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Self-Selected Training Load and RPE During Resistance and Aerobic Training Among Recreational Exercisers

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Abstract

This study compared training load and ratings of perceived exertion (RPE) during resistance training (RT) and aerobic training (AT) sessions at self-selected intensity. Participants were 54 recreationally trained subjects assigned to either RT or AT groups. During RT, participants performed three sets of 10 repetitions of each exercise at a self-selected intensity (load). After RT completion, participants performed one repetition maximum (1RM) and 10RM tests. During AT, participants performed a treadmill exercise at a self-selected intensity and duration (velocity and time). After AT completion, participants performed a treadmill maximal exercise test using a ramp protocol. During RT, subjects chose an intensity (43.6%–60.2% 1RM) below typical training recommendations, and RPE increased in successive exercise sets. During AT, participants chose an intensity (83.9% Heart $Rate_{peak}$) in line with typical training recommendations, and RPE increased from the first to second quartile of the

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session (from a mean of 3.9, standard deviation [SD] = 1.7 to a mean of 5.4, $SD = 1.7$; $p < .05$) and remained stable thereafter. These recreationally trained participants self-selected lower RT intensities than are typically recommended for strength and hypertrophy increases (>67% 1RM) and AT intensities in line with typically recommended intensity (64%–95% HR_{max}) for cardiovascular fitness increases. Thus, for recreational trained individuals to perform RT at recommended intensities, specific instruction will be required.

Keywords
exercise, fatigue, performance, strength, training

Introduction

Guidelines for both resistance training (RT; Ratamess et al., 2009) and aerobic training (AT; Garber et al., 2011) have been developed to aid individuals in designing conditioning programs for desired fitness gains. However, interindividual variability in training responses, including muscle hypertrophy and endurance, has been demonstrated following both RT (Burd et al., 2010; Glass & Stanton, 2004; Marshall, McEwen, & Robbins, 2011; Morton et al., 2016) and AT (Bonafiglia et al., 2016; Ekkekakis, 2009). Self-selection of training intensity may be affected by this individual variability, as self-selected RT (Focht, 2007) and AT (Ekkekakis, 2009) intensity and ratings of perceived exertion (RPE) have been shown to be significantly lower than prescribed values but generally within typically recommended training guidelines (e.g., Pescatello & American College of Sports Medicine [ACSM], 2000). The use of self-selected (vs. prescribed) exercise intensities has been encouraged by health professionals to help ensure program adherence (Ekkekakis, 2009; Focht, 2007; Johnson & Phipps, 2006).

RT intensity is typically based on a percentage of one repetition maximum (1RM) or some given repetition maximum (e.g., 10RM). The National Strength and Conditioning Association (NSCA) recommends >67%-85% 1RM in order to increase muscle hypertrophy and >85% 1RM to increase muscle strength (Sheppard & Triplett, 2016). However, research has shown that during RT sessions, untrained men and women self-select intensities that are lower than these recommended RT guidelines (Focht, 2007; Glass & Stanton, 2004; Ratamess, Faigenbaum, Hoffman, & Kang, 2008). Moreover, self-selected RT protocols are also associated with lower intensities in comparison with prescribed RT protocols, at least partly because, untrained exercisers (especially women) commonly experience an increased fear of injury or avoidance of excessive muscle mass associated with high training loads (Ratamess et al., 2008). Self-selection of a low load with a high number of repetitions (<67% 1RM and >12 repetitions) when performing RT may result in minimal increases in muscle strength and hypertrophy, which usually decreases motivation to continue training and reduces exercise adherence (Ekkekakis, 2009; Focht et al., 2015).

To increase aerobic fitness, moderate and vigorous AT intensities (64–95% maximal) are recommended for most healthy, recreationally trained adults (Garber et al., 2011). Young, but sedentary, adult men and women appear to be intuitively predisposed to self-select AT intensities within the training guidelines for improving aerobic fitness (Bonafiglia et al., 2016; Ekkekakis, 2009; Glass & Chvala, 2001). Self-selected intensities falling within typical training guidelines are also important from a psychological perspective, because self-selected AT intensities promote more pleasant and comfortable exercise experiences (Vazou-Ekkekakis & Ekkekakis, 2009). Currently, more information is needed concerning what RT and AT exercise intensity recreationally trained adults self-select and whether self-selected intensity falls within currently recommended training guidelines (Pescatello & ACSM, 2000; Sheppard & Triplett, 2016). The current study sought to determine what exercise load and perceptual response recreationally trained adults would self-select and report during RT and AT sessions. Our major hypotheses were that (a) self-selected RT intensity (%1RM) would be lower than that recommended by current training guidelines (67–85% 1RM for increases in muscle hypertrophy and > 85% 1RM for increases in strength; Sheppard & Triplett, 2016); and (b) self-selected AT intensity (%maximal heart rate [HR_{max}]) would be within the recommended range (i.e., 64–95% HR_{max} or 5–8 on the OMNI walk/run pictorial perceived exertion scale; Pescatello & ACSM, 2000; Robertson, 2004).

Method

Participants

A convenience sample of 54 volunteer participants were recruited from among health/fitness club members (22 women, 32 men; mean age = 22.7, standard deviation [*SD*] = 3.3 years; mean body mass = 70.2, *SD* = 12.8 kg; mean height = 1.72, *SD* = 0.08 meters). All volunteers reported regular participation in only RT (~200 minutes per week) or only AT (~138 minutes per week) of at least three days per week during the six months preceding the study. Participants were assigned to the RT (14 women, 24 men) or the AT (eight women, eight men) groups, based on their previous RT or AT experience, respectively (see Table 1). Also, past comparisons between men and women have shown no significant gender difference in self-selection of RT or AT intensity (Glass, 2008; Glass & Stanton, 2004)). In the current study, gender was initially included as a between-subjects factor in all analyses conducted on the dependent variables (i.e., training load and perceived exertion). However, no main or interaction effects involving gender (e.g., gender × experimental trial, gender × time, and gender × experimental trial × time) were omitted from future analyses. All

Table 1. Characterization of the Subjects and Resistance and Aerobic Training Load.

