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Original Research

The Effect of Rest Interval Length on Upper and Lower Body Exercises in Resistance-Trained Females

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ABSTRACT

International Journal of Exercise Science 14(7): 1178-1191, 2021. The purpose of this study was to investigate the effects of SHORT (1 min) and LONG (3 min) rest intervals (RI) on total volume lifted (TVL), repetition performance, fatigue index (FI), and blood lactate [La] during upper body (chest press) and lower body (leg press) exercise with low-intensity (75% of a 10-RM) in trained female lifters. Fourteen females (mean ± SD, age = 22.9 ± 5.4 years, training experience = 5.2 ± 2.5 years, height = 166.1 ± 6.9 cm, weight = 61.3 ± 5.1 kg, body fat % = 21.7 ± 3.3%) participated in this randomized, repeated-measures, cross-over design study. They performed four sets to failure on chest press (CP) and leg press (LP) under two conditions (SHORT and LONG RIs) in a counterbalanced manner. Paired-samples *t*-tests were used to analyze mean differences for TVL in CP and LP, separately. A 2 (exercise) x 2 (rest interval) repeated measures ANOVA was used to analyze mean differences in FI and average [La] values. A 2 (rest interval) x 4 (sets) repeated measures ANOVA was used to analyze mean differences in repetitions completed for each exercise. TVL for SHORT was significantly less when compared to LONG for both exercises. There was no significant difference in average [La] between RIs despite a greater FI in SHORT compared to LONG for both exercises. Lastly, [La] was higher during LP compared to CP irrespective of RI length. These results suggest that longer RIs are better for female lifters who want to optimize TVL with low-intensity resistance training. Metabolic stress, as measured by blood lactate, was greater during lower-body exercise.

KEY WORDS: Strength training, recovery, metabolic stress, total volume, rest period

INTRODUCTION

A rest interval (RI) is defined as the time dedicated to recovering between sets and between exercises during sessions of resistance training (RT) (1, 9, 10). There are several purposes for RIs, including replenishment of the ATP-CP energy system, buffering protons from anaerobic glycolysis, and removal of lactate that accrued during the set (9, 10). Originally, it was believed that shorter RIs were superior for chronic adaptations because they increased anabolic hormones, such as growth hormone, insulin growth factor 1, and testosterone (6, 9). However, recent research demonstrated that short and long RIs increase the concentration of these hormones similarly (9), and others have shown that the transient increase of anabolic hormones is unrelated to hypertrophy and strength (23). Moreover, quality of training may decline if RIs are too short, as indicated by decreased power production (28), repetition performance (38), and volume (13).

Two meta-analyses have concluded that higher training volume is essential for long-term RT outcomes, such as hypertrophy and strength (8, 31). Volume can be calculated as total volume load (TVL), which is the product of sets x repetitions x load (13). Conceptually, if RIs are too short, TVL will be diminished because lifters will perform fewer repetitions with the same intensity, or they will reduce intensity to maintain repetition performance. Hernandez et al. (13) recently demonstrated that TVL was significantly lower with 2-min (1,448 kg) and 5-min (1,793 kg) RIs compared to 8-min RIs (2,207 kg) during four sets of high-intensity bench press (85% 1-RM). In congruence, Ratamess et al. (28) reported that total repetitions performed significantly decreased during three sets of bench press with 75% 1-RM as rest intervals decreased from 3 min (27 repetitions), 2 min (24 repetitions), to 1 min (21 repetitions). Lower body exercise is also impacted by RI length, as Willardson et al. (38) reported that total repetitions performed during four sets of squats decreased as RIs were shortened from 5 min (28.5 repetitions), to 2 min (25.5 repetitions), to 1 min (22.5 repetitions). Based on acute data, it is logical to assert that long RIs may lead to superior RT outcomes by preserving TVL and quality of sets during individual training sessions. In support of this speculation, two recent publications have concluded that when the number of sets are matched, long RIs (3 min) are superior to short RIs (1 min) for chronic neuromuscular adaptations in untrained (19) and trained lifters (32).

It may be important to consider sex when selecting RIs for a client. A recent review (10) speculated that female lifters require shorter RIs than male lifters due to physiological differences that include muscle fiber distribution, size of type 1 muscle fibers, and glycogen utilization during high-intensity exercise (14). Moreover, it has been reported that females produce less blood lactate (29), experience smaller force decrements (39), and recover force quicker (8) than males during and after RT. Collectively, the research suggests that females tolerate metabolic stress better, and are more fatigue resistant than males, meaning they may not require long RIs during RT. Lactate, an anaerobic by-product that is formed when pyruvate binds to a hydrogen ion after glycolysis (20), is often used as a proxy measure of metabolic stress during various styles of RT (21). Research on the effect of RI length on blood lactate concentration [La] is equivocal, as some studies report no difference between short and long RIs (16) while others show that [La] is higher with short RIs (17). Regardless, the effect of RI length on [La] has scarcely been studied in female lifters.

