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Effects of 8-Week Elastic Resistance Exercise on Knee Isokinetic Rate of Velocity Development and Balance by Age

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Abstract

Ten women in their 20s and 10 women in their 50s were selected to investigate the effect of an elastic band exercise program for 8 weeks according to age on women's knee speed expression rate and balance. Knee isokinetic muscle strength measurement, single-legged standing with eyes closed, and YBT were performed 1 week before and after the exercise program. The measured data were analyzed through a mixed design two-way ANOVA, and if there was a significant difference, post hoc verification was performed using the bonferoni method. In our study, as a result of an 8-week elastic band exercise program, there was no difference in the speed development rate according to the measurement period, and the speed development rate according to age was found to be higher in people in their 50s than in their 20s. In our study, there was no difference in balance ability depending on the measurement period, and there was also no difference in balance ability depending on age. Discussing the results of our study, we found that 8 weeks of elastic band exercise cannot bring about significant changes in speed development ability and balance ability, which become more accurate with age.

Keywords: *rate of velocity development, equilibrium, elastic resistance exercise*

1. Introduction

Interest in successful aging is growing along with the global increase in average life expectancy, and the number of elderly people aged 65 or older in Korea has already entered an aging society, exceeding 14% in 2019. As of 2025, the proportion of the elderly population will reach 20%. It is expected that we will enter a super-aging society [1]

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As the human body ages, many degenerative changes occur [2]. Among them, the decline in muscle mass and strength decreases by more than 1% after the age of 40, and by the age of 80, the muscle mass decreases by 50% of the maximum muscle mass [3]. The decrease in skeletal muscle due to aging reduces muscle strength and muscle function, which causes lack of activity and decline in physical strength. The decline in skeletal muscle is caused by a decrease in protein synthesis rate and recovery ability due to aging, and shows a clear pattern after the age of 50[4, 5]. Skeletal muscle decline due to aging is closely related to the loss of fast-twitch fibers [6, 7] The decline in skeletal muscle and strength decreases more rapidly as physical activity decreases [4], causing several diseases due to aging and further affecting healthy lifespan. From this perspective, research on the prevention of muscle strength and skeletal muscle loss due to aging is considered necessary.

Physical aging can be delayed by improving muscle strength through exercise and increasing or slowing down the decline of skeletal muscle mass[8, 9], and can reduce the risk of loss of daily living skills, falls, and independence in the elderly. Phenomenon such as loss can be prevented [10]. Resistance exercise is a representative exercise for this purpose. Low-impact exercise uses barbells, dumbbells, body weight, props, etc., or uses body weight to increase muscle mass or improve muscle functions such as muscular endurance, muscle power, and balance. It is an effective exercise that helps increase fat mass [11]. Depending on whether or not one participates in resistance exercise, there are differences in the functions of various body organs, including the cardiovascular system, musculoskeletal system, and nervous system [12], and this response is more evident in people over 40 [13].

Probs Resistance exercise is exercise ball exercise, a representative stability exercise among prop resistance exercises, improves the sense of balance by increasing the stability of the trunk [14) and is helpful for muscle strength and coordination [15]. In addition, stability exercises help with imbalances in the musculoskeletal system, provide joint stability through control of the muscular nervous system, and help prevent injuries [16, 17] It also affects proprioception and the ability to maintain posture and improves body stability and sensory control ability [18]. The exercise ball can improve agility and perception and improve the sense of balance by using the instability of the tool itself through its elasticity.

Resistance exercise, which has such diverse positive effects, can slow down physical aging and improve the ability to resist various diseases, thereby increasing the independence of the elderly in daily life and preventing injuries. Since the decline in physical ability during the aging process is an inevitable phenomenon in the human life cycle, rather than reacting with frustration or rejection, efforts are made to reduce the extent of decline as much as possible and to delay the point in time, that is, physical ability through exercise. It is necessary to expect improvement [10].

Therefore, in this study, the walking ability factor and balance factor that appear by applying the same elastic resistance exercise to women in their 20s and 50s for 8 weeks were observed to determine the physical ability that appears during the aging process. We are trying to determine the effect of exercise on reduction.