	Resistance training ($n = 38$)	Aerobic training ($n = 16$)
Age (years)	22.5 ± 3.3	23.4 ± 3.2
Weight (kg)	70.5 ± 12.9	69.5 ± 12.7
Height (m)	1.73 ± 0.09	1.70 ± 0.07
Body fat (%)	15.2 ± 6.7	17.7 ± 5.1
1RM in kilogram		
Leg press	336.4 ± 90.7	
Bench press	67.1 ± 23.2	
Knee extension	150.8 ± 40.8	
Arm curl	38.0 ± 13.0	
10RM in kilograms (%1RM)		
Leg press	244.2 ± 72.1(74.6%*)	
Bench press	52.9 ± 18.5 (78.4%)	
Knee extension	108 ± 27.3 (72.3%*)	
Arm curl	28.8 ± 10.2 (75.9%)	
Self-selected load for 10 repetitions in kilograms (%1RM)		
Leg press	142.8 ± 48.4 (44.2%)*	
Bench press	41.8 ± 21.8 (60.1%)	
Knee extension	68.5 ± 24.0 (44.9%)*	
Arm curl	21.3 ± 9.4 (55.5%)	
Exercise duration (minutes)		34.5 ± 13.5
Self-selected speed (km/h)		9.9 ± 2.4
$VO_{2\ peak}$ (ml/kg/minute)		49.5 ± 5.8
HR_{rest} (beats/minute)		76 ± 13
HR_{max} (beats/minute)		189 ± 6
HR_{LA} (beats/minute)		155 ± 8
$HR_{average}$ (beats/minute)		160.7 ± 12.4
$\%HR_{max}$		85.2 ± 5.9
$\%HR_{AnT}$		104.1 ± 7.1
RPE		
Muscle	7.0 ± 1.7**	5.7 ± 1.4
Overall	7.4 ± 0.9**,***	6.3 ± 1.6***

Note. HR_{rest} = resting heart rate; HR_{peak} = peak heart rate; HR_{AnT} = heart rate at anaerobic threshold; Percentage body fat was measured by Jackson & Pollock protocol of three skinfolds (men: chest, abdomen, and thigh; women: abdominal, triceps, and suprailiac).
*Significantly different from bench press and arm curl ($p < .05$).
**Significantly different from aerobic training ($p < .05$).
***Significantly different from muscle RPE ($p < .01$).

participants were in good health and were not taking nutritional or pharmacological substances known to affect cardiovascular, respiratory, muscular, metabolic, or cognitive functions. Before participating, all volunteers read and signed an informed consent document approved by the local ethics committee.

Procedures

Prior to performing the self-selected RT or AT session, we gathered data for participants' height, weight, and body fat, and participants completed a general physical activity recall questionnaire. After the anthropometric measurements and physical activity questionnaire were completed, participants performed the test protocols for the RT or AT group to which they were assigned.

Resistance Training. During the RT session, participants self-selected training intensities when performing the 45° leg press (LP), free weight bench press (BP), knee extension (KE), and EZ bar arm curl (AC) in the order listed. The LP and KE exercises were performed using RT machines (High On, Righetto® Fitness Equipment, São Paulo, Brazil). The BP and AC were performed using free weights, that is, bar and plates (Spandex®, São Paulo, Brazil). All participants had been using these same resistance exercises and machines as part of their regular training sessions. During the self-selected session, three sets of each exercise were completed with a 90-second recovery interval between each set and exercise type. During the self-selected session, participants chose the resistance usually lifted during each set of each RT exercise in the gym. Following performance of 10 repetitions per set, participants were instructed to select a resistance intensity that provided a "good workout" for each exercise type.

Forty-eight hours after the self-selected RT intensity for each exercise type, 1RM and 10RM tests were performed. To determine test–retest reliability, the 1RM and 10RM protocols were determined during two separate occasions, separated by 48 hours. The 1RM and 10RM measurements were determined within three to five attempts, with rest intervals of 2-4 minutes between attempts of the same exercise and between different exercises (Sheppard & Triplett, 2016). All exercises were tested on the same day in the same order performed in the self-selected intensity session. Overall and both upper and lower limb RPE followed the completion of each set of each exercise.

Aerobic Training. The AT session was performed on a treadmill (ATL, Imbrasport®, São Paulo, Brazil) at a self-selected intensity and duration (velocity in km/hour and time in minutes, respectively). Participants were instructed to select a velocity and duration appropriate for training as follows: "select an exercise intensity and duration that you prefer and that you would feel happy to do regularly" (Da Silva et al., 2011). Adjustment of velocity (intensity) was allowed at any time during the self-selected AT session. The speedometer, initially set at 4.0 km/hour, was covered throughout the session so that participants, but not investigators, were blinded to the actual treadmill speed. RPE was measured every minute and immediately after the exercise session.

Forty-eight hours after the self-selected AT session, participant performed a maximal treadmill exercise test using a ramp protocol (Whipp, Davis, Torres, & Wasserman, 1981). The ramp protocol was performed at a constant velocity of 11.2 km/hour for women and 12.8 km/hour for men. The initial treadmill slope was 2%, and the slope increased by 2% every 2 minutes until voluntary termination owing to fatigue.