To the best of our knowledge, the effect of RI length on repetition performance during upper and lower body exercises in female lifters of any age has not been investigated. Only three studies have measured the effect of RI length on [La] (29), repetition performance (28), and fatigue (5) in female lifters. Irrespective of sex, few studies have assessed the effect of RI length on volume performed during low-intensity RT (6, 35, 41). Furthermore, limited research has evaluated the effect of RI length on fatigue index (FI) and [La] during upper and lower body exercises. Therefore, the purpose of this study was to measure the effect of 1-min (SHORT) and

3-min (LONG) RIs on TVL, repetition performance, FI, and [La] during upper body (chest press) and lower body (leg press) exercise with low-intensity (75% of a 10-RM) in trained female lifters. These RI durations were selected because they have been used in previous studies (19, 28, 32). We hypothesized that TVL would be higher with LONG and that repetition decline, as measured by FI, would be greater with SHORT for both exercises. We also hypothesized that [La] would be higher with SHORT for both exercises and that [La] would be higher during LP exercise regardless of RI length. Considering set-by-set repetition performance, we hypothesized that a uniform decline in repetitions completed would occur for both exercises, and that the decline would be significantly higher during SHORT.

METHODS

This study used a randomized, repeated-measures, cross-over design to compare the effect of SHORT and LONG RIs on repetition performance and TVL during failure-sets with low-intensity (75% of 10-RM) on CP and LP. During their first visit, the subject's 10 repetition maximum (10-RM) was determined for CP and LP, and they performed one failure-set with each exercise for familiarization. For their second and third visits, participants completed RT sessions using 1 and 3 min of rest between their sets. The order of RI conditions and order of exercises (i.e., CP or LP performed first) were randomized and counterbalanced. Dependent variables measured during each RT session were TVL, FI, repetitions performed, [La], and rating of perceived exertion (RPE). Visits one and two were separated by 2-3 days and visits two and three were separated by 5-7 days, and all visits occurred during the same time of the day. Participants were informed about the difficulty of the RT sessions and were instructed to eat/hydrate as they would for a day of high-volume, total-body lifting. The experimental procedures were approved by the University of New Mexico Institutional Review Board, and all participants provided written informed consent. This research was carried out fully in accordance with the ethical standards of the International Journal of Exercise Science (25).

Participants

Fourteen healthy, resistance-trained females volunteered for this study, which was based on a power analysis from Willardson and Burkett (38). By using the significant difference of volume performed between one-min (22.5 ± 4.8 repetitions) and five-min (28.5 ± 3.1 repetitions) conditions, it was concluded that approximately 14 participants would be sufficient to detect a significant difference in volume performed between one and three-min RIs ($\alpha = 0.05$; $1- \beta = 0.9$). All descriptive/demographic information for the participants is provided in Table 1. To qualify for participation, participants self-reported (e.g., physical activity questionnaire) they had performed total-body RT > 2 days per week for > 12 months, had experience with the CP and LP, consistently trained with low intensities (i.e., 12-20 repetitions per set), and routinely performed failure-sets. Moreover, participants self-reported that they were free of cardio-vascular, metabolic, viral, kidney, and liver disease with no orthopedic injuries that may prevent them from exercise. During the first lab visit, height (cm) and body weight (kg) were measured using a stadiometer and floor scale, respectively, and three-site skinfold (triceps, suprailliac, and thigh) were measured (15). These skinfold values were subsequently used to estimate body density and body fat (BF)% (36).

Table 1. Anthropometric and descriptive information for all participants.

Age (yr)	Training Experience (yr)	Height (cm)	Weight (kg)	BF%
22.9 ± 5.4	5.2 ± 2.5	166.1 ± 6.9	61.3 ± 5.1	21.7 ± 3.3

Note: Data are displayed as means ± standard deviation. *n* = 14; cm = centimeters; kg = kilograms; BF% = body fat percentage; yr = years

Protocol

Proper lifting technique and cadence were demonstrated by the same researcher, who is certified by the National Strength and Conditioning Association (NSCA) and American College of Sports Medicine (ACSM). After observing proper form and descriptions of the LP, participants performed 5-10 min of a self-selected warm-up before executing the first set of the exercise with ~50% of their estimated 10-RM for 10 repetitions. Following a rest period, successive sets were performed, and researchers continued to add weight until a successful 10-RM was determined. A rest period of 3-5 min was provided between each set. After a 10-min rest, the 10-RM procedure was repeated for the CP. A similar methodology has been used previously (21), which was adopted from the NSCA recommendations (11), and all 10-RMs were determined within five attempts. Previous research reported an excellent test-retest reliability of this 10-RM procedure, as the ICC was 0.98 (21). Following the 10-RM determination for both exercises, participants performed one failure-set for LP and CP with 75% of their 10-RM and they were familiarized with how to rate their effort on the OMNI-RPE scale (1-10). A metronome was used to maintain a repetition cadence of 2:1 (e.g. two seconds eccentric and one-second concentric contraction) during all sets of exercise, and this cadence was used for subsequent RT sessions.

