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One-set resistance training elevates energy expenditure for 72 h similar to three sets

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Abstract

To compare the effects of an acute one versus three-set full body resistance training (RT) bout in eight overweight (mean $\pm$ SD, BMI = 25.6 ± 1.5 kg m⁻²) young (21.0 ± 1.5 years) adults on resting energy expenditure (REE) measured on four consecutive mornings following each protocol. Participants performed a single one-set or three-set whole body (10 exercises, 10 repetition maximum) RT bout following the American College of Sports Medicine (ACSM) guidelines for RT. REE and respiratory exchange ratio (RER) by indirect calorimetry were measured at baseline and at 24, 48, and 72 h after the RT bout. Participants performed each protocol in randomized, counterbalanced order separated by 7 days. There was no difference between protocols for REE or RER. However, REE was significantly ($p < 0.05$) elevated ($\sim 5\%$ or ~ 400 kJ day⁻¹) in both the protocols at 24, 48, and 72 h post RT bout compared with baseline. There was a no change in RER in both the protocols at 72 h compared to baseline. A one-set RT bout following the ACSM guidelines for RT and requiring only ~ 15 min to complete was as effective as a three-set RT bout (~ 35 min to complete) in elevating REE for up to 72 h post RT in overweight college males, a group at high risk of developing obesity. The one-set RT protocol may provide an attractive alternative to either aerobic exercise or multiple-set RT programs for weight management in young adults, due to the minimal time commitment and the elevation in REE post RT bout.

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Conflict of interest None.

Keywords

Strength training; Resting energy expenditure; Ratings of perceived muscle soreness; Postexercise metabolism

Introduction

Resting energy expenditure (REE) accounts for approximately 60–75% of an individual's daily energy expenditure (Dolezal and Potteiger 1998; Hunter et al. 2000; Lemmer et al. 2001; Pratley et al. 1994). Determining modalities that increase REE is important as small perturbations in REE can have a significant impact on the regulation and maintenance of body weight (Dolezal and Potteiger 1998; Hunter et al. 2000; Lemmer et al. 2001; Pratley et al. 1994). Unlike aerobic exercise, which results in significant increases in energy expenditure during, and for a short time following cessation of the activity, the energy expenditure during resistance training (RT) is relatively low (Melby et al. 1993; Phillips and Ziuraitis 2003), but the increase in energy expenditure after the cessation of the activity and between RT session may be elevated (Dolezal et al. 2000; Melby et al. 1993; Taaffe et al. 1995).

Studies investigating an acute bout of a multiple-set (3–8 sets) RT session on REE have found significant elevations in REE ranging from 14.5 to 72 h post RT (Dolezal et al. 2000; Gillette et al. 1994; Jamurtas et al. 2004; Melby et al. 1993; Schuenke et al. 2002). However, these RT protocols may not to be easily adopted as higher volume; multiple-set RT programs may not be attractive or adhered to by sedentary overweight individuals in need of weight management. Therefore, understanding the effects of a single-set RT program as currently recommended (Haskell et al. 2007) by the American College of Sports Medicine (ACSM, one set of 8–12 repetitions for 8–10 exercises) on elevating REE compared to multiple-set RT program may provide insight into the dose–response effect of RT on REE. In addition, since the ACSM and many other health organizations (Conley and Rozenek 2001; Haskell et al. 2007; Jakicic et al. 2001; Pollock et al. 2000) recommend performing RT sessions 48–72 h apart, it is important to determine how long the elevation in REE may last in order to provide recommendations on the frequency of performing the RT session if an elevation in REE to aid weight management is desirable. However, to our knowledge, no studies have compared the dose–response effect of a low volume versus high volume acute full body RT bout using serial measures of REE.

The purpose of this investigation was to compare the effects of an acute, low volume [ACSM recommended, 1 set, 10 exercises, 10 repetition maximum (RM)] full body RT session compared to a high volume (3 sets, 10 exercises, 10 RM) full body RT session in sedentary young adults on REE using indirect calorimetry measured 24, 48, and 72 h after the RT session. We hypothesized that REE will be significantly greater at 24, 48, and 72 h in the high volume RT protocol compared to the low volume RT protocol.

