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Effects of 8-Week Resistance Training on Neuromuscular Fatigue in Young and Middle-Age Men

Byung-Kwan Kim

Researcher, Sports Science Institute, Dankook University, Korea
kbk5581@naver.com

Abstract

The purpose of this study was to investigate the effects of 8-week resistance training on muscle fatigue in men in their 50s and 30s. A total of 16 subjects (8 in their 30s and 8 in their 50s) were recruited, and moderate-intensity resistance exercise was conducted three times a week for eight weeks. EMG was measured before and after 8 week resistance training. Before 8 weeks exercise, MDF of pectoralis major significantly decreased in all groups, and MDF of triceps brachii significantly decreased only in the 30s group. After 8 weeks of exercise, MDF of pectoralis major significantly decreased in all groups, and MDF of triceps brachii significantly decreased only in the 30s group. The fatigue index before and after the 8-week exercise was changed only in the pectoralis major, and significantly decreased in the 30s group. As a result, the muscle fatigue level among the resistance exercises of men in their 50s may be similar to that of men in their 30s, and muscle fatigue can be reduced by 8 weeks of exercise.

Keywords: *Middle-aged men, Resistance exercise, Muscle fatigue, EMG, MDF*

1. Introduction

Aging, which progresses at the same time as aging, causes deterioration of physical strength and development [1], and the prevalence and mortality of various diseases due to deterioration of body composition and function increase rapidly. In particular, the decrease in physical strength is closely related to muscle mass, muscle strength, and muscle power [2], which is attributed to a decrease in skeletal muscle mass [3], an abnormality in contractile function [4], and a decrease in aerobic metabolic ability [5]. Decreased muscle mass and muscle function are known to accelerate between late middle age and old age [6]. Age-related muscle loss is 1-1.5% per year [7], and muscle mass is reported to decrease by 1-2% per year since age 50 [8]. In addition, intramuscular changes are accompanied by many changes in the neuromuscular system that can affect fatigue [9], including motor unit remodeling [10], reduced maximum motor unit discharge rate, and general shift from Type II fiber to Type I fiber configuration [11].

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Corresponding Author: kbk5581@naver.com
Tel: +82-041-550-3098
Researcher, Sports Science Institute, Dankook University, Korea

Fatigue resulting from repetitive muscle contraction reduces the generation of force [12], and muscle fatigue during exercise according to age is known to be caused by neural firing patterns, amount of physical activity, and distribution ratio of muscle fibers [13]. People who are aging are more susceptible to fatigue from activities requiring rapid contraction [14], which has been demonstrated through EMG studies using maximum voluntary contraction(MVC) [15], suggesting that muscle function maintenance is required to maintain daily life functions.

Resistance exercise, which is one of the methods to prevent muscle strength and muscle mass loss, is effective in increasing neuromuscular activation, muscle hypertrophy, and protein synthesis [16]. Elderly people have significantly lower transcription levels of MHCIIa and MHCIIx than young adults, but resistance exercise has been reported to promote MHCI synthesis rate [17]. However, some studies have reported that the increase in muscle mass does not prevent the loss of nerve root function [18].

On the other hand, neuromuscular changes due to aging have been mainly studied in the elderly, and even though they are affected by aging in middle age, they are often ignored [19]. Through this study, investigating the effect of resistance exercise on middle-aged men will be able to contribute to establishing evidence to prevent the reduction of muscle function due to aging.

2. Experiment Materials and Methods

2.1 Experimental Approach

Subjects in their 30s and 50s measured the body composition and EMG of 10RM chest press two weeks before the experiment, and then applied moderate (70-75% 1RM) intensity resistance exercise including squat, chest press, shoulder press, and Lat pull down exercise three times a week for eight weeks. EMG post-test was conducted within 2 weeks after the end of the 8-week resistance exercise program, and MDF was compared and analyzed according to age (30s, 50s) and time (1set, 3set).

2.2 Subject

The subjects of this study were 8 physically healthy men in their 30s (Age: 33.50 ± 3.07 years, height: 173.00 ± 0.06cm, weight: 70.35 ± 10.75kg, skeletal muscle mass: 30.39 ± 3.06kg, body fat percentage: 22.56 ± 5.90%) and 8 physically healthy men in their 50s (Age: 54.50 ± 2.98 years, height: 169.63 ± 0.05cm, weight: 69.84 ± 8.68kg, skeletal muscle mass: 30.63 ± 3.24kg, body fat percentage: 21.39 ± 4.11%). All the selected subjects were fully educated about the significance of the study, the expected benefits, the inherent risks and inconveniences, and signed a consent form that can be submitted at any time according to their will.

