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ORIGINAL ARTICLE

The Effect of eight weeks of resistance training (one and three set) on maximal strength and Lean body mass untrained women

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ABSTRACT
The purpose of this research was to compare the effects of an 8-week 1-set and 3-set resistance training program on maximal strength and lean body mass in untrained women. 19 untrained women with no history of strength training were selected as the sample using accidental sampling and were divided into homogenous 1-set (N = 10; 26.7 ± 1.88 yrs.; 160.3 ± 6.53 cm; 56.82 ± 6.9 kg) and 3-set groups (N = 9; 27.6 ± 2.06 yrs.; 162.8 ± 4.98 cm; 59.56 ± 6.7 kg). The subjects performed their exercises for eight weeks and three sessions per week. Exercise intensity was the same for both groups (80% of one-repetition maximum). At the beginning and end of the training period muscle strength was measured by 1RM bench press and squat and Lean body mass was measured. Data were analyzed in SPSS 21 using t-tests for dependent and independent samples at the 0.05 significance level. The results showed significantly increase in upper and lower body muscle strength after 8 weeks of resistance training in both 1-set and 3-set groups(P < 0.05). but The lean body mass in any of the groups did not increase significantly. Moreover, there is no significant difference between training groups. The results demonstrate that there is no significant difference between the performance of 1-set and 3-set resistance training in untrained women.
Keywords: *Resistance training, muscle strength, lean body mass, untrained women.*

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INTRODUCTION

Resistance training is an important component of training programs in most sports and plays a significant role in injury prevention and rehabilitation [32]. It has been estimated that as many as 80 percent of all lower-back problems are related to an imbalance in muscular strength between abdominals and the hip flexor muscles, and these problems can be fixed with resistance training of the abdominal and lower-back muscles [24]. Moreover, resistance training can slow down the decline in muscle strength and bone density with age. Therefore, it can reduce the risk of osteoporosis, which is more prevalent in women [24]. Exercise volume, intensity, and frequency are the main variables that must be taken into account when designing resistance training programs [3]. Exercise volume is an important factor in improving strength. It is calculated by multiplying the number of repetitions per set by the number of sets in each session [11]. Due to its special importance, exercise volume has always been an interesting topic for researchers and trainers. Most studies on exercise volume have examined the effect of the number of sets for each movement on muscle strength [4, 13, 14, 19, 31]. However, some studies have focused on the total number of repetitions [10, 17]. It is still unknown whether performing single or multiple sets for each movement leads to more desirable results. There is much research on the principles of overload, progressive resistance, exercise specificity, and exercise volume in weight training. Despite the large body of research on resistance training volume [4, 13, 14, 19, 31], researchers have not yet found conclusive evidence about an optimal volume for weight training. Some studies have shown that 3-set resistance

training produces better results [18, 20, 35], while others have reported no significant difference between 1-set and 3-set training programs [4, 13, 31, 36]. Each muscle is unique in terms of fiber composition, fiber diameter, and performance. Thus, different resistance training programs can have different effects on the strength and endurance of different muscles [9]. Moreover, lower body muscles are used more frequently in daily activities (e.g. walking, standing, etc.) and may need a different training volume for adaptation than upper body muscles. Paulsen *et al*. (2003) compared the effects of 1-set and 3-set strength training in the upper and lower body. Strength increased in both groups, but lower-body strength was higher in the group that performed 3 sets in leg exercises. Upper body strength was similar in both groups [22]. Rønnestad *et al.* (2007) and Bottaro et *al.* (2009) reported that 3-set strength training is superior to 1-set strength training in terms of strength and muscle mass gains in the leg muscles, while no difference was observed between 1- and 3-set training in upper-body muscles [4, 28]. On the other hand, Humburg *et al*. [14] and Thomas *et al.* [31] showed that a 3-set strength training program creates more strength in upper body muscles than a 1-set program, but no significant differences were observed in the effects of these programs on lower body muscles. In another study, Huang *et al.* [13] examined and compared the changes in maximal strength with different weight training workouts (1-set, 3-set, and 6-set) in 22 untrained men. Maximal strength increased in all these groups, but no significant differences were observed in 1 repetition maximum between the three groups after ten weeks of training [13].

