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The affective and behavioral responses to repeated "strength snacks"

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Background: A training program consisting of only one-repetition maximum (1RM) training results in similar strength adaptations as traditional resistance exercise. However, little is known regarding the affective or behavioral responses to this type of training. *Aim:* To examine the affective and behavioral response to either a traditional resistance exercise program or a biweekly 1RM-training program. *Methods:* Participants were trained for 8 weeks (2× per week). The HYPER group completed four sets of 8–12 repetitions; the 1RM group (TEST) worked up to a single maximal repetition. *Results:* The TEST group felt more revitalized and had an increase in positive engagement during their first visit, whereas the HYPER group showed an increase in feelings of physical exhaustion during their first and last visits. There were no pre to post differences for the change in behavior or self-efficacy between groups. *Conclusion:* 1RM training appears to elicit a more favorable affective response, compared with HYPER training, which may ultimately improve adherence to resistance-type exercise.

Keywords: vascular conductance, blood flow, affect, feelings, resistance training

Introduction

Recently, it was proposed that muscle size and strength from repeated bouts of exercise are separate physiological adaptations (i.e., changes in size are not driving changes in strength) (3). In support of this position, daily one-repetition maximum (1RM) training (performing a single 1RM each session) in the upper body (biceps curls) led to an increase in 1RM strength with no change in muscle size in a small group of resistance-trained individuals (5). Interestingly, in that same study, the contralateral limb performing three sets of 10 repetitions at 70% of 1RM alongside the 1RM training saw significant growth with no further strength adaptation over that gained by just performing the strength test (i.e., 1RM) by itself (5). We recently observed this same phenomenon in a larger sample of untrained individuals, where one group performed a strength test twice a week (1RM) and the other group performed traditional "hypertrophy" training (four sets of an 8–12 RM). Strength increases were statistically equivalent between groups, despite an absence of muscle growth in the 1RM testing group (TEST) (12). If strength can be acquired in the absence of muscle growth, individuals who are interested in only strength may be able to reach their training goals without the large volumes of work believed to be necessary in a resistance-training program.

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Given the low volume required with 1RM training, this form of training may elicit a more favorable affective response, which may increase exercise adherence.

The affective response to resistance exercise is perhaps one of the more overlooked variables in the resistance-training literature. This is important, as participation in resistance-type exercise is considerably low, despite recommendations from The United States Departments of Health and Human Services (17) and the American College of Sports Medicine (11). For example, Dankel et al. (7) found that only 18.6% of individuals met the guidelines for muscle-strengthening activity among a nationally represented sample of US adults. Other studies have found similar results, showing that approximately 14%–21% of individuals engage in resistance-type exercise (4, 6). It is likely that engagement in resistance exercise is even lower as the commonly used National Health and Nutrition Examination Survey defines muscle-strengthening activities as "any physical activities specifically designed to strengthen your muscles, such as weight lifting, push-ups, or sit-ups." Under this definition, it is plausible that some individuals participated in activities that are not traditionally considered "resistance exercise." Nevertheless, this lack of engagement may be explained, in part, by the affective response to resistance exercise (14). Arent et al. (2) examined the gradient of affect change across different intensities of resistance exercise, finding that moderate intensity (70% of a 10RM) strength training produced improvements in anxiety, positive affect, negative affect, energy, tiredness, tension, and decreased energy and calmness. Conversely, high intensities (10 repetitions at a 10RM) increased anxiety, negative affect, tiredness, tension, and decreased energy and calmness. Similarly, O'Connor et al. (13) examined the affective response following resistance exercise across different intensities, suggesting that moderate intensities reduce state anxiety for up to 120 min post-resistance exercise. It appears that higher intensities or more exhausting bouts of resistance exercise produce a more negative affect response in comparison with lower intensity less exhausting bouts. This is not unlike what occurs with aerobic type exercise, as several studies have shown that with increasing intensity there is a resultant decrease in affect scores (8, 14, 16). A review by Parfitt and Hughes (14) discusses this intensity–affect relationship, suggesting that affective response may have implications for future exercise behavior. Specifically, authors suggest that a positive affective response to exercise may help avoid the revolving door phenomena and improve physical inactivity statistics. Indeed, if the affective response is important for exercise adherence, it is worthwhile to examine exercise-induced feelings to emerging protocols (such as our biweekly 1RM training protocol referred to above). Although testing a 1RM is "high intensity," it is not fatiguing and requires considerably less volume and time than a traditional program. This low-volume approach to resistance exercise can be viewed as a "strength snack" alternative to traditional resistance exercise. Thus, the purpose of this study was to examine and compare the acute and chronic changes in the affective response to either traditional high-load resistance training or biweekly 1RM practice. In addition, we examined changes in behavior and self-efficacy between groups.