Subjects and methods

Participants/design

Ten young untrained adult males volunteered to participate in this study after providing written informed consent. Potential participants who used tobacco products, had a history of chronic disease (i.e., diabetes, heart disease, etc.), elevated blood pressure ($>140/90$ mmHg), lipids (cholesterol >240 mg L⁻¹; triglycerides >500 mg L⁻¹) (Eyre et al. 2004), fasting glucose (>126 mg dl⁻¹) (Grundy et al. 1999) or were physically active ($>2,100$ kJ week⁻¹ on the Minnesota Leisure Time Physical Activity Questionnaire (Richardson et al. 1994)

were excluded from the study. Participants were instructed to maintain their normal ad libitum diet and normal activities of daily living but to abstain from any exercise outside the protocol of the study. Two participants failed to complete the study protocol due to academic obligations. The participant characteristic of the eight participants who completed the study can be found in Table 1. REE, substrate oxidation, and dietary assessment were assessed at baseline, 24, 48, and 72 h after a single bout of a one-set and three-set supervised RT program following the ACSM's Guidelines for Resistance Training (Haskell et al. 2007). Participants performed both protocols in a randomized counterbalanced order 7 days apart. The study protocol was approved by the Institutional Review Board at Southern Illinois University, Edwardsville.

Procedures

Familiarization to RT testing—One week prior to beginning the protocols, participants came to the Exercise Physiology Lab for a familiarization session. The familiarization session was performed by each participant to teach proper form for each RT exercise, teach how the circuit was to be performed, and to allow them to become familiar with wearing the portable Cosmed k4b (Cosmed USA Inc., Chicago, IL, USA) while testing. The familiarization session consisted of the participant performing ten repetitions of each of the ten separate exercises at 50% of their estimated ten repetition maximum (10 RM). The exercises targeted all the major muscle groups as recommended by the ACSM (Haskell et al. 2007) and include the leg press, leg curl, calf raise, bench press, lat pull-down, shoulder press, biceps curl, triceps extension, abdominal crunch, and back extensions. RT was performed using Paramount weight stack resistance equipment (Paramount Fitness Corporation, Los Angeles, CA). The ten exercises were divided into three circuit rotations each consisting of three or four different exercises. Rotation one consisted of the leg press, bench press, and leg curl exercises. Rotation two consisted of the lat pull-down, calf raise, and shoulder press exercises. Rotation three consisted of the biceps curl, triceps extension, abdominal crunch, and back extension exercises. We chose the exercises in this order based on the ACSM recommendation to perform RT using large muscle groups followed by accessory muscles (Haskell et al. 2007). Rotation one was completed before moving to rotation two, which was completed before moving to rotation three. The participants were allotted 30 s of rest between each set in each rotation. A 4-min rest was allotted between each rotation. All lifts were conducted at 2-s concentric and 4-s eccentric movements (Pollock et al. 2000) to decrease the likelihood that momentum was being used to perform the lift and to ensure loading throughout the full range of motion. To keep the participants performing the exercise at the recommended speed a digital metronome (Korg KDM-2, China) was used during the workout. Every time the metronome beeped the participant performed the corresponding concentric or eccentric (up or down) movement. A stopwatch (CAL.WO73, Seiko S-Yard Co., LTD, China) was used to record the rest times between sets and rotations. While the participant was performing the familiarization session they were required to wear the Cosmed K4b2 to get used to wearing the device while exercising. The machine was on and running but since the familiarization session was a walk through, the data collected were not used.

(10RM) strength testing—Forty-eight hours after the familiarization period participants reported to the Exercise Physiology Lab to determine 10 RM for each of the ten exercises described above. Strength testing was conducted using the same order of exercises described previously. The strength testing protocol consisted of one warm-up set of ten repetitions using 50% of the participants predicted 10 RM. After a 1-min rest the participants attempted their 10 RM using an estimated weight. If more or less than ten repetitions were performed then the weight was adjusted accordingly and after another 1-min rest the participants

attempted their 10 RM once again. This was repeated for every exercise until their 10 RM was determined. Each participant determined their 10 RM within three attempts.

Resistance training protocols—Seven days after the 10 RM strength assessment each participant reported to the Exercise Physiology Laboratory in the morning after an overnight fast. After REE and substrate oxidation [expressed as respiratory exchange ratio (RER)] were measured participants performed either the one-set or three-set protocol in a random counterbalanced order as described above. Participants returned exactly 24, 48, and 72 h after the RT session to measure REE and RER. Four days after the 72 h measures (i.e., 7 days after performing one of the two RT protocols) participants were again assessed for REE and RER before performing the other RT protocol. Participants then returned exactly 24, 48, and 72 h after the RT session to measure REE and RER. Throughout the testing period, participants were instructed to maintain their activities of daily living and not to perform any exercise outside the prescribed RT for the study.

