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Original Article

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Effects of Blood Flow Restriction Exercise on Leg Muscle Thickness and Balance in Elderly Women with Sarcopenia

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| Abstract |

Purpose: The purpose of this study was to investigate the effect of blood flow restriction bridge exercise on leg muscle thickness and balance. In addition, it is to promote blood flow restriction exercise as the basis for early prevention, diagnosis, and treatment of sarcopenia in clinical practice.

Methods: Twenty elderly women aged 65 years or older were selected to participate in this study. The subjects were divided into two groups of 10: one with blood flow restriction with bridge exercise (BFRG) and the other with bridge exercise alone (BG).

As for the exercise method, the thickness of rectus femoris and vastus medialis and Berg balance scale were investigated by intervention for 30 minutes a day, 3 times a week, for a total of 6 weeks.

Results: There was significant difference in the thickness of the rectus femoris and vastus medial and within-group changes in the Berg balance scale ($p < 0.05$) before and after the experiment in the BFRG and BG groups ($p<0.05$). There was a significant difference in change between the two groups ($p < 0.05$).

Conclusion: There was a significant difference in the intragroup change of the Berg balance scale in the BFRG before and after the experiment, but there was no significant difference in the BG, and there was no significant difference in the change between the two groups.

Key Words: Blood flow restriction, Sarcopenia, Berg balance scales

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Ⅰ. Introduction

Skeletal muscle is one of the largest tissues in the body, and it is the source of human movement, and it makes various movements of bones and joints harmoniously through about 600 muscles contracting and relaxing (Pan et al., 2021). Sarcopenia, which is caused by a decrease in skeletal muscle, causes a rapid loss of skeletal muscle and function, which leads to a negative effect on the health of the elderly and lowers the quality of life, increases the risk of death and the incidence of falls (Dent et al., 2021; Lo et al., 2020; Pana et al., 2021).

As the cause of sarcopenia, the dysfunction and inflammation of mitochondria within the muscle are pointed out, and with aging, the size and strength of skeletal muscle fibers (type II) are lost and structural and functional changes occur (Pan et al., 2021). Recent clinical studies of physical exercise, nutraceuticals, and pharmaceutical interventions for the intervention of sarcopenia have revealed that the combination of an appropriate nutritional strategy and exercise regimen is the only effective strategy for alleviating sarcopenia (Dent et al., 2021; Lo et al., 2020).

However, although various forms of therapeutic exercise have powerful effects on skeletal muscle growth, it is still controversial (Hill, 2020). The intramuscular mechanism of therapeutic exercise is to weaken the inflammatory response through the restoration of mitochondrial homeostasis and the complex exchange of myokine and osteosteokin signals in muscles and bones to improve body function, reduce inflammation, improve oxidative stress profile, and alleviate sarcopenia (Cardoso et al., 2019; Lo et al., 2020).

The development of new blood flow restriction therapy reduces the risk of sarcopenia incapable of high-intensity resistance exercise in rehabilitation from postoperative musculoskeletal injury(Saatmann et al., 2021). Low-intensity exercise of 20% of 1RM through blood flow restriction results in improvements in muscle hypertrophy, strength, and endurance similar to high-intensity exercise (Loenneke et al., 2011). Blood restriction exercise is a beneficial strategy for increasing skeletal muscle mass and strength that can be obtained even in light exercise modes such as walking, and can induce muscle adaptation during exercise without high-intensity resistance exercise or training (Hill, 2020; Mok et al., 2020). Therefore, blood flow restriction exercise can have many health-improving effects similar to high-intensity exercise and can be performed with a lower perceptual response than high-intensity exercise (Mok et al., 2020). Blood flow restriction resistance exercise is an effective exercise strategy for people with physical limitations, and compared with high-intensity resistance exercise, a significant decrease in mechanical load and similar increases in muscle mass and strength are seen (Saatmann et al., 2021). However, blood flow restriction exercise requires a significant physical load, especially for the elderly with sarcopenia and chronic disease patients, who find it difficult to effectively perform high-intensity exercise programs due to the deterioration of cardiovascular and skeletal muscles (Mok et al., 2020).