2.3 Measurement procedure

2.3.1 Chest press

The chest press exercise to perform EMG evaluation was performed three sets at a strength of 10RM using a machine. The subjects sat with their backs to the chair and maintained the contact position of the five parts of the body (head, shoulder and torso, buttocks, and feet) and adjusted the height of the chair so that the handle was at the same height as the center of the chest in the posture of holding the handle with a closed pronation grip. In the pushing step, the elbow was fully extended in front of the chest and the handle was pushed, and when returning to the starting position, it was instructed to move slowly backward.

2.3.2 EMG measurement

A wired 4-channel electromyography (Laxha, Korea) was used to measure the electromyographic signals of the pectoralis major and upper arm triceps during chest press exercise. In order to obtain accurate data before the measurement, the hair of the skin epidermis was removed by shaving the electrode attachment area, and the skin surface was washed using alcohol cotton after shaving. Two surface electrodes were attached to the area 1 cm apart from the insertion area of the intramuscular electrode, and the wire connected to the electrode was fixed with a tape to prevent noise during measurement [20].

2.3.3 EMG analysis

EMG signals measured during chest press exercise were measured using 1set and 3set data, and Telescan software (ver. 3.15, LAXTHA) was used to analyze the original signal with MDF (Median frequency), an indicator of muscle fatigue. The power spectrum in the frequency range of 450-20Hz was obtained from the EMG signal of the short-axis contraction period according to the number of repetitions, and the frequency value occupying 50% of the total frequency area from the low-Edge region was calculated. In addition, to calculate the MDF value as a fatigue index, we subtracted 3set MDF from 1set MDF, divided 1set MDF, and multiplied by 100 [21]. Equal(1) is to the formula for calculating the fatigue index.

$$Fatigue\ Index = \frac{1set\ MDF(Hz) - 3set\ MDF(Hz)}{1set\ MDF(Hz)} \times 100 \quad (1)$$

2.4 Statistical Analysis

All the data collected in this study were analyzed using the IBM SPSS statistics (ver 22.0) statistical program to calculate the mean and standard deviation of all variables, and the difference according to group and time was analyzed using the mixed design two-way ANOVA method. If there was a significant difference, the post-hoc test was conducted using the Bonferroni method, and the statistical significance level was set at α =.05.

3. Result

3.1. MDF before 8 weeks resistance exercise

3.1.1. Pectoralis major

There was no significant difference in pectoralis major MDF between groups before 8 weeks resistance exercise, but there was a significant difference between sets. As a result of post hoc test, both groups showed significant decrease. Changes in pectoralis major MDF before 8 weeks resistance exercise are shown in Table 1.

Table 1. Changes in pectoralis major MDF before 8 weeks resistance exercise (Hz)

Age	1 set	3 set		F	*p*
30s	37.99±4.73	34.24±5.56 †	Group	.207	.656
50s	38.38±5.00	36.17±5.89 †	Set	16.482	.001
			(G) x (S)	1.109	.310

Mean±SD, †Significant difference to set.

3.1.2. Triceps brachii

There was no significant difference in triceps brachii MDF between groups before 8 weeks resistance exercise, but there was a significant difference between sets. As a result of post-hoc analysis, there was a significant decrease only in the 30s group. The change of triceps brachii MDF before 8 weeks resistance exercise is shown in Table 2.

Table 2. Changes in triceps brachii MDF before 8 weeks resistance exercise (Hz)

Age	1 set	3 set		F	*p*
30s	60.46±15.99	51.47±14.92†	Group	.000	.985
50s	58.29±17.42	53.95±16.24	Set	11.678	.004
			(G) x (S)	1.427	.252

Mean±SD, †Significant difference to set.

3.2. MDF after 8 weeks resistance exercise

3.2.1. Pectoralis major

After 8 weeks of resistance exercise, pectoralis major MDF did not show significant difference between groups, but showed significant difference between sets. As a result of post-hoc analysis, both groups showed a significant decrease. Changes in pectoralis major MDF before 8 weeks resistance exercise are shown in Table 3.

Table 3. Changes in pectoralis major MDF after 8 weeks resistance exercise (Hz)

Age	1 set	3 set		F	*p*
30s	37.71±3.00	37.03±2.26†	Group	1.850	.195
50s	41.27±5.53	40.13±5.09†	Set	24.096	.000
			(G) x (S)	.874	.386

Mean±SD, †Significant difference to set.

3.2.2. Triceps brachii

There was no significant difference in triceps brachii MDF between groups after 8 weeks resistance exercise, but there was a significant difference between sets. As a result of post-hoc analysis, there was a significant decrease only in the 30s group. The change of triceps brachii MDF before 8 weeks resistance exercise is shown in Table 4.

