Research Quarterly for Exercise and Sport, *86*, 190–195, 2015

ISSN 0270-1367 print/ISSN 2168-3824 online
DOI: 10.1080/02701367.2014.999190

Routledge
Taylor & Francis Group

EPOC Comparison Between Isocaloric Bouts of Steady-State Aerobic, Intermittent Aerobic, and Resistance Training

Beau Kjerulf Greer
Sacred Heart University

Prawee Sirithienthad and Robert J. Moffatt
Florida State University

Richard T. Marcello
Sacred Heart University

Lynn B. Panton
Florida State University

Purpose: Excess postexercise oxygen consumption (EPOC) is dependent on intensity, duration, and mode of exercise. The purpose of this study was to compare the effect of both exercise mode and intensity on EPOC while controlling for caloric expenditure and duration. **Method:** Ten low to moderately physically active men (22 ± 2 yrs) performed 3 nonrandomized isocaloric bouts of exercise separated by 7 days. The 1st session was resistance training (RT), followed by moderate-intensity steady-state (SS) aerobic exercise, and concluding with a high-intensity intermittent (IT) aerobic session. **Results:** Total energy expenditure, rate of energy expenditure, and duration did not differ among trials ($p > .05$). Respiratory exchange ratio was greater during the RT trial than the SS trial ($p < .05$). At 12 hr postexercise, resting metabolic rate (RMR) was higher after the RT trial (4.7 ± 0.67 mL/kg/min) and IT trial (4.6 ± 0.62 mL/kg/min) compared with their respective baseline measurements ($p < .008$) and the SS trial (4.3 ± 0.58 mL/kg/min; $p < .008$). At 21 hr postexercise, RMR was higher after the RT trial (3.7 ± 0.51 mL/kg/min) and IT trial (3.5 ± 0.39 mL/kg/min) compared with the SS trial (3.2 ± 0.38 mL/kg/min; $p < .008$). The SS trial did not influence RMR at either 12 hr or 21 hr postexercise. **Conclusion:** Both RT and IT aerobic work increased EPOC to a greater degree than did SS work, indicating that either mode may be more effective at increasing total daily caloric expenditure than SS aerobic exercise.

Keywords: high-intensity interval training, weight loss

The potential for excess postexercise oxygen consumption (EPOC) to contribute a practically important volume of caloric expenditure for weight control or loss remains controversial (Abboud, Greer, Campbell, & Panton, 2013; Borsheim & Bahr, 2003; LeCheminant et al., 2008). In addition, there are conflicting data and conclusions regarding the independent influences of exercise mode, intensity, volume, and duration on EPOC (Abboud et al., 2013; Borsheim & Bahr, 2003; LeCheminant et al., 2008; Matsuo et al., 2012; Melby, Scholl, Edwards, & Bullough, 1993). In general, higher exercise intensities, regardless of mode, produce higher EPOC than lower intensities when the exercise bout is controlled for volume (Borsheim & Bahr, 2003; Thornton & Potteiger, 2002). The same

Submitted May 22, 2014; accepted December 9, 2014.
Prawee Sirithienthad is now at Bangkok Hospital in Bangkok, Thailand.
Correspondence should be addressed to Beau Kjerulf Greer, Exercise Science Program, Sacred Heart University, 5151 Park Avenue, Fairfield, CT 06825. E-mail: greerb@sacredheart.edu

holds true in regards to duration of exercise, with higher durations producing higher degrees of EPOC; however, intensity accounts for a much larger percentage of the total variance in EPOC than does duration (Borsheim & Bahr, 2003).

Conclusions between mode comparisons are less definitive, as there is no method that exists without due criticism in regards to equating an aerobic training session with a resistance-training (RT) exercise. RT appears to have a larger effect on EPOC than steady-state (SS) aerobic training when controlling for energetic cost (Gillette, Bullough, & Melby, 1994) or exercise oxygen uptake (VO_2) and duration (Burleson, O'Bryant, Stone, Collins, & Triplett-McBride, 1998). However, the effect of intermittent/interval exercise has not been investigated extensively; Lyons et al. (2006) reported that intermittent upper-body ergometry produced a small but significantly elevated EPOC as compared with SS aerobic work equal in intensity and duration. Kaminsky, Padjen, and LaHam-Saeger (1990) and Almuzaini, Potteiger, and Green (1998) found similar results with lower-body exercise.

