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Comparison of Timed-Based Sets Metabolic Resistance Training vs. Repetition-Based Sets Metabolic Resitance Training on EPOC in Recreationally Active Young Women

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COMPARISON OF TIMED-BASED SETS METABOLIC RESISTANCE TRAINING VS. REPETITION-BASED SETS METABOLIC RESISTANCE TRAINING ON EPOC IN RECREATIONALLY ACTIVE YOUNG WOMEN

By

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RESEARCH PAPER APPROVAL

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CHAPTER 1

INTRODUCTION

The prevalence of overweight and obese females in the United States has continued to grow over the past 40 years. According to Go et al (2013), in 1974, 16.8% of adult women ages 20-74 were reported to be obese. This number has more than doubled to 36.1% in 2010. Overall, 74.8 million adult women are classified as being overweight or obese (Go et al., 2013).

As this trend appeared, weight loss exercise programming began to gain more attention, with a focus primarily on total calorie expenditure per session. At that time, the trend was toward aerobic exercise, so steady state aerobic activities were typically prescribed to the majority of weight loss clients. Many exercise practitioners today use more resistance training-based weight loss programs that focus on increasing muscle mass and post-exercise energy expenditure, which can be measured as excess post-exercise oxygen consumption (EPOC - the measure of oxygen consumption following exercise that accounts for elevated resting metabolic rate as the body recovers). Exercise sessions that increase EPOC will typically increase the total calorie expenditure for the combination of exercise and recovery.

Resistance training programs have been shown to elicit higher effects on EPOC compared to aerobic exercise (Elliot, Goldberg, & Kueh, 1992; Drummond, Vehrs, Schaalje, & Parcell, 2005). In the past two decades, many exercise specialists have manipulated resistance training modes (circuit, traditional, strength, etc.), volume, and rest intervals in an effort to determine which would have the greatest impact on EPOC. Circuit resistance training with high volume exercise intervals and short rest periods tends to produce higher and longer lasting effects on metabolism (Alcaraz, Gomez, Chavarrias, & Blazevich, 2011; De Deus, et al., 2012;

Kelleher, Hackney, Fairchild, Keslacy, & Ploutz-Synder, 2010; Farinatti & Castinheiras Neto, 2011; Murphy & Schwarzkopf, 1992; Pichon, Hunter, Morris, Bond, & Metz, 1996).

As the use of circuit based resistance training for weight loss has become more commonplace for metabolic acceleration, practitioners have adopted the term "Metabolic Resistance Training" (MRT).Metabolic resistance training refers to circuit resistance training that focuses on increasing EPOC with the use of minimal rest between exercises. The majority of the MRT protocol techniques are fairly consistent except for one aspect: the timing of sets. Over the years, popular fitness magazines and authors have promoted timed sets with little research to support this practice (Dos Remedios, 2009).

At this time, little is known regarding the relative impact on EPOC of timed interval sets and repetition sets, respectively. Obtaining this knowledge would provide practitioners with the information necessary to create a more effective weight loss program for individuals in need of weight reduction. The purpose of this study is to compare EPOC following bouts of timed-based sets of MRT and repetition-based sets of MRT in recreationally active females. We hypothesize that repetitions sets would produce greater effects on EPOC due to the ability of being able to calculate the amount of volume prior to the exercise session.

CHAPTER 2

METHODS

Participants

Ten healthy females at a mean age of 23 (± 3.63) years, height 64 (± .1927) inches and at a body mass of 154 (± 16.303) lbs were recruited through the use of flyers placed around campus and the Student Recreation Center. Participants had been recreationally active for at least one year and familiar with resistance training exercise (free weights and resistance machines). Participants exercise history was determined by a self-reported exercise habits questionnaire that was provided prior to the first testing session. Participants who reported any metabolic disorder, cardiovascular disease, pulmonary disease, physical limitations, or use of nicotine products were excluded from the study (Melanson et al., 2005). Participants signed an informed consent form prior to participation and the study protocol that was approved by the Southern Illinois University Carbondale Human Subjects Committee.

