RESTING ENERGY EXPENDITURE AND DELAYED-ONSET MUSCLE SORENESS AFTER FULL-BODY RESISTANCE TRAINING WITH AN ECCENTRIC CONCENTRATION

KYLE J. HACKNEY, HERMANN-J. ENGELS, AND RANDALL J. GRETEBECK

Division of Kinesiology, Health and Sport Studies, Wayne State University, Detroit, Michigan

ABSTRACT

Hackney, KJ, Engels, H-J, and Gretebeck RJ. Resting energy expenditure and delayed-onset muscle soreness after full-body resistance training with an eccentric concentration. *J Strength Cond Res* 22(5): 1602–1609, 2008—The purpose of this investigation was to determine the effect of an acute bout of high-volume, full-body resistance training with an eccentric concentration on resting energy expenditure (REE) and indicators of delayed-onset muscle soreness (DOMS). Eight resistance trained (RT) and eight untrained (UT) participants (mean: age = 23.5 years; height = 180.76 cm; weight = 87.58 kg; body fat = 19.34%; lean mass = 68.71 kg) were measured on four consecutive mornings for REE and indicators of DOMS: creatine kinase (CK) and rating of perceived muscle soreness (RPMS). Delayed-onset muscle soreness was induced by performing eight exercises, eight sets, and six repetitions using a 1-second concentric and 3-second eccentric muscle action duration. A two-factor repeated-measures analysis of variance revealed that REE was significantly ($p < 0.05$) elevated at 24, 48, and 72 hours post compared with baseline measures for both UT and RT groups. Ratings of perceived muscle soreness were significantly elevated within groups for UT and RT at 24 and 48 hours post and for UT only at 72 hours post compared with baseline ($p < 0.05$). Nonparametric analyses revealed that CK was significantly increased at 24 hours post for both UT and RT and at 48 and 72 hours post for UT only compared with baseline ($p < 0.05$). Resting energy expenditure and indicators of DOMS were higher in UT compared with RT on all measures, but no significant differences were determined. The main finding of this investigation is that full-body resistance training with an eccentric concentration significantly increased REE up to 72 hours postexercise in UT and RT participants.

KEY WORDS resting metabolic rate, postexercise metabolism, strength training, muscle damage, total daily energy expenditure

Address correspondence to Kyle Hackney, kjhackne@syr.edu.

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INTRODUCTION

Resting energy expenditure (REE) is estimated to account for 60–75% of total daily energy expenditure (17). Studies investigating REE after acute bouts of resistance training have found significant elevations ranging from 14.5 to 48 hours postexercise (10,13,15,18,24). To date, the most prolonged elevation occurred as a result of a single bout of leg press exercise with an eccentric concentration in resistance trained (RT) and untrained (UT) adult men (10). Therefore, the eccentric component of the muscular action may be important when determining the magnitude and duration of the acute increase in REE. Furthermore, the increase in REE using a full-body resistance training protocol with an eccentric concentration remains to be observed.

A further phenomenon that is often reported in the days after resistance training (8,10) and eccentric (10,23) muscular actions is delayed-onset muscle soreness (DOMS). Symptoms of DOMS include mild discomfort or pain, particularly when the muscle is stretched or palpated. Numerous theories have been proposed to explain the discomfort associated with DOMS, including muscle damage, connective tissue damage, inflammation, lactic acid, muscle spasm, and enzyme efflux (8). Typically, DOMS peaks between 24 and 72 hours and gradually disappears within 7 days (1,8). Thus, it has been hypothesized that mechanisms associated with muscle repair during the state of DOMS could potentially result in prolonged elevation of REE (13). However, little information is available concerning the influence of high-volume, full-body resistance training with an eccentric emphasis on REE and indicators of DOMS. Athletes, weightlifters, and bodybuilders may benefit from this knowledge when attempting to estimate the caloric intake required for positive energy balance. In contrast, understanding the increase in REE after high-volume resistance training may have a potentially positive effect in weight-control programs where a negative energy balance is necessary (9).