2. Experiment

2.1 Subject

The subjects of this study were 10 women in their 20s and 50s who lived in Cheonan, Chungcheongnam-do and had no experience in elastic resistance exercise. Both groups had no health problems or diseases to perform elastic resistance exercise. The research procedures, measurement methods, and exercise program of this study were explained to the selected research subjects, and they voluntarily agreed to participate in the study and then completed the study. proceeded. The individual characteristics of the study subjects are shown in Table 1.

Table 1. Physical characteristics of subjects

Group	N	Weight(kg)	Career(month)
20s	160.66±4.33	60.43±7.08	8.75±2.00
50s	156.69±4.61	55.28±6.61	7.32±2.10

2.2 Measurement Procedure

After recruiting research subjects who met the conditions for conducting the study and signed the research consent form, the research subjects were recruited and briefed in advance on the experimental methods and procedures. Isokinetic muscle function and balance were measured for each study subject 10 to 3 days before performing 8 weeks of elastic resistance exercise. The isokinetic speed development rate used data collected after knee isokinetic measurement (60°/sec Torque at 0.18, 60°/sec Accelation Time, 60°/sec Torque at 30°), and the balance was measured by standing with one foot closed and with one foot closed. Y-balance test (YBT) was used. To minimize the impact of fatigue caused by measurement on exercise performance, an elastic resistance exercise program was implemented 3 days after the end of pre-measurement for all subjects. Elastic resistance exercise was performed for 8 weeks, twice a week for 70 minutes. After completion of the exercise program, post-measurement was performed in the same manner as the pre-measurement, and the measured data were analyzed using mixed measure two-way ANOVA according to time and age.

2.3 Materials Measurement

2.3.1 Elastic Prop Resistance Exercise Program

The elastic resistance exercise program in this study was conducted for a total of 8 weeks. It was conducted twice a week, and each session lasted 70 minutes including a break. Exercise intensity was gradually increased every two weeks. The exercise items were the same each time using elastic bands and exercise balls, and some items were performed with the same exercise parts but changed movements as the intensity increased. The exercise movements are as shown in <Table 0>. Exercise intensity was set by checking the rating of perceived exertion (RPE) felt by the subjects during each exercise and adjusting the number of times and sets for each movement. The props used were elastic bands, and the product used was Theraband-Red (THERABAND, USA).

2.3.2 Isokinetic Function Measurement Method

The isokinetic measurement method was modified to suit the purpose of this study according to the ACSM (2011) guidelines. Biodex system 4 (Biodex, USA) was used for isokinetic measurements. The subject sat on the device and adjusted the chair so that the hip joint was bent at 90°, and the torso, pelvis, and thighs were fixed with a belt to prevent forces from other joints other than knee movement during measurement. The lateral epicondyle of the femur was aligned with the rotation axis of the dynamometer, and then the ankle was secured with a Velcro strap around the tibia medial malleolus. After fixing the necessary body parts and aligning the rotation axis, the maximum knee joint extension was set to 0° and the range of motion was set to 90° bending. In order to eliminate errors applied to the calf's weight during measurement, gravity correction was performed at a 25° position. After two preliminary exercises at a set load speed before measurement and a rest of at least

3 minutes, isokinetic muscle strength was measured in a state of flexion at a set angle with a “start” signal from the measurer. The angular velocity and number of times were performed 5 times at 60°/sec. Both knees were tested, and the side with the higher peak torque of 60°/sec knee extension was considered the dominant side. RVD used 60°/sec knee extension torque at 30°, 60°/sec knee extension torque at 0.18sec, and 60°/sec knee extension acceleration time from the measured isokinetic muscle strength data.

2.3.3 Balance Measurements(Y-balance test)

To measure balance in this study, the Y-balance test (YBT) and the eyes-closed one-leg stand were performed.