Participants performed a 5-10-min self-selected dynamic warm-up followed by two warm-up sets of 10 repetitions on their first exercise (CP or LP): one with 50% of their 10-RM, and one with 60% of their 10-RM. After the warm-up sets, the intensity was set to 75% of 10-RM, and participants performed four failure-sets with SHORT or LONG RIs between sets. As before, a metronome was used to maintain a repetition cadence of 2:1 seconds and researchers provided verbal encouragement during every set. Failure was achieved if the subject voluntarily terminated the set, could not complete the concentric phase of the lift, broke their form to complete the concentric phase of the lift, or could not maintain the 2:1 cadence for two consecutive repetitions. Lactate and RPE were measured immediately after each set, and the number of repetitions performed during the set was recorded at this time. After completing four sets, each participant rested for 30 minutes before repeating the procedure for the second exercise (LP or CP), beginning with the two warm-up sets (10 repetitions with 50 and 60% of 10-RM). The order of exercise and RI length were randomized and counterbalanced between participants. Thus, if a subject performed CP with SHORT RIs before LP with LONG RIs during their first RT session, they performed LP with SHORT RIs before CP with LONG RIs during their second RT session. Fatigue index (FI = number of repetitions during Set #1 – number of repetitions during Set #4/ number of repetitions during Set #1) and TVL (sets x repetitions x external load) were calculated for LP and CP at the end of each session.

Lactate was measured using a handheld lactate meter (Lactate Plus, NOVA Biomedical, MA) and lactate strips (Lactate Plus, NOVA Biomedical, MA). Researchers sterilized the earlobe with alcohol wipes before puncturing the earlobe to draw blood. Gauze was used to wipe the initial bolus of blood away, the ear was gently squeezed, and the second bolus of blood was sampled. Measurements were taken in duplicate after every set of exercise and the average of the two measurements was recorded. The data are displayed as an average of the four sets completed for all experimental conditions. Considering the quality of [La] measurement, the Lactate Plus device had a strong, positive correlation (r = 0.91) with a reference device, and the ICC for duplicate measurements was very strong (r = 0.99) (12).

Participants were asked to rank their RPE using the 1-10 OMNI-RPE scale (24) immediately after every set of exercise. Specifically, they were asked the question "how hard were your muscles working" and the scale was physically placed in front of them. For our study, the rating of "1" was associated with "no exertion at all" and a "10" rating was associated with "hardest exertion possible." The RPE data was not statistically analyzed and was only collected to ensure that participants maximized their effort during each set (i.e., each set was completed between an 8-10 on the scale).

Statistical Analysis

All statistical computations were performed using JASP version 0.12 software (JASP, Amsterdam, The Netherlands). For TVL, a paired-samples t-test was used to assess mean differences between SHORT and LONG RIs for CP and LP, separately. Moreover, a 2 (exercise) x 2 (rest interval) repeated measures ANOVA was used to analyze mean differences in FI and average lactate values. A 2 (rest interval) x 4 (sets) repeated measures ANOVA was used to analyze mean differences in repetitions completed for CP and LP, separately. The assumption of normality was checked using the Shapiro-Wilk test of normality during the paired-samples t-tests. If this assumption was violated ($p \leq .05$), the Wilcoxon signed-rank test was used to test the mean differences. The assumption of sphericity was checked using the Mauchly's test of sphericity during the repeated measures ANOVA analyses. If this assumption was violated ($p \leq .05$), the Greenhouse-Geisser test was used to test the mean differences. Pairwise comparisons using the Tukey procedure were used to analyze significant interactions from the repeated measures ANOVA. If there were no significant interactions, pairwise comparisons using the Bonferroni correction procedure for multiple comparisons were used to analyze significant main effects from the repeated measures ANOVAs. All pairwise comparisons are reported as mean ± SD. For all statistical tests, a probability level of $p \leq .05$ denoted statistical significance, except for when the Bonferroni correction procedure was used.

