The effect of resistance training with slow and fast speeds on some anabolic and catabolic hormones in healthy young women

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Abstract

Background and objective: Resistance training is a potential stimulus to increase muscle protein synthesis and the time under tension of muscle is one of the variables of strength training that contributes to its adaptation. The aim of this study was to investigate the effect of resistance training with slow and fast speeds on some anabolic and catabolic hormones in healthy young women.

Methods: This quasi- experimental study was conducted on 20 female students (mean age 21.65±2.03 years). The subjects were randomly and equally assigned to two groups with a time under tension of 1s-1s (fast contraction speed (FCS)) and 3s-3s (slow contraction speed (SCS)). The training load was the same in both groups and resistance training was done in a circular manner for six weeks, three days a week in eight stations. Blood samples were taken from the subjects to study the research variables before the training period and 48h after the last session of the training.

Results: There was no significant difference between the serum levels of GH($P = 0.82$), IGF-1($P = 0.13$) and cortisol($P = 0.59$) in both groups, but the levels of myostatin in the fast group increased and in the slow group decreased, and the difference between the two groups was significant ($P = 0.04$). Also, in the strength test, the slow group experienced further increased strength. ($P = 0.02$)

Conclusion: Although no significant changes in the levels of IGF-1, myostatin, and cortisol is observed in intragroup comparison at six weeks, resistance training with slow contraction speed can lead to further increases in the growth hormone levels and strength.

Keywords: Hormone ,Muscle, Training, Strength, Contraction, Tension

Introduction

Resistance training is a potential stimulus for increasing muscle protein synthesis, resulting in muscle hypertrophy and increased strength, which ultimately leads to an increase in the cross-sectional area of muscle fibers and changes in their composition.

Circular training is a type of resistance training that involves all parts of the body separately and improves muscle strength and neuromuscular adaptation (1). Training volume is one of the most important variables in resistance training and is usually calculated by the amount of lifted load multiplied by the number of repetitions by each set (load lifted × reps × sets). It can also refer to the total time that a muscle is under tension in a training session (the total time involved in concentric, eccentric, and isometric contractions between movements), which is called the time under tension (TUT) (2). The longer the time under tension, the higher likelihood of anemia and more metabolic changes and increased hormonal responses (2). Several studies have reported that training with specific methods of time under tension is very beneficial for muscle growth because it increases microscopic ruptures in muscles by pressing the muscles for a longer period of time (3). Alteration in the secretion of anabolic and catabolic hormones due to resistance training depends on various factors such as training intensity, training volume, movement speed, etc. Little is known about the optimal speed of these exercises and there is a lot of ambiguity about it. However, speed is one of the factors affecting hypertrophy, strength and hormonal changes. According to the results of research, alteration in hormone secretion due to exercise is the main factor in protein synthesis after resistance training and creating positive adaptations in the skeletal muscle structure (4). Anabolic hormones such as growth hormone (GH) and insulin-like growth factor-1 (IGF-1) are important in the growth and hypertrophy of body tissues. Growth hormone is one of the most important anabolic hormones, which increases muscle growth and hypertrophy both directly by facilitating the transport of amino acids into cells and indirectly by producing mediated proteins in the liver and other cells, called insulin-like growth factor1 (IGF-1) (5). IGF-1 is said to be one of the most important growth factors that play an important role in satellite cell activation, increasing protein synthesis, decreasing protein breakdown, muscle fiber hypertrophy and muscle growth (5). In contrast, myostatin, discovered by Mcpherron in 1997, is a new member of the large transforming growth factor β (TGF-β) family (regulator of some of the most important developmental interactions) that acts as a negative regulator of skeletal muscle mass. This hormone is mostly secreted by muscle cells and inhibits muscle growth by inhibiting the proliferation and differentiation of satellite cells (6). Cortisol is also a steroid hormone that has a catabolic effect on fibrous proteins and inhibits protein synthesis (4). Contradictory results can be seen in the research conducted in the field of resistance training and muscle growth factors. While Tofighi et al. (2012) concluded that eight weeks of resistance training significantly increases the amount of anabolic hormones (GH and IGF-1) (7); Bahram and Pourvaghar (2017) stated that 10 weeks of resistance training significantly reduces the serum levels of plasma myostatin (8). The results of some studies also indicate that rapid movements maximize hormonal responses and incur higher metabolic costs (9). On the other hand, other studies show that doing resistance training at a slow pace produces more intramuscular pressure and leads to ischemia