Gas analysis was performed using a portable gas analyzer (K4 b2, Cosmed, Rome, Italy). VO_{2max} was considered achieved if two of the following criteria were met: (a) respiratory quotient greater than 1.1; (b) oxygen uptake constant (VO_2) or with an increase of less than 2.1 mL/kg/minute in workload; or (c) a heart rate (HR) of 90% or greater of estimated HR maximum using the equation: $208 - (0.7 \times \text{age}$; Tanaka, Monahan, & Seals, 2001). Anaerobic threshold was determined as the VO_2 at which the ventilatory equivalent for VO_2 (i.e., VE/VO_2) and end tidal O_2 increased without VE/VCO_2 increasing (Whipp et al., 1981). Visual inspection to determine the anaerobic threshold was carried out independently by two experienced investigators. The anaerobic threshold values detected by the two investigators were then compared. If the two ventilatory threshold values were within 3% (in mL/minute), then those values were averaged and accepted. If the two anaerobic threshold values were more than 3% different, a third investigator independently analyzed the exercise test data to detect anaerobic threshold (Gaskill et al., 2001). However, in this study, the differences between the anaerobic threshold values detected by the two investigators did not differ by more than 3% for any participant. Finally, HR_{max} was defined as the highest value recorded during the test.

Measures

We collected anthropometric measures of weight, height, and fat percentage. The participants' body weight was assessed using a digital weight scale (Fillizola®, São Paulo, Brazil). Height was determined to the nearest miilimeter using a stadiometer (Sanny®, São Paulo, Brazil). Body density was estimated by the equation of Jackson, Pollock, and Ward (1980) using the sum of skinfolds (triceps, suprailiac, and thigh), determined using an adipometer calipers (Sanny®, São Paulo, Brazil) and converted to fat percentage by the formula of Siri (1961).

Assessments of training load, HR, and RPE were obtained during the self-selected RT and AT sessions. RT session training load was determined as weight lifted in kilograms for a specific exercise. RT intensity was calculated as the average percentage of 1RM and 10RM for lower limb (LP and KE) and upper limb exercises (BP and AC). During the RT sessions, differentiated ratings for peripheral perceptions of exertion in the lower/upper limbs (active muscle RPE) were obtained following each set, while undifferentiated ratings for the overall body (overall RPE) were obtained immediately after each session utilizing the OMNI resistance exercise scale (RES; Ratamess et al., 2008). In the AT sessions, HR (FS1, Polar®, Kempele, Finland) and active muscle and overall body RPE, by OMNI walk/run scale (Utter et al., 2004), were measured every minute and immediately after the exercise session. Prior to both the RT and AT sessions, one familiarization exercise session for the OMNI RPE scale was performed. First, perceived exertion was defined as the subjective intensity of effort, strain, discomfort, or fatigue that was felt during exercise (Noble & Robertson, 1996). Then instructional sets for the OMNI RPE scale were read to the participants (Robertson, 2004). Participants were given a copy of the OMNI RPE scale prior to the exercise session and instructed to familiarize themselves with the scale. During the familiarization session, participants used the OMNI RPE scale to rate the intensity of their exertional perceptions. The OMNI scale was in view of the participants at all times. Importantly, the low and high perceptual anchors for the RPE scale were established using a "memory" procedure as described previously (Robertson, 2004).

Statistical Analysis

Kolmogorov–Smirnov and *Levene's tests* were used to check normality and homogeneity between groups. An *independent t test* was performed to detect differences between group demographics. A *chi-square test* was performed to analyze the nominal variables included in the questionnaire. Comparisons of the questionnaire between the responses and training groups were performed using a *Mann–Whitney test*. 1RM and 10RM reliability for each exercise were determined using coefficients of intraclass correlation (ICC) and coefficients of variation (CV). A *paired-sample t test* was used to compare the percentage of 1RM, the percentage of 10RM, and the self-selected load between both training. A one-sample *t test* compared the relative values of maximum self-selected load and HR with the NSCA's and ACSM's training minimum recommendations for RT and AT, respectively. The *Kruskal–Wallis test* was used to examine differences of RPE (muscle and overall) within and between training types (RT and AT).

The AT session time was separated into quartiles for the comparison of the variables. RPE between sets during the RT session and between quartiles during the AT session were examined by the Friedman test. A one-way analysis of variance (ANOVA) with repeated measures was used to compare the load differences used for each set in the RT session and speed and HR in each quartile of the AT session. When a significant difference was shown by ANOVA, a Tukey post hoc analysis was performed to determine where significant differences existed between means. Effect sizes (Cohen's *d*) were also calculated by taking the mean difference and dividing by the pooled *SD*. Confidence intervals were calculated for RPE in AT (between quartiles) and RT (between the sets), and for speed and HR in AT between quartiles. For all analyses, we used $p < .05$ level of significance.

Results

No difference in participant anthropometric characteristics (age, weight, height, and body fat) was evident between groups (Table 1). The *chi-square analyses* revealed significant variability in response distributions for each question included in the questionnaire and there were significant differences when comparing responses between the RT and AT groups using the *Mann–Whitney test* (Table 2). Questionnaire responses indicated that 79.6% (RT 81.6%, AT 75.0%) of the participants did not a have personal trainer ($p < .01$). Also, 67.5% of the participants in the RT group indicated muscle strength and hypertrophy was a training goal ($p = .046$), and 75% of the AT group indicated weight loss was a training goal ($p < .01$). There was no difference between RT and AT training experience ($p = .341$) and training frequency per week ($p = .09$). Participants in the RT group reported significantly ($p < .01$) greater training duration per training session than the AT group. Perception of training results showed 56.3% of participants in the AT group felt fully satisfied with their training results, while 56.7% of participants in the RT group were moderately satisfied with their training results. The majority of participants (68.7%) reported not using HR to monitor AT intensity. The RT and AT groups showed similar overall RPE values of 7.2 to 6.8 respectively, during the self-selected session, with no difference between groups ($p = .246$).