RESULTS

For TVL, the assumption of normality was violated when comparing the mean differences between SHORT and LONG for CP but not for LP. Therefore, we used the Wilcoxon signed-rank test to test the mean differences for CP but not for LP. A paired t-tests revealed that LONG was significantly greater than SHORT for CP, t (13) = 0.000, p = 0.001, Cohen's d = 1.000 and LP, *t* (13) = -5.433, $p < .001$, Cohen's *d* = -2.200 (Figure 1). There was no statistically significant interaction between rest interval and exercise on the dependent variables FI and average [La]. However, there were statistically significant main effects on rest interval for the dependent variable FI, $F(1, 13) = 32.378$, $p < .001$, $\eta^2 = 0.009$ and on exercise for the dependent variable average lactate, $F(1, 13) = 17.557$, $p = .001$, $\eta^2 = 0.221$. Pairwise comparisons for FI and average [La] using the Bonferroni correction procedure are reported in Figures 2 and 3, respectively. There was a statistically significant interaction between rest interval and number of repetitions performed for each set during the CP trial, $F(3, 39) = 5.711$, $p = .002$, $\eta^2 = 0.020$ and during the LP trial, $F(3, 39) = 7.773$, $p = < .001$, $\eta^2 = 0.012$. The results of the Tukey post hoc tests for each exercise are shown in Figure 4.

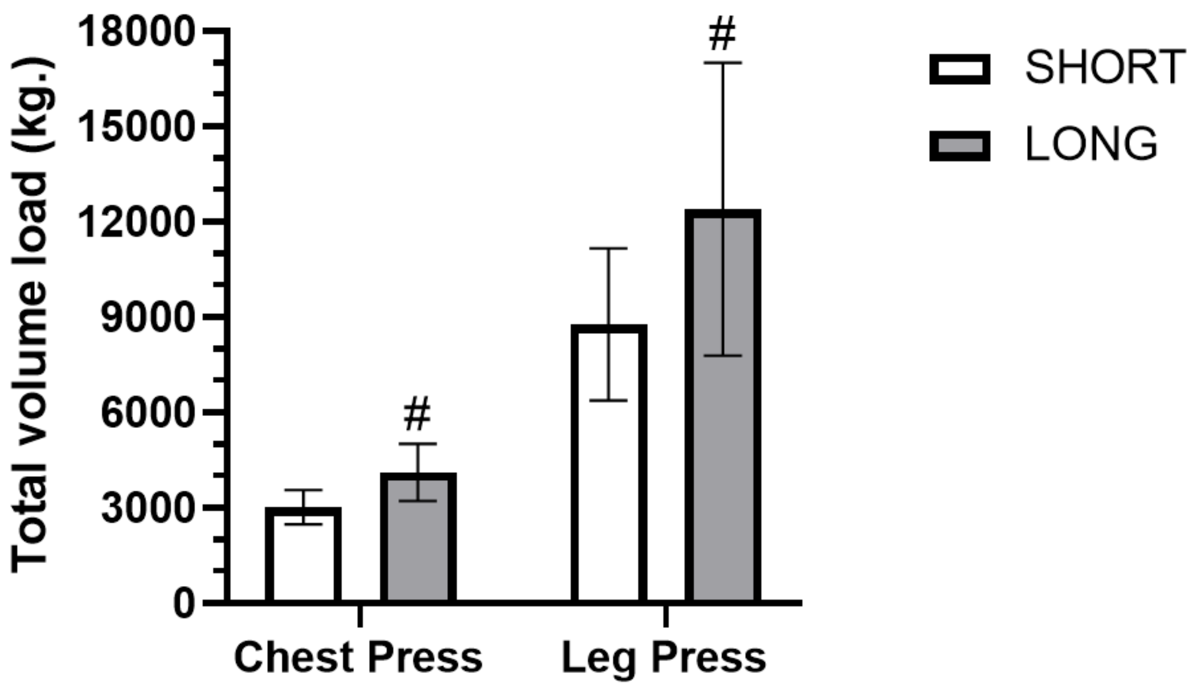

Figure 1. Total volume load (sets x repetitions x load) completed during chest press and leg press during SHORT (1 min) and LONG (3 min) rest interval sessions. Four sets were completed to task failure for each session. # $p \leq .025$ significantly greater than SHORT for that specific exercise. $n = 14$.

