Original Article

Multiple Sets resistance training: Effects of condensed versus circuit models on muscular strength, endurance and body composition

HAMID ARAZI[1], ABBAS ASADI[2]

[1]*Department of Exercise Physiology, Faculty of Physical Education and Sport Sciences, University of Guilan, Iran*
[2]*Roudbar Branch, Islamic Azad University, Roudbar, Iran*

ABSTRACT

Arazi H, Asadi A. Multiple sets resistance training: Effects of Condensed versus circuit models on muscular strength, endurance and body composition. *J. Hum. Sport Exerc.* Vol. 7, No. 4, pp. 733-740, 2012. The purpose of this study was to examine the effects of condensed multiple-set resistance training and circuit multiple-set resistance training on muscular strength, endurance, body composition and arm and thigh circumference in healthy males. Twenty seven healthy males volunteered to participate in this study and assigned into three groups; according to; condensed multiple-set group (COM; n=9), circuit multiple-set group (CIM; n=8) and control group (CON; n=10). Subjects in the COM performed resistance training exercises for 3 sets continuously; whereas subjects in the CIM performed resistance training program for 1 set of each exercise and come back to the first exercise and this approach was performed 3 times each training session. Pre and post 8 weeks of training, one repetition maximum (1RM) and muscle endurance (60% of 1RM) for leg press and bench press, body weight, arm and thigh circumference and body composition were measured. No significant differences in body mass, arm and thigh circumference and muscular strength for the bench press exercise were observed for any group during the 8 weeks of training period ($p > 0.05$). A significant increase in muscular strength for the leg press exercise was observed for COM after 8 weeks of training ($p < 0.05$). Both the COM and CIM groups showed significant improvement compared with pre training and CON in muscular endurance for the bench press and leg press exercises ($p < 0.05$). In conclusion, it can be recommended that, COM is better for improving muscle strength and both training programs are proper for increasing muscular endurance. **Key words**: RESISTANCE TRAINING SYSTEMS, CONTINUOUS, SEPARATE, MUSCULAR PERFORMANCE.

Corresponding author. Faculty of Physical Education and Sport Sciences, University of Guilan, Rasht, Iran. P.O.Box: 1438.
Phone: +98 131-66990161
E-mail: hamidarazi@yahoo.com
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INTRODUCTION

Resistance training is a modality of exercise that has grown in popularity over the past two decades, particularly for its role in improving athletic performance by increasing muscular strength, power and speed, hypertrophy, local muscular endurance, motor performance, balance, and coordination (Kraemer & Ratamess, 2000). Traditionally, resistance training was performed by few individuals (e.g., strength athletes and those who strived to gain muscle hypertrophy such as body builders). However, we now have a better understanding of the health-related benefits of resistance training; resistance training is now a popular form of exercise that is recommended by national health organizations such as the American College of Sports Medicine and the American Heart Association (American College of Sports Medicine, 1998; 2002) for most populations including adolescents, healthy adults, the elderly, and clinical populations (e.g., those individuals with cardiovascular disease, neuromuscular disease). According to the several benefits of resistance training; the data about the design of resistance training is no unequivocal vote. Numerous researchers compared different resistance training systems and found different results for the strength, endurance, body composition and physical fitness (Fleck & Kraemer, 2004). One of the important keys for the design of resistance training is number of sets. Single-set system and multiple-set system are common systems for improving muscular performance in trained and healthy subjects (Fleck & Kraemer, 2004; Fleck, 1999).