The purpose of the present study was to compare the effect of SS aerobic, intermittent aerobic (IT), and RT on EPOC while controlling for total caloric expenditure and rate of caloric expenditure (and therefore indirectly controlling duration) during the exercise bout. It was hypothesized that RT would stimulate the greatest elevation in resting metabolic rate (RMR) across all time points as compared with alternate trials and that RMR would be elevated post-IT as compared with the SS trial at 12 hr postexercise.

METHOD

Participants

Ten low to moderately physically active, nonsmoking, healthy male university students volunteered for the present study ($M_{age} = 22 \pm 2$ years). All procedures were approved by the institutional review board at Florida State University, and all participants provided written informed consent.

Procedure

The study design can be viewed in Figure 1. At least 7 days prior to any treatment, participants reported to the laboratory for anthropometric measurements (height, body mass) at 2100 hrs after fasting for 4 hours. Following 30 min of seated rest, RMR was assessed as the mean VO_2 (mL/kg/min) for 30 min using a ParvoMedics TrueMax® 2400 metabolic cart (ParvoMedics, Sandy, UT), which was used for all metabolic data collection. For metabolic data collection both at rest and during exercise bouts, data were sampled continuously and recorded as averages during 30-s sampling intervals; reported results are the means of these intervals. A one-way mouthpiece and nose clip were used during all such procedures.

The RMR procedure was repeated at 0630 hr after sleeping in the laboratory to establish both A.M. and P.M. baselines to account for circadian rhythm shifts. Food logs were kept for 72 hr prior to the initial RMR measurement; copies were provided for the participants so that diets could be replicated prior to subsequent RMR measurements. In addition, caffeine use and any strenuous physical activity independent of study requirements were discouraged for 24 hr and 72 hr, respectively, prior to all metabolic measurements.

After the A.M. RMR testing, participants performed a continuous, graded cycle ergometer (Monark Exercise AB, Vansbro, Sweden) test (modified YMCA protocol) to volitional exhaustion for determination of VO_2peak, determined by the highest VO_2 measurement averaged during a 30-s sampling interval. Following a familiarization protocol, participants also performed one-repetition maxi-

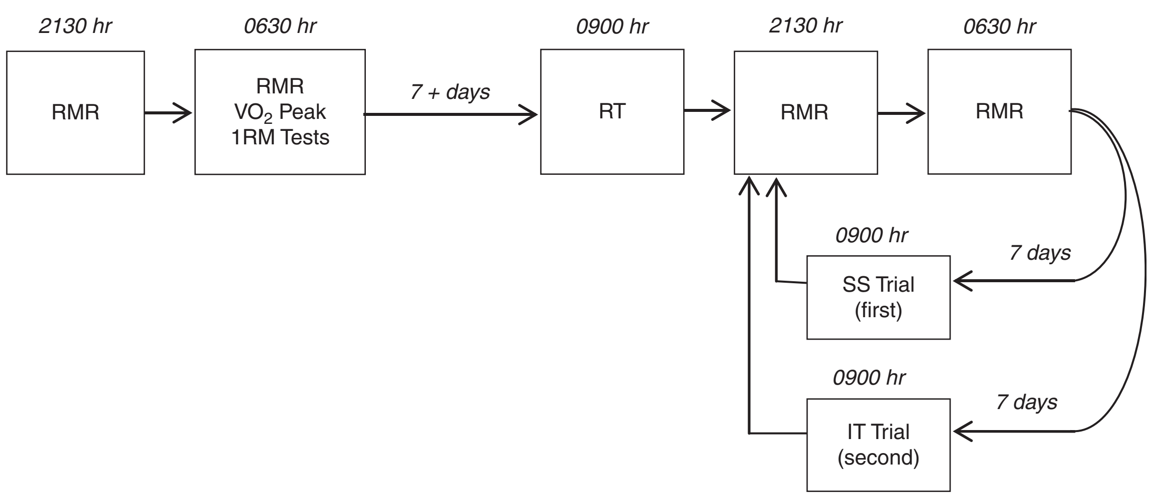

FIGURE 1 Study design. *Note.* All time expressed in military units. RMR = resting metabolic rate measurement; 1RM = one-repetition maximum; VO_2peak = peak oxygen uptake; RT = resistance training trial; SS = steady-state trial; IT = intermittent aerobic trial.

mums (1RM) for the following four lifts: seated machine pectoral flies, squats on a noncounterbalanced Smith machine, lateral pulldowns, and cable triceps pushdowns. These exercises were chosen based on equipment availability. The procedures for determining 1RM have been reported elsewhere (Abboud et al., 2013).