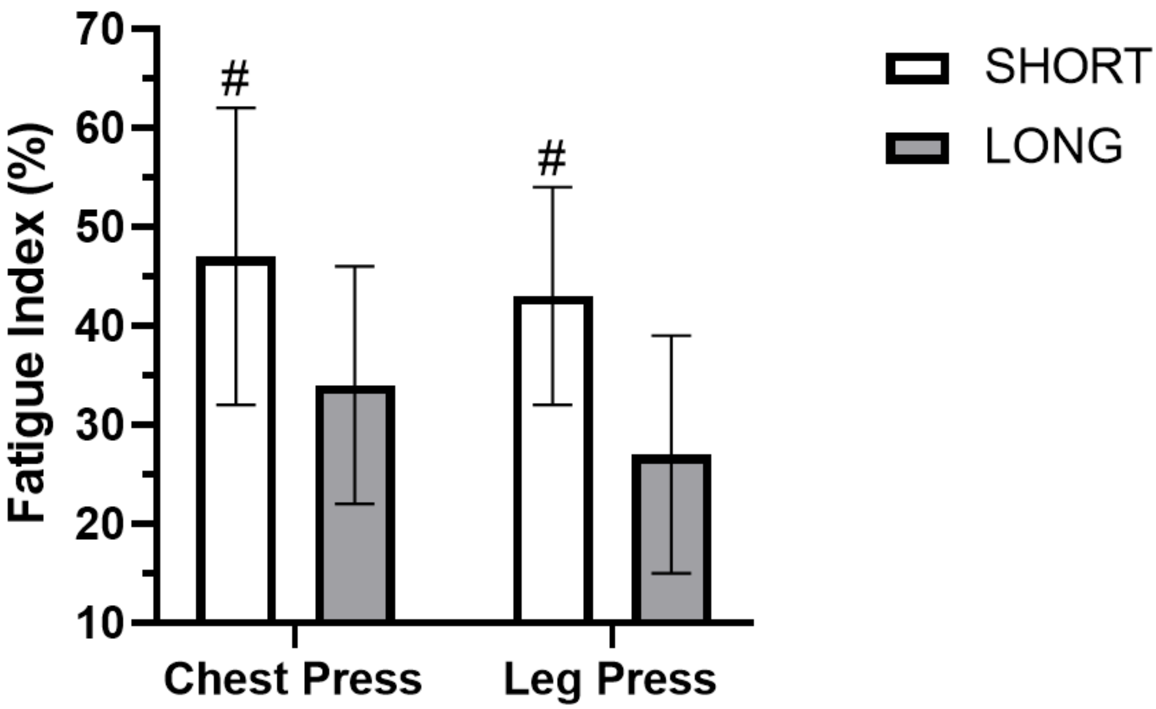

Figure 2. Fatigue index (repetitions completed during set #1 – repetitions completed during set #4/repetitions completed during set #1) for chest press and leg press during SHORT (1 min) and LONG (3 min) rest interval sessions. Four sets were completed to task failure for each session. #$p \leq .025$ significantly greater than LONG for that specific exercise. $n = 14$.