Dynamic balance ability in this study was tested using the Y-balance test. The measurement was performed by supporting the dominant leg (higher peak torque of 60°/sec knee extension) leg during isokinetic muscle strength measurement, and was used as comparative data. The Y Balance Test kit (Functional Movement Systems, Inc, USA:YBT) was used as a dynamic balance ability measurement device (Lee, 2018), and the subject's non-dominant leg length was measured to calculate the YBT score before the test. Leg length (Limb Length) was measured from the anterior superior iliac spine (ASIS) to the medial malleus in a comfortable lying position on the back. Measured twice and the higher value was used. After measuring the leg length, the subject was fully explained about the YBT measurement posture and a posture demonstration was provided. The subject took a 3-minute break after practicing once. With the dominant foot placed on the YBT tik center footrest and a standing posture, the test plate of the YBT kit in the anterior, posterolateral, and posteromedial directions was pushed as far as possible with the non-dominant foot to measure the recording (Plisky et al., 2009) measured a total of two times and recorded a high value. The calculation formula for Composite Scored is as shown in (1). If the support foot fell from the footrest, if the outstretched foot touched the ground, if it did not return to the correct posture after measurement, or if it supported the ground or the YBT kit, it was considered a failure and the measurement was re-measured. The YBT measurement posture is as shown in Figure 1 (Cook, 2010).

$$\frac{(\text{anterior score} + \text{posteriomedial score} + \text{posteriolateral score})}{(3 \times \text{leg length})} \times 100 \qquad (1)$$

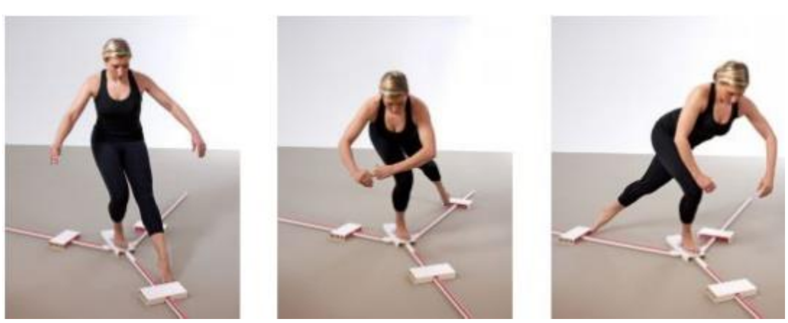

Figure 1. YBT measurement posture[19]

2.3.4 3 Balance Measurements(single-leg stance with closed eyes)

Static balance ability in this study was measured by single-leg stance with the eyes closed. The measurement was performed by supporting the dominant and was used as comparative data. The subject places both hands on the waist, closes his eyes at the start signal, and begins by raising the non-dominant knee to waist height, until the non-dominant foot touches the ground, the hand is lifted from the waist, or the position of the dominant foot moves. The time was recorded and used as data. The posture for measuring single-leg standing with closed eyes is as shown in Figure 2.

Figure 2. single-leg stance with closed eyes posture

2.4 Experimental Equipment

The experimental equipment used in this study is an elastic band (Theraband, USA) and exercise ball (Theraband, USA) for elastic resistance exercise, Biodex system 4 (Biodex, USA) for isokinetic velocity development rate, and Y-balance test. The FMS test kit (Functional Movement Screen: FMS, USA) was used.

2.5 Statics Analysis

In this study, the data was processed using the IBM SPSS statistics (ver 22.0) statistical program to calculate the average and standard deviation of all variables. When applying an 8-week elastic resistance exercise program, isokinetic velocity development rate and balance according to measurement period and age were analyzed using the Mixed Measure two-way ANOVA method. The statistical significance level was set at $\alpha=.05$.

3. Result

3.1 Rate of Velocity Development(RVD)

3.1.1 60° /sec Knee Extension Torque at 30°

Table 2 and Figure 3 shows the Mixed two-way ANOVA verification results and mean and standard deviation of 60°/sec knee extension torque at 30° according to measurement period and age during elastic resistance exercise for 8 weeks in this study. There was a statistically significant difference in 60°/sec knee extension torque at 30° depending on the measurement period ($p<.05$), but post-hoc testing showed no difference between the measurement periods. There was a statistically significant difference in 60°/sec knee extension torque at 30° according to age ($p<.01$), and as a result of post-hoc testing, it was found that those in their 20s were higher than those in their 50s both before and after. There was no interaction effect between measurement period and age.