In the self-selected RT session, relative training intensity for upper limbs (55.5%–60.1% 1RM) was greater ($p < .05$) than for lower limbs (44.2%–44.9% 1RM). In addition, in both RT and AT session, overall RPE was significantly greater ($p < .01$) than muscle RPE (Table 1).

Resistance Training

In this study, between-day reliability estimates for 1RM and 10RM for each exercise were moderate to high (i.e., ICC > 0.80 and CV < 10%). The 1RM for the two testing sessions, separated by 48 hours, showed ICC and CV of LP: $r = 0.96$, CV = 27.0%; BP: $r = 0.99$, CV = 34.6%; KE: $r = 0.97$, CV = 27.0%; and AC: $r = 0.99$, CV = 34.2%. The 10RM tests showed ICC and CV of LP: $r = 0.98$, CV = 29.5%; BP: $r = 0.99$, CV = 35%; KE: $r = 0.97$, CV = 25.3%; and AC: $r = 0.99$, CV = 35.4%. Paired Student's *t* tests showed no significant difference between the two testing sessions for the 1RM or 10RM test for any exercise tested.

Table 2. Questionnaire Responses.

Type of training	Resistance training ($n = 38$), %	Aerobic training ($n = 16$), %
Type of orientation		
Personal trainer	18.4%	25%
Coach of gym	81.6%**	75%*
Objective		
Fitness	5.4%	25%*
Muscle definition	21.6%	0%*
Weight loss	5.4%	75%*
Muscle strength and hypertrophy	67.5%	0%*
Training experience	45 months	39 months
Training frequency per week	4 days	4 days
Training duration	50 minutes	34 minutes*
Perceived results		
Unsuccessful	0%	0%
Moderate success	56.7%	43.7%
Successful	43.3%	56.3%
Self-selected training RPE	7.2	6.8
Used RM or %RM to monitor RT intensity or HR to monitor AT intensity		
No	84.2%	68.7%
Yes	15.8%	31.3%

Note. AT = aerobics training; RM = repetition maximum; RPE = ratings of perceived exertion; RT = resistence training.
*Difference between RT and AT ($p < .001$).
**Difference in type of orientation ($p < .01$).

The ANOVA with Tukey post hoc analysis of the self-selected RT session load yielded significant main effects for sets ($p < .004$). The load in successive sets increased (13%) in the LP and KE from the first to the second set and second to third set, while for the BP and AC there was no significant change in intensity. Self-selected average training relative load for all exercises was 51.2% 1RM with the average being 44.6% for the lower limb and 57.8% for the upper limb exercises. These relative values were lower ($p = .001$) than those recommended by NSCA, that is, more than 67% 1RM.

No differences in RPE between exercises were shown (Table 3). Univariate follow-up analyses revealed that all four exercises contributed to the multivariate effects for RPE. RPE increased significantly in successive sets for all exercises

Table 3. OMNI-RES Rating of Perceived Exertion After Each Set in the Resistance Training Self-Selected Session.

	$M \pm SD$	95% CI	ES	%CV
Leg press				
Set 1	6.0 ± 1.9	5.4–6.6		31.7
Set 2	7.2 ± 1.5*	6.7–7.6	0.8[a]	20.8
Set 3	7.9 ± 1.5 ***	7.4–8.4	1.1[a]; 0.8[b]	19
Bench press				
Set 1	5.9 ± 2.1	5.2–6.5		35.6
Set 2	6.9 ± 2.0*	6.3–7.6	0.7[a]	29
Set 3	8.0 ± 2.1***	7.3–8.7	1.0[a]; 0.9[b]	26.3
Knee extension				
Set 1	5.9 ± 1.7	5.3–6.4		28.8
Set 2	7.4 ± 1.4*	6.9–7.8	1.3[a]	18.9
Set 3	8.3 ± 1.2*,**	7.9–8.7	1.5[a]; 1.1[b]	14.5
Arm curl				
Set 1	6.7 ± 1.8	6.1–7.3		26.9
Set 2	7.7 ± 1.4*	7.2–8.1	0.7[a]	18.2
Set 3	8.6 ± 1.3*,**	8.2–9.0	1.0[a]; 0.9[b]	15.1
Average	7.2 ± 0.9*,**	6.9–7.5	NA	14.6

Note. M = mean; SD = standard deviation; ES = effect size; %CV = coefficient of variation; 95% CI = 95% confidence interval.
[a]ES in relation to Set 1.
[b]ES in relation to Set 2.
*Significantly different from first set ($p < .05$)
**Significantly different from second set ($p < .05$).

during the RT session. Mean number of repetitions per set completed in the self-selected intensity was 10.0 ($SD = 0.1$) repetitions.

Aerobic Training

Self-selected speed showed no significant difference between quartiles. HR estimates relative to HR_{max} were within the range recommended by ACSM (Garber et al., 2011) of 64% to 95% HR_{max} for moderate or vigorous intensity. HR showed an increase from the first to the second quartile with no further increase in third and fourth quartile (Table 4). RPE estimates were also within the range recommended by ACSM (Garber et al., 2011) of 5 to 8 on the OMNI walk/run pictorial perceived exertion scale. RPE means significantly increased from the first to second quartile and then showed small but not significant increases in the third and fourth quartiles (Table 4).

Table 4. Speed, HR and RPE During Each Quartile of Aerobic Training Self-Selected Session.