and accelerates the secretion of growth hormone (10). In this vein, Goto et al. (2008) stated that growth hormone increases in low-intensity resistance exercise and slow movements (three seconds rise and three seconds fall), but does not increase in high-intensity resistance exercise and rapid movements (one second rise and one second fall) (11). Some research also shows that there is no difference in hormonal responses between fast and slow resistance training (12). On the other hand, few studies have examined the effects of different speeds using isotonic devices, and most studies that have investigated the speed variable in resistance training have used isokinetic dynamometers, while the use of isokinetic exercises has less practical application due to lack of availability and high cost, and in terms of application, isotonic exercises are more general and applicable. Now, considering that not many studies have been done on the muscle time under tension, it seems necessary to study the changes in muscle growth factors in resistance training with different time under tension (while maintaining the training load). Therefore, considering the importance of hypertrophy and contraction rate, the researcher intends to investigate the effect of two resistance training programs with slow and fast speeds on some anabolic and catabolic hormones in inactive healthy young women.

Materials and Methods

Subjects

The research method of the present study is quasi- experimental. For this purpose, 20 inactive female students with a mean age of 21.65 ± 2.03 years and a body mass index of 21.2 ± 2.5 kg / m2, living in the dormitory of Kharazmi University in Karaj, volunteered to participate in this study. The inclusion criteria

were that were healthy, had no disease, only participated in the study, did not exercise on other days and not taken any effective medication or dietary supplement during the last six months. Also, in case of injury, absence from training sessions, lack of interest in continuing the study were excluded from the study. First, the objectives and method of conducting the research were fully explained to the participants, and then the informed consent and health questionnaire were completed by the participants. Then, before the start of resistance training, all participants were invited to the laboratory to be familiar with the necessary movements and training and their physical and physiological indicators such as age, height, weight, fat percentage and body mass index were measured and recorded. To calculate fat percentage, the Pollack-Jackson's three-point estimation method (triceps, abdomen and supra-iliac) was used; for body mass index, weight divided by height squared in meters formula was used, and to measure 1-repetition maximum (1RM), Brzycki equation (13) Weight ÷ (1.0278 - (0.0278 × Number of repetitions)) = one repetition maximum was used. The participants were homogenized according to anthropometric characteristics and randomly divided into two equal groups. The first group performed each strength training with a time under tension of one second-one second fast contraction speed (FCS) and the second group performed each strength training with a time under tension of three seconds-three seconds slow contraction speed (SCS) per contraction. The training load was the same in both groups and before and after six weeks of strength training, strength test was taken from both groups. The power test was such that each subject was placed on a dynamometer platform so that the legs were about 15 cm open parallel to each

other. The head had to be completely straight and the back straight, and they had to hold both sides of the bar with both hands and pull the bar with all their strength. Also, the knees were slightly bent and the participants were slightly tilted forward. The pointer that the device showed was the person's score and they had to be able to hold the pointer steady for about 3 seconds. Prior to each physical test and blood collection, the participants abstained from eating for two hours and from drinking caffeine for 12 hours (14).

Blood Sampling and Analysis

In order to measure blood samples, blood samples were taken from the brachial vein of the participants' non-superior hand in two stages before and after the implementation of the six-week protocol at 10:00 AM. To remove temporary effects of training, blood sampling was performed 48 hours after the last training session (14). The serum of the samples taken was isolated by centrifugation (10,000 rpm for four minutes) and kept at -70° C until measurement. In order to analyze the data related to GH and IGF-1, ELISA kits made by IBL in Germany and to analyze the data related to myostatin and cortisol, ELISA kits made by CUSABIO USA were used.