After a minimum of 7 days postbaseline testing for VO_2 peak and 1RM, participants returned to the laboratory at 0900 hr to engage in the RT protocol. For the exercises previously mentioned with the addition of calf raises executed with the same load used for squats, participants performed 60% of the 1RM for one set until fatigue with 1 min of rest between exercises. As is typical in circuit training, each exercise was performed for one set, and then the circuit was repeated. A high-volume, low-intensity RT protocol with short rest durations was used as most practitioners prescribing exercise to facilitate weight loss will anecdotally do so in a similar manner. Duration was fixed at 45 min (participants were allowed to complete the last exercise if time expired during activity), and expired air was collected throughout the lifting session. RMR was measured at 2130 hr and 0630 hr following the procedures outlined previously.

With 7 days between treatments, participants followed identical schedules for the SS and IT trials, respectively, in order. During the SS trial, participants cycled on the same cycle ergometer that was used for the VO_2peak assessment at the same %VO_2peak as they averaged during the RT session (approximately 39% VO_2peak). The trial was stopped when participants had expended the same total kilocalories measured during the RT session. Once SS metabolism was reached, the predicted workload may have been slightly adjusted to match the rate of energy expenditure observed during the RT trial.

The IT trial consisted of cycling at 90% VO_2peak for 30 s followed by a 0 load resistance for 120 s to 180 s. The variable rest period was used so that the average rate of energy expenditure and duration of the exercise bout would be similar to the RT and SS trials. Once the aggregate kilocalories matched the SS trial (as determined by 30-s sampling averages), another 30-s interval at 90% VO_2peak was performed followed again by the variable rest interval. Exercise was stopped when the total kilocalorie expenditure matched the total from the RT and SS sessions.

For both the SS and IT trials, RMR measurements were made on the same time course as the RT trial. The decision to not randomize treatment order was made for the following three reasons: (a) The RT treatment needed to be applied first so that rate of energy expenditure could be determined and then could be matched to cardiovascular exercise intensity based on the VO_2peak test; (b) the SS trial needed to be conducted prior to the IT trial as it provided the framework for the specific interval duration determinations; and (c) as treatments were kept 7 days apart, there are no reported data indicating the present order of treatments would increase the risk for a Type II error.

Data Analysis

All data were tested for normal distribution via a Shapiro-Wilk test. Data collected during the exercise sessions (VO_2, energy expenditure, duration, respiratory exchange ratio [RER]) and VO_2 and RER collected during RMR testing were analyzed parametrically via repeated-measures analysis of variance, and a Tukey's HSD test was used for post-hoc analysis. Energy expenditure was calculated via ParvoMedics 2400 software, which uses the Weir equations for such calculations (Weir, 1949). As all other analyses contained a variable that was not normally distributed, a Friedman's test was used to compare data. For nonparametric post-hoc analysis, a Wilcoxon post-hoc test with Bonferroni correction was used, creating a corrected alpha level of .008 from the original level of significance set at .05. Partial eta squared values η_p^2 were calculated for effect sizes as repeated measures were used.

RESULTS

All 10 participants who volunteered for the study completed the trials. Participant characteristics can be seen in Table 1, and results from maximal strength testing are displayed in Table 2.

As designed, exercise energy expenditure and duration did not differ among trials ($p > .05$). RER was higher in the RT trial as compared with the SS trial ($p < .05$). Data for the exercise trials are presented in Table 3. With duration capped at 45 min, all participants were able to complete five circuits of RT; however, no participant was able to complete a sixth.