Therefore, the purpose of this investigation was to determine the effect of an acute bout of high-volume, full-body resistance training with an eccentric concentration on

REE and indicators of DOMS in RT and UT males. We hypothesized that REE and indicators of DOMS would be significantly higher in UT participants after the acute resistance training session. We also hypothesized that both groups would have significant increases in REE and indicators of DOMS beyond 48 hours postexercise.

METHODS

Experimental Approach to the Problem

Participants were tested on four consecutive mornings for REE and indicators of DOMS. Indicators of DOMS included a marker of skeletal muscle damage, creatine kinase (CK), and a subjective rating of perceived muscle soreness (RPMS) measurement. After each of these measures on day one, participants performed a single bout of high-volume, full-body resistance training with an eccentric concentration. During this session, the duration of the eccentric muscle action in all exercises was prolonged (3 seconds) compared with the concentric action (1 second). After each set, participants provided a rating of perceived exertion (RPE) measurement to determine the relative intensity of each set. Total caloric intake was monitored for the 4-day period. Resting energy expenditure, CK, RPMS, RPE, and caloric intake were compared each day to determine differences between UT and RT groups. Within-group changes from baseline to day four were also determined in both groups.

Subjects

Sixteen college-aged men were recruited from athletic teams and university classes to participate in the experiment (Table 1). On the basis of prior resistance training history, participants were categorized into one of two groups: RT and UT. The RT subjects ($n = 8$) were participating in full-body resistance training at least 2 days per week for a minimum of 6 months, and the UT subjects ($n = 8$) had no resistance training experience within the past 6 months or at all. Before any data collection, participants read and signed an informed consent form approved by the institutional review board at the university and completed a health history questionnaire.

TABLE 1. Participant demographics .

	Untrained	Resistance trained
Age (y)	24.25 ± 1.13	22.75 ± 0.88
Height (cm)	181.27 ± 2.16	180.25 ± 2.18
Weight (kg)	95.30 ± 7.70	79.84 ± 2.63
Fat-free mass (kg)	68.82 ± 3.31	68.60 ± 1.01
Body fat (%)	25.27 ± 2.98	13.42 ± 0.86*
Caloric intake (kJ)	7993 ± 753	11884 ± 899*
Fat (%)	38.50 ± 0.02	32.50 ± 0.02*
Cho (%)	41.12 ± 0.01	48.12 ± 0.02*
Pro (%)	17.75 ± 0.01	17.75 ± 0.01

Values are means ± *SE*, $n = 8$ per group.
*Significantly different from untrained, $p < 0.05$.
Cho = carbohydrate; Pro = protein.

Body Composition

Hydrostatic weighing was performed to determine body density on all participants. Weight (kg) and height (cm) was measured using a calibrated standard scale and stadiometer, respectively. Body weight in water was measured using a custom-built underwater weighing tank and calibrated precision load cell (Eaton-Lebow Model 3397, Lebow Products, Troy, Mich) that was interfaced with a laptop computer and Daq Book/2000 Series portable data-acquisition system (IOtech, Cleveland, Ohio) and DaqView (version 7.13.14) data-acquisition and display software. Ten trials were performed to determine underwater water weight (kg). The mean of the heaviest three trials was used to determine body density. Residual volume was measured using oxygen dilution (29). The Brozek et al. (6) equation was used to determine body fat percentage and fat-free mass (FFM).

Dietary Log

Caloric intake was monitored by having each participant keep a 4-day dietary journal. Beginning with the first day of the study, each participant recorded meal time, food description, and amount of each food he ingested during the 4-day period. Additionally, each participant was asked to maintain his normal dietary habits during the course of the testing period. Dietary logs were then analyzed for daily caloric intake and percentage of macronutrients using nutritional dietary-analysis software (Nutritionist V: version 2.2, First Data Bank, Inc.).

