Original Article

Rest intervals during resistance training affect the rating-perceived exertion and muscle performance in untrained subjects

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Abstract:

Rest intervals of one to three minutes are recommended for novice and untrained subjects. However, the effect of these rest intervals on rating perceived exertion, repetitions performed, total training volume, and fatigue index has not been widely investigate. The aim of the present study was to compare the acute effect of short (1-min) versus long (3-min) rest intervals between sets and exercises on rating perceived exertion, repetitions performed, total training volume, and fatigue index in untrained subjects. Nine women and three men (age 20.7 ± 0.8 years, body mass 73.9 ± 19.3 kg, height 1.7 ± 0.1 m, body mass index 25.2 ± 5.3 kg/m² and body fat 15.8 ± 6.0 %) were included in this study. After familiarization and 10RM for nine exercises (chest press, leg press, front lat pull down, seated leg extension, up right row, seated leg curl, triceps extension, calf rise and biceps curl), the subjects were randomized and performed a session using a counterbalanced order with 1- and 3-min rest intervals between sets and exercises separated by 5-7 days. All subjects performed 3 sets at intensity corresponding to 10 repetitions maximum. We measured rating perceived exertion and repetitions performed and calculate total training volume and fatigue index. 3-min rest intervals elicits lower RPE ($Z=-5.638$, $P<0.0001$, $ES=0.86$), and higher RP ($Z=-6.547$, $P<0.0001$, $ES=0.67$), TTV ($Z=-4.066$, $P<0.0001$, $ES=0.12$), and FI ($Z=-7.913$, $P<0.0001$, $ES=1.59$) as compared with 1-min. For untrained subjects in the beginning of a training program, longer rest intervals recommended to avoid excessive exertion and may result in enhance training performance.

Key words: strength training, repetitions performed, training volume, fatigue index.

Introduction

Multiple-set resistance training promotes higher improvements in strength and hypertrophy as compared with single set (Krieger, 2010; Rhea et al., 2002). Therefore, training volume is an important variable related to these neuromuscular adaptations (American College of Sports, 2009). During a resistance exercise (RE) session the number of repetitions performed by a subject is influenced by the inter-set rest intervals (Ratamess et al., 2012; Tibana et al., 2012). In untrained subjects the rest interval between sets should be sufficient to promote an adequate bioenergetic recovery, facilitate the removal of metabolic waste products, and provide for the reestablishment of force production (Willardson, 2006).

Previous studies revealed that shorter rest intervals between sets and exercises (1- versus 3- or 5-min) elicit a more pronounced metabolic (Farinatti & Castinheiras Neto, 2011; Ratamess et al., 2007), hormonal (Bottaro et al., 2009), and cardiovascular stress (de Salles et al., 2009). This may explain the decreased number of repetitions and total training volume found in a RE session using short inter-set rest intervals (Tibana et al., 2012).

Metabolic acidosis, ventilation and oxygen uptake responses during dynamic RE are thought to mediate the rating of perceived exertion (RPE) (Mayhan et al., 2008), which could be useful to prescribe and monitor RE (Lagally et al., 2002). In this sense, the validated OMNI-Resistance Exercise Scale (OMNI-RES) is a pictorial representation of numerical categories ranging from 0 to 10 to assess and monitor RPE responses during RE (Robertson et al., 2003).

To date, studies examining the effects of rest intervals between sets during RE on RPE have raised controversial results. Woods et al. (2004) examined the effects of 1-, 2-, or 3-min rest intervals on RPE during 3 sets of 10 repetitions at 70% of 10 repetitions maximum (RM) of seated leg extension exercise in physically active subjects. The RPE response increased following the third set as compared with the second and first sets, regardless of rest interval length. Farah et al. (2012) investigated the effect of 30s and 90s rest intervals on RPE

between three sets of five exercises (bench press, seated leg extension, seated row, knee curl, and frontal rise) at 50% 1RM in recreationally trained subjects. They observed a higher RPE following 30s as compared with 90s rest interval. Therefore, further studies are necessary to understand the effects of different rest intervals between sets on RPE, especially during whole body RE sessions designed for hypertrophy and strength, which are commonly used in daily practice in untrained subjects.