Differences in postexercise metabolic data can be viewed in Tables 4 and 5. In terms of the primary outcome measure, RT and IT protocols increased VO_2 as compared with baseline levels ($p < .008$, $\eta_p^2 = .89$, .87, respectively) and the SS protocol at 12 hr postexercise ($p < .008$, $\eta_p^2 = .86$, .92). RT and IT protocols increased VO_2 as compared with the SS protocol at 21 hr postexercise ($p < .008$, $\eta_p^2 = .82$, .74). The SS protocol did not cause an elevation in VO_2 above baseline levels at either of the measured time points. As would be expected from the VO_2 results, energy expenditure (kcals) for 30 min was greater 12 hr after the RT

TABLE 1
Participant Characteristics

	Mean ± *SD*	*Range*
Age (years)	22 ± 2	22–28
Height (cm)	173.8 ± 11.6	155.0–188.0
Weight (kg)	77.1 ± 16.4	61.4–118.2
BMI (kg/m^2)	25.2 ± 4.4	20.3–34.5
VO_2peak (mL/kg/min)	34.5 ± 6.1	22.0–42.2

Note. BMI = body mass index; VO_2 = oxygen uptake.

TABLE 2
One-Repetition Maximums

	Mean ± *SD*
1RM Pectoral Fly (kg)	75.0 ± 22.1
1RM Squat (kg)	80.9 ± 21.2
1RM Lateral Pulldown (kg)	62.3 ± 26.9
1RM Tricep Pushdown (kg)	42.7 ± 10.7

Note. 1RM = one-repetition maximum.

TABLE 3
Means and Standard Deviations of Exercise Bouts Across the Three Trials

	RT	*SS*	*IT*
VO_2 (mL/kg/min)	12.4 ± 1.7	13.4 ± 1.6	13.3 ± 1.8
VO_2 (mL/min)	953.1 ± 133.25	1,030.9 ± 126.21	1,023.2 ± 137.2
EE (kcals)	217 ± 18.6	217 ± 19.5	219 ± 19.7
RER	1.05 ± 0.1*	0.92 ± 0.0	0.97 ± 0.1
Duration (min)	46.1 ± 2.3	43.4 ± 2.6	43.6 ± 1.8

Note. VO_2 = oxygen uptake; EE = energy expended; RER = respiratory exchange ratio; RT = resistance-training trial; SS = steady-state trial; IT = intermittent aerobic trial.
*Statistically significantly different than SS ($p < .05$).

and IT treatments as compared with baseline ($p < .008$, $\eta_p^2 = .84$, .76) and SS levels ($p < .008$, $\eta_p^2 = .69$, .90); however, energy expenditure 21 hr posttreatment was only elevated as compared with baseline ($p < .008$, $\eta_p^2 = .97$) and SS levels ($p < .008$, $\eta_p^2 = .77$) after the RT protocol. The only significant change in RER from baseline levels was at 21 hr after the RT protocol ($p < .008$, $\eta_p^2 = -.79$).

DISCUSSION

The primary finding of the present study was that when matched for caloric expenditure and duration, a high-volume RT session or a high-intensity IT aerobic training session creates greater postexercise rates of energy expenditure compared with SS aerobic exercise for up to 21 hr. To our knowledge, this is the only study to report that IT produces greater EPOC than SS aerobic exercise when bouts were matched specifically for energy expenditure as opposed to matching rate of energy expenditure (% VO_2peak) and duration. The influence of substrate choice, as reflected by RER, affects energy expenditure due to the varying efficiency of carbohydrate and fats, and therefore, distinguishing between rate of energy expenditure and total energy expenditure is both purposeful and necessary. Consistent with other investigations involving the metabolic effects of RT, energy expenditure may be underestimated in the RT trial as indirect calorimetry can only detect oxygen-dependent metabolic pathways; additionally, this underestimation may have been exacerbated in the present study as the average RER for the RT trial was > 1.0. This study is also unique in demonstrating equivalent increases in EPOC after RT or high-intensity IT for up to 21 hr.

TABLE 4
Means and Standard Deviations of Resting Metabolic Measurements Across Trials: 12-Hr Postexercise (P.M.)

