Research in Molecular Medicine

Resistance Training May Improve Rectus Femoris Muscle Parameters in Elderly Women

Zeinab Hooshmandi[1*], Farhad Daryanoosh[2], Pegah Jahani[3]

1. Department of Exercise Physiology, Faculty of Education and Psychology, Payame Noor University, Tehran, Iran.
2. Department of Exercise Physiology, Faculty of Education and Psychology, Shiraz University, Shiraz, Iran
3. Department of Radiology, School of Medicine, Shiraz University of Medical Sciences, Shiraz, Iran.

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ABSTRACT

Background: One of the important issues in aging is sarcopenia characterized by muscle mass and function reduction. The present study investigated the effect of high intensity interval resistance training (HIIRT) on muscular parameters in sarcopenic elderly women.

Materials and Methods: A total of 30 sarcopenic women aged 60 to 70 years (appendicular skeletal muscle mass index <6.76 kg/m^2, hand grip <20 kg) were randomly assigned to the experimental (n=15) and control (n=15) groups. The experimental group (EX) participated in the training protocol that was implemented in 2 phases, the first phase (2 weeks/3 times per week/50-55% 1RM) and the second phase (6 weeks/3 times per week/60-85% 1RM). The control group (C) did not participate in any training program during this period and performed their normal daily activities. Rectus femoris cross-sectional area (RFCSA), myostatin (MSTN) to insulin-like growth factor-1 (IGF-1), and MSTN to RF CSA were evaluated in two stages: Pre-test (week 0) and post-test (end of week 8) and compared between groups. Independent t-test and within groups one-way analysis of variance were subsequently utilized to assess the research variables through SPSS software, version 23 at 0.05 level of significance.

Results: The results showed that body mass (P=0.0001), body mass index (P=0.0001), MSTN to RF CSA (P=0.0001), and MSTN to IGF-1(P=0.04) decreased significantly in the experiment group compared to the control group. While ASMI (P=0.0001), handgrip (P=0.0001), RF CSA (P=0.0001), and walking speed (P=0.0001) significantly increased.

Conclusion: It seems that the HIIRT protocol resulted in an improvement in muscular parameters in sarcopenic elderly women. Based on our results, this type of training is safe and risk-free for the elderly and prevents the progressive reduction of muscle mass and strength. However, determining the exact mechanisms involved in these changes in response to HIIRT requires further molecular-cellular studies.

*** Corresponding Author:**
Zeinab Hooshmandi, PhD.
Address: *Department of Exercise Physiology, Faculty of Education and Psychology, Payame Noor University, Tehran, Iran.*
Phone: *+98 (917) 1248067*
E-mail: *z_hooshmandi@pnu.ac.ir*

Introduction

The increase in the world's elderly population indicates the importance of paying attention to the issue of aging and raises some concerns, which raise the urgent need for prevention, early diagnosis, and development of treatment for age-related conditions [1-3].

One of the age-related concerns is sarcopenia, or age-related skeletal muscle loss, which occurs slowly over several decades, with 1-2% of muscle loss per year from the fifth decade. Age-related changes in muscle composition and metabolism also reduce muscle function and strength [4-6]. Therefore, changes in muscle metabolism cause the onset of the disorder, while most chronic diseases and pathological conditions can be prevented by maintaining muscle mass and function. Muscle function has been identified as a predictor of disability, hospitalization, and death. Therefore, skeletal muscle plays an important role in performing daily activities, maintaining health, and preventing disease, so maintaining muscle mass, muscle function, and strength is a vital issue [7, 8]. Also, with aging, some anabolic factors such as insulin-like growth factor-1

(IGF-1) decrease and some catabolic factors such as myostatin (MSTN) increase, which is associated with decreased muscle volume and muscle mass resorption [9].

Previous studies have shown that decreased physical activity is one of the main causes of muscle mass loss in sarcopenic individuals [10]. Age-related changes in skeletal muscle can be exacerbated by a decrease in physical activity with increasing age, metabolic changes, and oxidative stress that can lead to intramuscular and extra muscular damage by free radicals [3].