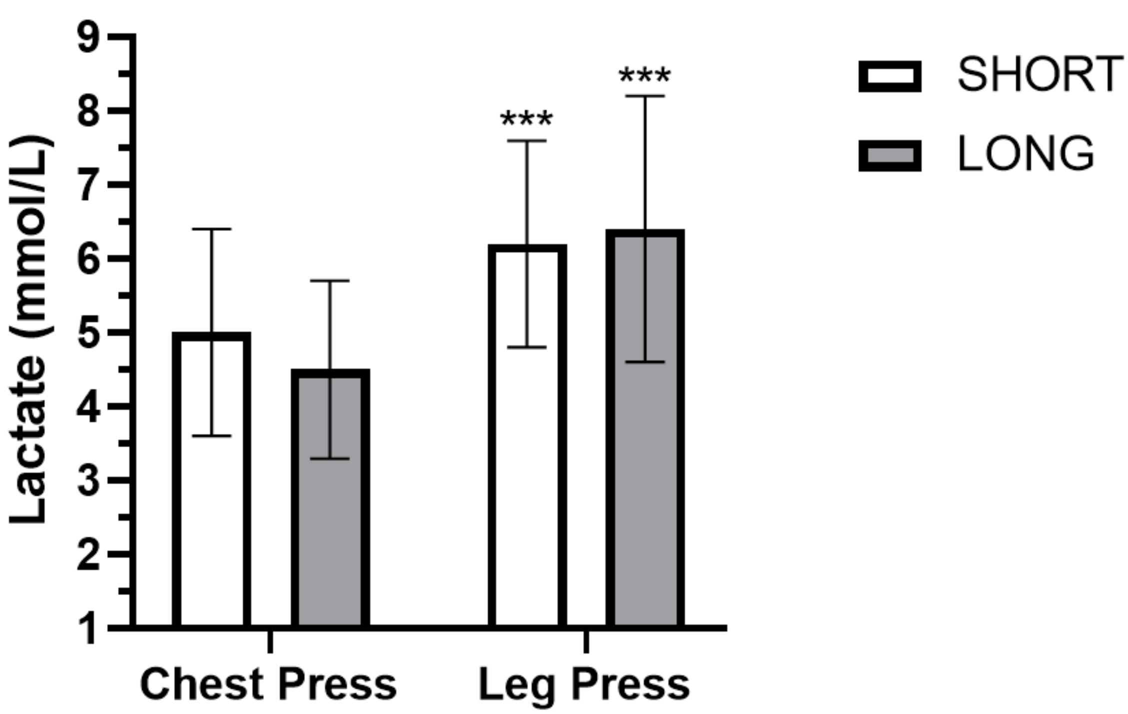

Figure 3. Blood lactate concentration averaged across all sets of chest press and leg press during SHORT (1 min) and LONG (3 min) rest interval sessions. Four sets were completed to task failure for each session. ***$p \leq .05$ significantly greater than chest press for that specific rest interval. $n = 14$.

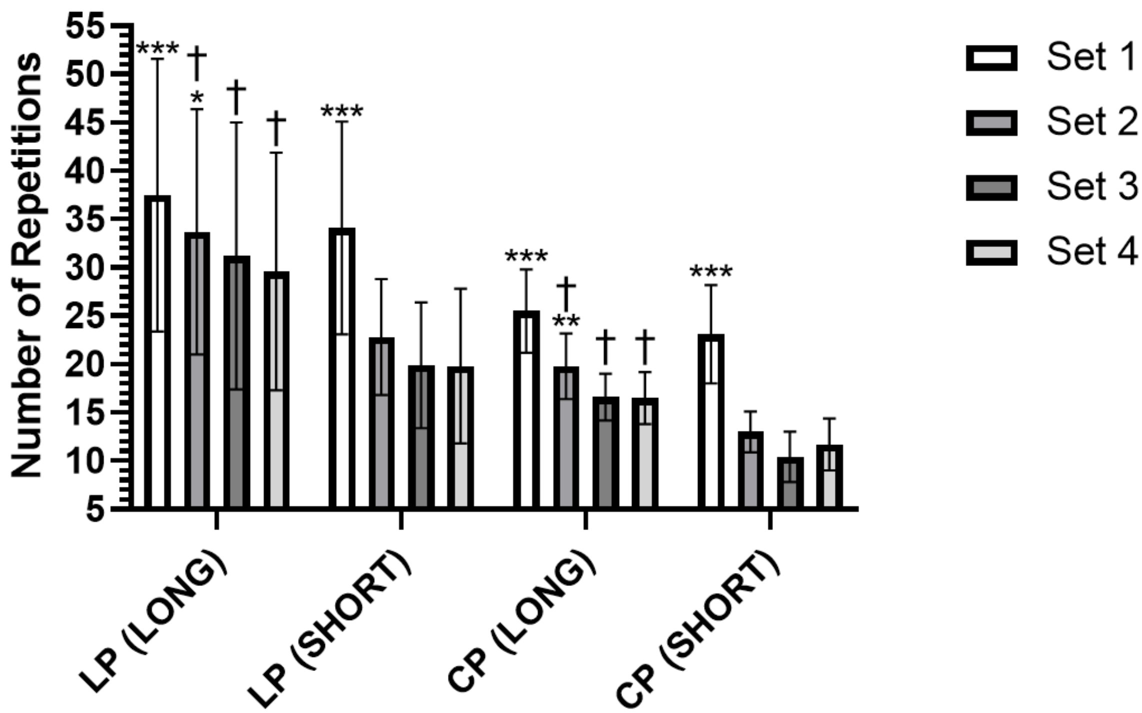

Figure 4. Repetitions completed per set during the SHORT (1 min) and LONG (3 min) rest interval sessions for the chest press (CP) and leg press (LP) exercises. Four sets were completed to task failure for each session. ***$p \leq .05$ significantly greater than sets 2, 3, and 4 within the same session; **$p \leq .05$ significantly greater than sets 3, and 4 within the same session; *$p \leq .05$ significantly greater than set 4 within the same session. †$p \leq .05$ significantly greater than SHORT for that specific set and exercise. CP = chest press; LP = leg press. $n = 14$.

DISCUSSION

The purpose of the current study was to investigate the effect of SHORT and LONG RIs on TVL, repetition performance, FI, and [La] during CP and LP with low-intensity (75% of 10-RM) in trained female lifters. To our knowledge, this is only the second study to assess the effect of RI length during low-intensity RT with female participants (5). The main finding of this study was that TVL for SHORT was significantly less compared to LONG for both exercises, which is largely explained by repetition decline between the first and second sets. Furthermore, there was no significant difference in average [La] between SHORT and LONG despite a greater FI in the SHORT compared to LONG for both exercises. A further finding of this study was that [La] was higher during LP compared to CP exercise, which may be explained by the differences in TVL or total repetitions performed. The largest decline in repetition performance during all four conditions occurred between set 1 and set 2. However, the decline between set 1 and 2 during the LP-LONG condition had the lowest decline of all four conditions.