	Baseline	*RT*	*RT*-η_p^2	*SS*	*SS*-η_p^2	*IT*	*IT*-η_p^2
VO_2 (mL/kg/min)	4.1 ± 0.57	4.7 ± 0.67*^	.89	4.3 ± 0.58	.48	4.6 ± 0.62*^	.87
VO_2 (mL/min)	316.8 ± 43.77	361.6 ± 51.58*^	.89	329.1 ± 44.36	.48	355.3 ± 47.84*^	.87
30-min EE (kcals)	50 ± 5.2	58 ± 4.5*^	.84	50 ± 5.3	.00	62 ± 7.2*^	.76
RER	0.82 ± 0.03	0.91 ± 0.06	.51	0.81 ± 0.04	.19	0.83 ± 0.04	.00

Note. VO_2 = oxygen uptake; EE = energy expenditure; RER = respiratory exchange ratio; RT = resistance-training trial; SS = steady-state trial; IT = intermittent aerobic trial; η_p^2 = partial eta squared.
*Statistically significantly different than baseline ($p < .008$). ^Statistically significantly different than SS ($p < .008$).

TABLE 5
Means and Standard Deviations of Resting Metabolic Measurements Across Trials: 21-Hr Postexercise (A.M.)

	Baseline	*RT*	*RT*-η_p^2	*SS*	*SS*-η_p^2	*IT*	*IT*-η_p^2
VO_2 (mL/kg/min)	3.3 ± 0.39	3.7 ± 0.51*^	.81	3.2 ± 0.38	.07	3.5 ± 0.39^	.64
VO_2 (mL/min)	250.9 ± 29.72	283.9 ± 39.51*^	.81	247.7 ± 29.59	.07	266.7 ± 30.09^	.64
30-min EE (kcals)	38 ± 3.4	45 ± 4.4*^	.97	39 ± 5.8	.17	45 ± 10.0	.43
RER	0.90 ± 0.02	0.83 ± 0.02*	−.79	0.82 ± 0.05	−.58	0.82 ± 0.04	−.77

Note. VO_2 = oxygen uptake; EE = energy expenditure; RER = respiratory exchange ratio; RT = resistance-training trial; SS = steady-state trial; IT = intermittent aerobic trial; η_p^2 = partial eta squared.
*Statistically significantly different than baseline ($p < .008$). ^Statistically significantly different than SS ($p < .008$).

The statistically significant differences found between trials for RMR despite using the conservative Bonferroni correction as well as the corresponding effect sizes support that Type I errors did not occur. However, the effect sizes at the 21-hr time point suggest a Type II error may have occurred in regards to comparing the RER for the IT ($\eta_p^2 = -.77$) and potentially the SS ($\eta_p^2 = -.58$) trial to baseline levels, especially considering the relatively small sample size. As RER is collected primarily to increase accuracy in estimations of caloric expenditure, this potential error does not affect any practical implications that may be drawn from the results of the present study.

Although the present study did not investigate mechanisms, the literature is robust as to potential reasons for an increased EPOC after RT or high-intensity IT as opposed to SS aerobic exercise. RT creates a higher degree of muscle damage than does non-eccentrically biased aerobic training such as cycling or flat running (Clarkson & Hubal, 2002); as protein repair/synthesis is an expensive metabolic process (Reeds, Wahle, & Haggarty, 1982), it was expected that the RT trial EPOC would be elevated as compared with that in the SS trial. Higher-intensity aerobic training stimulates increases in heart rate, ventilation, body temperature, and sympathetic output as compared with a lower intensity (American College of Sports Medicine et al., 2007); all of these may contribute to a greater EPOC, although it is improbable they would still influence EPOC at 12 hr postexercise. We hypothesize that the higher EPOC observed after the IT trial as compared with the SS trial is most likely due to greater upregulation of metabolic pathways typically associated with aerobic training, including myocyte remodeling and mitochondrial biogenesis (Gibala et al., 2006) or a heightened sympathetic nervous system response (Zanesco & Antunes, 2007).