In recent years, the interest in high intensity interval training (HIIT) has increased due to the different proportions of work to rest and the need to spend less time during the week [11, 12]. The effect of HIIT on many different groups, healthy and sick has been studied and different results have been observed [13] but it's effect on the elderly has not yet been fully studied. One of the newest training methods is high intensity interval resistance training (HIIRT), which is similar to HIIT because it includes short periods of high-intensity training and maximum effort and heart rate [14, 15].

The results of studies on the effect of resistance training on the elderly are contradictory. Some studies have reported an increase in muscle strength and muscle cross-sectional area, IGF-1, and a reduction in MSTN following resistance training [9, 16, 17].

Due to the lack of studies on the effect of HIIRT on the elderly and due to the growing elderly population in the world and the high costs of treatment and care of this group of people in the community, research in this area seems necessary [18]. So, the present study was designed to investigate the effect of HIIRT on muscular parameters in elderly sarcopenic women.

Materials and Methods

Participants and design of the study

The statistical population of this quasi-experimental study included all old women aged 60-70 years referred to Elderly Soroush Day Care Center (Shiraz, Iran). A total of 30 volunteer elderly sarcopenic subjects (appendicular skeletal muscle mass index <6.76 kg/m^2, grip strength <20 kg, and walking speed <0.8 m/s) according to the instructions of a European working group on sarcopenia in older people were identified [19]. Skeletal muscle mass analysis, ASMI, hand grip strength, and walking speed were measured to identify and determine sarcopenic individuals as previously described [20]. Subjects with any skeletal abnormalities, muscle problems, or severe heart problems preventing them from participating in the protocol were excluded from this study. Also, due to the possible effects of some drugs and steroid supplements on muscle mass and strength, subjects should not be treated with testosterone, estrogen, or other pharmacological interventions. Before this study, all subjects were examined for cardiovascular health and uncontrolled blood pressure and they completed the physical activity readiness questionnaire [21].

Sample size and random allocation

The sample size estimation was carried out using G*Power software, version 3.1.9.2. Assuming an effect size of 0.95, with an alpha level of 0.05, the total sample size was estimated at 30 (15 per group). Therefore, 30 subjects participated in this work with 80% power and were randomly divided into the experimental (n=15) and control (n=15) groups. Random allocation was done by the balanced block randomization method. Thus, 4 blocks were used. Assuming having two groups A and B, with 4 blocks.

Training protocol

In the present study, the training protocol consisted of 2 phases, the first phase, hypertrophy, and the second phase of HIIRT training. The training protocol is a periodized program that consists of one week of familiarizing train-

Table 1. Mesocycle 1, the first phase of training program in experiment group

Week	Rest Between Sets (sec)	Rest Interval (min)	Repetitions	Sets	1RM (%)
1	30	1	8	2	50
2	30	1	8	2	55

ing and two mesocycles. The first mesocycle was held for 2 weeks, including 3 sessions per week of training to identify and gain basic physical fitness and hypertrophy (Table 1). The second mesocycle, strength protocol or HIIRT, was performed for 6 weeks, including 18 sessions to increase strength (Table 2). A workout session lasted approximately 35 minutes, including warm-up time. The exercises were performed with 50-85% intensity of 1RM and the workload increased by 5-10% every week in proportion to the ability of the subjects according to the overload principle [22]. The control group did not have any specific sports activities during the study and only did daily life activities. The participants were urged not to change their diet during the exercise weeks and not to engage in other types of physical activities.

Sample collection and biochemical assay

Blood samples were taken from the subjects in 2 shifts (week 0 and week 8), and 5 mL venous blood samples were collected from the participants by a laboratory technician from 7 to 9 AM. after 10 hours of fasting and 48 hours after the last training session. Blood sampling was performed in a sitting position and after at least 15 minutes of rest. When the serum clotted after 10 to 20 minutes at room temperature, centrifugation was performed at 3000 rpm for 20 minutes and the supernatants were collected carefully and were stored at -80°C until analysis. Serum IGF-1 levels were measured by ELISA kit (Mediagnost, Germany), and, serum MSTN levels were measured by ELISA kit (R&D, the United States) based on the biotin double antibody sandwich technology respectively with a sensitivity of 0.091 ng/mL and 5.52 ng/L.