Methods

Participants

A total of 40 untrained individuals (18 males and 22 females) were recruited for this study. Two individuals (1 male and 1 female) in the hypertrophy training group (HYPER) were unable to complete the study due to personal reasons; thus, their data were excluded from further analyses, leaving a final sample of 18 individuals in the HYPER group and 20 individuals in the 1RM testing group (TEST). Individuals were classified as “untrained,” if they did not perform any resistance training for at least 6 months in the upper and lower body. Individuals were excluded if they were not between the ages of 18 and 35 years, resistance trained in the upper and lower body, if they used tobacco-related products, or if they had an orthopedic injury preventing exercise. The study received approval from the University’s institutional review board and each participant gave written informed consent before participation. The muscle size and strength data from this study have been published elsewhere (12).

Study design

During the first visit, participants completed a behavior change and self-efficacy questionnaire. Following the pre-visit, participants were enrolled in a training program consisting of 16 training sessions dispersed over 8 weeks. On the first and the last training visits, all participants completed the *Exercise-Induced Feelings Inventory* questionnaires. Following the 8 weeks of training, participants completed the post-testing visit, which consisted of the *Exercise-Induced Feelings Inventory* questionnaires, as well as the behavior change and self-efficacy questionnaire.

Training protocol

The HYPER group performed a high-volume resistance training program designed to produce muscle growth and increase strength (HYPER: $n = 18$; males = 7 and females = 11), whereas the TEST group completed a program designed to minimize muscle growth and maximize strength by simply performing a 1RM strength test (TEST: $n = 20$; males = 10 and females = 10). The training protocol for the HYPER group consisted of four sets with a goal of 8–12 repetitions on a knee extension (Hammer Strength Plate-Loaded Iso-Lateral Leg Extension; Life Fitness, USA) and chest press machine (Hammer Strength Plate-Loaded Iso-Lateral Bench Press; Life Fitness). Individuals trained to volitional failure; however, if the participant did not fall between the repetition range, the load was adjusted accordingly to achieve 8–12 repetitions during the next set. The training protocol for the TEST group consisted of five attempts to lift as much weight as possible once for that training visit with 90 s of rest between attempts. The load was progressively increased each attempt to try to reach or exceed their previous 1RM. During the attempts for knee extension, if the participants failed to hit the bar before the fifth attempt, the training session for that limb was terminated. Similarly, if the participants failed to fully lockout their arms on the chest press, the training session for that exercise was terminated. The majority of individuals completed three attempts but no one completed more than five attempts per limb/exercise for the TEST group during training. Participants in both the HYPER and TEST groups were encouraged during the training visits to beat their previous best. Additional details on the training protocol can be found elsewhere (12).

Exercise volume

Exercise volume was calculated as the total number of kilograms (Repetitions × Sets) lifted per week for both the HYPER and TEST exercise conditions. The lower body was separated by limb dominance, given the use of a unilateral knee extension. Limb dominance was determined by asking participants with which leg they would kick a ball.

Exercise-induced feelings

The Exercise-Induced Feeling Inventory is a 12-item questionnaire designed to assess the affective responses to a bout of exercise. Questions are on a 5-point scale ranging from 0: *do not feel* to 5: *feel very strongly*. The questionnaire evaluates three positive feeling states (positive engagement, revitalization, and tranquility), as well as one negative feeling state (physical exhaustion). Exercise-induced feelings were measured before knee extension exercise, after knee extension exercise, and after the chest press exercise on the first and the last training visits. Reliability and validity have been shown to be adequate (1).