Assessments

Body mass/BMI—Body mass was assessed between the hours of 7 and 9 a.m. using a digital scale accurate to ± 0.1 kg (Befour Inc., Model #PS6600, Saukville, WI). The participants were weighed prior to breakfast and after attempting to void and wore a standard hospital gown at the time of weighing. Height was assessed using a wall-mounted stadiometer (Model PE-WM-60-84, Perspective Enterprises, Portage, MI). BMI was calculated as weight (kg)/height (m^2).

Body composition—Fat-free mass (FFM), fat mass (FM), and percent body fat were assessed using dual energy X-ray absorptiometry (DXA—Lunar DPX-IQ, Madison, WI). DXA exams are performed during the morning with the participants clothed in a hospital gown. DXA is capable of detecting changes in fat-free mass of approximately 1.6–3.8% (Kohrt 1998).

REE and RER—The participants reported to the laboratory in the morning for the measurement of REE and RER, having refrained from food or any liquids except water for 12 h. After entering the laboratory the subjects rested supine for 20 min prior to data collection without wearing the hood. REE and RER were determined using a ventilated canopy hood system and a ParvoMedics' TrueOne® 2400 (Parvo-Medics', Sandy, UT) metabolic cart calibrated according to the specifications of the manufacturer. Each REE test involved for 30 min of measurement. The first 5 min of data collection were discarded while the last 25 min of data were averaged to determine REE. Oxygen consumption and non-protein RER values obtained during the REE were used to determine substrate oxidation (Jequier et al. 1987). Calibration of the ParvoMedics' TrueOne® 2400 was performed prior to each study according to the manufacturer's guidelines. Coefficients of variation (CV) for REE and RER were 2.1, and 1.9, respectively. The testing room was kept at a standard room temperature of 22°C, with light turned off during testing, with only the investigator and participant. The temperature and surroundings for the participant were the same for both protocols to avoid any effect the environment could have had on the participant.

Energy expenditure during the RT session—Energy expenditure during the RT protocol sessions (RTEE) was measured using a previously validated, portable, open-circuit indirect calorimetry system (Cosmed K4b2, Cosmed USA Inc., Chicago, IL, USA) that measures breath-by-breath ventilation, expired oxygen, and carbon dioxide (McLaughlin et al. 2001). The Cosmed was turned on 30 min prior to calibration according to manufacturer specifications. After 30 min the calorimeter was calibrated with known gases. The flow turbine was calibrated using a 3.00-L syringe. During the RT bout, the participant breathed

into a face mask that directed air into the unit housing the O₂ and CO₂ gas analyzers. The lightweight (~ 1.5 kg) portable system was attached by a harness around the chest and shoulders of the participant while the participant performed the RT exercises. The data were retrieved for analysis via serial port interface and software provided with the calorimeter. Calorimeter data were reduced to 20-s epochs, and the average values were reported. RTEE was calculated with EE estimated using the equations provided by the World Health Organization (1958). All participants were assessed with the same calorimeter. A coefficient of variation for RTEE using the Cosmed K4b2 was 2.6.

Energy expenditure by accelerometer—Participants wore an ActiGraph Model GT1M (ActiGraph, LLC, Pensacola, FL) the day before the RT bout and the subsequent 72 h for each protocol. The AC is small ($5.1 \times 3.8 \times 1.5$ cm), light weight (42.6 g), and powered by a 2430 lithium coin cell battery. One AC was used for all participants in this study. The AC was factory calibrated before the start of the study. The participants were instructed to wear the accelerometer around their waist and to only remove the accelerometer when they showered or were sleeping, to avoid damaging the device. Data were collected in 1-min epochs and retrieved for analysis via a coded infrared beam of light via a PC reader interface unit connected to a serial port interface and software provided with the AC. Energy expenditure per day was estimated from AC data (counts per minute) and body mass using the regression equation provided with the AC. After data collection, the AC used was checked against four ActiGraphs that had been previously calibrated using a standardized treadmill walking protocol. The AC used in this study was found to be within 10% of the counts per minute average obtained from the four ActiGraphs used as the standard.

Rating of perceived muscle soreness—After each REE measurement (i.e., 0, 24, 48, and 72 h), participants rated their overall muscle soreness using a self-reported RPMS scale ranging from 0 to 6 (Dolezal et al. 2000; Hackney et al. 2008). Each number corresponded to a description of soreness. Scores were calculated using the following description: 0 = no soreness, 1 = dull feeling of soreness, 2 = light continuous soreness, 3 = more than light soreness, 4 = annoying soreness, 5 = severe soreness, and 6 = intolerable soreness. Participants were also allowed to score in half-point increments.