Muscle cross-sectional area assay

Muscle ultrasound was performed using a B-mode ultrasound device (Philips Affiniti 50 model, Netherlands, 4 cm, 7 MHZ probe). To measure the cross-sectional area (CSA) of the rectus femoris muscle using B-mode ultrasound sonography, three photos were taken in the transverse mode at the 50% point of the subject's right thigh leg in the open arch position. The average of three measurements was calculated as the CSA of the muscle [23].

Statistical analysis

Data analysis was performed using descriptive and inferential statistics. After confirming the normality of data distribution and homogeneity of data with the Kolmogorov-Smirnov test, within-subjects variables-repeated measures (within groups one-way analysis of variance, ANOVA) was used to examine the changes of variables from pre-test to post-test in each group. An Independent t-test was used to compare the mean difference variables between the two groups. All analyses were performed using SPSS software, version 23 at a significance level of 0.05.

Results

The results showed that body mass (t=5.43, P=0.0001) and body mass index (t=5.40, P=0.0001) decreased significantly in the EX group compared to the C group (Table 3), while ASMI, hand grip, and speed increased significantly in the experiment group compared to the control group (Table 4). Within-group analyses showed RF CSA significant increase in experiment ($F_{(1, 14)}$=27.50; P=0.0001; η^2=0.66) while there was a non-significant change in the control group after 8 weeks. MSTN/IGF-1 ratio decreased significantly in EX ($F_{(1, 14)}$=13.13; P=0.003; η^2=0.48) but, there was a non-significant change in the C group. Furthermore, MSTN/CSA ratio decreased significantly in EX ($F_{(1, 14)}$=26.01; P=0.0001; η^2=0.65) while there was a significant increase (Table 4) in the C group after 8 weeks ($F_{(1, 14)}$=8.22; P=0.01; η^2=0.37). RF CSA increased significantly (Figure 1) while MSTN/IGF-1 ratio (Figure 2) and MSTN/CSA ratio (Figure 3) decreased significantly in the experiment group compared to the control group.

Discussion

In the present study, for the first time in Iran, the changes in muscle hypertrophy parameters were investigated using a periodized resistant training protocol in elderly sarcopenic women. The findings of the current study in-

Table 2. Mesocycle 2, second phase of training program in experiment group

Weeks	Sets	Rest Interval (min)	1st Repetition	Rest Between Repetitions (sec)	2nd Repetition	Rest Between Repetitions (sec)	3rd Repetition	1RM (%)
1	2	2.30	4	20	2	20	2	60
2	2	2.30	4	20	2	20	2	65
3	2	2.30	4	20	2	20	2	70
4	2	2.30	4	20	2	20	2	75
5	2	2.30	4	20	2	20	2	80
6	2	2.30	4	20	2	20	2	85

dicated that the HIIRT protocol significantly affected and improved the muscular hypertrophy parameters, such as muscle CSA, MSTN to IGF-1, and MSTN to CSA in the EX group. Also, the results of this research revealed that the HIIRT protocol improved functional factors such as handgrip strength and walking speed. Furthermore, there was a significant decrease in body mass and BMI in the EX group which has been confirmed in previous studies, indicating that resistance training can improve sarcopenia in older people [15, 24-26].

Vale et al. (2017) stated that 12 weeks of resistance training increases IGF-1 in elderly women [27]. However, Rashidi et al. (2019) reported conflicting results showing that 8 weeks of resistance training does not change IGF-1 levels in elderly women [28]. According to research results, IGF-1 often decreases during the first weeks of training, and after doing that for a longer period, it increases. One of the reasons is a significant increase in growth hormone (GH) levels. Therefore, an increase in GH in response to intense training and stimulation of muscle mass may cause an increase in IGF-1 [29]. Probably, in the present study, despite the short training period, the high intensity of the HIIRT protocol caused an increase in GH, followed by an increase in IGF-1. In fact, by reducing inflammation in the elderly, intensity training removes its inhibitory effect on the GH/IGF-1 axis and thus increases IGF-1 levels [28, 30]. However, in the present study, GH levels were not measured and it is suggested to be investigated in future studies.

