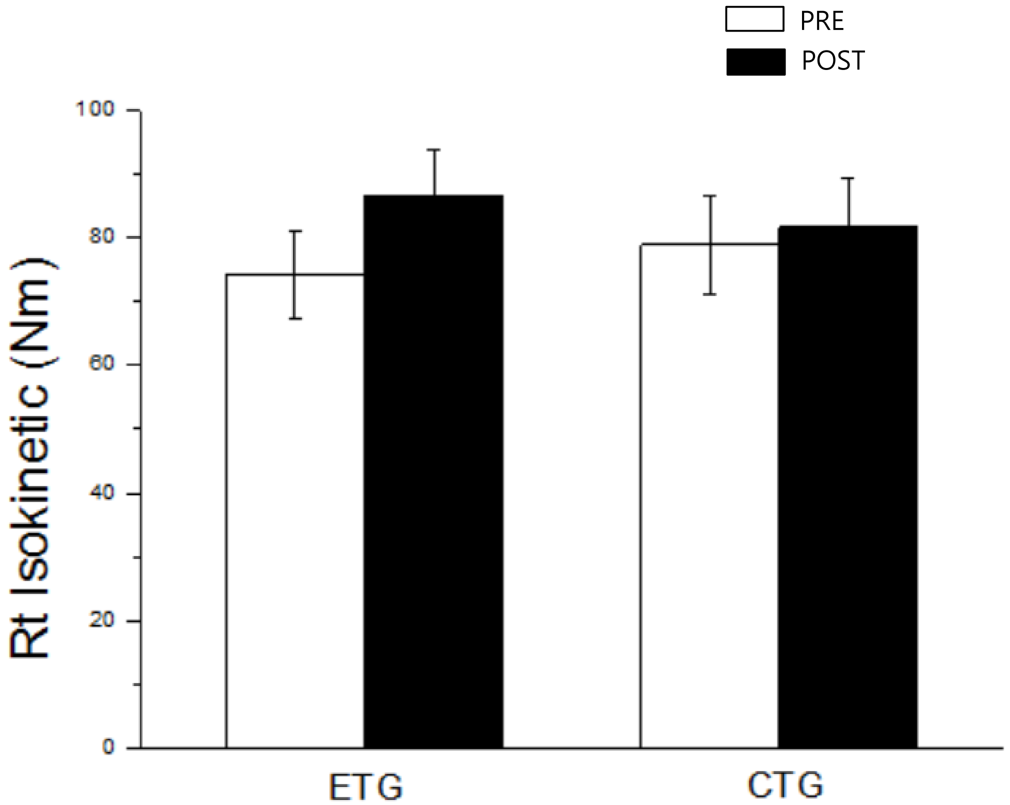

Figure 16. Right (Rt) knee Isokinetic in ETG (eccentric training group), CTG (conventional resistance training group).

By the result of right knee isokinetic (60 degree/sec), it was measure with BTE PRIMUS RS (BTE^{TM}. Inc.) before and after 8 weeks of exercise. The results showed increased at right knee isokinetic in eccentric training group. (PRE ETG vs. POST ETG, 74.330±6.862 vs. 86.467±7.311) In addition, there was no significant difference in ETG and CTG.