Dietary records—The participants were required to keep daily food records throughout the study. They were instructed to maintain their normal diet, be as detailed as possible (including brand name of food, serving size, etc.), and to record everything they consumed, except water. To promote accurate reporting of portion sizes, subjects were given 3-dimensional food models (Gibson 1990). Nutrient calculations were performed using the Nutrition Data System for Research software (Version 4.03, Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN, Food and Nutrient Database 31, released 2000).

Statistics and data analysis—A two-factor (protocol $\times$ time) repeated measures (time) analysis of variance (ANOVA) was used for main effects. If there was a significant interaction effect of group or time, we employed the Tukey post-hoc test. Statistical significance was defined at $p < 0.05$ for all tests. All values are expressed as mean $\pm$ standard deviation (SD). Data were analyzed using SAS (9.2, Cary, NC).

Results

Eight overweight Caucasian male adults completed the study and all assessments (Table 1). Adherence to the set RT protocol was excellent with participants completing all of the total prescribed exercises. The average time to complete the one-set protocol (16.4 ± 0.6 min) was significantly ($p < 0.001$) less compared to the three-set protocol, 36.7 ± 1.4 min. As

expected, the average volume for the one-set protocol ($4,601 \pm 555$ kg) was significantly less ($p < 0.001$) compared to the three-set protocol, $13,386 \pm 1,650$ kg. No major adverse events occurred during the study. There was no difference between subjects who dropped out of the study ($N = 2$) and those who completed the study for BMI or age.

Energy expenditure during resistance training bout

Performing the three-set protocol burned a significantly ($p < 0.001$) greater amount of energy (849 ± 134 kJ) during the RT bout compared to the one-set protocol (283 ± 38 kJ).

REE

There were no protocol by time interactions for REE expressed in absolute ($p = 0.64$) amounts or adjusted for FFM ($p = 0.61$). However, within protocols, both the one-set and three-set protocols were significantly elevated for REE expressed in absolute amounts at 24 h post (1 set, $p = 0.003$; 3 set, $p = 0.048$), 48 h post (1 set, $p = 0.024$; 3 set, $p = 0.008$), and 72 h post (1 set, $p = 0.001$; 3 set, $p = 0.01$) compared with baseline (Fig. 1). In addition, within protocols, both the one-set and three-set protocols were significantly elevated for REE expressed per kilogram of FFM at 24 h post (1 set, $p = 0.006$; 3 set, $p = 0.048$), 48 h post (1 set, $p = 0.034$; 3 set, $p = 0.011$), and 72 h post (1 set, $p = 0.001$; 3 set, $p = 0.002$) compared with baseline (Fig. 2). The average percentage increase in REE in absolute amounts from baseline to the 72-h period was 5.2% for one set and 4.6% for three set. REE expressed per kilogram of FFM increased 5.5% for one set and 4.6% for the three set, respectively (Figs. 2, 3).

Substrate oxidation

There were no protocol by time interactions for RER ($p = 0.33$). Although not significant there were similar reductions ($\sim 5.0 \pm 3.2\%$) in RER from baseline to 72 h of -0.3 ± 0.09 in the one-set protocol ($p = 0.17$) and three-set protocol, -0.3 ± 0.09 , $p = 0.32$.

Energy expenditure by accelerometer

There was no significant ($p > 0.05$) protocol by time interactions therefore, the data were collapsed. There was no significant change ($p > 0.05$) in energy expenditure of physical activity from baseline ($2,310 \pm 638$ kJ day⁻¹) to 72 h post ($2,018 \pm 585$ kJ day⁻¹).

RPMS

There was a significant protocol by time interactions for RPMS ($p = 0.009$). There was a significant difference between protocols at 24 h post ($p = 0.048$) and 48 h post ($p = 0.016$), but not 72 h post ($p = 0.083$). Within protocols, the one-set protocols was significantly elevated only at 24 h post ($p = 0.001$) but not 48 h post ($p = 0.242$) or 72 h post ($p = 0.624$) compared to baseline. In contrast, there was a significant elevation in RPMS at 24 h post ($p < 0.0001$), 48 h post ($p = 0.008$), but not 72 h post ($p = 0.1336$) compared to baseline.