Table 3. Baseline characteristics of each group

Group	Mean±SD			
	Age (y)	Body mass (kg)	Height (cm)	BMI (kg/m²)
Experimental	65.93±3.28	69.40±7.47	155.86±5.65	28.63±3.40
Control	65.46±2.32	63.40±5.48	156.20±5.34	26.12±3.41

BMI=Body mass index.

Table 4. Comparison of sarcopenia indices in experimental and control groups

Variables	Level	Group		Mean Difference	t	df	p
		Experimental	Control				
ASMI (kg/m²)	Pre Post	5.63±0.57 5.87±0.51	5.22±0.46 5.16±0.53	0.36	6.50	28	0.0001*
Hand grip (kg)	Pre Post	16.40±3.41 24.93±4.47	15.93±0.96 15.80±4.47	10.66	8.63	28	0.0001*
Speed (m/s)	Pre Post	1.71±0.21 2.10±0.16	1.66±0.15 1.63±0.17	0.41	6.79	28	0.0001*

*Significant difference between week 0 & week 8 (between-group comparisons)

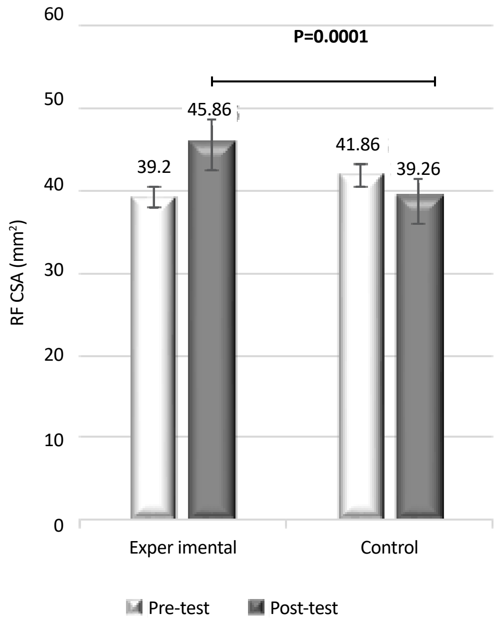

Figure 1. The change pattern of rectus femoris cross sectional area of studied groups

In the present study, a significant decrease in the MSTN to muscle CSA and MSTN to IGF-1 ratio was observed in the experimental group compared to the control, which has been confirmed in several studies. The results of some studies showed that MSTN mRNA, MSTN serum levels, or MSTN protein levels in muscles decrease in response to different periods of resistance training [24, 31]. However, some studies reported conflicting results and stated that resistance training increases MSTN levels or does not significantly change them [24, 31-34]. The subjects of the contradictory studies with the present study were young men. It should be noted that in young people, as well as in men, the basal levels of testosterone are higher than in elderly women, and increasing testosterone through resistance training is one of the inhibitory mechanisms of MSTN and prevents the degradation of muscle mass and atrophy. Also, by increasing the activity of satellite cells, it increases muscle hypertrophy. There-