Resistance training protocol

The resistance training protocol was circular and included squats, chest presses, leg presses, forearms with dumbbells, frontal thigh, rowing movements, back legs and back arms, and for the training load to be the same in both groups the following formula was used (15):

Volume × Intensity = training load

(Muscle time under tension × number of repetitions) × intensity = training load

After general warm-up (five minutes of soft running at a slow speed and no slope on the treadmill) and specific warm-up (performing protocol movements without weights), the resistance training protocol was performed in the first group with 80% of one repetition maximum and 15 repetitions with time under tension (one second flexion and one second extension) in each repetition, with one minute rests between sets; and it was performed in the second group with 50% of one repetition maximum and eight repetitions with time under tension (three seconds flexion and three seconds extension) in each repetition with one-minute rests between sets. It should be noted that the rest between stations was 30 seconds, and in order to comply with the principle of overload, the training protocol was performed twice in the first two weeks, three times in the second two weeks and four times in the third two weeks. On the other hand, for the same purpose and gradual progress, in the fourth week, 1RM of each movement was measured again and the participants practiced in the following weeks with the percentages of new one repetition maximum. The training place was the gym of Kharazmi University in Karaj.

Statistical Analysis

To examine the normality of data distribution, the Shapiro-Wilk test was used and Levene's test was used to evaluate the homogeneity of variances. Also, in order to analyze the collected data, analysis of covariance (ANCOVA) and paired and independent samples t-test with 95% confidence interval were used at a significance level of less than or equal to 0.05. The statistical analyses were performed using SPSS 16 software.

Ethical Considerations

It should also be noted that the entire research process was approved by the Ethics Committee in Physical Education and Sports Science Research of the Sports Science

Results

Body composition

The descriptive characteristics of the participants are presented as the mean and standard deviations in Table 1.

Table 1. The mean and standard deviation and results of independent-samples T-test of compositional indices

		Age (Year)	Height (cm)	Weight (Kg)	Lean weight (Kg)	Fat percentage (Percent)	BMI (Kg.m^2)
1s-1s	Pretest	21±1.6	163.3±3.09	54.5±5.7	41.68±1.8	22.2±2.07	20.4±1.4
	Posttest			54.0±5.05	*41.3±1.5	*21.8±1.8	*20.15±1.2
3s-3s	Pretest	22.3±2.3	160.3±3.05	56.5±8.2	42.16±3.6	24.06±2.2	22.01±3.1
	Posttest			*55.2±7.1	*41.7±3.5	*22.9±1.6	*21.5±2.7

*Significant difference with pre-test values

Also, the results of independent samples t-test in the pre-test of some physical and physiological indices such as age (P = 0.15), height (P = 0.11), weight (P = 0.53), lean weight (0.71 = P), fat percentage (P = 0.08) and BMI (P = 0.16) to examine the homogeneity of the participants showed that there was no statistically significant difference in the values presented in Table 1 between the participants and the groups are homogeneous with each other.

In the analysis of body composition data, it was observed that six weeks of resistance training in both groups caused a statistically significant difference in lean weight, fat percentage and BMI (P≤0.5).

Strength

In intergroup studies, a statistically significant difference was observed between the two groups in the strength test(P = 0.02). In intragroup studies (paired- samples T-test), a significant increase in strength from pretest to posttest was shown in both groups (P = 0.001), so that the strength increased more in the slow group.

GH and IGF-1 esponses to resistance training

In intergroup studies, according to the results of statistical analysis (covariance test) in Table 2, it was observed that after six weeks of resistance training, there is no statistically significant difference between fast and slow groups in serum values of GH (P = 0.82) and IGF-1 (P= 0.13).

In intragroup studies, regarding growth hormone, it was concluded that post-test values increased compared to pre-test in both groups, but only in the slow group, this increase was statistically significant (P = 0.007). But regarding IGF-1, no statistically significant changes were observed in both slow(P= 0.96). and fast(P= 0.88). groups.

Table 2. Results of covariance test(ANCOVA) and paired- samples T-test of muscle growth indices and Strength

Variable	Group	Pretest	Posttest	Percentage of change	Intragroup P	Intergroup P
GH (ng/ml)	(1s-1s)	6.3±1.2	6.6±1.4	4.8	0.53	0.82
	(3s-3s)	5.1±0.6	6.4±1.1	25.5	*0.007	
IGF-1 (ng/ml)	(1s-1s)	113.6±6.1	113.2±10.5	-0.35	0.88	0.13
	(3s-3s)	115.4±8.6	115.3±2.7	-0.09	0.96	
Myostatin (ng/ml)	(1s-1s)	6.11±1.8	6.7±3.3	9.66	0.48	#0.04
	(3s-3s)	4.9±2.6	4.34±0.7	-11.4	0.54	
Cortisol (ng/ml)	(1s-1s)	193.5±30.2	199.07±38.2	2.9	0.78	0.59
	(3s-3s)	205.3±29.4	183.7±35.4	-10.5	0.24	
Strength (Kg)	(1s-1s)	86.2±11.7	89.6±10.8	4.1	*0.001	#0.02
	(3s-3s)	88.4±6.0	93.2±6.6	5.4	*0.001	

