

The influence of variable range of motion training on hormonal responses and muscle strength

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Abstract

Introduction: Traditional resistance training increases strength and power; however, exercises that use the entire range of motion (ROM) may not provide the optimal stimulus for enhancing sports performance. The purpose of this investigation was to compare partial ROM *vs.* full ROM lower-body resistance training on hormonal responses and muscle strength in young women.

Material & Methods: Fourteen young women (age 26.9 ± 5.1 years, height 166.7 ± 5.1 cm, and body mass 62.5 ± 11.8 kg) voluntary to participate in this study. Volunteers were randomly assigned to 2 groups: (a) full ROM (FROM; n = 7) or (b) partial ROM (PROM; n = 7). The subjects in FROM group were introduced to perform hamstring with machine, squat, dead lift and leg press with 60 to 80 percent of one repetition maximum (1RM), 3 days a week for 8 weeks. The subjects in PROM group were introduced to perform that same training with first half ROM and second half ROM with 50 to 80 percent of 1RM, 3 days a week for 8

weeks. Maximal strength was measured by 1RM before and after the intervention and growth hormone (GH), testosterone (Ts), cortisol (Cor) and testosterone to cortisol ratio (Ts/Cor ratio) were measured at baseline and immediately and 30 min after the last session of training.

Results: The results indicated that muscle strength in each station were increased significantly after both of training methods ($P < 0.05$) and no significant differences were observed between FROM and PROM methods. Repeated-measure analyses of variance revealed that GH and Ts levels had not significant changes after the FROM or PROM resistance training; however, Ts/Cor ratio was increased and Cor levels were decreased after both of training methods ($P < 0.05$). For hormonal responses, no significant differences were observed between FROM or PROM resistance training.

Conclusions: The results suggest that muscle strength and hormonal responses can be improved with both FROM and PROM resistance training and there is no significant difference between these methods.

Keywords: Full range of motion, Partial range of motion, Anabolic hormones, Women, Strength

1. Introduction

Resistance training increases muscle strength, power and hypertrophy (1,2). Variables such as exercise order, frequency, volume, intensity, between-set rest intervals, and others are consider when the coaches and trainers design the resistance training programs (1,3,4). Besides these critical variables, range of motion (ROM) can also be manipulated for strength gains (5,6). Although some studies that have investigated the acute effects of performing partial or full ROM (PROM or FROM) strength training have suggested that lifting through a FROM is superior for strength gains when compared with lifting with PROM or mixed ROM (7), but the other studies reported that exercises that use the entire ROM may not provide the optimal stimulus for enhancing sports performance (8,9). In addition, resistance exercise is often

performed within a specific, restricted joint ROM after orthopedic injury or surgery or when pain and muscle weakness limit ROM (10).

A great amount of research on the chronic effects of resistance training has been carried out in the area of PROM *vs.* FROM resistance exercise (5-11). These investigations have focused on the effects of different ROM training and its effectiveness in promoting the development of FROM and PROM strength. However, the results from these previous investigations are still contradictory. For example, Clark et al. (2008) examined whether variable ROM training was superior to FROM strength training. They found that variable ROM training significantly increased peak force when compare with the FROM exercise (9). Massey et al. (2004) compared PROM *vs.* FROM training and reported that PROM and FROM positively influenced the development of maximal bench press strength (6). In a related study, Massey et al. (2005) reported a statistically significant gain in bench press 1 repetition maximum (1RM) strength for a FROM group when compared with partial and mixed ROM groups (7). Therefore, because of controversy between studies relating to strength gains and the lack of studies comparing PROM and FROM resistance training on hormonal responses, the purpose of this investigation was to compare PROM *vs.* FROM lower-body resistance training on hormonal responses and muscle strength in young women.

Materials and Methods

Subjects

Fourteen young women with no resistance training experience participated in this study. Seven subjects in the FROM group (age = 27.1 ± 5.1 years; body mass = 64.1 ± 11.6 kg; height = 168.5 ± 2.1 cm) and seven in the PROM group (age = 26.7 ± 5.4 years; body mass = 60.8 ± 12.6 kg; height = 164.8 ± 6.7 cm) completed the study protocol. The subjects were divided in the FROM or PROM group randomly based on their maximum strength. The inclusion criteria for participation in the study included being older than 18 years and being free of clinical problems that could be aggravated by the protocol. Our participants were not engaged in any systematic exercise programs at

least 6 months before the study, none of them had any disease or had been consuming any drugs that could affect the study results. The participants were notified of the research procedures, requirements, benefits, and risks before providing informed consent. The study was approved by the Ethics Committee of Marvdasht branch, Islamic Azad University, Iran.