Despite significant differences, the practical importance of the present study's results should be addressed. At 21 hr postexercise for the RT and IT trials, participants were expending approximately 12 kcals/hr more than after the SS trial, and lines of best fit between the 12-hr and 21-hr marks indicate that RMR may have stayed elevated above the SS trial value for up to 48 hr. Although this caloric amount is practically important (at least 300 additional calories for 24 hr as compared with the SS trial), it should be noted that the RT-induced or aerobic training-induced increase in RMR will attenuate as participants become better trained (Abboud et al., 2013; Matsuo et al., 2012). In the case of RT, this is most likely due to the decrease in muscle damage associated with chronic RT, otherwise known as the repeated bout effect (Clarkson & Hubal, 2002). It is currently unknown whether a similar adaptation would occur in response to high-intensity IT, but because the sympathetic response to aerobically oriented exercise is attenuated as a training adaptation (Zanesco & Antunes, 2007), it remains a distinct possibility.

Additionally, it is important to consider the differential effects that exercise intensity or mode have on appetite for those seeking weight loss or better weight control, as caloric intake is a more significant factor in the energy balance equation than is EPOC. It has been shown that higher-intensity (70% VO_2peak) aerobic exercise stimulates appetite to a greater degree than an isocaloric, lower-intensity (40% VO_2peak) session (Pomerleau, Imbeault, Parker, & Doucet, 2004), which would potentially negate any intensity-induced EPOC contributions toward a negative energy balance. It has also been reported that chronic, SS aerobic training (70%–80% heart rate maximum) increases postprandial perceived fullness (i.e., satiety) to a larger degree than moderately high-intensity RT (three to four sets, 8–10 repetitions, 75%–85% 1RM) matched by exercise duration (Guelfi, Donges, & Duffield, 2013). Therefore, any potential EPOC-induced calorically related benefits from either high-intensity IT or RT as compared with SS, lower-intensity aerobic training may be indirectly attenuated or even negated by an increase in appetite or a decrease in the satiety response to food.

Higher-intensity aerobic exercise is also associated with decreased adherence rates and exercise completion (Perri et al., 2002), although high-intensity interval running was perceived as more enjoyable than moderate-intensity SS running (Bartlett et al., 2011). Future exercise-oriented studies with implications for weight control should consider including measures related to appetite, enjoyment of exercise, or adherence as these variables are important for designing successful weight-related interventions.

WHAT DOES THIS ARTICLE ADD?

Many exercise practitioners rationalize the use of RT or IT instead of SS aerobic sessions by the assumed greater energetic cost of recovery, but investigations of such hypothesized costs are relatively scant or poorly controlled. In addition, this is the first study to compare EPOC differences between RT and IT, and it did so by controlling for both total energy expenditure, rate of energy expenditure, and duration of exercise.

Energy expenditure was increased during recovery from RT and IT as compared with SS aerobic exercise. This indicates that practitioners are at the very least basing their programming on scientifically sound rationales. However, it is important to note that the EPOC response likely declines with improved training status and ultimately represents a small contribution to the energy balance equation. Despite the significant results of the present study, practitioners should remain focused primarily on the caloric expenditure achieved during the exercise session and should continually inquire as to what modes and intensities of exercise their clients find most enjoyable and use this information to guide their training plans.

REFERENCES

Abboud, G. J., Greer, B. K., Campbell, S. C., & Panton, L. B. (2013). Effects of load-volume on EPOC after acute bouts of resistance training in resistance-trained men. *Journal of Strength and Conditioning Research*, *27*, 1936–1941.

Almuzaini, K. S., Potteiger, J. A., & Green, S. B. (1998). Effects of split exercise sessions on excess postexercise oxygen consumption and resting metabolic rate. *Canadian Journal of Applied Physiology*, *23*, 433–443.

American College of Sports Medicine, Armstrong, L. E., Casa, D. J., Millard-Stafford, M., Moran, D. S., Pyne, S. W., & Roberts, W. O. (2007). American College of Sports Medicine position stand: Exertional heat illness during training and competition. *Medicine & Science in Sports & Exercise*, *39*, 556–572.

Bartlett, J. D., Close, G. L., MacLaren, D. P., Gregson, W., Drust, B., & Morton, J. P. (2011). High-intensity interval running is perceived to be more enjoyable than moderate-intensity continuous exercise: Implications for exercise adherence. *Journal of Sports Science*, *29*, 547–553.