Numbers are expressed as mean ± standard deviation (± SDM)
 *Significant difference from pre-test values (P≤0.5)
#Significant changes between groups

Cortisol and Myostatin responses to resistance training

In intergroup studies, it was observed that after six weeks of resistance training, there is no statistically significant difference between fast and slow groups in serum values of cortisol (P = 0.59), but in the case of myostatin (P = 0.04 and effect size 0.38) this difference is significant, indicating a moderate effect.In intragroup studies, myostatin levels decreased in both fast (P = 0.48) and slow (P = 0.54) groups, but none of these changes were statistically significant. However, cortisol levels increased in the fast group (P = 0.78) and decreased in the slow group (P = 0.24), but these changes were not statistically significant.

Discussion

The results of the present study showed that after six weeks of resistance training, strength values increased by 4.1% in the fast group and 5.4% in the slow group, which indicates that in the latter group, the muscle time under tension was longer. The rate of increase in strength is also greater. Also, this increase is statistically significant in the slow group

compared with the other group. In the area of resistance training, researchers have found that by creating environmental fatigue, the effectiveness of training can be increased, therefore, some researchers have suggested training with longer contraction times (16). According to previous research, the longer the time under tension, the more likely it is to lead to anemia and metabolic changes, and to increase hormonal responses. This condition can lead to increased utilization of fast-twitch motor units (17). Also, Westcott et al. (2001) in the study of the long-term effects of different time under tension reported that people who used slow systems of resistance training experienced a significant improvement in strength (18). In addition, the present study showed that six weeks of resistance training with fast speed (one second - one second) and intensity of 80% 1RM as well as slow speed (three seconds - three seconds) and intensity of 50% 1 RM increased serum GH values, and this increase was only significant in the slow group. There was no statistically significant difference between the two groups in comparing the results. In Goto et al.'s (2008) study, GH was increased in low-intensity resistance exercise

and slow movements, but no significant increase was observed in high-intensity resistance exercise and fast movements (19). In the present study, an increase in GH may be followed by resistance training related to an increase in nitric oxide (NO) because various studies have shown that NO facilitates the release of GH from the anterior pituitary gland into the bloodstream (7). Also, according to research in this regard, local accumulation of metabolic products such as H + ions and lactate in active muscles, stimulates metabolic receptors and sends neuronal messages to the central nervous system and hypothalamus, which can increase the secretion of growth hormone from exercise (4). Although lactate concentration was not measured in the present study, it can be said that the increase in lactate due to these two types of resistance training is probably one of the reasons for the increase in growth hormone.

Another important conclusion of the present study was that six weeks of fast and slow resistance training had no significant effect on serum IGF-1 concentration in inactive women. There was no statistically significant difference between the two groups in comparing the results. In general, the effect of physical activity on serum IGF-1 has different results, as some studies have shown that physical activity does not change the levels of this hormone much (20). Consitt et al., who studied hormonal responses to resistance exercise in women, came to similar conclusions (21). In contrast, the findings of some researchers (increasing IGF-1 levels) contradict the results of this study (22, 23). In another study conducted by Borst et al. (2000), after 13 weeks of resistance training with different volumes, a significant increase in IGF-1 levels was seen in both training groups (24). This discrepancy may be related

to the participants' readiness, type and duration and intensity of training, and accuracy of measuring instruments. Cappon et al. also reported different results from the present study. One of the possible reasons for this discrepancy is that in their research, nutritional manipulations have been suggested that can be effective factors. The researchers also measured IGF-1 levels in the muscle tissue and noted in their research that these changes may not be reflected in plasma (25). Looking at the studies that reported significant changes, it can be seen that the training period was longer than the present study. Also, early physical activity is an important determinant of IGF-1 circulation (26). The lack of change in this hormone may be due to the inactive lifestyle of people. In the present study, the participants were beginners and according to the different results of the research, it is possible that both the initial training status of the individuals and the relative physiological pressure applied during the training affected their response. In the absence of IGF-1 alteration, insulin-like growth factor binding proteins (IGFBPs) can be pointed, which on the one hand increase the half-life of IGF-1 in the blood and on the other hand decrease IGF-1 release.