	$M \pm SD$	95% CI	ES	%CV
Speed (km/hour)				
1st quartile	9.4 ± 2.1	8.2–10.5		22.3
2nd quartile	9.9 ± 2.5	8.6–11.3	0.3[a]	24
3rd quartile	10.1 ± 2.6	8.7–11.4	0.3[a]; 0.2[b]	27.3
4th quartile	10.2 ± 2.7	8.8–11.6	0.4[a]; 0.2[b]; 0.1[c]	26.5
HR (beats/minute; $\%HR_{max}$)				
1st quartile	148 ± 17.8 (73.7%)	138.5–157.5		12
2nd quartile	160.2 ± 14.3 (85.8%)*	152.6–167.8	1.4[a]	9.1
3rd quartile	164.8 ± 12.9 (86.8%)*	157.9–171.7	0.9[a]; 0.4[b]	7.8
4th quartile	167.9 ± 13 (89.4%)*	161.0–174.8	1.2[a]; 1.0[b]; 0.5[c]	7
$RPE_{average}$				
1st quartile	3.9 ± 1.7	3–4.8		52.4
2nd quartile	5.4 ± 1.7*	4.4–6.3	1.1[a]	34.6
3rd quartile	6.5 ± 1.6*,**	5.6–7.3	1.2[a]; 0.9[b]	33.3
4th quartile	7.1 ± 1.7*,**,***	6.2–8.0	1.6[a]; 1.5[b]; 0.8[c]	22.1

Note. M = mean; SD = standard deviation; ES = effect size; %CV = coefficient of variation; 95% CI = 95% confidence interval; HR = heart rate; $RPE_{average}$=rating of perceived exertion average.
[a]ES in relation to 1° quartile.
[b]ES in relation to 2° quartile.
[c]ES in relation to 3° quartile.
*Significantly different from first quartile ($p < .05$).
**Significantly different from second quartile ($p < .01$).
***Significantly different from third quartile ($p < .01$).

Discussion

This is one of the first investigations to compare self-selected and recommended training loads separately for RT and AT sessions. The major findings in these recreationally trained participants were as follows: Self-selected RT intensity was below the recommended training intensity zone (Sheppard & Triplett, 2016), while self-selected AT intensity and RPE were within the recommended training range (Garber et al., 2011). Our finding, that a self-selected RT intensity was lower than recommended is consistent with findings of previous studies on several different participant groups using different recomended training guidelines. Groups of trained women (Ratamess et al., 2008), untrained college women (Focht, 2007), older women (Elsangedy et al., 2013), and comprising both men and women (Glass & Stanton, 2004) were shown to self-select an RT intensity less than 60% 1RM recommended by ACSM (Pescatello & ACSM, 2000), 67% 1RM recommended by NSCA (Wathen, 1994), 50% 1RM recommended by ACSM (Chodzko-Zajko et al., 2009), and 60% 1RM recommended by ACSM (Pescatello & ACSM, 2000), respectively.

While the finding that AT self-selected intensity and RPE were within recommended values for promoting cardiovascular fitness agrees with one previous study on adult men (Chu, Lu, & Lin, 2010), this finding does not agree with a study using physically active men and women (Krinski et al., 2010). A review by Ekkekakis (2009) indicated that most individuals self-select an intensity within cardiovascular training guidelines when the guideline is 64% to 70% HR_{max}.

The recommended RT training zone for strength and hypertrophy used in the current study was 67-85% 1RM (Sheppard & Triplett, 2016). In the current study, trained men and women self-selected lower RT intensities ranging from 44.2-60.1% 1RM. Dias, Simão, Saavedra, & Ratamess (2017) indicated that participants who trained under the supervision of a personal trainer self-selected significantly greater loads during RT exercises compared with those who trained on their own. The questionnaire responses showed that most of our participants did not a have a personal trainer which probably contributed to their self-selection of a lower training intensity. In fact, self-selected intensities may be influenced by participants' own perceptions or misconceptions about RT (Ratamess et al., 2008). Participants in the current study self-selected intensities below the recommended intensity zone for gains in muscle strength and hypertrophy, even though 67.5% of them indicated that strength and hypertrophy was a training goal. The self-selection of lower than recommended RT intensity agrees with other studies finding self-selected RT intensities of 42% 1RM in older women (Elsangedy et al., 2013), 56% 1RM in untrained college women (Focht, 2007), and 42% to 57% 1RM in untrained men and women (Glass & Stanton, 2004). The present and previous findings suggest that trained young (24 years) women (Focht et al., 2015) and men (Portugal, Lattari, Santos, & Deslandes, 2015) do not self-select RT intensities within the recommended training zone (67%–85% 1RM) for producing improvements in muscular strength and hypertrophy. However, this does not mean that gains in strength or hypertrophy do not occur using lower self-selected intensities than recommended by the NSCA (Sheppard & Triplett, 2016). A previous study by Burd et al. (2010) showed that low-load high volume (24.0 ± 1.1 repetitions per set) RT did induce acute muscle anabolism in healthy, recreationally active men.

In the self-selected RT training session, the loads increased in successive sets of the lower limb exercises of LP and KE indicating a 10RM load was not used in the first set of an exercise. In the upper limb exercises of BP and AC, the loads did not increase in successive sets. In the self-selected session, participants selected an average training intensity corresponding to 44.6% 1RM for the lower limb exercises and 57.8% 1RM for the upper limb exercises resulting in an overall intensity of 51.2% 1RM. One possible explanation for the increase of load in successive sets of lower limb exercises is a lower initial intensity compared with the upper body exercises, which allowed an increase in intensity. The self-selection of a lower training intensity for lower limb exercises is in agreement with Portugal et al. (2015), who found in trained men that self-selected intensities for upper and lower body exercises averaged 48% 1RM with the average self-selected intensity for lower and upper limb exercises being 37% and 58% 1RM, respectively. These results agree with previous investigations suggesting differences in self-selected exercise intensities between upper and lower limb exercises (Ratamess et al., 2008) and smaller versus larger muscle group exercises (Elsangedy et al., 2013).