Thus, the aim of the present study was to compare the effect of 1- versus 3-min rest intervals between sets on RPE, number of repetitions, total training volume and fatigue resistance in untrained subjects. The initial hypothesis is that a longer rest interval will result in lower RPE and higher training volume in untrained subjects.

Materials and Method

Participants

Twelve untrained subjects (9 women and 3 men) age 20.7 ± 0.8 years, body mass 73.9 ± 19.3 kg, height 1.7 ± 0.1 m, body mass index 25.2 ± 5.3 kg/m² and body fat 15.8 ± 6.0 % volunteered for the study. Subjects were classified as untrained according to the American College of Sports Medicine (ACSM), as they had no previous experience with regular resistance training (American College of Sports, 2009). All subjects were healthy and had no orthopedic or cardiovascular diseases. Before taking part in the experimental protocols, subjects were properly informed of all the purposes, procedures, benefits and risks of the study. The study was approved by the Research Ethics committee of Western Kentucky University and all subjects provided written informed consent (HS12-053). The study was conducted in accordance to the Declaration of Helsinki.

Procedure

Subjects participated in eight experimental sessions and were asked to refrain from strenuous physical activity during the study. Briefly, the first visit consisted of baseline anthropometric measurements and a familiarization with the procedures of the study and the RE session. Subjects returned 72 h later to complete the second RE familiarization session. The third through sixth visits consisted of performing 10-repetition maximum tests and retests (10RM). The following resistance exercises were tested: chest press, leg press, front lat pull-down, seated leg extension, up right row, seated leg curl, triceps extension, calf rise and biceps curl. On the seventh and eighth experimental days, RE sessions were randomly performed with 1- and/or 3-min rest intervals between sets. Experimental trials were separated by 5-7 days.

Familiarization Session and Strength Testing

During familiarization, subjects received standardized instructions on technique and performed one exercise for each main muscle group with 3 sets of 10–12 submaximal repetitions. After the familiarization, 10RM tests were performed for all exercises using a counterbalanced order on four separate days with a minimum of 72 h between testing. The heaviest load achieved during the test was considered the 10RM. No exercise was allowed in the 72 h between tests to avoid interference with test–retest reliability. To minimize the error during tests, the following strategies were adopted: (a) standardized instructions concerning the testing procedure were explained to each participant before the test; and (b) the mass of all weights and bars used were determined using a precision scale. The 10RM was determined in fewer than 5 attempts interspersed with a rest interval of 5 min, and 10 min was allowed before testing the next muscle group. On each test and re-test trial, four or five exercises were evaluated using a counterbalanced order, alternating lower and upper limbs. All test–retest and training sessions were performed at the same time of the day. The intraclass correlation coefficient (model 1.1 one-way random single measures) revealed an optimal reliability for all exercises ($R > 0.98$).

Resistance Training Sessions

After a warm-up (one set of 10 repetitions of chest press at 40% of 10RM), all subjects completed the first exercise bout consisting of nine resistance exercises utilizing the following order: chest press, leg press, front lat pulldown, seated leg extension, up right row, seated leg curl, triceps extension, calf rise and biceps curl (Cybex International, Medway, MA, USA). For all exercises, three sets were performed at 10RM. A rest interval of 1- or 3-min was utilized between sets and exercises, and the total duration of the session was 50–80 min. Five to seven days after the first RT session, subjects completed a second trial with the same protocol characteristics, with the exception of the rest interval between sets and exercises (1- or 3-min). Participants were instructed to perform each repetition at a moderate velocity (i.e., 3 s for concentric and eccentric phases, respectively). The exercise order was consistent during the entire study. Sessions were supervised by experienced strength training professionals and were designed according to the ACSM guidelines (American College of Sports, 2009) for novice individuals.