Dietary intake

There were no differences in reported dietary intake (total energy, carbohydrate, fat, and protein) within or between protocols during the study. For the one-set protocol, the mean intakes for total energy, and percent of dietary carbohydrate, fat, and protein were $9,689 \pm 1,572$ kJ day⁻¹, $51.8 \pm 1.9\%$, $31.8 \pm 3.4\%$, and $16.4 \pm 2.9\%$, respectively. For the three-set protocol, the mean intakes for total energy, and percent of dietary carbohydrate, fat, and protein were $9,816 \pm 550$ kJ day⁻¹, $52.8 \pm 3.6\%$, $31.4 \pm 3.3\%$, and $15.0 \pm 2.1\%$, respectively.

Discussion

To our knowledge, this is the first study to compare the effects of an acute, full body RT bout comparing the ACSM recommended one-set protocol versus a three-set protocol in overweight college-aged males using serial measures of REE. Results indicated that both the RT protocols elevated REE by ~ 420 kJ (6%) after 24 h in absolute and relative to fat-free mass and this elevation was maintained in both protocols for 72 h post RT bout.

The results of this investigation support the current ACSM recommendation for RT, which is one set of eight to ten exercises focusing on the major muscle groups (Haskell et al. 2007). Although this recommendation is most often cited for overall muscular fitness, the fact that a single set can elevate REE for 72 h may be an important modality for weight management. It is important to note that studies investigating an acute bout of a multiple-set (3–8 sets) RT session on REE have found significant elevations of ~ 7% in REE ranging from 14.5 to 72 h post RT (Dolezal et al. 2000; Gillette et al. 1994; Jamurtas et al. 2004; Melby et al. 1993; Schuenke et al. 2002). However, unlike the current study, the design of these RT studies may be difficult to follow by the general public since a high set number (3–8 sets) and a longer time to complete the RT session (60 min) may not be desirable. In addition, the fact that the RPMS was significantly elevated only for the first 24 h in the one-set protocol compared to 48 h in three-set protocol may be important when attempting to have sedentary individuals adopt a RT program. Therefore, the current study suggests that a one-set protocol is as effective in elevating REE up to 72 h compared to a three-set protocol and the duration and extent of perceived soreness was significantly less in the one-set protocol. These factors may be important when considering the use of RT as a modality for weight management, in particular, overweight college-aged males who are at great risk for developing obesity (Haskell et al. 2007).

The importance of increasing REE may be with the interaction between REE and energy balance. Increasing REE sufficiently could possibly result in a negative energy balance that could prevent an increase in fat mass. Our findings suggest that a one-set RT protocol following the ACSM guidelines for RT (Haskell et al. 2007) can sufficiently elevate REE similar to a three-set RT protocol. The increase in energy expenditure that was achieved in both the one- and three-set protocol increased REE (420 kJ) to a level that reduced the positive energy balance of ~ 420 kJ day⁻¹ that has been proposed to be associated with weight gain in 90% of the population as proposed by Hill et al. (2003). This is particularly important in weight management programs, in which a one-set RT protocol lasting 15 min can be utilized to raise REE to an adequate level to prevent increases in fat mass. In fact, the elevation in REE that was measured following the one-set protocol was achieved by RT lasting only 15 min compared to the 35 min of RT for the three-set protocol. Since lack of time is often cited as a barrier to exercise, the fact that a RT bout that takes ~ 15 min to perform and can elevate REE for 72 h may be advantageous for overweight individuals at risk of developing obesity. It is important to note that during the RT bout, the participants had a three-fold increase in energy expenditure when they performed the three-set protocol relative to the one-set protocol. The three-fold disparity in energy expenditure during the RT bout itself is the difference between losing one kilogram in a month and losing half a kilogram in a month and a half. Therefore, for individuals with more time, the three-set protocol may result in greater overall energy expenditure.