Participants self-selected an average load of 75.4% 10RM to perform 10 repetitions per set during the self-selected RT session, indicating sets were not performed to volitional fatigue. Muscular fatigue may be needed to cause maximal increases in strength but not power (Drinkwater et al., 2005; Izquierdo et al., 2006). However, for the recommended training intensity of 67%-85% 1RM, 6-12 repetitions should be able to be performed before the onset of fatigue (Sheppard & Triplett, 2016). Given this range of repetitions, some participants may have performed sets to or close to volitional fatigue, especially in the second or third set of a given exercise, even though on average 10 repetitions per set were performed. Sets performed at light to moderate loads, in some cases, are associated with reduced training adaptations in comparison to sets perfomed at higher loads (Garber et al., 2011). This could explain, at least in part, why 56.7% of RT participants considered their training to be only a moderate success.

AT session intensity was measured as a percentage of HR_{max}, as used in other investigations described in a review by Ekkekakis (2009). For cardiovascular fitness increases because of AT moderate or vigorous intensities (64%–95% HR_{max}) are recommended for most adults (Garber et al., 2011). In this study, average training HR during the self-selected AT session was 160 beats/minute which was 83.9% HR_{max}. This value is within recommended intensities to cause cardiovascular fitness increases. Other studies corroborate these results reporting self-selection of 67-83% HR_{max} in untrained women (Lind, Joens-Matre, & Ekkekakis, 2005) and 75.7% HR_{max} in trained men (Chu et al., 2010) as self-selected intensities. The result that individuals do self-select an AT intensity within recommended guidelines is also in agreement with a review showing that in 37 of 63 studies individuals chose a HR within training recommendations of 64-70% HR_{max} (Ekkekakis, 2009).

During the AT self-selected session, mean velocity was 9.9 km/hour, and velocity did not significantly change during the session. HR increased from the first to second quartile and showed no significant change from the second to the third and fourth quartiles. RPE in the self-selected session showed a similar pattern as HR with an increase from the first to second quartile and then no further change. These findings did not agree with those of Lind et al. (2005), who reported that sedentary middle-aged women gradually increased treadmill speed throughout the AT session, with a subsequent stabilization of speed, HR, and RPE in the final minutes. The reasons for these discrepancies are unclear but might include differences in study protocols and participants characteristics.

The use of RPE to control intensity during RT and AT has been recommended by the ACSM (Garber et al., 2011) and NSCA (Sheppard & Triplett, 2016). The 10-point OMNI RPE scales used in this study have been validated for both RT (Robertson et al., 2003) and walk/run (Utter et al., 2004). This study provides some insight into use of RPE to control intensity. The relationship of 20-point and 10-point RPE scales is well established (Robertson, 2004). Using a 20-point scale, it is recommended that AT be "somewhat hard" to "hard" for overall perception (Garber et al., 2011). Using the 10-point OMNI walk/run scale used in this study, the mean muscle (mean = 5.7, $SD = 1.4$) and overall (mean = 6.3, $SD = 1.6$) RPE were "somewhat hard" (6 on the 10-point scale). On the 10-point OMNI RES, the mean muscle (mean = 7.0, $SD = 1.7$) and overall (mean = 7.4, $SD = 0.9$) RPE were "somewhat hard" (6 on the 10-point scale) to "hard" (8 on the 10-point scale). Therefore, both RT and AT presented RPE responses within the training recommendations.

Our results are in agreement with the findings of previous studies that RT self-selected RPE is "light" to "hard" (Focht, 2007) with 20-point scale and "somewhat hard" (Glass & Stanton, 2004) with 10-point scale, indicating intensity below and within the recommended intensity zone. Thus some, but not all, of our recreationally trained participants did self-select an RT resistance that would cause an overload training stimulus based on a target RPE. RPE increased in successive sets of all exercises. This finding shows RPE increases in successive sets even without increasing the load, perhaps because of the cumulative energy expenditure caused by successive sets (Mayo, Iglesias-Soler, & Del-Olmo, 2014) or increased anabolic metabolites (Robertson et al., 2003).

Different from Lagally and Robertson (2006) who showed that RPE of active muscle was significantly higher than overall RPE, the current study showed no significant difference between active muscle RPE (mean = 7.0, $SD = 1.7$) and overall RPE (mean = 7.4, $SD = 0.9$) in a self-selected RT session. Changes in peripheral and respiratory muscle tension are monitored through a common neurophysiological pathway that transmits exertional signals from the motor to the sensory cortex as effort sensation. As exercise intensity increases, the number of central motor feed-forward commands required to increase motor unit recruitment and firing frequency in both peripheral (muscle RPE) and respiratory (overall RPE) skeletal muscle must also increase (Robertson, 2004).

The RPE during the self-selected AT session after the second quartile was higher than after the first quartile of the session. This agrees with Kilpatrick, Robertson, Powers, Mears, and Ferrer (2009), using OMNI scale, who showed RPE increased in a 30-minute self-selected intensity session as the session progressed. The mean OMNI walk/run RPE was 5.7 ($SD = 1.4$) indicating, "moderate" to "heavy effort" (Glass & Chvala, 2001; Utter et al., 2004). In the current study, RPE increased significantly from the beginning to the end of exercise, which is also in agreement with Kilpatrick et al. It is possible that the fatigue contributed to the increase in RPE as exercise duration increased (Borg, 1998; Robertson, 2004). The self-selected intensity was slightly above anaerobic threshold (104% HR_{AnT}) which may have also contributed to the increased RPE as the AT session progressed.

In summary, the primary findings of this study were that self-selected RT intensity was below the recommended intensity zone for RT, while self-selected AT intensity was within the recommended intensity zone for cardiovascular fitness training. The majority of our recreationally trained participants did not use an RM or a percentage of 1RM to control resistance training intensity or HR to control AT intensity. Participants in the current study did report a "somewhat hard" to "hard" (OMNI: 6–8) overall RPE for both the self-selected RT and AT sessions which is within the recommended RPE training range.