The single-set system, the performance of each exercise for one set, is one of the oldest resistance training systems, whereas a multiple-set system can involve performing multiple sets (e.g., 3 sets) with the same resistance. The comparison of multiple- and single-set resistance training has been extensively reviewed (Carpinelli & Otto, 1998; Brzycki, 1990; Carpinelli, 2002; Feigenebaum & Pollock, 1999), and the results in the literature range from a nonsignificant finding of superiority of single-set training to a significant finding of superiority of a multiple-set regimen. Other recommendation for performing resistance exercise training can become circuit resistance training system. Circuit system consists of a series of resistance exercise performed in succession with minimal rest between exercises. It appears that circuit system can improve time to lactate threshold, body composition, and increases in strength and endurance (Tskin, 2009; Beckham & Earnest, 2000). Previous studies examined the effects of each training system separately and or compared single-set vs. multiple-set systems; multiple-set vs. circuit system, but no study compared multiple-set system (continuously or condensed multiple system) and circuit multiple-set system (compound of circuit and multiple-set systems). Therefore, the purpose of this study was to examine the effects of 8 weeks condensed multiple-set system and circuit multiple-set system on strength, endurance, body composition and arm and thigh circumference in healthy males.

MATERIAL AND METHODS

Participants

Twenty-seven healthy males volunteered to participate in this study and were assigned into three groups; condensed multiple group (COM; n=9), circuit multiple group (CIM; n=10), and control group (CON; n=10). Subjects were informed as to the experimental procedures and signed informed consent statements and medical history forms in adherence with the human subjects' guidelines of the University Health Sciences Center before any data collection. Subjects had been never involved any type of resistance training and had normal dietary intake during the study. The subjects were instructed to not use any anabolic androgenic steroids or other ergogenic substances. There were no significant differences among groups in age, height, body mass, percent body fat and body mass index (BMI) at pre training (Table 1).

Table 1. *Subjects characteristics. Data are mean ± SD.*

	COM	CIM	CON
	(n=9)	(n=8)	(n=10)
Age (yr)	21±2.2	20.8±2.7	20.9±2.2
Height (cm)	175±4.6	173.8±5.6	174.5±4.4
Body mass (kg)	68.7±6	68.7±7.8	69.2±6
Body fat (%)	15.6±2.5	15.4±2.6	13.4±2.9
BMI ($kg \cdot m^{-2}$)	22.4±1.8	22.7±2.2	22.6±1.3

COM, condensed multiple; CIM, circuit multiple; CON, control; BMI, body mass index

Testing

One week before the start of training period, the subjects were familiarized with the resistance training program. During the familiarization session, subject initial characteristics such as; age, height, body weight, percent body fat, one repetition maximum (1RM) for bench press and leg press exercises were obtained. Two days after, thigh and arm circumference and muscle endurance (60% 1RM) for the bench press and leg press exercises were assessed. Subjects were tested pre and post an 8-week of training. The same researchers conducted all training and testing sessions. Pre and post training anthropometric measures of weight, and percent body fat were taken. Height was measured to a nearest to 0.1 cm using height rod. Body weight with minimal clothing was measured to the nearest 100 g (CAMRY) on a lever-type balance in a fasted state after emptying the bladder. Subjects had 3 skin fold sites (chest, abdominal, and thigh) measured to determine body composition or percent body fat. The measurement was used according to the method by Jackson and Pollock (Jackson & Pollock, 1985). All skin fold measurements were taken using Lafayette caliper (Skin Fold Caliper, Model 01127 INDIANA). Skinfold thickness was based on the average of the two trials. If the two skinfold measurements at the same site differed by more than 0.5 mm, a third measurement was obtained and the mean value used. The circumferences of mid thigh and mid upper arm of the right limbs were assessed. Upper and lower body muscular strength was measured using the one repetition maximum (1RM) bench press and leg press exercises on Sport Art Fitness weight machines. A warm-up set of 10 repetitions at 40-60% of perceived maximum was performed by subjects. Three subsequent attempts were then made to determine the 1RM. Subjects were allowed to perform maximum 8 repetitions during bench press and leg press, and was used equation of Brzycki (Brzycki, 1993) for the determine of 1RM. Three to 5 minutes rest periods were used in between lifts to ensure optimal recovery.

$$\mathbf{1RM} = \frac{\mathbf{weight\ (kg)}}{\mathbf{1.0278 - (0.0278 \times number\ of\ repetitions)}}$$

Upper and lower body muscular endurance was assessed by measuring the maximal number of repetitions performed for both the bench press and leg press exercises using Sport Art Fitness weight machines. A load was selected which corresponded to 60% (Benedict, 1999) of subjects' 1RM. Each subject was instructed to perform each exercise to momentary muscular exhaustion. The total number of repetitions performed was recorded. Any repetitions not performed in a full range of motion were not counted.