Experimental Protocol

A within-subject experimental design was used to assess the effect of the two MRT protocols on EPOC. Each participant visited the lab on three separate occasions with two to seven days between each testing day. Resting measurements (resting metabolic rate, height, and weight), 24 hour dietary recall, and 10 repetition max (10RM) for Smith machine squat, bent over row, Romanian deadlift, and bench press were determined during the first testing session (Crommett, & Kinzey, 2004; Melanson et al., 2005; Farinatti, Silva, & Monteiro, 2013). For the 10RM test, participants performed a warm-up set of each exercise. Participants rested for one minute before the first testing set with two minutes rest between each set following. The weight increased with each set until the 10RM was reached. The exercise order used for the first session was maintained for all the testing sessions.

Two to seven days later, participants completed one of the two MRT protocols (time or repetition; Thorton, Rossi, & McMillan, 2011). Participants were split randomly into two groups in order to facilitate the use of a counter-balanced design: Group A performed the time-based condition protocol during testing session two and then the repetition sets protocol during testing session three. Group B completed the protocols in the opposite order. Participants were advised to continue with their normal activity routine leading up to 24 hours before the testing day (including structured exercise). For the 24 hours prior to testing, participants were asked to refrain from caffeine and structured exercise.

The repetition-set testing condition consisted of three sets of the four exercises described above in the order of lower body, then upper body exercise, and agonist then antagonist muscle groups (Kelleher, Hackney, Fairchild, Keslacy, & Ploutz-Synder, 2010). Participants performed ten repetitions per exercise at a tempo of one second eccentric phase, one second pause, and one second concentric phase (Thornton, Rossi, & McMillan, 2011). The load for each exercise was placed at the participants 10RM (70% of 1RM) with a rest period of 20 seconds between exercises and 90 seconds between sets (De Deus, et al., 2012; Farinatti & Castinheiras Neto, 2011).

The time-based condition consisted of three sets of the four exercises described above. The load for each exercise was placed at the participants 10RM (70% of 1RM) with a rest period of 20 seconds between exercises and 90 seconds between sets (De Deus, et al., 2012; Farinatti & Castinheiras Neto, 2011). The participants performed each exercise for 30 seconds with the instruction to perform every repetition in a controlled manner. Repetitions were counted during the timed interval condition to compare the volume between the two conditions.

Participant's metabolic rate was tested prior and following the final third set of each testing session (described below). They sat quietly for 30 minutes prior to each testing session and VO_2 data collection began in the last 15 minutes of the 30 minute period. VO_2 readings were collected for 24 minutes immediately following the final third set of both testing conditions.

Instruments / Apparatus

The participant's VO_2 were tested using KORR™ CardioCoach Plus indirect calorimeter. The CardioCoach Plus measures the volume of air expired and the concentration of oxygen in the inspired and expired air. CardioCoach prototype was first developed in 1989 for National Aeronautics Space Administration as way to test astronaut's cardiorespiratory system. In 1994 KORR™ made the equipment compacted and usable for clinicians and practitioners. 2005 the CardioCoach was validated by an independent organization to accurately measure VO_2 (Dieli-Conwright, Jensky, Battaglia, McCauley, & Schroeder, 2009). CardioCoach Plus has a galvanic fuel cell oxygen sensor and a fixed-orfice differential pressure pneumotach air flow senor. The manufactures specification states the oxygen sensor has an accuracy of ±0.2%, a resolution of 0.01%, and was a range 0 to 30%. The manufactures specification states that the air flow sensor has an accuracy of ±2%, resolution 0.01 lpm, range -40 to 150 lpm, and a breath rate 5 to 40 breaths/minute. A Polar Heart Rate Monitor was used in conjunction with the metabolic cart to record heart rate.

Data Collection/Analysis Procedures

Data were summarized in session means with variance presented as standard deviation. Independent sample t-test was performed to compare the mean difference in volume, post testing conditions, and pre-test condition. One-way analysis of variance (ANOVA) were conducted on the pre-test and RMR to adjust for any difference in individual metabolic rate. ANOVA was also used every fifteen seconds for the first ten minutes to compare the difference in EPOC between the timed based set, repetition set condition and the control (RMR) session. To control for type one error on the EPOC ANOVA test, the Holm's sequential Bonferroni correction procedure was used (Hunter, Seelhorst, & Snyder, 2003; Thorton, Rossi, & McMillan, 2011).

CHAPTER 3

RESULTS

RMR/Volume

Participants RMR was collected during the first testing session and used as the control to compare to pre-testing condition fluctuations in metabolism and post-test measurements. The resting VO_2 was 3.4170 ml/kg/min (± .7146) and resting heart rate (RHR) was 65 (± 6.21) beats per minute. When comparing total volume (repetition x total weight) between the repetition set testing condition and the timed set testing condition, no significant difference was noted ($P= .962$ (2 tailed)). The repetition condition had a volume of 9495 (± 1022.76). The timed set condition had a volume of 9463.5 (± 1814.51) (See Table 1).