11 Left knee Isokinetic

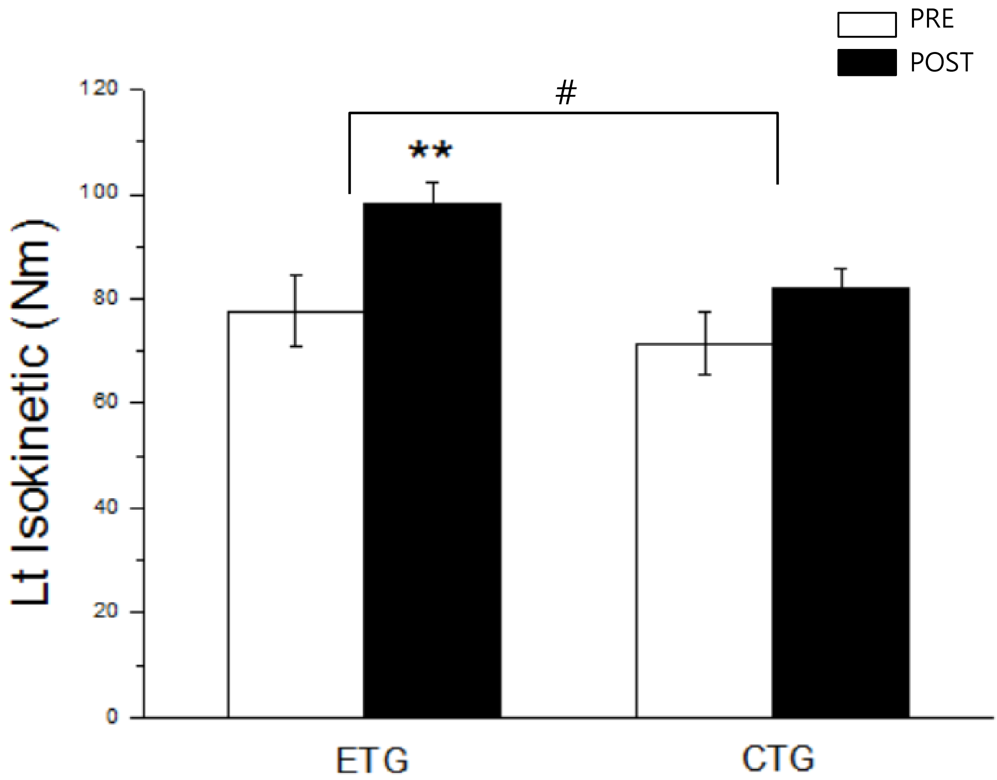

Figure 17. Left (Lt) knee Isokinetic in ETG (eccentric training group), CTG (conventional resistance training group). PRE ETG, **; vs. PRE CTG, #; ETG vs. CTG

By the result of left knee isokinetic (60 degree/sec), it was measure with BTE PRIMUS RS (BTE^{TM}. Inc.) before and after 8 weeks of exercise. The results showed significant improvement at left knee isokinetic in eccentric training group. (PRE ETG vs. POST ETG, 77.587±6.836 vs. 98.308±4.040, $p<0.01$) In addition, there was significant difference in ETG and CTG (ETG vs. CTG, 98.308±4.040 vs. 82.179±3.677, $p<0.05$).

12 Right Knee Power

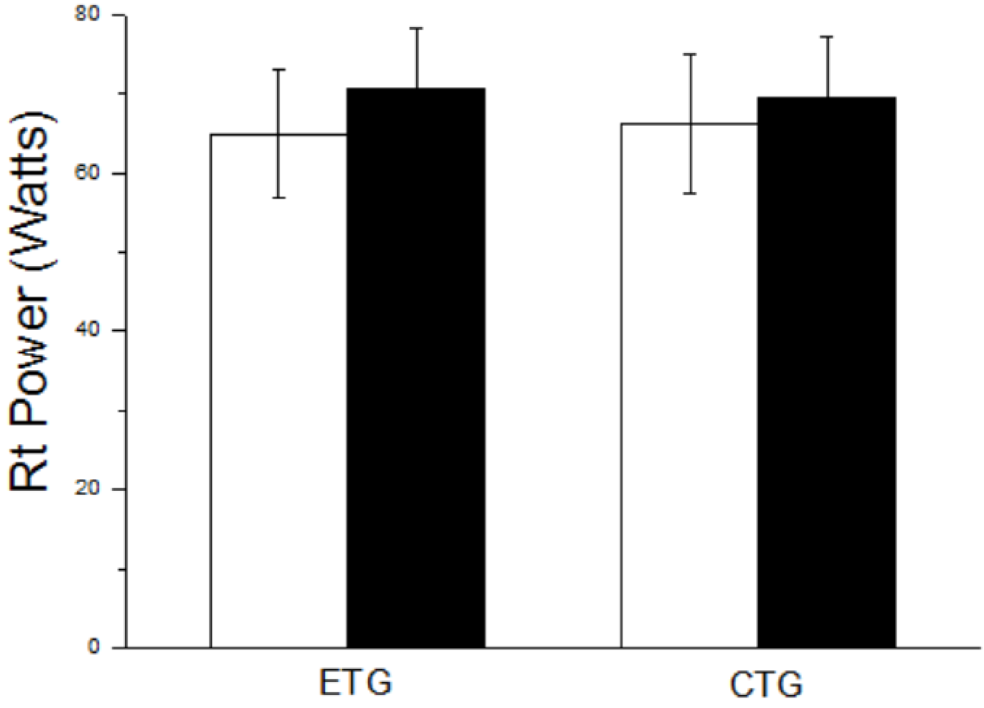

Figure 18. Right (Rt) knee Power in ETG (eccentric training group), CTG (conventional resistance training group).