Rating of Perceived Exertion Assessment

During the two familiarization sessions, subjects were instructed regarding anchoring procedures and then the OMNI-RES scale was presented to each subject in order to assess RPE during the last 15 s of each set and exercise. The OMNI-RES scale has been validated in young adults to assess RPE during RE (Lagally et al.,

2009) with intraclass reliability coefficients ranging from 0.69 to 0.95 (Robertson et al., 2003). The OMNI scale has both verbal and mode specific pictorial descriptors (individuals performing RE) distributed along a comparatively narrow numerical response range (0–10), and is presented as a visually discernible exertional intensity gradient. The scale also provides verbal descriptors along with the narrow numerical range and was designed to subjectively evaluate the individual perceived exertion to the RE sessions. OMNI-RES was validated for use by female and male adults during upper- and lower-body RE (Robertson et al., 2003). During each set participants were reminded to “think about your feelings of exertion” and the scale was in clear view during the entire exercise set. A standardized definition of RPE and a set of instructions pertaining to the OMNI-RES were read before each experimental protocol according to the procedures described by Robertson et al. (2003). RPE is defined as the subjective intensity of effort, strain, discomfort, and/or fatigue that is felt during exercise.

Resistance Exercise Parameters

The number of repetitions, total training volume, and the fatigue index were compared in each RE session. Total training volume is characterized by summation of the total number of repetitions performed during a training session multiplied by the load used (kg) (American College of Sports, 2009). Fatigue Resistance may be defined by the decline in the number of repetitions between the first and third set and it was used as the muscular fatigue index (FI) in each protocol: $[FI = (3^{rd} \text{ set}/1^{st} \text{ set})/100]$; where a higher percentage value (%) indicates a superior fatigue resistance (Dipla et al., 2009).

Statistical Analyses

Descriptive statistics (mean values and standard deviations) were used to report total training volume, RPE, number of repetitions and fatigue index data. The Shapiro-Wilk normality test and a homoscedasticity test (Bartlett criterion) were used to test the normal distribution of the data. Since the RPE, number of repetitions and fatigue index data were not normally distributed; a Wilcoxon signed-rank test was used to determine the differences between conditions. For total training volume a dependent t-test was used. In addition, the Chi squared test (X^2) was applied to determine the differences between sets [protocols (1- and 3-min) x sets (1, 2 and 3)]. SPSS (Statistical Package for Social Sciences) version 17.0 (IBM, Armonk, NY) was used for statistical analysis with an alpha level accepted at $p \leq 0.05$. Finally, effect size (ES) was used to determine the magnitude of the results (Rhea, 2004) (<0.50 = insignificant, 0.50 – 1.25 = small, 1.25 – 1.90 = moderate, >2.0 = high).

Results

Figure 1 shows that the total training volume was higher ($Z=-4.066$, $P<0.0001$, $ES=0.12$, figure 1D) and RPE was lower ($Z=-5.638$, $P<0.0001$, $ES=0.86$, figure 1A) during the RE session with 3-min as compared with 1-min of rest interval ($P<0.05$).

Comparison between RE sessions revealed that 3-min rest intervals between sets elicited a more favorable fatigue index ($Z=-7.913$, $P<0.0001$, $ES=1.59$, figure 1B), and greater number of repetitions performed ($Z=-6.547$, $P<0.0001$, $ES=0.67$, figure 1C), as compared with 1-min rest intervals.

Fig. 1. Comparison between entire exercise sessions performed with 1-minute and 3-minutes of rest interval between sets to (A) Rating Perceived Exertion; (B) Fatigue Index; (C) Repetitions performed; and (D) Total Training Volume. * Different than 1-min ($P<0.05$). Values are means and standard-deviation; $N=12$.

The RPE values during the RE sessions with 1- and 3-min of rest intervals are presented in Table 1. Briefly, when 1-min rest intervals were used the RPE increased significantly during subsequent sets for all

exercises ($P < 0.05$). However, with 3-min rest intervals the RPE presented similar responses during sets 1 and 2 for seated leg curl ($X^2=1,000$, $P=0.32$) and calf rise ($X^2=1,286$, $P=0.26$). Moreover, similar responses were observed during sets 2 and 3 for up-right row ($X^2=1,800$, $p = 0.18$), triceps extension ($X^2=2,778$, $p = 0.10$) and calf rise ($X^2=1,000$, $P=0.32$). In addition, the comparison between 1 and 3-min rest intervals revealed that a shorter rest interval resulted in a greater RPE for chest press, front lat pull-down, seated leg extension, and up-right row ($P < 0.05$).

Table 1. Comparison between Rating Perceived Exertion (RPE) obtained each exercise during two resistance exercise sessions performed with 1-minute or 3-minutes of rest interval between sets. The data are presented as mean (standard-deviation).