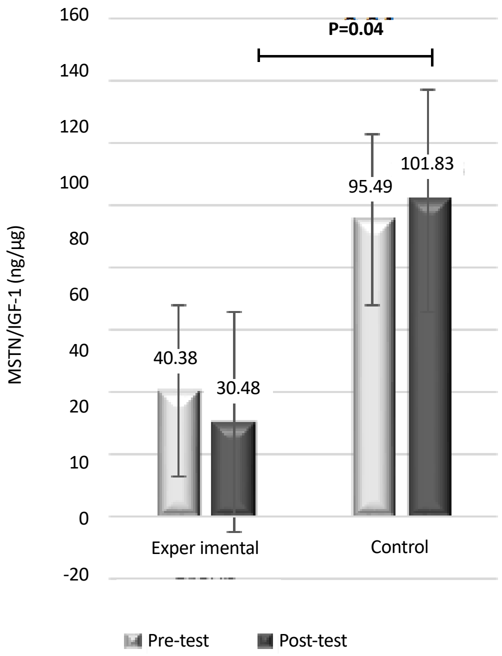

Figure 2. The change pattern of MSTN/IGF-1 ratio of studied groups

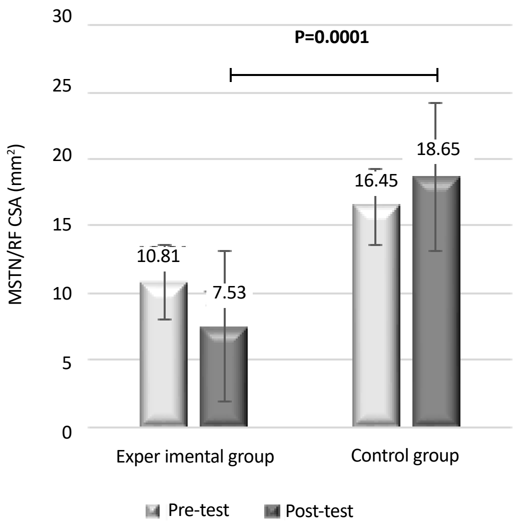

Figure 3. The change pattern of MSTN/RF CSA ratio of studied groups

fore, some of the observed differences in the results are caused by the age and gender of the subjects [7, 24].

The results of the present study showed that 8 weeks of resistance training caused hypertrophy of the rectus femoris muscle. The results of this study are in contradiction with the results of studies stating that significant hypertrophy of muscles, especially in sarcopenic elderly people who have hypertrophic disorders compared to young people, only occurs in response to long-term periods of resistance training (more than 12 to 16 weeks) [35]. Probably, in the present study, the high intensity of the exercise caused the expected positive hypertrophic changes [11]. It is also possible that the positive changes of IGF-1 and the reduction of MSTN caused muscle hypertrophy (increased ASMI and muscle CSA) [7, 36].

During aging, satellite cell activity and IGF-1 signaling are impaired, while MSTN increases. IGF-1 is one of the indicators of satellite cell activity; therefore, the increase of IGF-1 in response to resistance training is a symbol of increasing the activity of satellite cells and thus stimulating hypertrophic responses [7, 11, 36]. It is likely that the HIIRT protocol, due to high intensity and splitting a set by inserting 20-second rest intervals, allows high-intensity training to be performed without reducing volume; also, by creating mechanical and metabolic stimulation, it provides a suitable anabolic environment for increasing muscle hypertrophy, strength, and function [15]. Therefore, it is likely that in this study, the high mechanical stress resulting from the high intensity of the HIIRT protocol through the increase of anabolic hormones including IGF-1 has caused the activation of PI3K/Akt/mTOR signaling, the increase of anabolic signaling, inhibition of catabolic signaling, and stimulation of hypertrophy and has improved functional factors such as strength and walking speed [37].

However, in the present study, there were some limitations such as a small study population, a short period of intervention, and non-measurement of other sarcopenia risk factors such as oxidative stress parameters and inflammatory markers. So, further investigations in future studies are suggested.

Conclusion

It seems that the HIIRT program is a safe and applicable resistance training protocol for older people and resulted in improvement in sarcopenia indices and muscular hypertrophy parameters in sarcopenic elderly women owing to the type and the special design of training protocol, taking into account the short rest periods, and high intensity of exercises.

Ethical Considerations

Compliance with ethical guidelines

This study was reviewed and approved by the Ethics Committee of the Faculty of Rehabilitation Sciences of Shiraz University of Medical Sciences (Code: IR.SUMS.REHAB.REC.1399.013).

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Authors contribution's

Conceptualization, visualization methodology, investigation, resources, data curation, software, validation, formal analysis and writing the paper: Zeinab Hooshmandi; Supervision, project administration: Farhad Daryanoosh, Radiology imaging: Pegah Jahani.

Conflict of interest

The authors declared no conflict of interest.

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