Table 2. Difference of 60°/sec knee extension torque at 30°

Group	pre	post		F	P
20s	92.19±24.07	96.75±24.91	Time	5.050	.037
			Group	11.784	.003
50s	63.35±13.91	66.25±12.47	Time * Group	.25	.623

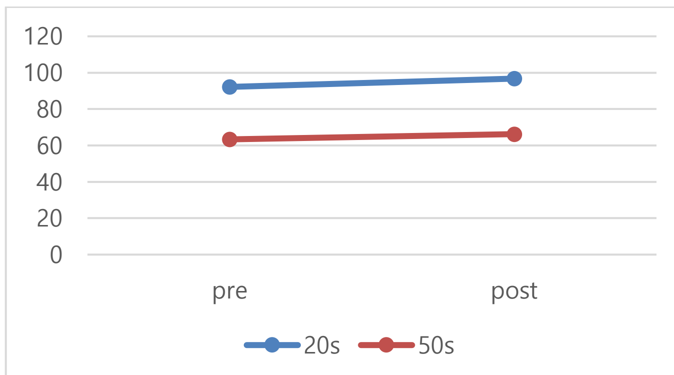

Figure 3. Difference of 60°/sec knee extension torque at 30°

3.1.2 60° /sec Knee Extension Torque at 0.18sec

Table 3 and Figure 4 shows the mixed two-way ANOVA verification results and mean and standard deviation of 60°/sec knee extension torque at 0.18sec according to measurement period and age during 8 weeks of elastic resistance exercise in this study are shown in Table 3. There was no statistically significant difference in 60°/sec knee extension torque at 0.18sec depending on the measurement period. There was a statistically significant difference in 60°/sec knee extension torque at 0.18sec according to age ($p<.01$), and as a result of the post-hoc test, those in their 20s were found to be higher than those in their 50s both before and after. There was no interaction effect between measurement period and age.

Table 3. Difference of 60°/sec knee extension torque at 0.18sec

Group	pre	post		F	P
20s	106.84±27.25	106.74±14.95	Time	.601	.448
			Group	40.937	.000
50s	55.78±13.51	61.61±15.99	Time * Group	.642	.433

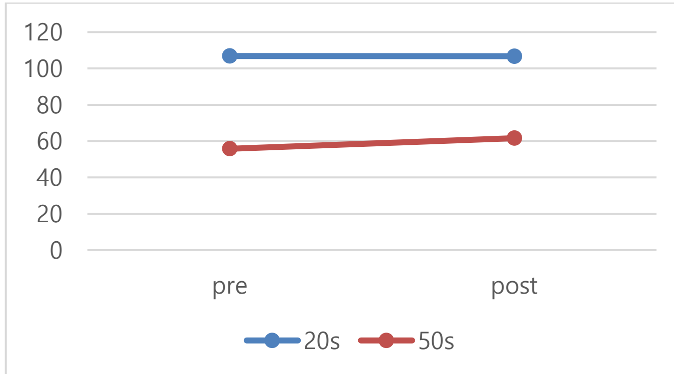

Figure 4. Difference of 60°/sec knee extension torque at 0.18sec °

3.1.2 60° /sec Knee Extension Accelation Time

Table 4 and Figure 5 shows The Mixed two-way ANOVA verification results and mean and standard deviation of 60°/sec knee extension acceleration time according to measurement period and age during 8 weeks of elastic resistance exercise in this study are shown in Table 4. There was no statistically significant difference in the 60°/sec knee extension acceleration time depending on the measurement period. There was a statistically significant difference in the 60°/sec knee extension acceleration time according to age ($p<.001$), and as a result of the post-hoc test, those in their 20s were higher than those in their 50s both before and after. There was no interaction effect between measurement period and age.