One-Maximum Repetition Test

Maximal strength was determined using a concentric, 1-RM (12), as previously described (13). The warm-up consisted of riding a stationary bicycle for 5 min, two sets of progressive resistance exercises similar to the actual exercises utilized in the main experiment, and 2-3 min of rest accompanied by some light stretching exercises. After the warm-up, subjects performed the 1-RM test, and the heaviest weight that could be lifted once using the correct technique was considered as 1-RM for all the exercises and used to calculate the percentage of resistance. One-maximum repetition test was done before and at the end of the intervention.

Strength Training

Two familiarization sessions were designed to habituate subjects with the testing procedures and laboratory environment. The main aim of these sessions was to familiarize subjects with different resistance exercises using weight-training machines and also to familiarize them with performing the 1-RM test. During the familiarization sessions, it was ensured that all the subjects used the correct techniques for all exercises prior to taking part in the main test sessions. Subjects executed four resistance exercises selected to stress the lower-body muscles in the following order: hamstring with machine, squat, dead lift and leg press.

The subjects in FROM group were introduced to perform hamstring with machine, squat, dead lift and leg press with 60 to 80 percent of 1RM, 3 days a week for 8 weeks. The subjects in PROM group were introduced to perform that same training with first half ROM and second half ROM with 50 to 80 percent of 1RM, 3 days a week for 8 weeks. The subjects were instructed to maintain their normal diet over the duration of the study.

Anthropometric and body composition measurements

Height and body mass were measured, and body mass index (BMI) was calculated by dividing body mass (kg) by height (m^2). Waist circumference was determined by obtaining the minimum circumference (narrowest part of the torso, above the umbilicus) and the maximum hip circumference while standing with their heels together. The waist to hip ratio (WHR) was calculated by dividing waist (cm) by hip circumference (cm). Body fat percentage was assessed by skinfold thickness protocol. Skinfold thickness was measured sequentially, in triceps, supra iliac, and thigh by the same investigator using a skinfold caliper (Harpenden, HSK-BI, British Indicators, West Sussex, UK) and a standard technique.

Biochemical analyses

For menstrual status, all the participants were menstruating regularly and defined as eumenorrheic (28- to 32-day menstrual cycles during the previous year); all testing was performed during the follicular phase of the menstrual cycle. Blood samples were taken (5 ml) at rest and immediately and 30 min after the resistance training. Serum obtained was frozen at -80°C for subsequent analysis. The growth hormone (GH) level was measured in duplicate using an electrochemiluminescent method by Roche (Cobas e411 model, Germany) instrument. The sensitivity of measurement was 0.1 ng/ml. Cortisol (Cor) and testosterone (Ts) concentrations were measured using an enzyme-linked immunosorbent assay (ELISA) kits (Monobind Inc; USA).

Statistical analysis

Results were expressed as the mean \pm SD and Shapiro-Wilk Test was applied to evaluate the normal distribution of variables. Paired-sample t-test, independent-sample t-test, and 2×3 repeated measures ANOVA test were used for data analyzing. The significance level of this study was set at $P < 0.05$ and the data were analyzed using SPSS software for windows (version 17, SPSS, Inc., Chicago, IL).

3. Results

Anthropometric and body composition parameters of the subjects are presented in Table 1. No significant differences were observed on the

anthropometric and body composition parameters of the subjects at baseline. The results showed that the WHR and body fat percent decreased significantly after 8 weeks of FROM and PROM resistance training ($P < 0.05$); however no significant difference was observed between two groups.

Table 1. Anthropometric and body composition characteristics (mean \pm SD) of the subjects

	FROM (n=7)		PROM (n=7)	
	Baseline	After training	Baseline	After training
Age (Year)	27.1 \pm 5.1		26.7 \pm 5.4	
Height (Cm)	168.5 \pm 2.1		164.8 \pm 6.7	
Body mass (Kg)	64.1 \pm 11.6	64.3 \pm 10.8	60.8 \pm 12.6	60.9 \pm 13.0
BMI (Kg/m ²)	22.5 \pm 3.9	22.6 \pm 3.6	22.2 \pm 3.6	22.2 \pm 3.7
WHR	0.80 \pm 0.04	0.77 \pm 0.02*	0.85 \pm 0.03	0.81 \pm 0.03*
Body fat (%)	30.8 \pm 4.9	27.8 \pm 3.8*	29.0 \pm 6.8	26.7 \pm 6.6*

* $P < 0.05$, pre-training *vs.* post-training values.