Given the contradictory results of previous studies and the fact that most studies have examined untrained individuals, especially women, there is clearly a need for further investigation. Moreover, according to statistics, women are more susceptible than men to longevity and age-related diseases. Thus, incorporating strength exercises into women's training programs has been recommended [32]. As mentioned earlier, exercise volume is an important factor in designing resistance training programs. It can influence neural, hypertrophic, metabolic, and hormonal responses as well as post-exercise adaptations [3]. While high exercise volume may lead to overtraining and cause injuries, low exercise volume may fail to produce the desired adaptations; therefore, it is critical to determine the optimal exercise volume [35]. On the other hand, if a low-volume training program can produce the same results as a high-volume program, the former is recommended. The purpose of the present research was to compare the effects of 1-set and 3-set resistance training programs on upper and lower body muscle strength and lean body mass in untrained women.

MATERIAL AND METHODS

The present research is quasi-experimental. The population consisted of 20-30-year-old untrained women with a BMI of 20-25 kg/m^2 and with no history of resistance training and musculoskeletal and cardiovascular diseases. 19 women were selected as the sample using accidental sampling and were divided into homogenous 1-set (N = 10; 26.7 ± 1.88 yrs.; 160.3 ± 6.53 cm; 56.82 ± 6.9 kg) and 3-set groups (N = 9; 27.6 ± 2.06 yrs.; 162.8 ± 4.98 cm; 59.56 ± 6.7 kg) based on their personal characteristics (age, BMI, and fat percentage) and pretest scores (upper and lower body muscle strength and lean body mass).

After completing an informed consent form and a medical questionnaire, the subjects were made familiar with the correct way of performing the movements and with the test procedures. At the beginning of the training program, the height and weight of the subjects were recorded and their skinfold thickness was measured using the Jackson-Pollock 3-site method (triceps, suprailiac, and abdominal) on the right side of the body. After calculating body fat percentage, fat weight and lean body mass (LBM) was calculated using the following formula(27):

(1) fat weight = current weight × % Fat

(2) lean body mass(LBM) = current weight -fat weight

In a separate session, 1-repetition maximum (1RM) bench press and squat was determined indirectly using submaximal estimation. After general warm-up, each subject selected a weight and performed one set with 10 repetitions as specific warm-up. Then, by increasing and decreasing the weights, the test ended when the subject performed 4-6 repetitions maximum for each movement. Brzycki Formula was used to determine the 1RM [6]:

$$1RM = \frac{w}{1.0278 - (r \times 0.0278)}$$

where w is the amount of weight used in kg and r is the number of repetitions until fatigue.

After these measurements, the subjects in both groups participated in an 8-week resistance training program (3 sessions per week) consisting of bench press and squat. Exercise intensity was similar in both

groups (70% of 1RM in the first week and 80% of 1RM in weeks 2 to 4). At the end of the fourth week, 80% of 1RM was calculated again and the weight was adjusted accordingly [13, 18, 19, 31]. Exercises continued at the same intensity up to the eighth week. The subjects of the first and second groups performed one set and three sets of each movement respectively. Each set included 8 repetitions, with 2-minute rests between sets and movements for both groups [22, 28].

All the stages of the research took place under similar standard conditions (24-26°C) at a specific time, by taking the subjects' menstrual cycle into account, and in a gym with similar lighting and ventilation for both groups. 24-hour diet recall questionnaire and 3-day food intake record were distributed among the subjects. The subjects' diet was analyzed and in a session before the training period the participants were advised about their nutrition in order to correct eating habits and ensure similar diets. Also the subjects were asked to avoid regular exercise and to not consume any supplements during the period of the research. All the exercise sessions started with general (slow running and stretching) and specific warm-up (performing one set of movement with 12-14 repetitions at 30-40% of 1RM) and ended with a 5-minute cool-down (stretching and slow running). At the end of the training period, maximal strength and lean body mass of the subjects were assessed again.

Data were described using descriptive statistics and tables. The results of the Kolmogorov-Smirnov test showed that the data are normally distributed. T-test for dependent samples was used to compare changes in muscle strength and lean body mass within groups before and after the training period, and t-test for independent samples was used to compare differences between groups at the 0.05 significance level.