Table 4. Difference of 60°/sec knee extension accelation time

Group	pre	post		F	P
20s	34.00±25.41	24.00±9.66	Time	3.625	.073
			Group	18.027	.000
50s	62.00±24.40	51.00±25.49	Time * Group	0.025	.876

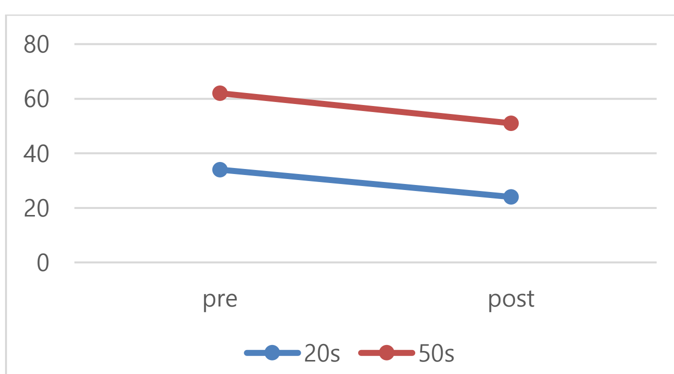

Figure 5. Difference of 60°/sec knee extension accelation time

3.1 Balance

3.1.1 Single-Leg Stance with Closed Eyes Test

Table 5 and Figure 6 shows The Mixed two-way ANOVA verification results and mean and standard deviation of **Single-leg leg stance with closed eyes** according to measurement period and age during elastic resistance exercise in this study for 8 weeks are shown in Table 5. There was a statistically significant difference in standing on **single-leg leg stance with closed eyes** depending on the measurement period ($p<.001$), and post-test results showed that the post-test was higher than the pre-test for both those in their 20s and 50s. There was no statistically significant difference in standing on **single-leg leg stance with closed eyes** according to age. There was no interaction effect between measurement period and age.

Table 5. Difference of Single-leg leg stance with closed eyes test

Group	pre	post		F	P
20s	20.22±14.72	33.58.21.45±	Time	27.895	.000
			Group	1.586	.224
50s	15.02±9.70	22.91±10.21	Time * Group	1.854	.191

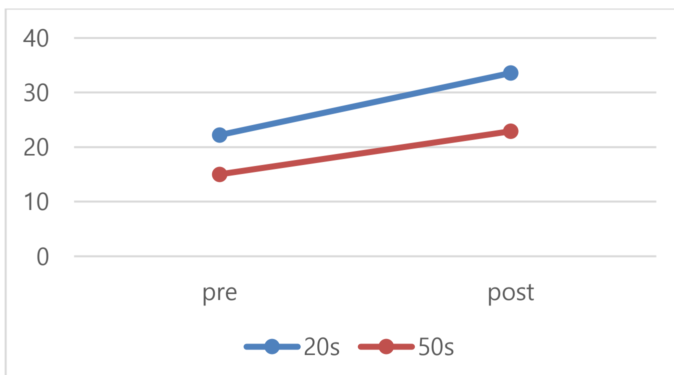

Figure 6. Difference of Single-leg stance with closed eyes test

3.1.1 Y-balance Test

Table 6 and Figure 7 shows The Mixed two-way ANOVA verification results and mean and standard deviation of YBT according to measurement period and age during 8 weeks of elastic resistance exercise in this study. There was a statistically significant difference in YBT depending on the measurement period ($p<.01$), and post-test results showed that the post-test was higher than the pre-test for people in their 50s. There was no statistically significant difference in YBT according to age. There was no interaction effect between measurement period and age.

Table 6. Difference of Y-balance test

Group	pre	post		F	P
20s	98.22±6.15	100.52±4.81	Time	7.498	.014
			Group	2.040	.170
50s	93.99±8.47	96.95±5.92	Time * Group	0.117	.736