Resting Energy Expenditure

Resting energy expenditure was measured on four consecutive mornings (7:00 AM) via indirect calorimetry using a Sensormedics metabolic cart (Vmax series 229). Participants were instructed to get a restful night's sleep (~8 hours) and to refrain from eating or drinking anything but water for 12 hours before the REE measurement. They were asked to discontinue any aerobic or resistance training sessions for 48 hours before the first measure and for the remainder of the study. In addition, they were offered free transportation from home to the research lab or were allowed to drive to the research lab using their own vehicle. These conditions were verified by examining dietary logs and verbal questioning. After verification on each morning, participants rested in a supine position for at least 20 minutes in a quiet, dark, thermoneutral environment before the REE measurement. During this time, participants were instructed to minimize movement and to remain as quiet as possible. After the familiarization period, a hood connected to the indirect calorimetry system was placed over the participant for an additional 30-minute testing period. The metabolic cart was calibrated using gases of known concentration. Resting energy expenditure was extracted by taking the lowest mean value that was consistently measured during a steady state.

Muscle Soreness

After REE measurement, participants rated their muscle soreness using a self-reported RPMS scale (10,23). Ratings of perceived muscle soreness were scored two times using a scale ranging from 0 to 6. Each number corresponded to a description of soreness when a specific muscle group was either palpated by the participant or lightly stretched. 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. The average of the two scores (palpated and lightly stretched) was used as the RPMS for each muscle group (chest, back, shoulders, hamstrings, quadriceps, biceps, and triceps). The mean score of all muscle groups was used for an overall score for RPMS each day.

Creatine Kinase

After RPMS measurement, a resting venous blood sample (~5 ml) was collected from an antecubital vein and analyzed for CK by the university hospital.

Full-Body Resistance Training With Eccentric Concentration

Immediately after CK measurement on day one, participants were transported by vehicle to the department exercise facility. After a 5-minute warm-up on a stationary bicycle, each participant was introduced to the resistance training protocol. Eight sets of six repetitions were performed on eight exercise machines (combination of Paramount, Pyramid, and Trotter machines). Participants were instructed to perform the exercise with an eccentric emphasis using a 1-second concentric and 3-second contraction duration training protocol. Because UT participants were being tested, the first few sets (i.e., 1–3) of each lift were performed with very little weight to allow the participants to become familiar with the exercise machines and to allow both groups to become accustomed to the eccentric concentration. The training session was also arranged into three rotations to help UT participants become familiar and comfortable with the exercise equipment. The details of the high-volume, full-body resistance training protocol, including exercises, sets, repetitions, and rest intervals, are reported in Table 2. After each set, participants subjectively rated the approximate intensity using an RPE Borg CR-10 scale (11). Rating of perceived exertion was rated from 0 to 10, where a verbal assignment of 0 justified no effort (as in resting) and a rating of 10 indicated maximal performance. Ratings of perceived exertion for each exercise were averaged to determine a value of RPE per set. The total duration of the exercise session was approximately 1 hour.

Statistical Analyses

A 2 × 4 (group by time) repeated-measures ANOVA was used to determine significance for REE ($\text{kJ}\cdot\text{kg FFM}^{-1}\cdot\text{d}^{-1}$) and RPMS. Creatine kinase ($\text{U}\cdot\text{L}^{-1}$) was analyzed using a rank-order method for nonparametric statistics (21,26). Where significance was found, the Holm sequential Bonferroni post hoc procedure was used for multiple comparisons for both methods. Participant demographic data including age (years), height (cm), weight (kg), body fat percentage (%), lean mass (kg), caloric intake (kJ), macronutrients composition (%), weight lifted (kg), and RPE were analyzed using independent-sample *t*-tests. Statistics were performed using SPSS (version 13.0), and significance was set at $p < 0.05$. All reported values are means ± standard error (SE).

TABLE 2. Resistance training protocol.*

Rotation 1†	Rotation 2‡	Rotation 3
Chest press	Lat pull-down	Shoulder press
Leg press	Leg curl	Leg extension
Biceps curl	Triceps extension	

*Eight sets, 6 repetitions, 30 seconds rest between sets, and 3 minutes rest between rotations.

†Completed all sets before moving to rotation 2.

‡Completed all sets before moving to rotation 3.

One-second concentric and 3-second eccentric muscle action duration.