The results from the 1RM tests are shown in the Table 2. Paired-sample t-test revealed that maximum strength in each station (hamstring with machine, squat, dead lift and leg press) was increased significantly after 8 weeks of FROM and PROM resistance training ($P < 0.05$). The results indicated that in the squat, maximum strength was increased 16.6% in the FROM group and it was increased 15.8% in the PROM group. For the hamstring, maximum strength was increased 24.3% in the FROM group and it was increased 22.5% in the PROM group. For the dead lift, maximum strength was increased 22.1% in the FROM group and it was increased 20.4% in the PROM group.

Table 2. Results from 1RM tests before and after 8 weeks of training (mean \pm SD)

	FROM (n=7)		PROM (n=7)	
	Baseline	After training	Baseline	After training
Squat (Kg)	30.7 \pm 4.4	35.8 \pm 4.4*	32.8 \pm 3.9	38.0 \pm 4.*
Hamstring (Kg)	37.8 \pm 4.8	47.0 \pm 5.0*	40.4 \pm 4.3	49.5 \pm 4.1*
Dead lift (Kg)	23.5 \pm 4.7	28.7 \pm 4.6*	25.0 \pm 2.8	30.1 \pm 2.6*
Leg press (Kg)	160.0 \pm 16.3	180.4 \pm 16.3*	171.4 \pm 25.4	191.7 \pm 25.5*

* $P < 0.05$, pre-training *vs.* post-training values.

At the end, maximum strength in the leg press was increased 12.5% in the FROM group and it was increased 11.6% in the PROM group. Independent-sample t-test demonstrated that there were no significant differences in the maximum strength gains in each station between these resistance training methods.

Changes of GH level after FROM and PROM resistance training are presented in the Figure 1. The data revealed that GH concentration had tendency to the increase immediately after FROM and PROM resistance training and it received to the baseline level, 30 min after the training. No significant differences were observed during the blood sampling or between two methods.

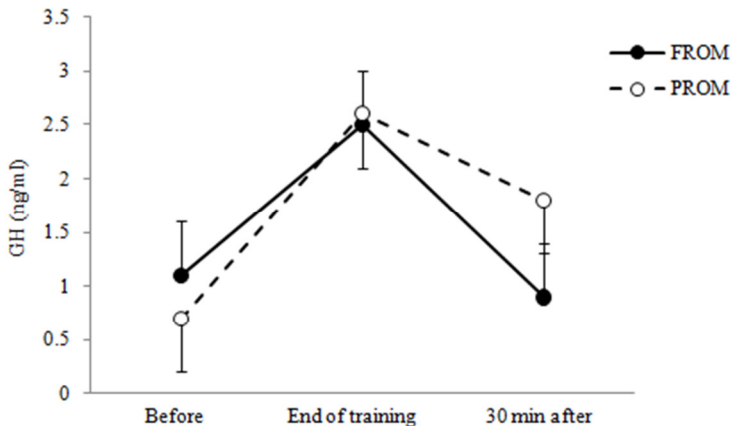


Figure 1. Changes of GH level in response to 8 weeks of FROM or PROM resistance training

Changes of Ts level after FROM and PROM resistance training are presented in the Figure 2. The data revealed that Ts concentration had tendency to the decrease after FROM and PROM resistance training. No significant differences were observed during the blood sampling or between two methods.

Repeated measures ANOVA test revealed that Cor level was decreased significantly in response to 8 weeks of FROM and PROM resistance training (Figure 3). No significant differences were observed between two resistance training methods.