Behavior change and self-efficacy

A behavior change and self-efficacy questionnaire was administered pre- and post-intervention to evaluate (1) intent to change behavior, (2) attitude about behavior, (3) self-efficacy, and (4) control beliefs. The questionnaire consisted of 12 total items, consisting of three questions on "intent to change," five questions regarding "attitudes about exercise," two questions on "self-efficacy," and two questions on "control beliefs." Questions for "intent to change," "self-efficacy," and "control belief" were slightly modified from pre- to post-intervention. For example, for pre-intervention, questions were phrased in the context of being enrolled in the study: "Had I not been enrolled in this study, I intended to perform resistance exercise twice per week in the forthcoming month," whereas post-intervention questions were phrased in the context of continuing the resistance-training program: "I intend to continue to perform resistance exercise twice per week in the forthcoming month." For attitudes about behavior, a caveat was added as well. Thus, instead of ranking attitudes in response to "engaging in a resistance regimen twice per week," participants were asked to rank attitudes in response to "continuing this resistance exercise regimen twice per week." All questions were answered on a 1–7 Likert scale.

Statistical analyses

Data are presented as mean [95% confidence interval (CI)] unless otherwise noted. Independent samples *t*-tests were used to compare demographic information. A one-way analysis of covariance with baseline values as a covariate assessed whether the changes in behavior change and self-efficacy over the 8-week period differed by group. For exercise-induced feelings, a repeated measures of analysis of variance (ANOVA) across time (pre, mid, and post) with a between-subject factor of group was completed for Visits 1 and 16. If there was an interaction, a one-way repeated measures ANOVA was used to determine differences across time within each group and an independent sample's *t*-test was used to determine differences across groups within each time point. An additional repeated measures ANOVA across time (Pre 1 vs. Pre 2) with a between-subject factor of group was used to determine a training effect. If there was an interaction, a paired samples *t*-test was used across time within each group and an independent sample's *t*-test was used across each group within each time point. Statistical significance was set at $p \leq 0.05$.

Results

Demographics

Descriptive data are presented as mean [standard deviation (SD)]. There were no differences between groups for age [HYPER: 21 (SD 3) years vs. TEST: 22 (SD 4) years, $p = 0.562$], height [HYPER: 169.3 (SD 8.4) cm vs. TEST: 173.5 (SD 8.5) cm, $p = 0.134$], or body mass [HYPER: 79.3 (SD 22.6) kg vs. TEST: 70.4 (SD 14.4) kg, $p = 0.150$]. Four individuals in the HYPER group failed to complete one or more of the feelings questionnaires and were excluded from the analysis of affect.

Exercise volume

The weekly exercise volume (Repetitions × Exercise load) for each group is displayed in Fig. 1. By design, the TEST group completed relatively minimal volume compared with the HYPER group.