RESULTS

Body fat percentage was lower in RT ($p = 0.002$) compared with UT; however, caloric intake per day was significantly elevated in the RT group ($p = 0.005$). The RT subjects also ingested significantly less fat ($p = 0.045$) and more carbohydrates ($p = 0.029$) compared with the UT group. No significant differences were observed in protein intake (Table 1). No significant differences in weight lifted during each set and exercise were observed in the familiarization phase (i.e., sets 1–3) between the UT and RT groups. However, significant differences ($p < 0.05$) in weight lifted on each set and exercise were observed during sets 4–8 (Table 3). Total weight lifted was significantly higher ($p < 0.05$) in the RT compared with the UT group (Figure 1). No significant differences in RPE after each set were reported between the UT and RT groups, and the Pearson correlation was $r = 00.98$ (Figure 2).

Between the UT and RT groups, REE in kilojoules per kilogram of FFM per day did not differ on any day. Within groups, both UT and RT were significantly elevated at 24 hours post (UT; $p = 0.031$; RT, $p = 0.017$), 48 hours post (UT, $p = 0.016$; RT, $p = 0.003$), and 72 hours post (UT, $p < 0.001$; UT, $p = 0.027$) compared with baseline measures (Figure 3). The average percent increase in REE for the 72-hour period was 9.2% for UT and 7.9% for RT.

Creatine kinase levels increased in both groups but were not significantly different between groups at any time point. Within groups, both UT and RT were significantly elevated at

Table 3. Mean weight lifted (kg) per exercise for sets 4–8.

Exercise	Set 4	Set 5	Set 6	Set 7	Set 8	Total per exercise
UT						
Chest press	51.14 ± 6.20	57.10 ± 4.60	62.22 ± 3.91	64.20 ± 4.02	65.05 ± 5.53	299.72 ± 16.76
Leg press	54.83 ± 4.98	63.64 ± 5.63	68.46 ± 5.45	65.90 ± 6.57	74.13 ± 6.28	327.27 ±25.67
Biceps curl	37.78 ± 4.36	39.49 ± 3.95	39.49 ± 3.27	36.93 ± 3.09	36.07 ± 4.24	189.77 ± 16.99
Lat pull-down	48.86 ± 3.51	51.70 ± 3.64	53.40 ± 3.72	52.27 ± 3.54	51.14 ± 3.62	257.37 ± 17.00
Untrained shoulder press	32.67 ± 5.15	33.52 ± 5.40	31.25 ± 5.34	31.25 ± 5.34	29.55 ± 4.95	158.24 ± 24.37
Leg extension	45.45 ± 4.02	51.70 ± 3.42	58.52 ± 3.59	62.50 ± 3.62	67.04 ± 4.09	285.22 ± 15.72
Leg curl	43.75 ± 3.83	48.30 ± 3.09	51.14 ± 3.51	51.14 ± 3.08	52.84 ± 2.97	247.15 ± 14.42
Triceps extension	36.93 ± 4.02	36.93 ± 5.26	36.07 ± 5.60	36.08 ± 5.76	36.08 ± 6.04	182.10 ± 25.25
RT						
Chest press	65.06 ± 4.54	72.72 ± 3.40*	76.14 ± 3.15*	78.69 ± 3.96*	81.25 ± 3.8*	373.86 ± 14.35*
Leg press	72.72 ± 5.15*	85.80 ± 3.54*	95.74 ± 4.06*	95.74 ± 11.95*	114.49 ± 6.75*	464.49 ± 20.08*
Biceps curl	44.60 ± 2.39	47.16 ± 2.50	48.58 ± 4.31	42.90 ± 3.63	39.49 ± 3.95	222.73 ± 15.05
Lat pull-down	56.25 ± 2.57	61.07 ± 2.33*	61.65 ± 3.01	59.36 ± 3.17	57.67 ± 3.40	296.02 ± 13.38
Resistance trained shoulder press	44.03 ± 3.84	49.72 ± 3.85*	53.98 ± 3.36*	56.25 ± 5.24*	50.57 ± 3.36*	254.44 ± 17.87*
Leg extension	53.97 ± 3.37	60.76 ± 2.42*	66.47 ±2.09	72.16 ± 3.38	79.54 ± 4.02*	332.95 ± 9.24*
Leg curl	48.86 ± 1.66	53.40 ± 1.66	55.68 ± 2.54	57.94 ± 3.81	56.25 ± 3.93	272.16 ± 12.22
Triceps extension	50.57 ± 2.50*	53.98 ± 2.80*	53.12 ± 3.27*	50.57 ± 2.81*	48.86 ± 2.88	257.10 ± 12.62*

Sets 1–3 were a familiarization phase where no significant differences in weight lifted between the untrained and resistance trained groups ($p < 0.05$) were observed
Mean ± *SE* kilograms performed for six repetitions.
*Statistically significant ($p < 0.05$) from untrained group.
UT = untrained; RT = resistance training.