RESULTS

Table 1 shows the anthropometric characteristics of the subjects (mean ± standard deviation). Table 2 provides the mean and standard deviation of muscle strength and lean body mass in the pretest and posttest. The results show that upper and lower body 1RM strength significantly increased in 1-set and 3-set groups ($P < 0.05$). but The lean body mass in any of the groups did not increase significantly. Moreover, the data indicate that there is no significant difference between the two groups in maximal strength and lean body mass.

Table 1. Anthropometric characteristics of the subjects (mean ± standard deviation)

Group	Age (yrs.)	Height (cm)	Weight (kg)	BMI (kg/m^2)	%Fat
3-set (N = 9)	27.66 ± 2.06	162.8 ± 4.98	59.56 ± 6.7	22.43 ± 1.47	25.73 ± 2.08
1-set (N = 10)	26.7 ± 1.88	160.3 ± 6.53	56.82 ± 6.9	22.04 ± 1.72	25.05 ± 2.7

Table 2. Comparison of muscle strength and lean body mass in the pretest and the posttest

Variable		Group	Stage	Mean ± SD	Dependent t	p	Independent t	p
Muscle Strength	Bench press (kg)	3-set	Pretest	20.35 ± 3.7	-49.49	0.000	0.54	0.59
			Posttest	31.88 ± 3.64*				
		1-set	Pretest	21.5 ± 4.86	-20.58	0.000		
			Posttest	30.7 ± 5.43*				
	Squat (kg)	3-set	Pretest	74.32 ± 16.93	-17.92	0.000	0.22	0.82
			Posttest	115.12 ± 23.23*				
		1-set	Pretest	76.91 ± 19.75	-11.38	0.000		
			Posttest	112.66 ± 24.79*				
lean body mass(LBM)		3-set	Pretest	43.65 ± 4.13	-2.09	0.069	0.61	0.54
			Posttest	43.95 ± 4.27				
		1-set	Pretest	42.46 ± 4.28	-1.95	0.082		
			Posttest	42.7 ± 4.51				
Notes: * Significant difference compared to the pretest ($P < 0.05$).								

DISCUSSION AND CONCLUSION

The purpose of this research was to compare the effects of 1-set and 3-set resistance training programs on upper and lower body muscle strength and lean body mass in untrained women. The results showed that after 8 weeks of training upper and lower body muscle strength significantly increased in both 1-set

and 3-set groups (P = 0.000). Exercise intensity was 80% of 1-repetition maximum (1RM), which has been shown to produce necessary adaptations for strength gain [7, 12]. Adaptations to resistance training that lead to increased maximal strength are: (1) neural adaptations such as increased mobilization of motor units, recruitment of motor units in agonist muscles, stimulation of motor units at higher frequency, spontaneous inhibition, and increased neuromuscular coordination; (2) muscular adaptations such as increased muscle cross-sectional area and change in muscle structure; and (3) metabolic adaptations [23, 34]. In the early stages of resistance training (6-8 weeks), neural adaptations are the dominant mechanism for increased strength, but in later stages (12-26 weeks) strength gain is the results of increased myofibrillar area (hypertrophy) [16].

In the present research, a significant increase in strength occurred in both training groups. Some researchers believe that early increase in maximal strength is associated with neural adaptations; thus, performing a bout of resistance training can produce necessary adaptations and exercise volume has no effect in this regard [9]. The results of this research showed no significant difference between the 1-set and 3-set training groups in maximal strength, both in the upper and lower body muscles.