Resistance training program

One week before the start of training program, the subjects were familiarized with the training protocol. During the familiarization session, each subject was given instructions for the use of the body building machines and proper form of each exercise. Resistance training programs were performed 3 times a week; including 60-70 minutes (e.g., 15 minutes warm up, 40-50 minutes resistance training and 5 minutes cool down) for 8 weeks. All workouts started with a general warm up and included cool down periods (e.g., low-intensity aerobic exercise, stretching, and etc.) of approximately 5-10 minutes. Subjects in the condensed multiple program (COM) performed resistance training exercises for 3 sets continuously; such as, 3 sets of leg press, knee flexion, knee extension, lat pull down, bench press and arm curl; whereas subjects in the circuit multiple program (CIM) performed resistance training program for 1 set of each exercise (e.g., leg press, knee flexion, knee extension, lat pull down, bench press and arm curl) and come back to first exercise and this approach was performed 3 times each training session (Table 2). The volume of resistance training program (repetition × set × load) for both the COM and CIM groups were the same. Subjects were tested every 2 weeks, and resistance exercises were designed based on new 1RM for each exercise. Two minutes rest in between sets and 48 hours in between training sessions were used to ensure optimal recovery.

Table 2. *Resistance training for COM and CIM groups.*

Group	Week 1-2	Week 3-4	Week 5-6	Week 7-8	Rest periods
			Reps-intensity		
COM	12-60% 1RM	10-70% 1RM	8-75% 1RM	6-80%1RM	2 min
CIM	12-60% 1RM	10-70% 1RM	8-75% 1RM	6-80%1RM	2 min