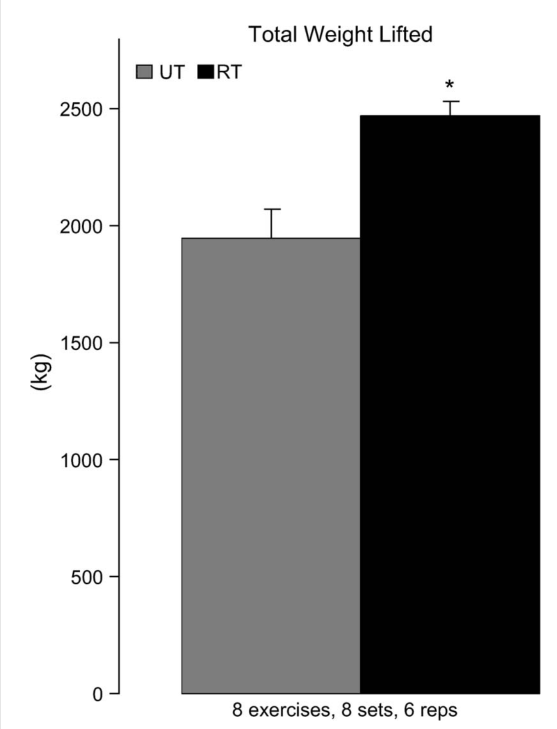

Figure 1. Total weight lifted during the acute resistance training session for untrained (UT; $n = 8$) and resistance trained (RT; $n = 8$) subjects.* Statistically different from UT, $p < 0.05$.

24 hours post (UT, $p = 0.002$, RT, $p = 0.02$) and UT only at 48 hours ($p = 0.002$) and 72 hours post ($p = 0.003$) compared with baseline (Figure 4). Between groups, RPMS were not significantly different at any time point. Within groups, RPMS values were significantly elevated for both UT and RT at 24 hours post (UT, $p < 0.001$; RT, $p = 0.003$) and 48 hours post (UT, $p < 0.001$; RT, $p = 0.02$) and for UT only at 72 hours post (UT, $p = 0.001$) exercise (Figure 5).

Discussion

The aim of this investigation was to determine the effect of an acute bout of high-volume, full-body resistance training with an eccentric concentration on REE and indicators of DOMS in RT and UT males. We hypothesized that REE and indicators of DOMS would be significantly higher in UT participants after the acute resistance training session and that REE and indicators of DOMS would be significantly elevated beyond 48 hours postexercise. The main finding of this investigation indicates that REE can be significantly elevated up to 72 hours postexercise in both UT and RT groups. Although our results are difficult to compare with those of other investigations because of different exercise protocols, some comparisons can be made.

Recently, Haugen et al. (14) investigated the validity of repeated morning REE measurements using the indirect calorimetry hood method. Their results indicate that consecutive REE measurements in the morning were stable, highly correlated, and not statistically different from each other. Because we employed similar methodology, we believe the increases in REE occurred as a result of the full-body resistance training with eccentric concentration intervention.