Declaration of Conflicting Interests

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References

Bonafiglia, J. T., Rotundo, M. P., Whitall, J. P., Scribbans, T. D., Graham, R. B., & Gurd, B. J. (2016). Inter-individual variability in the adaptative responses to endurance and sprint interval training: A randomized crossover study. *PLoS One*, *11*(12), e0167790. doi:10.1371/journal.pone.0167790

Borg, G. (1998). *Borg's perceived exertion and pain scales*. Champaign, IL: Human Kinetics.

Burd, N. A., West, D. W., Staples, A. W., Atherton, P. J., Baker, J. M., Moore, D. R., . . . Phillips, S. M. (2010). Low-load high volume resistance exercise stimulates muscle protein synthesis more than high-load low volume resistance exercise in young men. *PLoS One*, *5*(8), e12033. doi:10.1371/journal.pone.0012033

Chodzko-Zajko, W. J., Proctor, D. N., Fiatarone Singh, M. A., Minson, C. T., Nigg, C. R., Salem, G. J., & Skinner, J. S. (2009). American College of Sports Medicine position stand. Exercise and physical activity for older adults. *Medicine & Science in Sports & Exercise*, *41*(7), 1510–1530. doi:10.1249/MSS.0b013e3181a0c95c

Chu, C. Y., Lu, S. Y., & Lin, K. F. (2010). Influences of exercise experience and exercise settings on heart rate responses during self-selected intensity exercises. *Journal of Exercise Science & Fitness*, *8*(2), 73–77. doi:10.1016/S1728- 869X(10)60011-1

DaSilva, S. G., Guidetti, L., Buzzachera, C. F., Elsangedy, H. M., Krinski, K., De Campos, W., . . . Baldari, C. (2011). Psychophysiological responses to self-paced treadmill and overground exercise. *Medicine & Science in Sports & Exercise, 43*(6), 1114–24. doi: 10.1249/MSS.0b013e318205874c

Dias, M. R. C., Simão, R., Saavedra, F. J. F., & Ratamess, N. A. (2017). Influence of a personal trainer on self-selected loading during resistance exercise. *The Journal of Strength & Conditioning Research*, *31*(7), 1925–1930. doi:10.1519/JSC.0000000000001663

Drinkwater, E. J., Lawton, T. W., Lindsell, R. P., Pyne, D. B., Hunt, P. H., & McKenna, M. J. (2005). Training leading to repetition failure enhances bench press strength gains in elite junior athletes. *The Journal of Strength & Conditioning Research*, *19*(2), 382–388.

Ekkekakis, P. (2009). Let them roam free? Physiological and psychological evidence for the potential of self-selected exercise intensity in public health. *Sports Medicine*, *39*(10), 857–888.

Elsangedy, H. M., Krause, M. P., Krinski, K., Alves, R. C., Nery Chao, C. H., & Da Silva, S. G. (2013). Is the self-selected resistance exercise intensity by older women consistent with the American College of Sports Medicine guidelines to improve muscular fitness? *The Journal of Strength & Conditioning Research*, *27*(7), 1877–1884. doi:10.1519/JSC.0b013e3182736cfa

Focht, B. C. (2007). Perceived exertion and training load during self-selected and imposed-intensity resistance exercise in untrained women. *The Journal of Strength & Conditioning Research*, *21*(1), 183–187. doi:10.1519/R-19685.1

Focht, B. C., Garver, M. J., Cotter, J. A., Devor, S. T., Lucas, A. R., & Fairman, C. M. (2015). Affective responses to acute resistance exercise performed at self-selected and imposed loads in trained women. *The Journal of Strength & Conditioning Research*, *29*(11), 3067–3074. doi:10.1519/JSC.0000000000000985

Garber, C. E., Blissmer, B., Deschenes, M. R., Franklin, B. A., Lamonte, M. J., Lee, I. M., . . . Swain, D. P. (2011). American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: Guidance for prescribing exercise. *Medicine & Science in Sports & Exercise*, *43*(7), 1334–1359. doi:10.1249/MSS.0b013e318213fefb

Gaskill, S. E., Ruby, B. C., Walker, A. J., Sanchez, O. A., Serfass, R. C., & Leon, A. S. (2001). Validity and reliability of combining three methods to determine ventilatory threshold. *Medicine & Science in Sports & Exercise*, *33*(11), 1841–1848.

Glass, S. C. (2008). Effect of a learning trial on self-selected resistance training load. *The Journal of Strength & Conditioning Research*, *22*(3), 1025–1029. doi:10.1519/JSC.0b013e31816a5b70

Glass, S. C., & Chvala, A. M. (2001). Preferred exertion across three common modes of exercise training. *The Journal of Strength & Conditioning Research*, *15*(4), 474–479.

Glass, S. C., & Stanton, D. R. (2004). Self-selected resistance training intensity in novice weightlifters. *The Journal of Strength & Conditioning Research*, *18*(2), 324–327. doi:10.1519/R- 12482.1

Izquierdo, M., Ibanez, J., Gonzalex-Badillo, J. J., Häkkinen, K., Ratamess, N. A., Kraemer, W. J., . . . Gorostiaga, E. M. (2006). Differential effects of strength training leading to failure versus not to failure on hormonal responses, strength, and muscle power gains. *Journal of Applied Physiology*, *100*(5), 1647–1656. doi:10.1152/japplphysiol.01400.2005

Jackson, A. S., Pollock, M. L., & Ward, A. (1980). Generalized equations for predicting body density of women. *Medicine & Science in Sports & Exercise*, *12*(3), 175–182.