By the result of right knee power, it was measure with BTE PRIMUS RS (BTE™. Inc.) before and after 8 weeks of exercise. The results showed increased at right knee power in eccentric training group. (PRE ETG vs. POST ETG, 64.953±8.146 vs. 70.605±7.606) In addition, there was no significant difference in ETG and CTG.

13 Left Knee Power

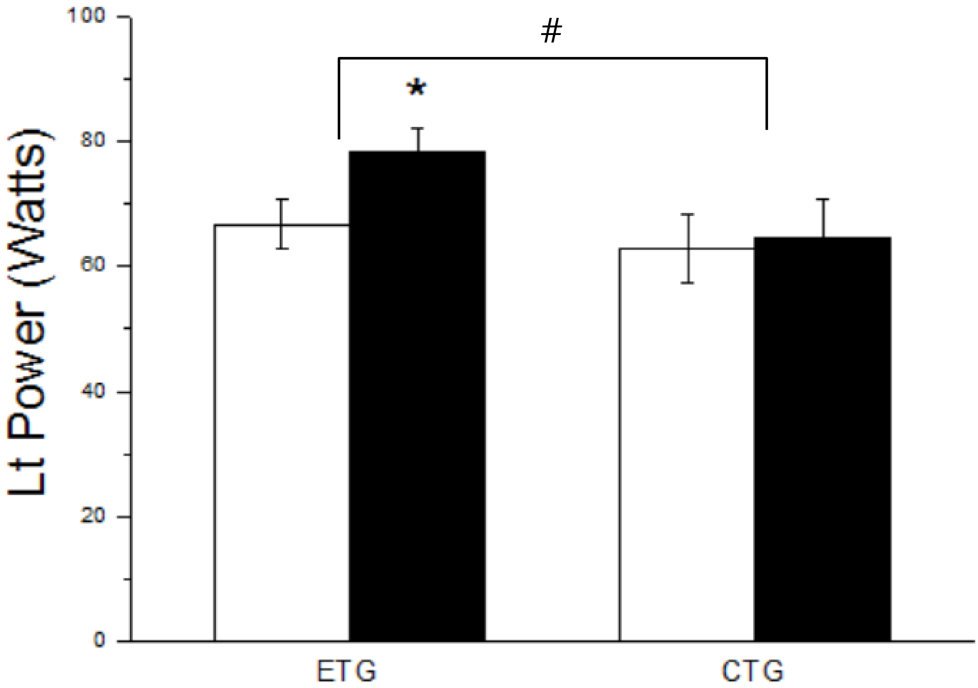

Figure 19. Left (Lt) knee Power in ETG (eccentric training group), CTG (conventional resistance training group). PRE ETG, *; vs. PRE CTG, #; ETG vs. CTG

By the result of left knee power, it was measure with BTE PRIMUS RS (BTE™. Inc.) before and after 8 weeks of exercise. The results showed significant improvement at left knee power in eccentric training group. (PRE ETG vs. POST ETG, 66.817±4.083 vs. 78.316±3.988, $p<0.05$) In addition, there was significant difference in ETG and CTG (ETG vs. CTG, 78.316±3.988 vs. 64.734±5.947, $p<0.05$).

Discussion

Many studies report muscle weakness due to aging, based on the reduction of muscle strength evaluation (Hortobagyi et al., 1995). However, the muscle's need to stretch and contract by external forces in daily life, in order to try to shrink and induce tension, is achieved through a third of the activities, such as eccentric contraction (e.g. stair descent) (Enoka., 1996). Compared to isometric contraction and shortening contraction, the rotational force of the muscle at the time of eccentric contraction exerts a greater force (Phillips et al., 1991). When this role increases by the passive element of muscle, an increase in muscle strength occurs. Performing the eccentric movement is more difficult for elderly people. According to recent studies, eccentric muscle capability is reported to be preferentially retained through the change with aging (Hortobagyi et al., 1995; Porter et al., 1995; Porter et al., 1997; Poulin et al., 1992).