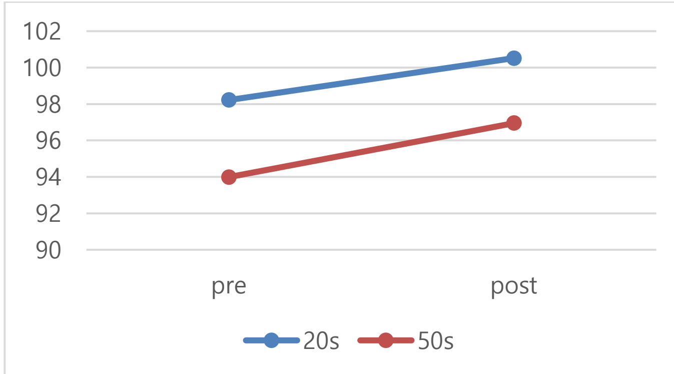

Figure 7. Difference of Y-balance test

4. Discussion

Resistance exercise is one of the methods that help develop physical abilities such as strength, muscular endurance, and balance by developing skeletal muscles. Traditionally, it has been performed using equipment like dumbbells and barbell machines. However, recently, resistance exercises using portable tools like elastic bands and stability balls have gained attention due to their accessibility for older adults, patients, women with lower muscular strength, and beginners. This study aims to examine the age-related effects of eight weeks of resistance exercises using elastic tools on Accelation Time, Torque at 0.18 seconds, Torque at 30 degrees, one-leg standing with eyes closed, and the Y Balance Test in participants aged in their 20s and 50s. The discussion will focus on the observed exercise adaptation effects based on age.

The rate of force development (RFD) is represented by Accelation Time, Torque at 0.18 seconds, and Torque at 30 degrees measured during isokinetic strength assessment at a steady 60°/sec. RFD is associated with gait abilities and tends to decrease with advancing age. Improving RFD necessitates enhancing muscular strength, wherein increased force generation through strength augmentation leads to faster limb movements, thereby enhancing exercise performance [20].

Skeletal muscles constitute around 30-40% of body weight and diminish rapidly with aging [21]]. Aging correlates with a swift decline in the fast-twitch fibers of skeletal muscles [22]. To delay this decline, resistance exercises are crucial, as they promote gains in both strength and muscular endurance [23]. The sustained stress imposed on neuromuscular systems through resistance exercises aids in calcium fortification within the sarcoplasmic reticulum, subsequently augmenting energy efficiency during force production [23].

This study employed an eight-week elastic tool-based resistance exercise intervention to examine age-related differences in RFD. Pre- and post-intervention assessments of Accelation Time, Torque at 0.18 seconds, and Torque at 30 degrees revealed no significant alterations based on measurement time but exhibited statistically significant disparities between age groups. Participants in their 20s demonstrated consistently higher values than those in their 50s pre- and post-intervention. This decline in RFD associated with age, likely due to the decrease in fast-twitch muscle fibers [22], was observed. However, both age groups showed a slight increase in mean values post-intervention, likely attributed to neuromuscular development leading to enhanced strength, although the short exercise duration might have limited its pronounced effects[24].

Balance is maintained through a highly complex mechanism, involving the coordinated control of all body segments [25]. Enhancing balance exercises improves the ability to maintain body position and relies on neuromuscular development, particularly proprioception enhancement—the ability to sense limb positions

[26]. Balance encompasses postural reactions, motor processing, and sensory processing and involves coordinated processes to minimize sway and maintain appropriate weight distribution [27]. These abilities can be developed through resistance exercises [28].

Balance is categorized into static and dynamic balance, where static balance refers to the ability to maintain posture within a base of support without body movement, and dynamic balance involves maintaining the body's center of gravity within the base of support during movement while resisting external stimuli to maintain desired posture [29]. Dynamic balance is crucial in controlling and maintaining posture during physical activities in sports or daily routines.

Balancing abilities necessitate the proper coordination of the musculoskeletal and central nervous systems, emphasizing the importance of core muscle and lower limb stabilization exercises for enhancing these abilities. Elastic band exercises are known to fulfill these requirements for stabilizing the musculoskeletal system and neurotraining. Additionally, balance relies on the coordination of movement and stability, involving the vestibular system, visual perception, proprioception, and body awareness [30]. identified reduced proprioceptive ability, weakened reflexes, loss of postural maintenance due to decreased strength, and diminished joint coordination in the lower limbs as factors contributing to declining balancing abilities [31].

In this study, balance was observed through one-leg standing with eyes closed and the Y Balance Test (YBT). Both groups exhibited statistically significant increases in one-leg standing with eyes closed post-intervention compared to pre-intervention. The YBT showed a statistically significant increase in the 50s age group post-intervention, whereas the 20s group did not show statistical significance, but a tendency towards a slight increase in mean values. This suggests that the eight-week elastic resistance exercise for lower limb skeletal muscles in this study contributed to improving lower limb stability and proprioception

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