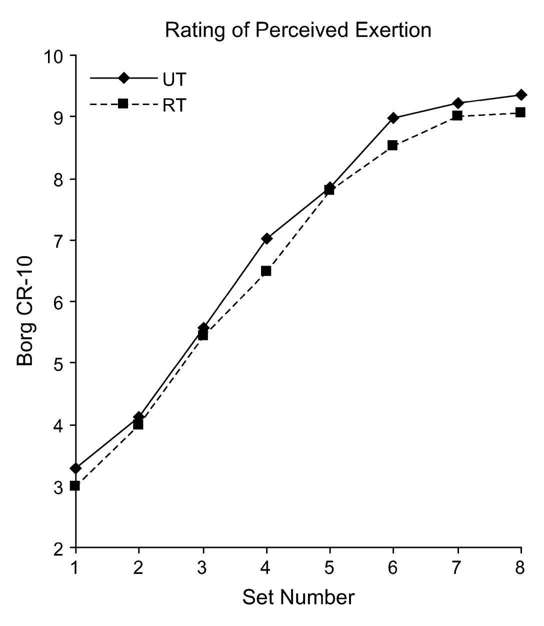

Figure 2. Average rating of perceived exertion per set during resistance training session for untrained (UT; $n = 8$) and resistance trained (RT; $n = 8$) subjects.

Our results are in agreement with several investigations that have found elevations in REE using resistance training as an intervention in young, healthy participants. Melby et al. (18) and Gillette et al. (13) have reported significant increases up to 15 and 14.5 hours, respectively, after high-volume resistance training. Melby et al. (18) incorporated six sets of 10 upper- and lower-body exercises. Each was performed at approximately 70% of one-repetition maximum using 8–12 repetitions. Gillette et al. (13) incorporated a similar protocol, but only five sets were performed. Both studies found elevations in male participants; however, it is important to note that their measurements did not span beyond 15 hours, and, therefore, we can only speculate whether additional perturbances in REE occurred beyond this point.

Schuenke et al. (24) measured postexercise metabolism up to 48 hours postexercise and found significant elevations at 14, 19, and 38 hours after resistance training. The resistance protocol used Olympic-style exercises (bench press, power cleans, and parallel squats) performed four times in a circuit. Participants performed 8–12 repetitions, with 2-minute rest intervals at a 10-repetition maximum intensity. Additionally, Jamurtas et al. (15) found significant increases in REE at

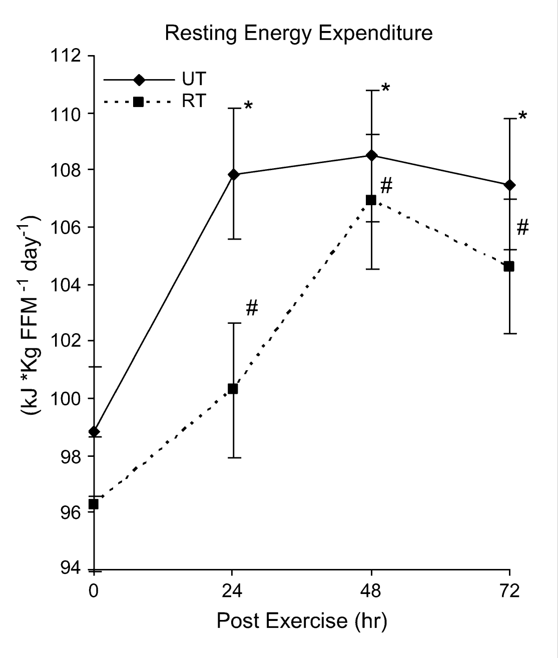

Figure 3. Resting energy expenditure responses from baseline to 72 hours postexercise in untrained (UT) and resistance trained (RT) subjects. *Statistically different from baseline for UT ($n = 8$); #statistically different from baseline for RT ($n = 8$), $p < 0.05$.