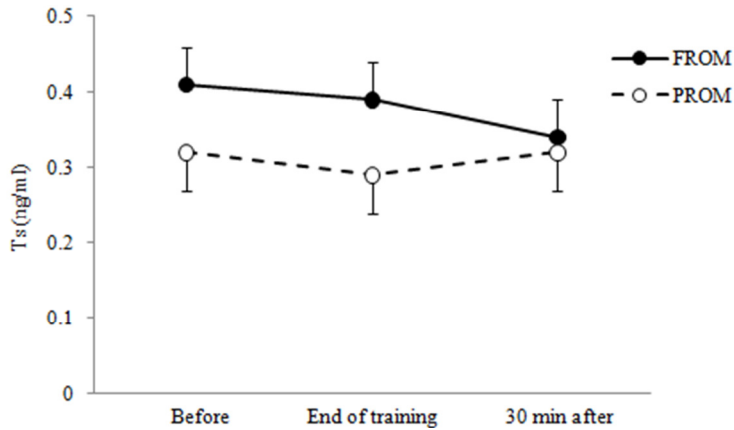


Figure 2. Changes of Ts level in response to 8 weeks of FROM or PROM resistance training

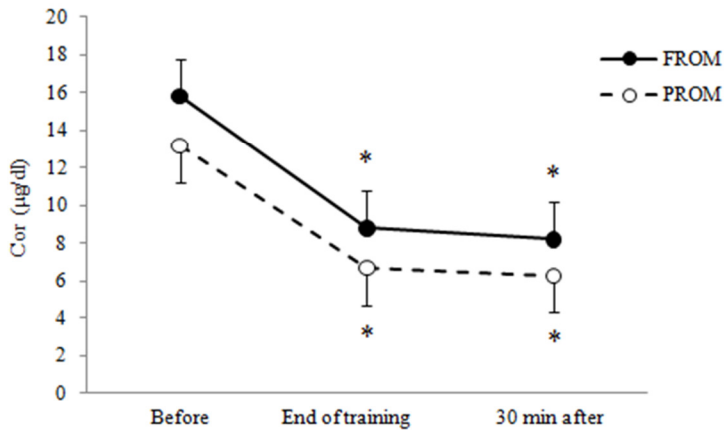


Figure 3. Changes of Cor level in response to 8 weeks of FROM or PROM resistance training

* $P < 0.05$, Significant difference compare to the baseline values.

As shown in the Figure 4, repeated measures ANOVA test demonstrated that Ts/Cor ratio increased in response to 8 weeks of FROM and PROM resistance training ($P < 0.05$); however, no significant differences were observed between these methods.

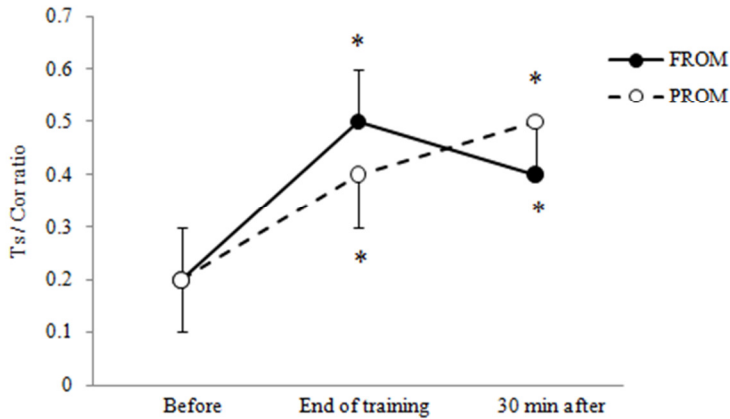


Figure 4. Changes of Ts/Cor ratio in response to 8 weeks of FROM or PROM resistance training

* $P < 0.05$, Significant difference compare to the baseline values.

4. Discussion

The purpose of this study was to compare the effects of FROM vs. PROM resistance training on hormonal responses and muscle strength in young women. The results of this study suggest that muscle strength and katabolic effect of hormones such as Cor can be improved with both FROM and PROM resistance training. The result indicated that maximum strength in each station was increased significantly after 8 weeks of FROM and PROM resistance training and there were no significant differences in the maximum strength gains were observed in each station between these resistance training methods.

Several studies have been exploring the effects of different resistance training ROM on neuromuscular responses (5-11). At the first study, Graves et al. (1989) investigated the effect of different ROM resistance training on strength gains at specific angles and showed that muscle strength improves more at the joint angles trained and not completing the FROM may result in weakness at untrained angles (5). In agreement with the results of present study, Graves et al. (1992) in another study reported that PROM resistance training also improves FROM strength in the lumbar extensor muscles (10). Massey et al. (2004) compared the effects of PROM and FROM training on the development of maximal bench press strength. They divided their male subjects into 3 groups.