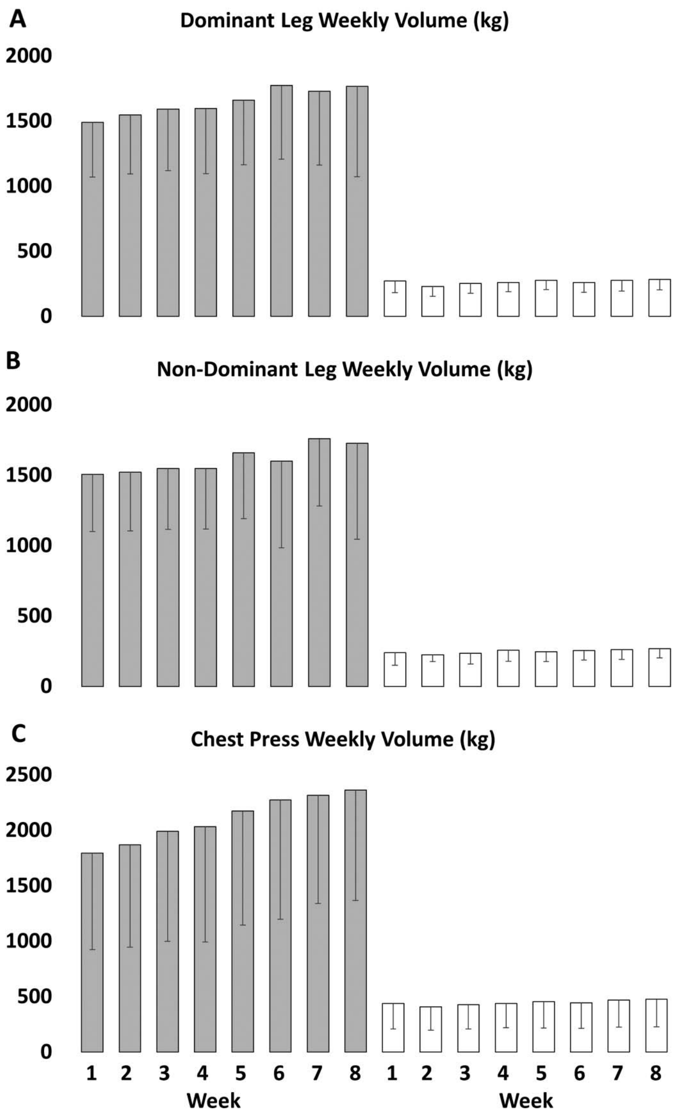

Fig. 1. The average weekly volume for the dominant leg knee extension (A), non-dominant leg knee extension (B), and the chest press exercise (C) for both the HYPER (gray bars) and TEST (white bars) conditions. Variability is represented in standard deviations. HYPER: hypertrophy training group; TEST: testing group

Exercise-induced feelings

For Visit 1, there was a significant interaction (Group × Time) for revitalization ($p = 0.005$; Table I). Follow-up tests found significant increases across time for the TEST ($p = 0.047$) group but not for the HYPER group ($p = 0.069$). For Visit 16, there was no interaction ($p = 0.199$) or main effect of time ($p = 0.899$). Finally, there was no interaction ($p = 0.270$) or time effect ($p = 0.671$) for changes in the pre values for revitalization following 8 weeks of resistance training.

For tranquility, there was no significant interaction ($p = 0.489$) for Visit 1, but there was a main effect of time ($p = 0.015$; Table I). Tranquility decreased [mean (95% CI)] from pre to

Table I. The mean and 95% CI for composite scores for revitalization, tranquility, positive engagement, and physical exhaustion across time (pre, mid, and post) for both the first and the last training sessions

		Pre	**Mid**	**Post**
Revitalization				
First training session†	HYPER	2.5 (2.0, 3.0)	1.7 (1.2, 2.3)	1.8 (1.2, 2.3)
	TEST	2.2 (1.7, 2.6)[a]	2.5 (2.1, 3.0)[b]*	2.6 (2.2, 3.1)[b]*
Last training session	HYPER	2.4 (1.9, 2.8)	2.2 (1.8, 2.6)	2.1 (1.5, 2.6)
	TEST	2.4 (2.0, 2.8)	2.6 (2.2, 2.9)	2.6 (2.1, 3.1)
Tranquility				
First training session£	HYPER	2.8 (2.4, 3.2)	2.4 (1.9, 2.8)	2.3 (1.8, 2.7)
	TEST	3.1 (2.7, 3.4)	2.9 (2.5, 3.3)	2.8 (2.3, 3.2)
Last training session£	HYPER	3.1 (2.7, 3.5)	2.5 (2.1, 3.0)	2.4 (1.9, 2.9)
	TEST	3.1 (2.7, 3.4)	2.8 (2.4, 3.2)	2.5 (2.1, 2.9)
Positive engagement				
First training session†	HYPER	2.7 (2.3, 3.2)	2.6 (2.2, 3.1)	2.5 (2.1, 3.0)
	TEST	2.5 (2.1, 2.9)[a]	3.0 (2.6, 3.4)[b]	3.1 (2.7, 3.4)[b]
Last training session	HYPER	2.7 (2.3, 3.2)	2.8 (2.4, 3.1)	2.8 (2.4, 3.2)
	TEST	2.9 (2.5, 3.3)	3.1 (2.8, 3.4)	3.1 (2.7, 3.4)
Physical exhaustion				
First training session†	HYPER	1.0 (0.5, 1.6)[a]	2.3 (1.7, 2.8)[b]	2.7 (2.1, 3.3)[c]
	TEST	1.4 (1.0, 1.8)	1.4 (0.9, 1.8)*	1.4 (0.9, 1.9)*
Last training session†	HYPER	1.1 (0.6, 1.7)[a]	2.2 (1.7, 2.8)[b]	2.7 (2.1, 3.3)[c]
	TEST	1.5 (1.0, 2.0)	1.5 (1.0, 2.0)*	1.7 (1.2, 2.2)*