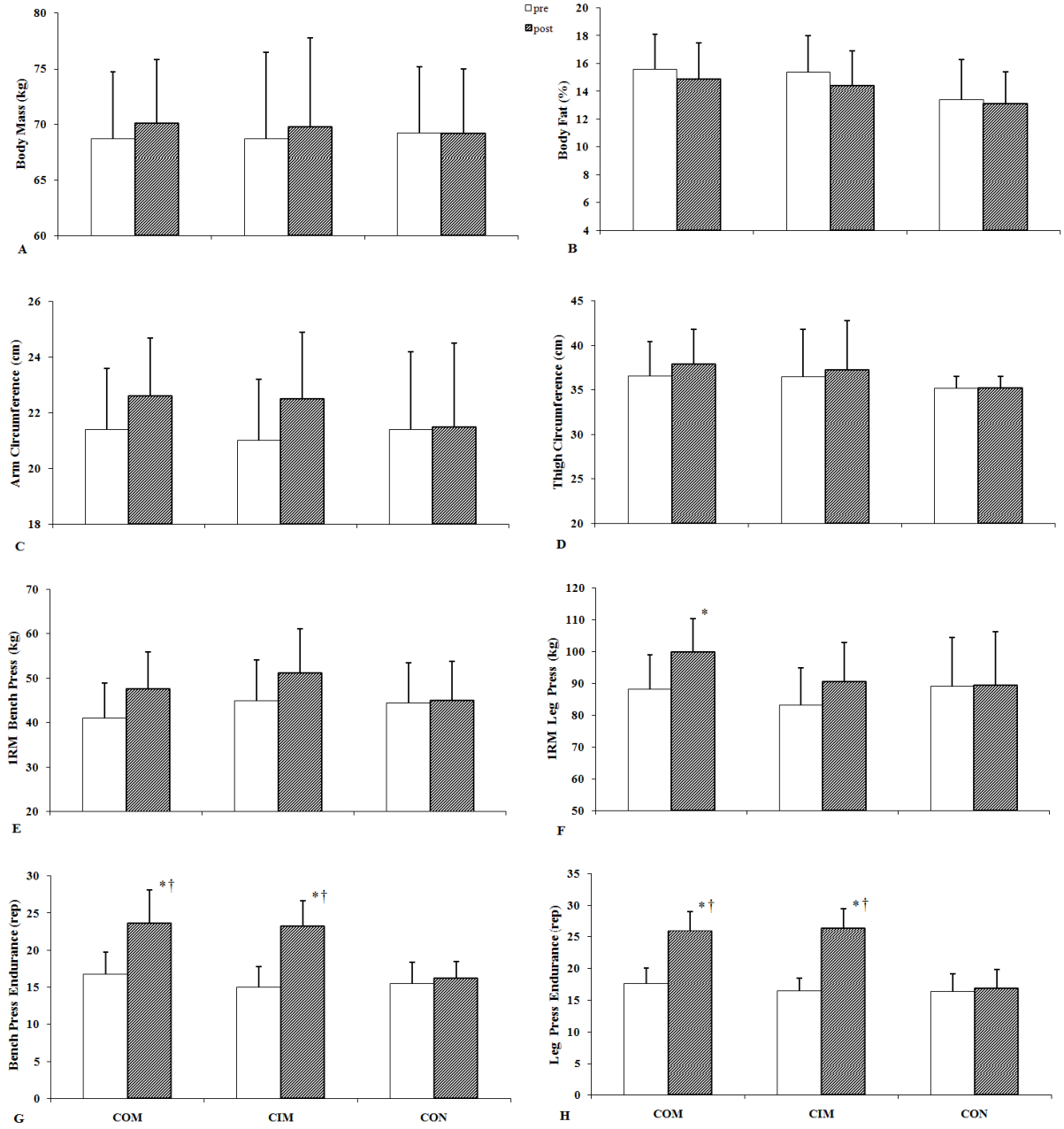
COM, condensed multiple group; CIM, circuit multiple group.

Statistical analysis

All data are presented as mean ± SD. A two-way analysis of variance (ANOVA) with repeated measures (groups × time) was used to analyze the data. Bonferroni's post hoc analyses to determine pairwise differences were performed when significant F-values resulted. The level of significant was set at $p < 0.05$.

RESULTS

No significant differences in body mass, arm and thigh circumference and muscular strength for the bench press exercise were observed for any group during the 8 weeks of training period ($p > 0.05$). A significant increase in muscular strength for the leg press exercise was observed for COM after 8 weeks of training ($p < 0.05$). Both the COM and CIM groups showed significant improvement compared with pre training and CON in muscular endurance for the bench press and leg press exercises ($p < 0.05$). Changes in all variables are presented in Figure 1.



Values are mean ± SD. Significantly different (p < 0.05) from the corresponding pre training value.*
† Significantly different (p < 0.05) from the corresponding CON value.

***Figure 1**. Changes in body mass (A), body fat (B), arm circumference (C), thigh circumference (D), 1RM bench press (E), 1RM leg press (F), bench press endurance (G) and leg press endurance (H) pre and post 8 weeks of training.*

DISCUSSION

A different kind of resistance training system that may be effective in improving strength and in preparing athletes for competition is multiple-set resistance training system. This type of resistance training program consists of 3 sets of exercise with the same resistance. In this study we wanted to examine the effects of two types of multiple-set resistance training program (traditional or condensed multiple-set vs. circuit multiple-set) on strength, endurance, arm and thigh circumference and body composition in healthy males. Body mass, body fat, arm and thigh circumference improved approximately 3-5% for the COM and CIM groups after 8 weeks of training, but these improvements were not statistically significant.