Borsheim, E., & Bahr, R. (2003). Effect of exercise intensity, duration and mode on post-exercise oxygen consumption. *Sports Medicine*, *33*, 1037–1060.

Burleson, Jr, M. A., O'Bryant, H. S., Stone, M. H., Collins, M. A., & Triplett-McBride, T. (1998). Effect of weight training exercise and treadmill exercise on post-exercise oxygen consumption. *Medicine & Science in Sports & Exercise*, *30*, 518–522.

Clarkson, P. M., & Hubal, M. J. (2002). Exercise-induced muscle damage in humans. *American Journal of Physical Medicine and Rehabilitation*, *81*(Suppl. 11), S52–S69.

Gibala, M. J., Little, J. P., van Essen, M., Wilkin, G. P., Burgomaster, K. A., Safdar, A., … Tarnopolsky, M. A. (2006). Short-term sprint interval versus traditional endurance training: Similar initial adaptations in human skeletal muscle and exercise performance. *Journal of Physiology*, *575*, 901–911. doi:10.1113/jphysiol.2006.112094

Gillette, C. A., Bullough, R. C., & Melby, C. L. (1994). Postexercise energy expenditure in response to acute aerobic or resistive exercise. *International Journal of Sport Nutrition*, *4*, 347–360.

Guelfi, K. J., Donges, C. E., & Duffield, R. (2013). Beneficial effects of 12 weeks of aerobic compared with resistance exercise training on perceived appetite in previously sedentary overweight and obese men. *Metabolism*, *62*, 235–243.

Kaminsky, L. A., Padjen, S., & LaHam-Saeger, J. (1990). Effect of split exercise sessions on excess post-exercise oxygen consumption. *British Journal of Sports Medicine*, *24*, 95–98.

LeCheminant, J. D., Jacobsen, D. J., Bailey, B. W., Mayo, M. S., Hill, J. O., Smith, B. K., & Donnelly, J. E. (2008). Effects of long-term aerobic exercise on EPOC. *International Journal of Sports Medicine*, *29*, 53–58.

Lyons, S., Richardson, M., Bishop, P., Smith, J., Heath, H., & Giesen, J. (2006). Excess post-exercise oxygen consumption in untrained males: Effects of intermittent durations of arm ergometry. *Applied Physiology, Nutrition, and Metabolism*, *31*, 196–201.

Matsuo, T., Ohkawara, K., Seino, S., Shimojo, N., Yamada, S., Ohshima, H., … Mukai, C. (2012). Cardiorespiratory fitness level correlates inversely with excess post-exercise oxygen consumption after aerobic-type interval training. *BMC Research Notes*, *5*, 646. doi:10.1186/1756-0500-5-646

Melby, C., Scholl, C., Edwards, G., & Bullough, R. (1993). Effect of acute resistance exercise on postexercise energy expenditure and resting metabolic rate. *Journal of Applied Physiology*, *75*, 1847–1853.

Perri, M. G., Anton, S. D., Durning, P. E., Ketterson, T. U., Sydeman, S. J., Berlant, N. E., … Martin, A. D. (2002). Adherence to exercise prescriptions: Effects of prescribing moderate versus higher levels of intensity and frequency. *Health Psychology*, *21*, 452–458.

Pomerleau, M., Imbeault, P., Parker, T., & Doucet, E. (2004). Effects of exercise intensity on food intake and appetite in women. *American Journal of Clinical Nutrition*, *80*, 1230–1236.

Reeds, P. J., Wahle, K. W., & Haggarty, P. (1982). Energy costs of protein and fatty acid synthesis. *Proceedings of the Nutrition Society*, *41*, 155–159.

Thornton, M. K., & Potteiger, J. A. (2002). Effects of resistance exercise bouts of different intensities but equal work on EPOC. *Medicine & Science in Sports & Exercise*, *34*, 715–722.

Weir, J. B. (1949). New methods for calculating metabolic rate with special reference to protein metabolism. *Journal of Physiology*, *109*, 1–9.

Zanesco, A., & Antunes, E. (2007). Effects of exercise training on the cardiovascular system: Pharmacological approaches. *Pharmacology and Therapeutics*, *114*, 307–317.