Superscript letters (a, b, and c) represent differences within each condition. Meaning, time points with different letters were significantly different within a specific group ($p < 0.05$) and time points with the same letter were not significantly different ($p > 0.05$). The "†" symbol indicates a significant interaction. The symbol "*" indicates significant difference between groups (HYPER vs. TEST) for a given time point (pre, mid, and post). "£" represents a time effect detailed in the "Results" section. HYPER: hypertrophy training group; TEST: testing group; CI: confidence interval mid [−0.3 (−0.5, −0.05), $p = 0.018$] and from pre to post [−0.4 (−0.7, −0.07), $p = 0.018$], but there were no differences from mid to post [−0.1 (−0.2, 0.08), $p = 0.272$]. For Visit 16, there was no significant interaction ($p = 0.506$) for tranquility, but there was a main effect of time ($p < 0.001$; Table I). Tranquility decreased from pre to mid [−0.4 (−0.6, −0.1), $p = 0.004$], from pre to post [−0.6 (−0.9, −0.3), $p < 0.001$], and from mid to post [−0.2 (−0.4, −0.01), $p = 0.036$]. Finally, there was no interaction ($p = 0.398$) or time effect ($p = 0.296$) for changes in the pre values for tranquility following 8 weeks of resistance training.

For positive engagement, there was a significant interaction for Visit 1 ($p = 0.027$; Table I). Follow-up tests found significant increases across time for the TEST group ($p = 0.003$) but not the HYPER group ($p = 0.596$). For Visit 16, there was no interaction ($p = 0.772$) or main effect of time ($p = 0.448$). Finally, there was no interaction ($p = 0.213$) or time effect ($p = 0.268$) for changes in the pre values for positive engagement following 8 weeks of resistance training.

For physical exhaustion, there was a significant interaction for Visit 1 ($p < 0.001$, Table I). Follow up tests found significant increases across time for the HYPER group ($p = 0.003$) but not for the TEST group ($p = 0.947$). For Visit 16, there was a significant interaction for physical exhaustion ($p < 0.001$; Table I). Follow-up tests found significant increases across time for the HYPER group ($p < 0.001$) but not for the TEST group ($p = 0.393$). Finally, there was no interaction ($p = 0.991$) or time effect ($p = 0.649$) for changes in the pre values for physical exhaustion following 8 weeks of resistance training.

Behavior change and self-efficacy

There were no pre to post differences for the change in behavior or self-efficacy between groups ($p > 0.05$; Table II).

Discussion

To our knowledge, this is the first study to examine changes in exercise-induced feelings before and after a resistance-training program. Interestingly, one's feelings (in response to exercise) do not appear to change appreciably across time (pre- to post-intervention). Thus, if an individual did not have a positive affective response to resistance exercise, it does not appear that this will meaningfully change through participation in a training program. In addition, it appears that the overall affective response was more favorable in the 1RM group compared with the HYPER group. Notably, despite the TEST group performing maximal efforts, the HYPER group displayed increased feelings of physical exhaustion across time for both pre- and post-interventions. Conversely, revitalization and positive engagement increased across time within the first visit for the TEST group. These increases are likely due to the nature of testing maximal strength. For example, the novelty of setting a new personal 1RM record may have contributed to the positive response, which was only statistically significant during the first training session. The lack of statistical significance during the post-visit is likely due to the higher baseline (i.e., positive engagement and revitalization both had higher baseline values during the post-visit) (Table I). Perhaps, the most notable differences were the feelings of exhaustion observed within the HYPER group. Literature on the affective response to aerobic exercise would suggest that the response is intensity dependent (14); however, it appears that the affect response to

Table II. The adjusted pre-scores, as well as pre- to post-change [mean (95% CI)] for both the HYPER and TEST conditions as well as the between group differences [mean (95% CI)]

1–7	Adjusted pre	Pre–post changes in behavior		Between group (95% CI)
		HYPER	TEST	
Harmful–beneficial	6.18	0.45 (0.09, 0.82)	0.38 (0.04, 0.73)	0.06 (−0.45, 0.59)
Unpleasant–pleasant	5.08	−0.66 (−1.45, 0.11)	−0.29 (−1.04, 0.44)	−0.37 (−1.47, 0.73)
Bad–good	6.00	−1.12 (−2.15, −0.09)	−0.23 (−1.20, 0.73)	−0.88 (−2.37, 0.59)
Worthless–valuable	6.03	−0.21 (−1.0, 0.59)	−0.05 (−0.82, 0.71)	−0.16 (−1.31, 0.98)
Unenjoyable–enjoyable	5.29	−0.50 (−1.37, 0.37)	−0.69 (−1.52, 0.13)	0.19 (−1.02, 1.41)
1 (unlikely)–7 (likely)				
Intent to change behavior	3.29	1.71 (1.20, 2.22)	1.30 (0.82, 1.78)	0.41 (−0.29, 1.12)
Self-efficacy	5.39	0.47 (−0.06 1.02)	0.57 (0.04, 1.10)	−0.09 (−0.85, 0.67)
Control beliefs	4.01	0.28 (−0.38, 0.95)	0.89 (0.25, 1.53)	−0.60 (−1.54, 0.32)