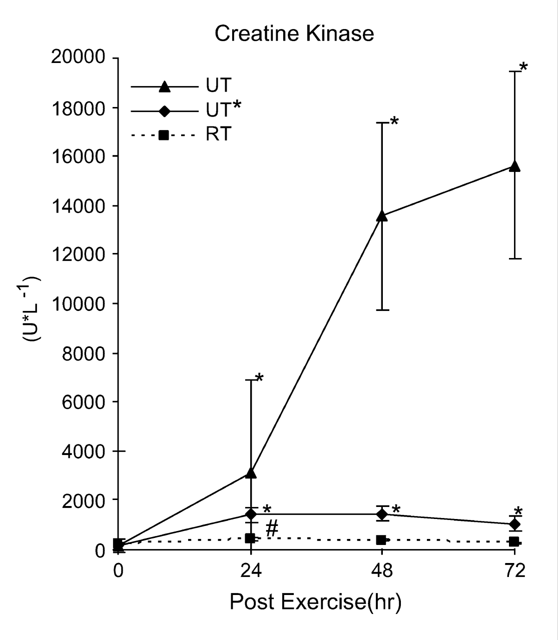

Figure 4. Creatine kinase responses from baseline to 72 hours postexercise in untrained (UT) and resistance trained (RT) subjects. *Statistically different from baseline for UT ($n = 8$); *statistically different from baseline with three abnormal responses removed for UT* ($n = 5$); #statistically different from baseline for RT ($n = 8$), $p < 0.05$.

10 and 24 hours after training. Participants performed four sets of 10 different upper- and lower-body exercises. Intensity was set at 70–75% of their predetermined one-repetition maximum, and the typical number of repetitions completed was between 8 and 12. Therefore, there seems to be support for postexercise elevations in REE after high-volume resistance training or Olympic-style lifting.

Although each of the described protocols did use upper- and lower-body training methods, they did not aim to emphasize the eccentric portion of the resistance training session. In contrast, Dolezal et al. (10) have reported increases in REE up to 48 hours after resistance training with an eccentric overload in RT and UT subjects. The Dolezal et al. (10) protocol consisted of lower-body leg extensions performed for eight sets at an estimated six-repetition maximum from a separate cohort using a 1-second concentric and 4-second eccentric contraction duration. We attempted a type of protocol similar to that of Dolezal et al. (10) with the addition of several upper- and lower-body exercises. Therefore, our protocol incorporated eight sets of six repetitions using a 1-second concentric and 3-second contraction duration. This design was intended to allow comparison of the studies by keeping sets, repetitions, and eccentric emphasis similar. In this regard, the addition of upper- and lower-body exercises was the major difference between the studies. Thus, the addition of these exercises may explain our significant elevation at 72 hours postexercise compared with 48 hours postexercise in the Dolezal et al. (10) investigation. Overall, it seems that high volume and an eccentric emphasis may be needed to optimally induce perturbances in REE in the postexercise period.

There are several factors that may be associated with an elevation in REE in the postexercise period. Within the first 24 hours, mechanisms associated with the rapid and slow components of excess postexercise oxygen consumption may have contributed to an immediate elevation (5). 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 (2,3,5,12). However, it seems that these processes are associated with temporary elevations and do not explain prolonged REE elevations observed beyond 24 hours postexercise (20).

Prolonged elevations in REE between 24 and 72 hours postexercise may be triggered by factors associated with DOMS and the overall muscle-repair process. Indicators of muscle damage such as CK provided us with a comparable measure of muscle trauma. Both the RT and UT groups displayed significantly increased CK levels in our investigation. The extent of the elevation was more pronounced in the UT group, indicating a greater degree of muscle damage. This was especially apparent in three UT participants where CK levels spiked beyond 33,000 $U{\cdot}L^{-1}$, which required close

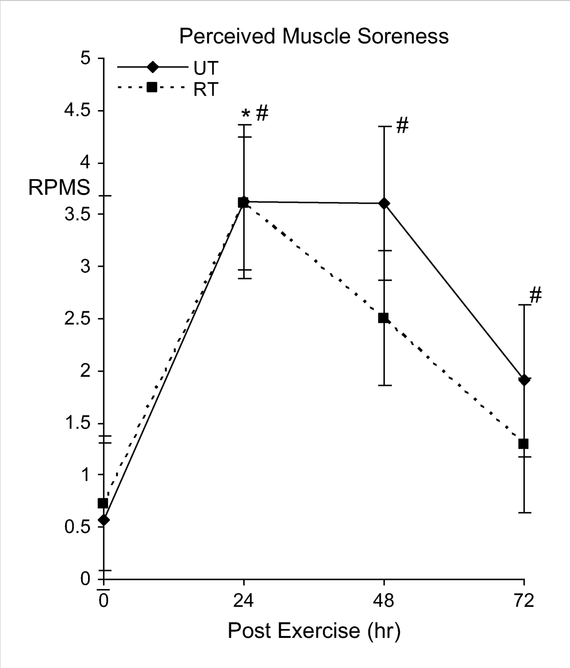

Figure 5. Rating of perceived muscle soreness responses from baseline to 72 hours postexercise in untrained (UT) and resistance trained (RT) subjects. *Statistically different from baseline for UT ($n = 8$); #statistically different from baseline for RT ($n = 8$), $p < 0.05$.