Exercises	Set 1			Set 2			Set 3		
	1-min	3-min	ES	1-min	3-min	ES	1-min	3-min	ES
Chest Press	6.73 (1.10)	6.73 (0.90)	0.00	7.82 (0.87) [#]	7.27 (0.65) ^{*#}	0.65	8.72 (0.90) ^{#†}	7.82 (0.98) ^{*#†}	1.05
Leg Press	6.73 (0.79)	6.27 (1.19)	0.61	7.45 (0.93) [#]	7.27 (1.01) [#]	0.20	8.64 (0.92) ^{#†}	8.00 (1.00) ^{#†}	0.72
Front Lat Pull-Down	6.82 (1.17)	6.64 (0.67)	0.16	7.64 (1.21) [#]	7.27 (0.47) [#]	0.32	8.55 (0.93) ^{#†}	7.64 (0.67) ^{*#†}	1.02
Seated Leg Extension	7.09 (1.30)	6.91 (1.30)	0.15	8.27 (0.79) [#]	7.55 (0.93) ^{*#}	0.97	8.91 (0.83) ^{#†}	7.90 (0.94) ^{*#†}	1.26
Up Right Row	6.82 (1.47)	6.91 (0.83)	0.06	8.09 (0.94) [#]	7.45 (0.82) [#]	0.71	8.82 (0.98) ^{#†}	8.00 (1.00) ^{*#}	0.87
Seated Leg Curl	7.09 (0.54)	7.45 (0.69)	0.71	8.09 (0.30) [#]	7.64 (0.67)	1.58	8.73 (0.47) ^{#†}	8.27 (0.90) ^{#†}	1.02
Triceps Extension	6.64 (0.81)	6.73 (1.10)	0.12	7.36 (0.67) [#]	7.09 (0.94) [#]	0.42	8.09 (0.70) ^{#†}	7.55 (1.04) [#]	0.82
Calf Rise	6.64 (1.03)	6.55 (1.21)	0.09	7.27 (0.79) [#]	6.91 (1.14)	0.49	7.90 (0.70) ^{#†}	7.09 (1.14)	1.22
Biceps Curl	6.91 (1.22)	6.64 (0.92)	0.23	7.82 (0.87) [#]	7.27 (0.79) [#]	0.65	8.64 (0.92) ^{#†}	7.91 (0.94) ^{#†}	0.83

* RPE lower than 1-min; [#] greater than Set 1; [†] greater than Set 2. ES: Effect Size

Table 2 shows the comparison between RE parameters obtained during each session. Overall, a higher number of repetitions, total training volume and fatigue index was found when 3-min intervals were employed during the RE session as compared with 1-min rest intervals ($P < 0.05$).

Table 2. Comparison between resistance training parameters obtained during two resistance exercise sessions performed with 1-minute or 3-minutes of rest interval between sets. The data are presented as mean (standard-deviation).

Exercises	Repetitions Performed		Total Training Volume		Fatigue Index (%)	
	1-min	3-min	1-min	3-min	1-min	3-min
Chest Press	26.91 (4.09)	32.00 (4.02) [*]	1,163.90 (742.36)	1,378.18 (829.10) [*]	26.91 (4.09)	32.00 (4.02) [*]
Leg Press	38.18 (6.46)	38.45 (5.59)	3,319.64 (1,104.76)	3,331.18 (989.66)	38.18 (6.46)	38.45 (5.59)
Front Lat Pull-Down	27.73 (4.20)	32.36 (2.54) [*]	1,149.27 (521.98)	1,366.36 (662.34) [*]	27.73 (4.20)	32.36 (2.54) [*]
Seated Leg Extension	29.91 (5.24)	33.82 (4.92) [*]	2,056.27 (920.47)	2,333.27 (1,003.67) [*]	29.91 (5.24)	33.82 (4.92) [*]
Up Right Row	27.00 (3.13)	32.91 (4.18) [*]	626.36 (293.99)	753.27 (370.20) [*]	27.00 (3.13)	32.91 (4.18) [*]
Seated Leg Curl	28.64 (3.91)	32.00 (4.40) [*]	1,711.91 (565.92)	1,830.18 (645.01)	28.64 (3.91)	32.00 (4.40) [*]
Triceps Extension	27.73 (4.29)	35.18 (8.84) [*]	628.27 (285.41)	749.45 (350.82) [*]	27.73 (4.29)	35.18 (8.84) [*]
Calf Rise	40.64 (8.31)	47.09 (11.13) [*]	3,681.64 (952.37)	3,905.82 (1,319.14)	40.64 (8.31)	47.09 (11.13) [*]
Biceps Curl	27.09 (4.57)	31.45 (4.97)	542.00 (236.80)	616.82 (373.63)	27.09 (4.57)	31.45 (4.97)