The activities of daily life require the use of absolute power in order to perform a given task. For a given absolute level of muscle expression, eccentric contraction requires only a small amount of energy consumption less than during isometric and shortening contraction (Enoka., 1996; Tesch et al., 1990). For this reason, muscle strengthening and protocol by eccentric contraction is the preferred route to optimum results.

The purpose of this study is to improve upon whether or not an increased regulation time in the eccentric exercise program for older adults would result in a larger gain in strength and functional capacity compared with conventional resistance exercise. Not only do both exercise training protocols take into account improvements in the elderly's conditioning, but also the significant differences that were observed between ETG (Eccentric Training Group) and CTG (Conventional Training Group).

We observed improvements in knee extension muscle strength and functional performance tests for both groups after 8 weeks of training. Studies have shown a fast increase in maximum strength after 8 weeks of eccentric training, followed by stabilization gains (Cadore et al., 2013; Dias C.P. et al., 2015; Hakkinen et al., 1994). This study did not investigate the mechanism responsible for the time course of muscle adaptations in both groups, but our findings suggest that 8 weeks of both eccentric and conventional resistance exercise should be enough to significantly impact elderly strength and functional capacity (Pinto el al., 2014).

In this study, there was no significant difference found between ETG and CTG in both sides of isometric knee extension. However, both sides of post ETG showed a significant increase in isometric knee extension compared to pre ETG. Also, there was no significant difference in the isometric knee extension of the left side of post CTG compared to pre CTG. These results not only express that both types of exercise can increase muscle strength, but also that eccentric exercise is more effective in increasing muscle strength of the affected body parts in the elderly (Roig et al., 2010)

The strength and functionality values found in this study resemble those found in previous studies on knee extensions (Rice, D. A. et al.,2015), leg presses (Hanson, E.D. et al.,2009), and chair-rising tests (Peiffer et al., 2010; Tiedemann A et al., 2008). What's more the stair climbing test the subjects of our study, who had a shorter time to perform the test compared to conventional resistance exercise (Hanson, E.D. et al., 2009; Peiffer et al., 2010; Tiedemann A et al., 2008). Previous studies showed that gains in muscle strength and mass in healthy adults aged from 18 to 65 years old are higher in exclusively eccentric exercise as compared to exclusively concentric exercise programs (Roig et al., 2009). Symons' study group showed, however, that the eccentric exercise group did not demonstrate gains in voluntary strength that was superior to those of the isometric and concentric groups (Symons et al., 2005).

In this study, there was significant difference found between ETG and CTG on the left side of 60°/sec isokinetic and power test. However, the right side of isokinetic and power test did not show as significant difference as left side, respectively. The value of results are increases as left side.

It is important to mention that we matched the progression of the exercise intensity between groups by the results of the Dosing test from the Eccentron (BTE^{TM}. Inc.) and 1RM test from the 60 angular velocity of isokinetic at the baseline evaluation. In addition, from the Dosing test through the Eccentron (BTE^{TM}. Inc.), it sets the exercise target zone at 50% of the full strength per each person. In the same way, subjects who participated in conventional resistance exercise groups did measure their 1RM by isokinetic peak torque and then divided that by 50% of 1RM which is the full strength.

The functional tests used in this study are closely related with the stair-climbing test, the 4m walk test, and the chair rising test (Dias, C.P. et al., 2015). A number of tasks involve a high risk of falls for the elderly, therefore functional capacity seems to be more important than strength capacity for the elderly. The majority of work of reduces the high risk of falls that are performed eccentrically, such as the stair descent. Thus, the assessment of the eccentric priority tasks (e.g., the stair descent) should primarily focus on the potential benefits derived from the exercise training conducted by the eccentric exercise group (Dias, C.P.et al., 2015). To check for functional capacity, the balance test is one of them. We expect the eccentric exercise group to present a better performance because the balance generally involves rapid responses from muscle spindles and other proprioceptors to a sudden increase in the length of the muscles (Ellaway el al., 2015).