Johnson, J. H., & Phipps, L. K. (2006). Preferred method of selecting exercise intensity in adult women. *The Journal of Strength & Conditioning Research*, *20*(2), 446–449. doi:10.1519/R-17935.1

Kilpatrick, M. W., Robertson, R. J., Powers, J. M., Mears, J. L., & Ferrer, N. F. (2009). Comparisons of RPE before, during, and after self-regulated aerobic exercise. *Medicine & Science of Sports & Exercise*, *41*(3), 681–686. doi:10.1249/MSS.0b013e31818a0f09

Krinski, K., Elsangedy, H. M., Buzzachera, C. F., Colombo, H., Alves, R. C., Santos, B. V., . . . Da Silva, S. G. (2010). Physiological and perception responses comparison during treadmill walking at self-selected pace between genders. *Revista Brasileira de Medicina do Esporte*, *16*(4), 291–294. doi:10.1590/S1517- 86922010000400012

Lagally, K. M., & Robertson, R. J. (2006). Construct validity of the OMNI resistance exercise scale. *The Journal of Strength & Conditioning Research*, *20*(2), 252–256. doi:10.1519/R-17224.1

Lind, E., Joens-Matre, R. R., & Ekkekakis, P. (2005). What intensity of physical activity do previously sedentary middle-aged women select? Evidence of a coherent pattern from physiological, perceptual, and affective markers. *Preventive Medicine*, *40*(4), 407–419. doi:10.1016/j.ypmed.2004.07.006

Marshall, P. W., McEwen, M., & Robbins, D. W. (2011). Strength and neuromuscular adaptation following one, four, and eight sets of high intensity resistance exercise in males. *European Journal of Applied Physiology*, *111*(12), 3007–3016.

Mayo, X., Iglesias-Soler, E., & Del-Olmo, M. F. (2014). Effects of set configuration of resistance exercise on perceived exertion. *Perceptual & Motor Skills*, *119*(3), 1–13. doi:10.2466/25.29.PMS.119c30z3

Morton, R. W., Oikawa, S. Y., Wavell, C. G., Mazara, N., McGlory, C., Quadrilatero, J., . . . Phillips, S. M. (2016). Neither load nor systemic hormones determine resistance training-mediated hypertrophy or strength gains in resistance-trained young men. *Journal of Applied Physiology*, *121*(1), 129–138. doi:10.1152/japplphysiol.00154.2016

Noble, B. J., & Robertson, R. J. (1996). *Perceived Exertion*. *Champaign*. IL: Human Kinetics.

Pescatello, L. S., & American College of Sports Medicine. (2000). *ACSM's guidelines for exercise testing and prescription* (9th ed.). Philadelphia, PA: Wolters Kluwer/Lippincott Williams and Wilkins.

Portugal, E. M. M., Lattari, E., Santos, T. M., & Deslandes, A. C. (2015). Affective responses to prescribed and self-selected strength training intensities. *Perceptual & Motor Skills*, *121*(2), 465–481.

Ratamess, N. A., Alvar, B. A., Evetoch, T. K., Housh, T. J., Kibler, W. B., Kraemer, W. J., & Triplett, N. T. (2009). Progression models in resistance training for healthy adults. *Medicine & Science in Sports & Exercise*, *41*(3), 687–708.

Ratamess, N. A., Faigenbaum, A. D., Hoffman, J. R., & Kang, J. (2008). Self-selected resistance training intensity in healthy women: The influence of a personal trainer. *The Journal of Strength & Conditioning Research*, *22*(1), 103–111. doi:10.1519/JSC.0b013e31815f29cc

Robertson, R. J. (2004). The OMNI picture system of perceived exertion. In R. J. Robertson (Ed.), *Perceived exertion for practitioners: Rating effort with the OMNI picture system* (pp. 9–20). Champaign, IL: Human Kinetics.

Robertson, R. J., Goss, F. L., Rutkowski, J., Lenz, B., Dixon, C., Timmer, J., ... Andreacci, J. (2003). Concurrent validation of the OMNI perceived exertion scale for resistance exercise. *Medicine & Science in Sports & Exercise*, *35*(2), 333–341. doi:10.1249/01.MSS.0000048831.15016.2A

Siri, W. E. (1961). Body composition from fluid spaces and density: Analysis of methods. In J. Brozek & A. Henschel (Eds.), *Techniques for measuring body composition* (pp. 223–244). Washington, DC: National Academy Press.

Sheppard, J. M., & Triplett, N. T. (2016). National Strength and Conditioning Association—Program design for resistance training. In G. G. Haff & N. T. Triplett (Eds.), *Essentials of strength training and conditioning* (4th ed., pp. 439–470). Champaign, IL: Human Kinetics.

Tanaka, H., Monahan, K. D., & Seals, D. R. (2001). Age-predicted maximal heart rate revisited. *Journal of the American College of Cardiology*, *37*(1), 153–156.

Utter, A. C., Robertson, R. J., Green, J. M., Suminski, R. R., Mcanulty, S. R., & Nieman, D. C. (2004). Validation of the adult OMNI scale of perceived exertion for walking/running exercise. *Medicine & Science of Sports & Exercise*, *36*(10), 1776–1780. doi:10.1249/01.MSS.0000142310.97274.94

Vazou-Ekkekakis, S., & Ekkekakis, P. (2009). Affective consequences of imposing the intensity of physical activity: Does the loss of perceived autonomy matter? *Hellenic Journal of Psychology*, *6*, 125–144.

Wathen, D. (1994). National Strength and Conditioning Association—Load assignment. In T. R. Baechle (Ed.), *Essentials of strength training and conditioning* (pp. 435–446). Champaign, IL: Human Kinetics.

Whipp, B. J., Davis, J. A., Torres, F., & Wasserman, K. (1981). A test to determine parameters of aerobic function during exercise. *Journal of Applied Physiology: Respiratory, Environmental and Exercise Physiology*, *50*(1), 217–221.

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