One group trained with FROM, another group trained with PROM, whereas the last group trained with mixed ROM (partial and full). They found no difference in 1RM bench press strength gains between groups (6). Clark et al. (2011) using 2 groups of athletes with extensive resistance training backgrounds investigated the effects of 5 weeks of mixed ROM training, consisting of PROM training performed in a different phase of the ROM for each set, on isokinetic and isometric bench press and ballistic bench throws. They compared these with a control group performing FROM bench press. Their results revealed that the mixed ROM group significantly improved bench throw displacement under the FROM testing condition, despite there being no significant increase in peak force during the FROM countermovement. In contrast, the mixed ROM group produced significantly greater peak force in the half ROM countermovement throws. Interestingly, they reported a decrease in bench throw displacement, bench throw peak force, and half ROM bench throw peak force in the FROM group. Thus, they concluded that mixed ROM training is better than FROM training to improve an athlete's reactive strength and dynamic force performance at shorter muscle lengths (8). On the other hand, Pinto et al. (2012) reported that muscle strength can be improved with both FROM and PROM resistance training, but FROM resistance training may lead to greater strength gains (11). Massey et al. (2005) using female subjects found that bench press strength gains when training through a FROM were superior to those through a PROM and mixed training (7). These discrepant results may be attributed to the subjects training status and the subject populations.

Resistance exercise is the most effective way for achieving an acute increase in the concentration of anabolic hormones, which in turn stimulates strength and muscle hypertrophy (14,15). The amount or time of acute hormonal responses after resistance exercise, may be related to gaining of muscle strength and hypertrophy (16,17). The role of acute hormonal responses is very important because anabolic hormones such as GH and Ts will increase protein synthesis in muscle cells (18). The results of present study revealed that GH and Ts concentrations had not significant changes in response to 8 weeks FROM or PROM resistance training. Häkkinen et al. (2000) also reported that

maximal strength was increased in response to 6-month of heavy resistance training combined with explosive exercises in middle-aged and elderly women without any changes on GH, serum Ts and free Ts concentration (19). Increased blood lactate concentration has been suggested as a primary stimulus for the exercise-induced GH and Ts response (20,21). Some evidence demonstrates an increasingly wide and varied role for lactate other than that of a simple metabolic intermediary. For example, Lassarre et al (1974) suggested that the level of circulating GH during submaximal exercise is associated with anaerobic glycolysis in muscle (22). This suggestion implicated lactate, pyruvate and a small number of other metabolic intermediaries of the Embden–Meyerhoff pathway in the exercise-induced increase in circulating GH (20). Of these, only lactate has demonstrated a seeming growth in ubiquity of function. Lactate has been observed to inhibit the post-tetanic reuptake of Ca^{2+} ions by sarcoplasmic reticulum (23), to stimulate insulin secretion (24) and to stimulate Ts secretion (21) and it has been suggested that it is involved in promoting wound repair (25). We did not measure blood lactate concentration but it seems that the lack of effect of FROM and PROM resistance training on GH and Ts concentration might be due to the absence of increase in blood lactate concentration.

At the end, the data revealed that Ts/Cor ratio was increased and Cor levels were decreased after both of training methods. The ratio between the concentration of Ts and Cor is frequently used as an index of the stress level in exercise training. Changes in this ratio are responsible for several training responses such as hypertrophy and strength gain (26,27). Cor is primarily related to catabolic processes, as the degradation of proteins from skeletal muscles. However, a prominent role of the acute Cor response is to meet the greater metabolic demands caused by the resistance exercise (28). In previous studies the acute Cor response has occurred when the overall stress of the exercise protocol has been very high (29) and the response has been linked to the volume and/or intensity of total work to a given heavy-resistance exercise protocol (30). Long-term resistance training may lead to an overall reduction of acute Cor responses to exercise stress in men (31). Recently, Mehrpuya and Moghadasi (2019) reported that 8 weeks of resistance training increases

GH and Ts concentration but it had not significant effect on Cor level in the healthy middle-aged men (32). These discrepant results may be attributed to the subject populations and the intervention method. Mehrpuya and Moghadasi (2019) used middle-aged men (32) whereas this study used young women.

5. Conclusion

Use of variable ROM in resistance training is a practical method for strength gains and anabolic hormones secretion in novice subjects. The results of present study indicated that both of FROM and PROM resistance training equally increases strength gains and hormonal responses can be improved with both of these methods.

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