Pre-Test

ANOVA test indicated that there were no fluctuations in VO_2 when comparing the initial resting values with the resting measurements taken on the two different condition days ($F = .247$; sig = .787). Independent sample t-test showed no significant difference between the VO_2 values recorded at rest during the repetitions testing condition and the timed set testing condition. The repetition condition has a resting VO_2 of 3.505 ml/kg/min (± .573) and timed set condition was 3.602 ml/kg/min (± .5109).

Post-Test

In the two conditions, VO_2 and HR were significantly different from the resting control (RMR) for the first seven minutes. ANOVA results showed post-test VO_2 and HR were not significantly different between the two conditions. Despite the fact that at 7:45 min/sec, $F=3.254$: ($P=.05$) and at 8:30 min/sec $F = 4.61$ ($P=.016$), Holm's sequential Bonferroni correction test reported a type one error with VO_2. The false positive indicates that these values were not significantly different from the control (see Figure 1). Independent sample t-testing on the two testing conditions showed no significant difference (sig. (2-tailed) .973; 95% con = -.5493). Repetition set condition EPOC was 5.13 ml/kg/min (± .59914) and HR of 95.26 (± 19.08). Timed set condition EPOC was 5.1290 ml/kg/min (± .5893) and HR 95.311 (± 14.259). The mean values are comprised from the total time of 24 minutes even though VO_2 started to return to a resting state at 7:45 min/sec. Net mean values for VO_2, HR, volume, and EPOC are presented in Table 1.

Figure 1. Comparison of EPOC of the first ten minutes

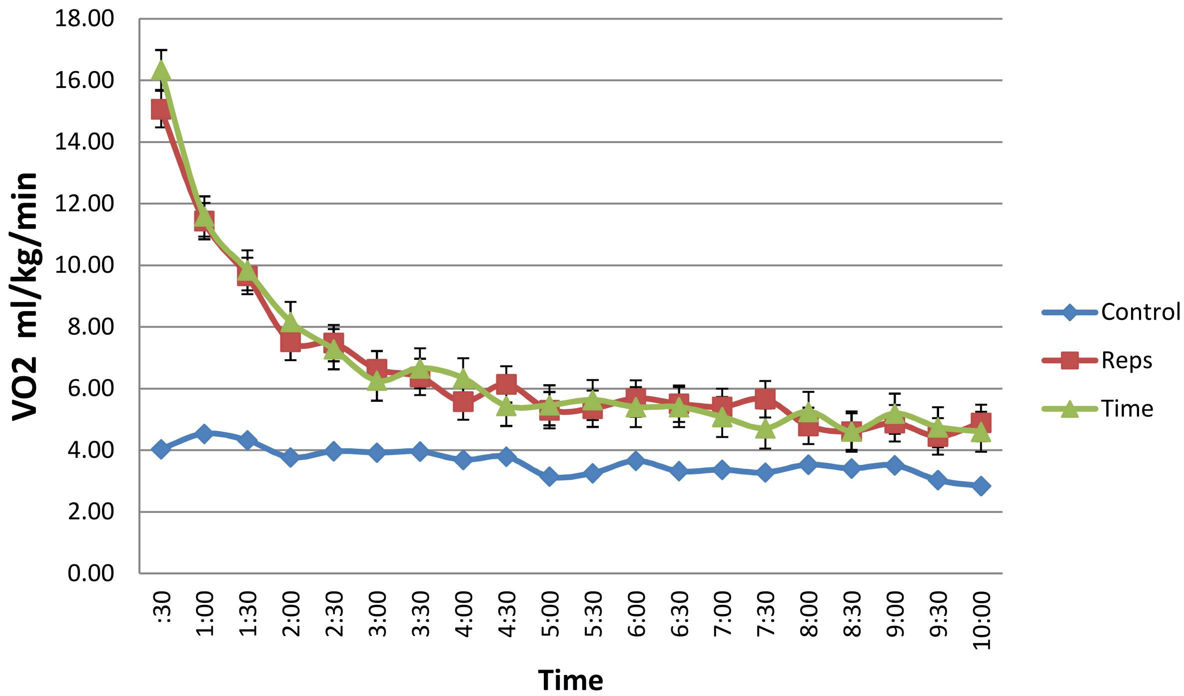

Table 1. VO_2, EPOC, Volume & HR mean for CN, Timed, and Rep.