As hypothesized, significantly higher TVL was performed with LONG for both exercises, and these results agree with several previous publications. Recently, Hernandez et al. (13) reported a dose-response relationship between RI length (2, 5, and 8 min) and TVL (1,448, 1,793, and 2,207 kg) during high-intensity bench press (85% of 1-RM) in trained male lifters. Similarly, TVL for five upper body exercises was greater with 3 vs. 1 min RIs (22), and others reported that repetition performance was higher with 5 compared to 1-min RIs for bench press and back squat (38). The current study is most comparable to Fink et al. (7) who reported that total repetitions were greater after 2.5-min RIs compared to 30-second RIs for bench press (118 vs. 77 repetitions) and squat (148 vs. 95 repetitions) with low-intensity (40% of 1-RM). Indeed, intensity and RI length may have an important relationship, as one study reported a dose-response relationship between RI length and the total number of repetitions performed with 50% of 1-RM but not 80% of 1-RM (35). This suggests that longer RIs have a more positive effect on repetition performance when lower intensities are used.

Our results partially conflict with Ratamess et al. (28) as the authors reported nearly identical total repetitions performed with 1 and 3-min RIs (27 vs. 29 repetitions) during sets of bench press in trained female lifters. Methodological differences may explain the conflicting results, including that Ratamess et al. used a higher intensity (75% of 1-RM), a free-weight exercise (bench press), and did not explicitly define how effort/proximity to failure was controlled (28). Interestingly, their male participants performed 21 and 27 repetitions for 1 and 3-min RIs, respectively, but the authors submit that between-sex differences occurred because of disparities in baseline strength (28). Collectively, the current data suggest that TVL and total repetition performance have a positive, linear relationship with RI length, which is true for low and high-intensity lifting (40).

Repetition performance set-by-set for all experimental conditions generally revealed that the largest decline in repetitions completed occurred between sets one and two (Figure 4). Because the participants served as their control, they performed the same number of sets (four) and the same external load (75% of their 10-RM) for all conditions. This means that the repetition decline between sets one and two had a large effect on the overall difference in TVL between RI conditions. Our results agree with Senna et al. (35) who reported a significant decline in repetitions between sets one and two (-14 repetitions), with lesser declines between sets two and three (-2 repetitions) and sets three and four (-2 repetitions). The repetition decline between sets one and two was not as dramatic (-6 repetitions) when 3-min RIs were used in the same protocol (35). Previous researchers have labeled the influence of short RIs on repetition performance as a "plateauing effect" as repetitions drop by 40-65% between sets 1 and 2 when short RIs (1-3 min) are used (41). A visual analysis of Figure 1 suggests that besides the 3-min LP condition, our data demonstrates a plateauing effect on repetition decline.

It seems that the large repetition decline between sets one and two is less common with moderate-high RT intensities (16, 28). Specifically, Ratamess et al. (28) reported that female participants sustained repetition performance between the first and second sets of the exercise with 1-min RIs, but repetitions in the third set were significantly lower than the first (10 vs. 7.7 repetitions). Moreover, Kraemer et al. (16) reported that participants maintained repetition performance (i.e., 10 repetitions) at a fixed absolute intensity (i.e., 10-RM) for three sets of bench press and LP when using a 3-min RI. Differences in intensity (75% of 10-RM vs. 10-RM) and differences in the population (trained female lifters vs. power-trained male football players) may explain the disparate outcomes. Ultimately, the current data support that repetitions decrease set-by-set when RIs are too short, and the largest decrement occurs between the first and second set. To combat this, it may be practical for female lifters to exercise at a lower RPE, or with higher repetitions in reserve, during the first set of each exercise because it may increase their total repetition performance and TVL for the entire session.

For FI, we reported a statistical main effect on RI length, but not exercise, meaning that RI length affected CP and LP performance similarly. This partially supports our hypothesis because FI was higher with SHORT compared to LONG RIs. However, our hypothesis that FI would be lower for LP regardless of RI length was not confirmed. Because upper body musculature generally has a greater distribution of fast-twitch muscle fibers (26), and exercisers have a reduced ability to extract oxygen during upper-body tasks (2), we anticipated superior fatigue resistance during LP. Collectively, our study reflects the existing research that when relative loads are matched, upper and lower body muscle groups fatigue at similar rates during RT, and longer RIs decrease the rate of fatigue (33, 38).