In terms of upper body movements, the present findings are consistent with the results of [1, 2, 4, 5, 9, 22, 29, 31]. However, our findings are inconsistent with Thomas *et al*. [31] who reported that 12 weeks of 3-set resistance training at 80% of 1RM leads to higher strength gain in bench press, Humburg *et al.* [14] who reported higher strength gain in bench press and biceps curl in the 3-set strength training program [14], Rhea e*t al*. [25] who showed that a 3-set strength training for 12 weeks is superior to a 1-set program in eliciting maximal strength gains in bench press in recreationally trained men, and Marx *et al.* [20] who reported that after 24 weeks, the 3-set strength training program produces more strength gain in bench press in untrained women [20]. This inconsistency may be due to differences in the fitness of the subjects [25] or training period [20, 25, 31]. The subjects of Rhea *et al*. [25] were recreationally trained men who were more prepared to participate in the strength training program, which may have influenced their adaptations to strength training. However, the subjects of the present research were untrained women with no experience in resistance training. Moreover, the training period was 12 weeks in Thomas *et al*. [31] and Rhea *et al*. [25] and 24 weeks in Marx *et al*. [20], while the subjects of the present research participated in an 8-week training program.

In terms of lower body movements, the present findings are consistent with the results of [12, 13, 14, 26, 31, 33]. However, our findings are inconsistent with Marshall *et al.* [19] who showed higher strength gain in squat in the 4-set group compared to the 1-set group after 10 weeks of resistance training, Bottaro *et al.* [5] who reported that after 12 weeks of strength training the 3-set group had higher strength gain than the 1-set group in knee extension, Kelly *et al.* [18] who showed that after 8 weeks of strength training using isokinetic system maximal knee extension significantly increased in the 3-set group compared to the 1-set group, and Rhea e*t al*. [25] who showed that after 12 weeks of strength training the 3-set program produced higher strength in leg press than the 1-set program. This inconsistency may be due to differences in the fitness of the subjects [18, 19, 25] or the training and test protocols [5]. The subjects in Marshall *et al*. [19] were 32 trained men who participated in a 10-week training program, the subjects in Kelly *et al.* [18] were 40 male and female physical education students who were relatively more prepared to participate in the strength training program. The subjects in Rhea *et al*. [25] were also trained men who had necessary training adaptations. However, the subjects of the present research were 19 untrained women with no experience in strength training. In addition, the subjects in Bottaro *et al*. [4] performed exercises on an isokinetic system and their strength was assessed using such a device, while in the present research the subjects' strength was assessed using indirect 1RM determination.

The results of this research showed that performing one set and three sets of resistance training for eight weeks did not significantly increase lean body mass. The present findings are consistent with the results [12, 21, 30]. However, the results of Wilhelm *et al.* [33] showed a slight increase in knee extensor muscle mass following 6 weeks of resistance training [33], and Bottaro *et al.* [5] found an increase in the muscle mass of untrained men following 12 weeks of resistance training [5]. The inconsistency of these studies with present findings is probably due to differences in the age [33] and gender of the subjects and in the training period [5]. Wilhelm *et al*. [33] studied 27 elderly women who participated in a 10-week training program, while the subjects studied in the present research were 19 untrained women between 20 and 30 years of age. Moreover, the subjects studied in Bottaro *et al.* [4] were untrained men who participated in a 12-week training program, whereas the subjects of the present research were untrained women who participated in an 8-week training program. Since women naturally have lower testosterone levels than men [27], increased muscle mass reported by Bottaro et al. can be attributed to higher testosterone levels of their male subjects compared to the female subjects of the present research. Furthermore, the present

findings showed no significant difference between the effect of 1-set and 3-set training programs on lean body mass. This is consistent with the results [5, 12, 21, 30, 33].

Initial increases in muscular strength with resistance training is due to neural adaptations because of improved movement coordination and motor learning as well as the ability of the brain to recruit a greater number of motor units. Later, in addition to neural adaptations, hypertrophy plays a key role in increased muscle strength. Strength training causes changes in the central nervous system by increasing the electromyography (EMG) amplitude, stimulating agonist and antagonist motor units, and reducing neural inhibition. This increases coordination of stimulated muscles and allows them to use greater force, resulting in improved strength performance [8, 15, 34]. In the present research, strength increased as a result of resistance training, while no significant changes were observed in lean body mass. Thus, it can be concluded that muscular strength increased without any change muscle size due to neural adaptation.

Based on the present findings, untrained individuals can use a lower volume in the early stages of resistance training. Hence, coaches are recommended to optimize exercise duration and volume when designing training programs for untrained individuals. Nonetheless, further research is required to arrive at conclusive results.

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