monitoring beyond the normal study protocol (Figure 4). Therefore, numerous events associated with the repair process may have an unknown energetic cost and may partially explain the pronounced increase in REE specifically in the UT group. These processes may include mobilizing neutrophils, macrophages, cytokines, prostaglandins, and other events associated with the inflammatory process (27).

Increased protein degradation and synthesis in the recovery period after activity may also result in significant REE elevations (28). Increased protein synthesis has been reported after prolonged aerobic exercise (7), and this rate has been significantly elevated at 3, 24, and 48 hours after resistance training. The cost of this process is reported to be energetically expensive (16) because it is estimated that protein synthesis may account for up to 20% of REE (28). Furthermore, there may be an interaction between resistance training (22) and nutrition in the postexercise period where factors such as amino acid availability (4) and the insulin response may facilitate the increase in REE during the 72-hour period in RT and UT subjects (19).

Even though tight controls were administered, our investigation was limited in some areas. First, the subjects were asked to refrain from eating and drinking anything but water before the REE measurement. In addition, the participants were also asked to discontinue all exercise that was not associated with the study, and they were instructed to get a good night of rest (~8 hours). Any lack of compliance from baseline to 72 hours post may have influenced our REE results. Secondly, subjects were asked to eat normally and to record the foods they consumed. However, if subjects changed their typical diet because of being involved with the investigation, it may have influenced energy balance and REE.

Additionally, although all participants did refrain from eating before the REE measurement, caloric intake before and immediately after the resistance training protocol was not controlled. As a result, the timing of nutritional intake may have influenced REE by altering protein synthesis (19,27). Furthermore, as a cautionary note, although the RT subjects tolerated the exercise protocol well, the exercise protocol used in this study may have been too intensive for some of the UT subjects, as evidenced by the highly elevated CK levels in three subjects. Some degree of resistance training may be necessary in previously untrained subjects before using exercise protocols as intense as the one in this study.

The strengths of our investigation are also evident in that we were able to compare the differences in response between two groups of individuals with opposing exercise habits on a similar relative exercise protocol. In this regard, we used machine resistance training with an eccentric emphasis to produce significant metabolic disturbances in the postexercise period. We were also one of few studies to observe REE and indicators of DOMS on consecutive mornings. The novel finding of our investigation was that REE can be increased up to 72 hours posttraining in both RT and UT participants. To date, this is the longest duration for which significant augmentations in REE after resistance training have been observed, and the results may have physiological and practical importance, depending on the goal of exercise training.

PRACTICAL APPLICATIONS

Our findings suggest that individuals who are attempting to elicit muscle hypertrophy by facilitating a positive energy balance and who are performing high-volume, full-body training may require additional caloric intake on the days after training to encourage growth. This is specifically relevant if there is an emphasis on exercise form during training. In this scenario, the participant may be unknowingly emphasizing the eccentric component of the muscle action causing further augmentations in REE. Our investigation found that RT participants elevated their REE approximately 8% as a result of the acute resistance training stimulus. This suggests that estimating or measuring REE may be important to calculate the additional caloric intake required for each individual as a result of an acute bout of training. Furthermore, this does not take into consideration the energy expended during the resistance training session itself or any additional aerobic training that may also occur on the same day or in the days after.

In contrast, individuals who are attempting to facilitate a negative energy balance and lose body mass or body fat may be searching for additional means to expend calories. Although it is not our goal to advocate the specific training method used in this study, because the training protocol may be too intense for the beginning exerciser, our investigation did observe an approximately 9% increase in REE after one acute bout of high-volume, full-body resistance training in UT participants. This may also be particularly relevant when proper form is encouraged, because the eccentric aspect of the muscle action may be emphasized during this process. Consequently, using full-body resistance training with an eccentric concentration may be an even more important method to increase total daily energy expenditure than initially expected.

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