Numerous studies have shown that exercise increases IGFBPs; Therefore, it is possible that IGF-1 levels have increased in the present study. However, the level of IGFBPs may also have increased, and since IGF-1 has a combined affinity for binding to IGFBPs, no change has been observed in its level (27). But since none of these hormonal carriers have been measured in this study, it can not be discussed with certainty. From the present study, it was concluded that six weeks of fast and slow resistance training had no significant effect on serum myostatin concentration in inactive women, but there was a statistically

significant difference between the two groups. Similar results have been reported in several other studies (26, 28). In contrast, the findings of some other studies contradict the results of this study (8, 29). In a study conducted by Allison et al. (2012), pure muscle mass increased after 12 weeks of resistance training and no effect was observed on serum anabolic hormones and satellite cells (30). The absence of changes in anabolic hormones in the Allison study may be due to an increase in these hormones in the early stages, which returned to baseline after 12 weeks. For this purpose, in our study, we chose a time of less than 12 weeks, i.e., six weeks. Walker et al. (2004) found that plasma myostatin levels decreased by 20% in response to 10 weeks of resistance training. In this study, the amount of myostatin was measured by Western blotting, which is a semi-quantitative method (20). While in the present study, the ELISA method was used, which is a quantitative method. Myostatin is a secretory cytokine from skeletal muscle whose gene deletion or inhibition of its activity leads to increased skeletal muscle strength and mass (31). The reason for differences between studies may be the type of protocol, intensity and duration of training, gender, characteristics of subjects, measurement method or differences in the sampling time. On the other hand, in most studies, myostatin mRNA was measured in response to exercise in the skeletal muscle. Due to the fact that myostatin protein undergoes post-translational modifications after synthesis, myostatin mRNA cannot accurately represent blood circulation levels and its active form (26). Therefore, in the present study, serum levels were used to evaluate myostatin changes. It has also been shown that changes in myostatin in response to exercise are associated with changes in the number and activity of its receptors in the skeletal muscle (32).

In the present study on cortisol, it was concluded that six weeks of fast and slow resistance training had no significant effect on its concentration. Gotto et al.'s (2009) study also showed that high-intensity resistance training and fast movements did not change cortisol levels (16), which is consistent with the results of the present study. However, low-intensity resistance training and slow movements increased cortisol levels, which is not consistent with the results of this study. In another study, Gorzi et al. (2011) stated that cortisol levels increased significantly after 10 weeks of resistance training, which may be in response to severe exercise intensity (33). Increased central body temperature can be one of the causes of increased cortisol secretion, which researchers have attributed to the release of hormones from carrier proteins and changes in carrier proteins. Therefore, it is possible that the increase in cortisol in Goto and Gorzi's research is due to the increase in the central body temperature, which has not been measured in the present study. According to Goto's research, large individual differences in cortisol levels may obscure small changes in cortisol (16). Cortisol is also released in response to physiological and psychological stress. Therefore, the physiological stresses in these two types of exercise may not have been sufficient to stimulate cortisol secretion. It should be noted that sleep time, stress and mental conditions and nutrition of the subjects in this study is not controlled and is one of the limitations of the present study. From the results of different researches, it can be said that different factors such as individual differences, nutritional status and training status play a role in the response of cortisol to resistance training (34).

Conclusion

The results of this study showed that six weeks of slow and fast resistance training did not cause significant changes in IGF-1, myostatin and cortisol levels but increased growth hormone levels, which is only significant in the slow movement group. Comparing the results between groups, only the values of myostatin and strength showed a statistically significant difference that the rate of increase in strength in the slow movement group was higher than the fast group. Therefore, it seems that athletes and coaches can be advised to emphasize resistance training with slow movements in their training. It has to be noted, however, that in this study, muscle strength is not measured, which is one of the limitations of the present study, and considering that training at different speeds can affect the speed of muscle action. Although slower training has a better effect on gaining strength, it may negatively affect the speed of energy production, which has concerns for speed-power athletes in various sports. However, this issue needs further research using different protocols. Finally, it is suggested that the present study be performed with related receptors as well as the response of muscle growth factors with a delay of several hours.

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