Because blood flow-restricting exercise has the effect of increasing muscle strength and muscle mass in the elderly with sarcopenia, research on this is necessary (Lopes et al., 2019).

Therefore, the purpose of this study is to investigate the effect of blood flow-restricting piercing exercise on the thickness of rectus femoris and vastus medialis and the Berg balance scale. It is to provide basic data.

Ⅱ. Method

1. Subject

The subjects of this study were 20 elderly women 65 years of age or older in an elderly institution located in OO Metropolitan City. The purpose of this study, exercise method, and possible side effects were explained to the subjects, and consent was obtained to participate in the study. To confirm sarcopenia, a Korean-type sarcopenia screening diagnostic questionnaire was used, and the questionnaire consisted of five items related to muscle strength, gait assistance, getting up from a chair, climbing stairs, and falling.

The item score ranges from 0 to 2 points, and a score of 4 or more out of 10 points was classified as sarcopenia. In the study of Kim et al. (2018), when the sarcopenia screening diagnostic score was 4 or less, the diagnostic sensitivity was 16.7% for men and 32.2% for women, whereas the specificity was 97.5% for men and 86.3% for women. And the positive predictive value was 45.8% for men and 19.2% for women. In addition, the negative predictive value is 90.1% and 92.7%, so if the score is 4 or more, the possibility of sarcopenia is high.

This questionnaire has high validity and has been translated according to the Korean situation(Kim et al., 2018).

Subjects were selected as those who could understand and carry out the instructions, those who could walk without assistive devices, those who did not take drugs that affect balance and leg strength, those with high blood pressure, and those without cardiovascular disease. Exclusion criteria were those with high blood pressure of 140/90 mmHg or higher, those with cardiovascular disease, and those with balance difficulties.

2. Experimental procedure and exercise method

The method of group classification of subjects was a single-blind test, and a blood flow restriction with bridge exercise group and a bridge exercise group using a randomized method. A blood flow restriction cuff was applied between the hip joint and the knee joint, and 100 mmHg pressure was applied by moving it toward the body as far as possible. For bridge exercise, in the supine position, both feet were shoulder-width apart and the knees were bent by 60°, both hands were placed on the floor, and the hip joint was extended at the same time as the movement started. The bridge exercise group in the same posture as the blood flow restriction bridge exercise group without applying blood flow restriction. All groups were treated for a total of 8 weeks, 3 times a week, and 30 minutes a day. For warm-up and finish-up exercises, 5 minutes of stretching was applied 20 minutes before and after this exercise. And all groups completed the training without any abnormalities.

3. Measurement

1) Muscle thickness

Ultrasound (MyLab25Gold, Esaote, Italy) was used to measure the muscle thickness. The modulation range was 6～9 MHz, and it was measured using a 7.5 MHz linear transducer. To measure thickness of rectus femoris, place a cushion behind the knee joint in a sitting position and draw a line from the anterior superior iliac spine to the knee bone in a flexion 30° position. The thickness of rectus femoris was measured with a transducer at the 30% proximal point. To measure the thickness of vastus medialis, a cushion was placed behind the knee in the supine position, and a line was drawn from the anterior superior iliac spine to the center of the patella(Lee 2018).

All measurements were repeated three times and the average value was obtained.

2) Balance

Berg balance scale was used to measure the balance of the elderly. The Berg balance scale is a measure that evaluates both static and dynamic balance. It consists of 14 items, all items on a scale of 0 to 4, with a total score of 56 points (standing up from a sitting position, standing without holding, sitting in an upright position without leaning on a chair, sitting from a standing position, moving from chair to chair, standing with both eyes closed, standing with feet crossed, from a standing position, extend arms forward, picking up objects on the floor, looking back, turning 360 degrees in place, alternating feet on a stool, standing with one foot in front of the other and standing on one leg). The lower the score, the more it is judged that there is a problem of balance. In this measurement tool, the intra measurer reliability is r=0.99 and the inter-measurer reliability is r=0.98 (Bogle Thorbahn & Newton, 1996).