It appears that, a series of circuit resistance training can affect body composition in regards to body mass and body fat. Body composition changes will most likely depends on the type of exercise, with hypertrophy promoting circuits or multiple sets producing greater improvement in body mass (Hass et al., 2000). Marx and coworkers (Marx et al., 2001) showing a body fat reduction in untrained women with only 1 circuit session performed 3 times per week. The traditional 3 days per week, three 10-station circuits per day using intensities of 40-55% of 1RM produced significant reductions in body fat (Wilmore et al., 1978). In the body mass and body fat percentage of improvements was minimal for the COM and CIM; likewise 5.5 and 3.5% of improvement in arm and thigh circumference for the COM and 3 and 2% of improvement in arm and thigh circumference for the CIM were observed. It seems that performing 3 sets of exercise continuously is superior to 3 sets with circuit model (separately) for increasing arm and thigh circumference and body mass.

Other finding of this study was to significant increases in 1RM leg press for the COM group. However, CIM group showed 8% improvement in 1RM leg press, but this increase was not statistically significant. Likewise, both the COM and CIM groups indicated 16 and 13% improves in 1RM bench press, but these improves were not significant. Previous researchers reported that circuit resistance training can improve strength and intermuscular coordination. Using loading 40-60% of 1RM during circuit resistance training has been shown to improve both upper and lower body strength in men and women (Wilmore et al., 1978; Esquivel & Welsch, 2007). However, application of this load to trained subjects may prove less effective for developing maximal strength. Additionally, a circuit resistance training was sufficient to increase maximum strength and muscular endurance but not isometric strength when compared with multiple circuits over 13 weeks of training in individuals who were slightly trained (Hass et al., 2000). In 10 weeks study, 12 untrained males- 8 in the experimental group and 4 in the control group- exercised circuit weight training twice a week. The circuit weight training program significantly increased 1RM strength (15-42%) (Gettman & Pollock, 1981). It is well accepted that multiple-set system can improve strength in untrained population (Fleck & Kraemer, 2004; Fleck, 1999). The current results of this investigation detected that condensed multiple-set program produce greater improvement in muscular strength than circuit multiple-set. However circuit program was performed 3 series, improves in muscle strength was greater for the COM group. Perhaps condensed multiple-set system induced higher tension in muscle fiber and consequently muscular strength increased.

In this study we found that both the COM and CIM increased muscular endurance in bench press and leg press compared with pre training and CON. The percentage of improvement for the CIM was greater than COM in bench press and leg press endurance exercise (bench press; 55 vs. 40%, leg press; 61 vs. 47%). This finding was supported by previous researchers (Fleck & Kraemer, 2004; Fleck, 1999; Tskin, 2009; Beckham & Earnest, 2000). It is well accepted that a circuit resistance training improves cardiovascular and muscular endurance. In the present study 3 circuits were performed by CIM group and the increase in

muscular endurance is remarkable for this group. However, we found no statistically significant differences between CIM and COM in muscle endurance, amount of increases for CIM groups was greater. Dissimilar muscle groups involved during circuit program and it can be one of the important mechanisms for increasing muscle endurance using CIM.

CONCLUSION

Overall, in this study we found that COM is better for increasing body mass, arm and thigh circumference and muscular strength. Likewise, CIM is better for increasing muscular endurance. However, we found no statistically significant improvements in body fat, body mass, arm and thigh circumference and 1RM bench press, the percentage of increases are remarkable. The sample size is very important note in experimental studies, the small group sizes in this study could have caused outliers to influence the mean values of the respective muscular strength and endurance, arm and thigh circumference and body composition scores more than would have been the case with larger group sizes. These data will enable us to give more general recommendation for the use of COM model in the development of muscular strength, arm and thigh circumference and body composition and CIM model in the development of muscular endurance.

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