	VO_2	HR	Volume	EPOC
CN	3.417 ml/kg/min (± .7146)	65 (± 6.21)	--	--
Pre-test Rep	3.505 ml/kg/min (± .573)	--	--	--
Pre-test Timed	3.602 ml/kg/min (± .5109)	--	--	--
Post-test Rep (24 min duration)	--	95.26 (± 19.08)	9495 (± 1022.76)	5.13 ml/kg/min (± .59914
Post-test Timed (24 min duration)	--	95.311 (± 14.259)	9463.5 (± 1814.51)	5.129 ml/kg/min (± .5893)

CN= Control; HR = Heart Rate; EPOC = Excess Post Exercise Consumption; Rep = Repetition set condition; Timed = Timed set condition. Values are mean ± SD.

CHAPTER 4

DISCUSSION

The small difference in pre-testing and RMR testing condition indicate small fluctuation in metabolism between the three measurement sessions (not statistically significant, however). Mean volumes in both the repetition and timed set conditions were almost identical. The effect of both testing conditions on EPOC was very similar, and VO_2 returned to a resting state at relatively the same time, as well. Although VO_2 returned to a resting state within the 24 minutes, heart rate stayed above resting throughout the whole post-test measurement; however the heart rate values were similar for both conditions. Future studies may want to incorporate blood samples to examine post-exercise metabolism more precisely.

Comparing the data on the two testing conditions showed that neither condition is the superior form of MRT in terms of a greater generation of caloric burn post exercise. An examination of Figure 1 reveals no significant difference in mean EPOC between the two conditions. Previous research have used two separate exercise protocols such as traditional strength training with long rest periods vs. circuit weight training with short rest periods which accounted for two different effects on EPOC. In this study, the protocols were almost identical and as discussed earlier, the fact that volume was so similar between the two conditions and the rest interval were identical may have contributed to the lack of difference in EPOC values. Other studies have also used different exercises modalities such as exercise machines (leg press, leg curl) and power exercise (power clean) which may have contributed to the their longer effects on EPOC. Using exercise machines such as leg press allows individuals to produce greater volume with higher loads and power exercise recruits more muscles fibers which can cause a higher metabolic demand (Alcaraz, Gomez, Chavarrias, & Blazevich, 2011; Hunter, Morris, Bond, & Metz, 1996).

During the two testing protocols, each individual responded to the conditions differently. Some preferred to have a set goal (10 repetitions) vs. having a set time and vice versa. When prescribing timed sets or repetition sets of MRT for individual exercisers, personal preference should obviously be considered. Taking into account the results of this study, using an exercise protocol that the individual enjoys and can be consistent with may be the more important factor to consider. Practitioners should determine the format (repetition or timed set) that their clients they prefer and utilize that protocol (Ekkekakis, Lind, & Vazou 2009). Including the client in the exercise format decision making process is a sound strategy for increasing adherence that is all too often ignored by personal trainers.

Limitations

One of the limitations of this study was the diameter of the bar on the Smith machine, which may have posed a grip challenge for some of the participants with smaller hands. The Smith machine is older and has lost some of the surface that aids in increased friction between the bar and the participants' hands. Some of the subjects had to reposition their grip in the middle of the sets which could have prevented them from achieving more repetitions. Unfortunately, this effect was not noted accurately by the researcher, so we can only speculate on the impact that it may have had on the results.

Another limitation was not controlling for the phases of menstrual cycle and oral contraceptives. This factor may have had an effect on metabolism (Melanson et al., 2005). Since there was no fluctuation in resting VO_2 on the three testing days, it is assumed that this limitation likely had minimal effects; however future studies with larger sample sizes may want to control for these factors in order to continue to minimize fluctuations in both resting and post-exercise VO_2. We chose to not control for these factors due to the small size of the subject pool that we had access to for the study, but larger studies may not have this concern.

Conclusion

Based on the results of the study, repetition set metabolic resistance training and timed set metabolic resistance training produce similar effects on EPOC. Because both were similar, either will be beneficial to use in a weight loss program. When choosing which protocol to follow, practitioners should include the client’s preference, doing so will help ensure adherence to the program.

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