4. Data analysis

All data collected in this study were processed using SPSS 21.0 (SPSS Inc., USA). In addition, the Shapiro-wilk test was used to confirm normality, which is a general characteristic of the subject. Since the normal distribution was accepted, a paired t-test was used for changes within a group. And for the change between groups, the before-and-after differences between groups were compared using an independent t-test. All significance levels were set to α=0.05.

Ⅲ. Results

1. General characteristics of subjects

The subjects of this study were a total of 20 subjects, and the average age of 10 patients in the blood flow restriction group was 71.00±3.52, the average height was 149.40±2.59cm, the average weight was 51.30±4.00kg, and the BMI was 23.00±1.93kg/m^2. The average age of 10 people in bridge exercise group was 71.00±3.01, the average height was 150.40±3.97cm, the average weight was 53.70±4.83kg, and the BMI was 23.74±2.03kg/m2. There was no significant difference between each group in the general characteristics of the study subjects ($p>0.05$)(Table 1).

Table 1. General characteristics of subjects (n=20)

	BFRG (n=10)	BG (n=10)	P
Age (years)	71.00±3.52	71.00±3.01	0.76
Height (㎝)	149.40±2.59	150.40±3.97	0.89
Weight (㎏)	51.30±4.00	53.70±4.83	0.53
BMI(㎏/㎡)	23.00±1.93	23.74±2.03	0.92

BFRG: blood flow restriction with bridge exercise group, BG: bridge exercise group, Mean±SD

2. Thickness of the rectus femoris

There was a significant difference in BFRG and BG before and after the experiment in the changes in the thickness of rectus femoris muscle within group ($p<0.05$), and there was a significant difference in the change between the two groups ($p<0.05$)(Table 2).

3. Vastus medialis thickness

There was a significant difference in BFRG before and after the experiment in the within group change in medial broad muscle thickness ($p<0.05$), there was no

significant difference in BG (p>0.05), and there was a significant difference in the change between the two groups (p<0.05)(Table 2).

4. Berg balance scale

There was a significant difference in BFRG before and after the experiment in the within-group change of Berg balance scale (p<0.05), there was no significant difference in BG (p>0.05), and there was no significant difference in the change between the two groups (p<0.05)(Table 2).

Ⅳ. Discussion

The purpose of this study was to examine the effect of bridge exercise with blood flow restriction on the thickness and balance changes of rectus femoris and vastus medialis in elderly women with sarcopenia.

Blood flow resistance exercise can be a useful exercise alternative for the elderly and chronic disease patients characterized by impaired glucose metabolism, decreased musculoskeletal system, and progression of sarcopenia (Saatmann et al., 2021).

Hill (2020) conducted low-load eccentric blood flow resistance exercise and low-load concentric blood flow resistance exercise for 36 voluntarily participating women for 4 weeks. The effects of eccentric maximum torque, concentric maximum torque, maximum voluntary isometric torque, muscle thickness, and cross index evaluation measured in the contralateral arm without muscle activation were studied. It was found that low-load eccentric blood flow resistance exercise increased muscle strength more than low-load concentric blood flow resistance exercise. This is because the unique

Table 2. A comparison of between pro-post (㎜)(score)

		BFRG	BG	t	P[3)]
RFT	Pre	2.87±0.56	2.90±0.69		
	Post	4.13±0.67	3.09±0.68		
	Difference[1)]	1.26±0.35	0.19±0.21	3.41	0.00*
	t	11.18	2.82		
	p[2)]	0.00**	0.02*		
VFT	Pre	2.71±0.73	3.03±0.51		
	Post	3.69±0.63	3.08±0.52		
	Ddifference[1)]	0.98±0.27	0.05±0.17	2.36	0.03*
	t	11.14	0.89		
	p[2)]	0.00**	0.39		
BBS	Pre	42.60±2.71	43.30±2.16		
	Post	45.20±2.97	43.60±2.11		
	Difference[1)]	2.60±0.69	0.30±1.82	1.39	0.18
	t	11.76	0.52		
	p[2)]	0.08**	0.62		