The ~ 6% increase in REE are in agreement with other studies using single (Lemmer et al. 2001; Pratley et al. 1994) and multiple (Byrne and Wilmore 2001; Dolezal and Potteiger 1998; Hunter et al. 2000) sets over 8–26 weeks. Increases in REE are most often attributed to increases in FFM. However, since energy expenditure was measured after only a RT session, changes in FFM are highly unlikely. It is important to note, however, that even after

adjusting for FFM, REE increased significantly in both protocols after 24 h and was maintained for 72 h. However, the fact that REE increased as a result of RT after adjustment for FFM, suggests that other factors may also be contributing to the increase. Within the first 24 h, mechanisms associated with the rapid and slow components of excess post exercise oxygen consumption may have contributed to an immediate elevation (Borsheim and Bahr 2003). These factors include elevated body temperature, resynthesis of glycogen from lactate, ion redistribution, replenishment of oxygen stores in blood and muscle, resynthesis of adenosine triphosphate and creatine phosphate, circulation and ventilation, and residual hormone effects (Bahr 1992; Bangsbo et al. 1990; Borsheim and Bahr 2003). However, it seems that these processes are associated with temporary elevations and do not explain prolonged REE elevations observed beyond 24 h post exercise (Bahr 1992; Bangsbo et al. 1990; Borsheim and Bahr 2003). For, example, although not measured in this study, myofibrillar protein turnover (Kim et al. 2005) could increase REE and has been shown to account for as much as 20% of REE (Welle and Nair 1990). In addition, sympathetic nervous system activity may be related to changes in REE. For example, low volume RT has been shown to increase muscle sympathetic nerve activity (Pratley et al. 1994) and to elevate rates of muscle protein synthesis and breakdown up to 48-h post-exercise. Finally, changes in insulin or IGF-1 may contribute to alterations in the repair and resynthesis of skeletal muscle that may contribute to an elevation in REE beyond 24 h (Nindl et al. 2009). Further, study is warranted to elucidate the mechanisms associated with increases in REE due to RT.

It is important to note that the strength of this study was the methodology used to measure REE. Haugen et al. (2003) measured the validity of repeated morning REE measurements using the indirect calorimetry hood method as used in the current study. Their results indicate that consecutive REE measurements in the morning were stable, highly correlated, and not statistically different from each other. Also, we measured energy intake during the 2 weeks, the participants were being studied and found no changes or differences in energy intake or macronutrient consumption. We also provided a familiarization session to reduce any affect that a learning effect may potentially have had on REE (Hackney et al. 2008). The fact that the energy expenditure of physical activity measured using accelerometers did not change across the 72 h in both protocols indicates that the participants maintained their normal activities of daily living. Finally, there was no difference at baseline between protocols indicating that the 7 days between performing the RT bouts was sufficient to allow for REE to return to baseline. Taken together, we believe the increases in REE occurred as a result of the full-body resistance training protocols and not due to measurement error or changes in energy balance by the participants.

In conclusion, our investigation found a single-set RT bout using the ACSM guidelines that was as effective as a three-set RT bout in elevating REE for up to 72 h post RT in overweight college males, a group at high risk of developing obesity. The increase in REE by $\sim 420 \text{ kJ day}^{-1}$ may eliminate the positive energy balance that has been proposed to be associated with weight gain in 90% of the population. Furthermore, this does not take into consideration the energy expended during the resistance training session itself that may also occur on the same day or in the days after as part of an exercise program. Likewise, the one-set RT protocol may provide an attractive alternative to either aerobic exercise or multiple-set RT programs for weight management in busy young adults, due to the minimal time commitment. Studies with larger samples of both men and women are needed to assess potential gender differences in the energy expenditure and substrate oxidation response to the dose-response effects of RT.

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Fig. 1.

Schematic of the exercise and respiratory collection timeline. One- and three-set protocol performed in randomized counterbalanced order. Four days after the 72 h measures (i.e., 7 days or 176 h after performing one of the two RT protocols) participants were again assessed for resting energy expenditure (REE) and resting exchange ration (RER) before performing the other RT protocol

Fig. 2.

Absolute change in resting energy expenditure (REE) in response to an acute, full body one-set and three-set resistance training protocol. Values are mean $\pm$ SD. *Significantly different from 0 h within protocol, $p < 0.05$

Fig. 3. Relative change in resting energy expenditure (REE) adjusted for fat-free mass (FFM) in response to an acute, full body one-set and three-set resistance training protocol. Values are mean $\pm$ SD. *Significantly different from 0 h within protocol, $p < 0.05$

Table 1

Participant characteristics

Variable	Mean $\pm$ SD
Age	21.0 $\pm$ 1.5
Weight (kg)	91.4 $\pm$ 8.6
Height (cm)	175.9 $\pm$ 5.4
BMI (kg/m ²)	25.6 $\pm$ 1.5
Body fat (%)	29.1 $\pm$ 2.2
Fat mass (kg)	22.2 $\pm$ 2.0
Fat-free mass (kg)	59.0 $\pm$ 2.8

Values are mean $\pm$ SD