Further research is needed to determine if a longer period of training (more than 8 weeks) and/or having one or two more groups could help to determine further differences between eccentric and conventional training. In addition, if there is a concentric mode in the Eccentron device, it would be easier to compare the exercise mode in different groups.

Conclusion

The purpose of this study is to investigate the effect of eight weeks of eccentric exercise training on muscle strength and functions in elderly people, when compared to conventional resistance exercise training.

This study showed improvement in the eccentric exercise group in isokinetic and power tests through knee extension muscle strength and two of four functional tests (e.g. gait speed and stair climb) for eccentric exercise groups after 8 weeks of training. In addition, eccentric strength is also potentially conserved in the elderly as in a previous study (Roig et al, 2009). A continuous and regular eccentric exercise program is effective, which counteracts the reduction of muscle strength and muscle functions that can become noticeable through aging. Therefore, it was found to have a positive effect on sarcopenia and physical fitness of the elderly.

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국문 초록

8주간 하지의 신장성 운동이 노인의 근력과 근기능에 미치는 영향

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서론: 근감소증은 나이가 들어가면서 근육의 양과 근 기능이 줄어드는 현상으로 이는 결국 근력과 신체 기능에 상관관계가 있음을 알 수 있다. 따라서 본 연구에서는 8주간 하지의 신장성 운동과 보편화된 저항성 운동이 노인의 근력과 근기능에 미치는 영향에 대하여 알아 보고자 한다.

방법: 연구의 대상은 경기도 S시에 거주하는 만 70세 이상 그리고 일상 보행활동에 문제가 없는 남녀를 대상으로 하였으며, 8주간의 신장성 운동 프로그램에 참여하는 운동군 8명과 보편화되어 있는 저항성 운동군에 포함되어 있는 대조군 8명으로 구성되었다. 사전 및 사후측정에서는 신체조성 항목으로 신장, 체중, Body Mass Index(BMI), 체지방률, 허리 둘레, 엉덩이 둘레와 허벅지 둘레를 측정하고, 근력(악력, 무릎 신근)과 근 기능(걷기, 계단 오르기, 의자 일어서기, 균형 감각)을 측정하였다. 운동군에서는 8주간의 신장성 전문 기계(Eccentron-BTE^{TM}. Inc)를 30분씩 주 2회 실시하고, 대조군에서는 8주간의 다리 밀기(Seated leg press-EN Dynamic. ENRAF NONIUS)를 신장성 운동에서 보여주는 강도인 전체 힘의 50%의 강도를 적용하여 30분씩 주 2회 실시하였다. 통계 기법은 Two-way repeated ANOVA를 사용하여 분석하였으며, 사후 검증을 통하여 그룹간의 차이를 분석하였다.

결과: 운동 프로그램 참여 후 운동의 효과를 검증한 결과, 운동군과 대조군에서 근력에 포함되는 왼발의 등속성 60°/sec와 근 기능에 포함되는 Gait speed (4m 걷기), 계단 오르기에서 그룹간의 상호작용이 유의하게 나타났다. 그리고 오른쪽과 왼쪽의 허벅지 둘레 (p=0.003, p=0.001), 의자 일어서기 (p=0.048), 오른쪽과 왼쪽의 등척성 (Isometric) (p=0.000, p=0.002), 오른쪽의 등속성 (Isokinetic) 60°/sec(p=0.041)가 운동군에서 증가하였다. 대조군에서는 오른쪽과 왼쪽의 등척성 (Isometric) (p=0.022, p=0.008) 과 근육량/체중 (p=0.017)에서 유의하게 증가하였다. 악력 (p=0.156), Body Mass Index(BMI) (p=0.471), 체지방률 (p=0.960) 은 운동군과 대조군에서 상호작용 효과가 나타나지 않았다.

결론적으로, 지속적이고 규칙적인 신장성 운동 프로그램의 초기 운동시에는 평소와 다른 근육의 당김과 같은 일시적으로 불편함을 느낄 수 있겠지만, 근력과 근기능의 개선에 있어서 짧은 시간의 운동만으로도 효과적이었으며, 이로 인하여 노인의 근 감소 예방에 긍정적인 영향을 미칠 것으로 나타났다.

주요어: 신장성 운동, 근력, 근 기능, 근 감소증, 노화

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