The table is set up for the first word to represent “1” and the second to represent “7”. For example, the first line represented how an individual rated the behavior from harmful (i.e., 1) to beneficial (i.e., 7). HYPER: hypertrophy training group; TEST: testing group; CI: confidence interval

resistance exercise may be more dependent on fatigue as opposed to the external load. This is in line with the findings of Arent et al. (2), who found that performing 10 repetitions at a 10 rep maximum intensity produced a more negative affect response compared with performing a submaximal amount of repetitions at that same intensity. Interestingly, fatigability does not always appear to explain the affective response. Richardson et al. (15) observed a similar affective response between high-load resistance exercise completed at a low-velocity and low-load resistance exercise completed at a high velocity. This was observed despite higher ratings of perceived exertion and fatigue in the high-load group. It is important to note that both protocols in that study produced some level of fatigue, which may be suggestive of a fatigue threshold in regard to the affective response. While considering these data along with this study, we would suggest that the affective response is different with resistance exercise, and may depend on the volume of work completed, and be influenced by the level of fatigability (as opposed to the external load). In addition, we speculate that the perceived discomfort may have contributed to the more negative affective response in the HYPER group (9). Future research is necessary to look at the affective response to other fatiguing protocols (i.e., low-load exercise to failure), which we would suspect to elicit a similar affective response as high-load exercise to failure.

Regarding behavior change and self-efficacy, there were no differences between groups (Table II). Thus, much like feelings, it does not appear that the attitudes toward resistance exercise are largely influenced by engagement in resistance exercise. In fact, all attitudes toward resistance exercise (with the exception of harmful → beneficial) trended toward a decrease (Table II) when measured following 8 weeks of resistance exercise. This would suggest that individuals tended to view resistance exercise as less pleasant, less good, less valuable, and less enjoyable following 8 weeks of resistance training. In combination with the emotional response to exercise, we believe this data indicate that individuals will not be more likely to improve most attitudes toward exercise following 8 weeks of resistance exercise training. It is important to note that we had poor internal consistency for our behavior change and self-efficacy questionnaire during our post-visit (Cronbach's $\alpha < 0.7$). Thus, if significant group differences in behavior change and self-efficacy did occur, we may have been limited in our ability to see those changes.

One of the most striking contrasts of this study was the volumes of work completed. For example, on average, the TEST group performed 15% and 21% of the volume performed by the HYPER group for the lower and upper body, respectively. As such, biweekly 1RM training may be seen as a "strength snack." Although we did not time the duration of the visits, the exercise volume indicates that individuals in the test group spent less time performing exercise compared with the HYPER group. Francois et al. (10) demonstrated that the performance of brief intense "exercise snacks" (six 1-min work bouts, consisting of walking at 90% of heart rate max) before meals reduced postprandial and subsequent 24 h glucose concentrations in an insulin resistant population compared with a 30-min bout of continuous moderate exercise (60% heart rate max). Similar to this, we believe that the "strength snack" may provide a viable and perhaps more tolerable alternative for individuals who may experience a negative affective response to traditional resistance exercises. Importantly, the overall affective response appeared to favor the TEST group, despite the drastic contrast in volume of work performed.

This study is not without limitation. First, our internal consistency for behavior change and self-efficacy questionnaires was low (Cronbach's $\alpha < 0.7$). Thus, we had a limited ability to gauge changes for those measures. However, we did have good internal consistency in our exercise-induced feelings, which corroborated the lack of group difference in self-efficacy/behavior change.

Conclusions

Results of this study suggest that the affective response to resistance exercise may be dependent upon fatigability and not absolute load. In addition, if an individual did not have a positive affective response to resistance exercise, it does not appear that this will meaningfully change through participation in a training program. Overall, the affective response appeared to favor the TEST condition (particularly with physical exhaustion). This type of training may help improve participation for individuals with a lack of time (18), providing a sort of "strength snack" (10).

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Conflict of interest

All authors declare that they have no conflicts of interest that are relevant to the content of this article.

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