BFRG: blood flow restriction with bridge exercise group, BG: bridge exercise group, RFT: rectus femoris thickness, VFT: vastus medialis thickness, BBS: berg balance scale, [1)]Difference: post-pre, [2)]Paired t-test, [3)]Independent t-test, Mean±SD, *p<0.05 ** p<0.01

characteristic of eccentric muscle contraction can enhance the facilitation of cross movement compared to concentric and isometric resistance exercises. It was said to be a unique alternative to maintaining.

In another study, Cardoso et al. (2019) studied the effects of continuous moderate-intensity exercise with partial blood flow restriction in 42 subjects with chronic kidney disease. It was said that the program related to blood flow restriction exercise had a positive effect on muscle strength increase.

In this study, there was a significant difference between blood flow resistence with bridge movement group and bridge exercise group before and after the experiment due to the change in the thickness of rectus femoris muscle, and there was a significant difference in the change between the two groups. Lo et al(2020) reported that muscle adaptation by neural adaptation in the cerebral cortex has a positive effect on intramuscular glucose and mitochondrial metabolism. It is thought that the eccentric contraction of rectus femoris muscle had an effect on the muscle thickness due to the neural adaptation. Also, this is consistent with study of an increase in thickness of quadriceps femoris by 12 weeks of blood flow restriction exercise and leg press exercise in 19 elderly subjects (Yasuda et al., 2014).

There was a significant difference in the intragroup change in vastus medialis thickness in blood flow restriction with bridge exercise group before and after the experiment, and there was a significant difference in the change between the two groups. Bridge exercises affect hip extensor and rectus femoris muscles, but less effect on vastus medialis.

Mok et al. (2020) studied the negative effects of blood flow restriction on perceptual responses in walking in 18 healthy young men, and said that gait with blood flow restriction induces a greater response to perceptual parameters related to exercise adaptation. However, Akin and kesilmis (2020) stated that low-intensity blood flow restriction exercise for dynamic balance development had a positive effect on dynamic balance. These results suggest that gait with blood flow-restriction may have a negative effect on perception response of healthy young adults, and that it requires a significant physical load for the elderly and chronic disease patients who have difficulty in effectively performing high-intensity exercise programs due to problem of cardiovascular and skeletal muscles. Another study found that blood flow-restricting exercise improved the quality of life by affecting walking in the elderly (Clarkson et al., 2017). And it was reported that stair climbing exercise with blood flow restriction had an effect on the muscle strength of knee joint extension (Jun & Park, 2015).

There was a significant difference in the intragroup change of balance in this study before and after the experiment in bridge exercise with blood flow restriction group, but there was no significant difference in the change between the two groups. Various exercises and proprioception training are essential to increase balance ability (Arient et al., 2019; Gribble et al., 2012), but this study used only blood flow restriction and bridge exercise, and it is thought that there was no significant difference in balance. However, since bridge exercise with blood flow restriction group showed a larger change of 2.30 than bridge exercise group, if sufficient time is applied, there is a possibility that a significant difference may occur. As a result, blood flow restriction exercise is considered to be a method that can increase muscle strength even with relatively light exercise in the elderly who have difficulty in activities daily life due to sarcopenia.

This study is difficult to generalize to only a small number of subjects and elderly women with sarcopenia in a specific area. In order to popularize blood flow restriction exercise in the future, I think that research is

needed to develop an effective strategy to minimize the negative effect on perceptual response.

Ⅴ. Conclusion

There were significant differences in thickness of rectus femoris and vastus medialis, within and between groups of Berg balance scale before and after bridge exercise with blood flow restriction in this study. In the future, it is expected that blood flow restriction exercise will suggest a new standard for sarcopenia in clinical practice and contribute to early prevention, diagnosis and treatment.

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