Table 4. Changes in triceps brachii MDF after 8 weeks resistance exercise (Hz)

Age	1 set	3 set		F	*p*
30s	57.98±14.48	51.00±12.54†	Group	.502	.490
50s	61.34±21.77	60.11±21.30†	Set	4.890	.044
			(G) x (S)	2.391	.144

Mean±SD, †Significant difference to set.

3.3. Changes in the Fatigue Index

3.3.1. Pectoralis major

There was no significant difference in the fatigue index of pectoralis major according to the 8-week resistance exercise, but there was a significant difference by set. As a result of post-hoc analysis, there was a significant decrease only in the 30s group. The change in the fatigue index of pectoralis major according to the application of 8 weeks resistance exercise is shown in Table 5.

Table 5. Changes in fatigue index of the pectoralis major (%)

Age	Pre	Post		F	*p*
30s	9.77±9.21	4.21±2.60†	Group	1.850	.195
50s	6.04±4.98	2.64±2.65	Time	24.096	.000
			(G) x (T)	.894	.366

Mean±SD, †Significant difference to time.

3.3.2. Triceps brachii

The fatigue index of triceps brachii according to 8 weeks resistance exercise did not show significant difference according to group and time. The change in the fatigue index of triceps brachii according to the 8-week resistance exercise is shown in Table 6.

Table 6. Changes in fatigue index of the triceps brachii (%)

Age	Pre	Post		F	*p*
30s	14.10±13.31	10.65±13.17	Group	4.403	.055
50s	7.08±5.98	1.96±2.24	Time	1.762	.206
			(G) x (T)	.067	.800

Mean±SD.

4. Discussion

Fatigue resulting from repetitive muscle contraction reduces the generation of force [12], and muscle fatigue during exercise as aging progresses is known to be caused by firing patterns, amount of physical activity, and distribution ratio of muscle fibers [13]. Resistance exercise is proposed to improve this, but there is a lack of research on muscle fatigue and training effects for middle-aged men who are affected by aging. Through this study, the difference in muscle fatigue and training effects among exercises of young men in their 30s and middle-aged men in their 50s were analyzed.

As a result of this study, the muscular fatigue characteristics of middle-aged men were similar to those of young men in the pectoralis major, and the triceps brachii were different. In addition, it was confirmed that resistance exercise for 8 weeks may improve muscle fatigue during exercise of the same intensity.

MDF, which analyzes the frequency components of EMG signals, is used as an indicator of muscle fatigue because it has a negative correlation with intramuscular decrease in pH [22], fast motor unit muscle fiber conduction velocity and duration of individual motor unit action potentials [23].

Regardless of the resistance exercise program adaptation, the significant decrease in MDF between 1set and 3set can be explained by the accumulation of muscle fatigue due to continuous exercise performance [24]. When exercise was performed at the same weight intensity before and after 8 weeks, MDF showed a significant decrease, but the decrease in the actual mean value was noticeably improved, indicating that the fatigue level decreased. This can be more clearly confirmed by the fatigue index calculated by MDF before and after the 8-week resistance exercise program.

The decrease in MDF may mean that the fatigue level of the motor unit was reduced due to the increase in neuromuscular efficiency according to the adaptation to resistance training. The fact that there was no difference in the training effect according to the group supports the previous study that there was no difference in the torque of early muscle contraction between men in their 20s and men in their 50s and that there was no difference in the fatigue index of middle-aged and young groups in muscle contraction through electrical stimulation [25, 26].

On the other hand, in a previous study that tracked changes in muscle strength and muscle mass according to aging, it was reported that muscle mass slightly increased in middle age, but muscle strength and power decreased, and activity of nerve root may be a determinant of aging rather than muscle mass [19]. Resistance training with 60-80%1RM strength was applied to middle-aged men for only 6 weeks, muscle strength was significantly increased, and some studies reported that the effect was maintained after 2 weeks of training discontinuation [13]. The results of this study suggest that resistance training adaptation of middle-aged men and young men may be similar.

5. Conclusion

10RM chest press 1set and 3set MDF of men in their 50s and 30s before resistance training showed significant differences except for triceps brachii of men in their 50s. After the 8-week resistance exercise program, MDF showed significant differences except for triceps brachii in men in their 50s. The fatigue index before and after the 8-week resistance exercise program showed a significant difference only in the pectoralis major of men in their 30s, but the average value was reduced overall.

As a result, the muscle fatigue level among the resistance exercises of men in their 50s may be like that of men in their 30s, and muscle fatigue can be reduced by 8 weeks of exercise. Therefore, if the muscle function according to the life cycle is reasonably maintained in middle age, the effect of aging can be changed.

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