Of interest, a recent study demonstrated that central (i.e., neural) fatigue was greater after low-intensity (40% of MVIC) compared to high-intensity (80% of MVIC) RT (4). Although speculative, it is possible that fatigue is greater after RT with long RIs because lifters perform more volume during the session. In fact, this was demonstrated by Filho et al. (5) who reported that compared to 1-min RIs, neuromuscular fatigue was significantly higher after training with 3-min RIs, which was attributed to higher TVL and time-under-tension (TUT). Considering these outcomes, it is possible that when RIs are too short, higher peripheral fatigue ensues, which limits repetition performance in subsequent sets. On the other hand, longer RIs allow for higher repetitions per set and TVL for the entire session, which may lead to greater central fatigue after the session.

Surprisingly, we reported a statistical main effect on exercise, but not RI length, for [La]. The fact that [La] response was similar between SHORT and LONG is contrary to our original hypothesis, as we assumed that lactate clearance would be negatively affected by shorter RI duration. This result is interesting because higher TVL was performed during LONG for both exercises, and previous studies have reported that [La] is greater after higher volume lifting (3, 37). Instead, our results agree with previous research by Lopes et al. (20) who reported that [La] was similar between 30-sec and 2-min RIs despite a significantly higher TVL during the 2-min RI. Similar results were sustained by Rahimi et al. (27) when the [La] response was similar during four sets of high-intensity bench press (85% of 1-RM), regardless of short (i.e., 1-min) or long (i.e., 2-min) RIs. Although TVL was not significantly different between conditions, the absolute values indicate that higher TVL was performed during the long RIs (i.e., 4,350 vs. 3,600 kg), making their results more comparable to ours (27). Our results oppose the findings of Senna et al. (34) when higher [La] occurred with 1-min RIs compared to 3-min RIs despite more repetitions being performed during the latter condition. Interestingly, this phenomenon was only observed during the chest fly, as [La] was similar between RI conditions during bench press (34). Based on our results and others, it seems that the [La] response to different RI lengths is greatly nuanced and potentially influenced by the muscle group, number of joints involved, and exercise modality used. Regardless, the bulk of the literature suggests that [La] is similar between short and long RIs, and our results reflect this notion.

The fact that [La] was higher during LP compared to CP, irrespective of RI length, deserves further discussion. It is logical to presume that [La] would be greater during LP simply because a larger muscle group is being exercised (quadriceps vs. pectoralis major), but the limited research in this area does not support this speculation. Specifically, Lira et al. (18) reported that [La] response was not significantly different between upper- and lower- body RT when repetition numbers were similar. Thus, our results may have differed from the results of Lira et al. (18) simply because participants performed more repetitions during their LP sets compared to CP. This concept is supported by Rogatzki et al. (30) because they reported that [La] was higher after endurance RT (2 x 20 repetitions) compared to strength RT (5 x 5 repetitions) despite TVL being similar between conditions. This suggests that more consecutive repetitions per set (e.g., 20 vs. 5) may be more influential than TVL at increasing lactate. In fact, [La] may increase with TUT as da Silva et al. (3) reported that [La] increased linearly during 8-RM, 10-RM, and 12-RM performance on the bench press. In our study, we controlled repetition cadence, meaning that TUT was higher during the LP condition because more repetitions were performed. In short, differences in [La] between LP and CP may be explained by differences in muscle size, phenotype, TUT, and/or total repetitions performed, but our study is not equipped to answer this question directly.

These results were sustained in resistance-trained females who were familiar with low-intensity, high-volume RT and should not be extrapolated to other populations. Also, we measured upper- and lower- body performance with CP and LP only and cannot say if results would be similar with free-weight exercises for the same muscle groups. Moreover, we operationalized "SHORT" and "LONG" RIs as 1 and 3 min, respectively, and our study is not equipped to answer what would happen with RIs within this range (i.e., 2 min) or outside this range (i.e., 30 sec or 4 min). Last, we thoroughly educated the participants about the difficulty of our protocol and instructed them to eat/hydrate the same way for both lifting sessions (i.e., eat as they normally would before a hard session of RT), but did not assess if diet/hydration was replicated between trials.

The current study demonstrated that a significantly lower TVL was performed during sets of upper and lower body exercises when RIs were short (1 min) vs. when RIs were long (3 min). Regardless of RI length or exercise, the largest decline in repetition performance took place between the first and second sets of exercise and decrements were much less between sets two through four. Uniquely, [La] response was not affected by RI length and was larger for LP compared to CP for both conditions, which may be explained by differences in TVL. On the contrary, FI did not differ between exercises and was significantly higher during short RIs for LP and CP. This infers that upper and lower body repetition performance was affected similarly by short RIs, despite differences in muscle size and phenotype. Therefore, we conclude that 3 min RIs are better for female lifters who want to optimize TVL with low-intensity RT and future research should delineate if the acute differences in TVL between short and long RIs translate to divergent training adaptations.

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