* Different than 1-min ($P < 0.05$).

Discussion

The main finding of the study was that untrained subjects display lower RPE, higher total training volume and fatigue index during an RE session using 3-min rest intervals, thus confirming the initial hypothesis. Therefore, it is apparent that untrained subjects who adhere to ACSM recommendations (American College of Sports, 2009) for RE should be aware of manipulating rest intervals between sets.

Previous studies investigated the effects of rest interval length on RPE (Farah et al., 2012; Woods et al., 2004). The results of the present study corroborate the findings of Farah et al. (2012) such that RPE increases more pronouncedly using shorter compared to longer rest intervals. Farah et al. (2012) analyzed the effect of 30 and 90 s rest intervals on RPE during multiple-set RE sessions. Physically active men performed bench press, knee extension, seated row, knee curl, and frontal rise with 50% 1RM in three sets of 12, 9, and 6 repetitions, respectively. In the RE session with 30 s, the RPE increased between sets in all exercises, while with 90 s, the RPE increased from the first set to the second set in bench press, knee extension and knee curl. With 30 s rest interval the RPE was higher as compared with 90 s in the third set for most exercises, except bench press.

However, Woods et al. (2004) [ENREF_21](#) reported that despite the increase in RPE response following sets, rest interval length ranging from 1- to 3-min did not affect perceived exertion. The above-mentioned study used physically active subjects (men and women) that performed 3 sets of 10 repetitions of seated leg extension exercise with an intensity of 70% 10RM. The controversial results could be attributed, at least in part, to the lower intensity used in Wood's study. Nevertheless, the use of only one exercise, training to failure versus not to failure, and training status may affect the results of the studies and limit more comparisons.

Schoenfeld et al. (2016) investigated the effects of 1- versus 3-min rest intervals on muscle strength and hypertrophy in resistance-trained men. The training lasted 8 weeks and training consisted of 3 sets of 8-12RM with seven exercises per session. Maximal strength was significantly greater for both 1RM squat and bench press when 3-min rest intervals were utilized as compared with 1-min rest intervals. In the present study, subjects performed a higher number of repetitions and total training volume during with 3-min rest periods accompanied by lower RPE as compared with 1-min rest intervals. Therefore, it is plausible to speculate that the findings of Schoenfeld's study may be associated with a higher total training volume in the group using longer rest intervals between sets (Schoenfeld et al., 2016).

The possible mechanisms to explain the lower RPE, higher total training volume and fatigue resistance by using 3-min rest intervals may be associated with the improved recovery of phosphocreatine energy and anaerobic systems, lower accumulation of H^+ ions and reduced disturbances in the concentration gradients of other ions (i.e., Na^+ , K^+ , Ca^{2+} , Mg^{2+} , and Cl^-). Moreover, there is an association of increased blood pressure, heart rate, respiratory frequency and lactate levels with an elevation of RPE, which would be higher with 1-min rest intervals (Tucker et al., 2015).

The present study had some limitations that should be highlighted, such as the reduced number of subjects and the lack of metabolic, respiratory and cardiovascular parameters measured. It should be noted, that these results should be considered only for untrained subjects at the early onset of a training program. On the other hand, the RE sessions applied in the present study were very similar to daily practice training and were prescribed as recommended by the ACSM (American College of Sports, 2009) which increases the external validation of the results.

Conclusion

In summary, the results revealed that a RE session using 3-min rest intervals is associated with higher total training volume, fatigue resistance, and lower RPE. Thus, for untrained subjects in the early beginning of a training program, longer rest intervals recommended to avoid excessive exertion and may result in improved training performance, which could be associated with a higher adherence.

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