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ORIGINAL

The effect of rest interval length on the repetitions recovery during lower body resistance exercises

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Data Interpretation
E Manuscript Preparation
F Literature Search
G Funds Collection

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abstract

Background The purpose of the current study was to compare the effect of two different rest intervals on the number of repetitions performed in lower body resistance exercises in consecutive sets.

Material/Methods 12 trained men (age 22.85 ±1.7 yrs; height 175.63 ±4.6 cm; weight 75.54 ±4.8 kg) volunteered to participate in the study. The subjects completed two experimental sessions that consisted of 6 lower body exercises for 3 sets with 8RM (repetition maximum) load. The two experimental sessions differed only in the length of the rest interval between the sets and exercises: one session with 1-minute and the other sessions with a 3-minute rest interval.

Results Results demonstrated that in the case of the 1-minute rest interval, repetitions in four of six exercises were reduced in the second set compared to the first one, and two of the six exercises in the third set compared to the second one, and all of the exercises in the third set compared to the first one ($p < 0.05$). However, for the 3-minute rest interval, one of the six exercises were reduced in the second set compared to the first one, and for the third set compared to the second one, and five of the six exercises for the third set compared to the first one ($p < 0.05$). For all exercises, the total number of repetitions in the 1-minute rest interval was significantly lower than 3-minute rest interval ($p < 0.05$).

Conclusions In resistance training comprising all lower body exercises, 1-minute rest periods resulted in decreasing the total number of repetitions compared to 3-minutes periods between sets and exercises.

Key words Strength training, recovery, performance, training volume

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INTRODUCTION

Resistance training can increase muscular strength, hypertrophy, power and endurance. The main variables in a resistance training program include training intensity, or load, frequency and intermittent training repetitions, sequences of movements, the relationship period between a set and movements, the contraction type and its velocity [1]. Manipulating in each of these variables is identified according to the training program aim and an athlete's needs. Theoretically, making a mistake in a variation of each of these variables can cause overtraining; therefore, any change in variables should be done carefully. The amount of rest between sets is one of the main variables in a resistance training program, which can be effective in metabolic [2], hormonal [3, 4, 5, 6], and cardiovascular responses [1], and also performance and performing subsequent sets [5, 7, 8, 9, 10, 11, 12]. Previous studies which investigated the effects of various resting intervals on the training volume in isolated movements (squat or chest press) indicated that the relaxation level between sets has an important effect on the total volume performed training during one training session [7, 10, 12, 13, 14, 15, 16, 17, 18].

For example, Saberi et al. investigated the effects of three rest intervals of 90, 150, 240 seconds on sustainability in chest press repetitions in subsequent sets [13]. Their results show that in each of the three rest intervals, the number of repetitions decreased significantly. Furthermore, the ability to keep repetitions in 240 second rest intervals was greater than at 90, 150 second rest intervals. In comparison to 90 s rest intervals, in the 150 s period, the ability to keep repetitions was greater [13]. However, the limitation in Saberi et al. study and other similar studies is that the effects of rest intervals on performed repetitions in only one movement were considered (chest press or squat).Previous studies that have examined rest interval lengths between sets for single exercises demonstrated significant differences in repetition performance and the completed exercise volume. Also Miranda et al. [19] reported that rest intervals between sets and exercises directly affected the total volume of a training session for upper body exercises. On the other hand, since Willardson et al. [17, 18] indicated that there was a difference between the movement of the upper body part (chest press) and the lower body part (squat) with regard to the time of the rest period between sets; it is possible that performance would be negatively affected with a shorter rest interval condition, and in the exercises performed late in a training session irrespective of the rest interval and the need to possibly include longer rest intervals between sets at the end of a workout.

Until now, few studies have investigated the effect of various rest intervals on the performed repetitions numbers during a resistance training session which is composed of several movements [8, 19, 20]. Miranda et al. [19, 20] after examining the effects of various rest intervals in the performed numbers of repetitions in the upper part of the body reported that the relationship between periods of intervals and movement had a direct effect on the total training volume during one resistance training session on the upper part of the body. Their results indicated that one-minute rest between sets causes a decrease in the total training volume and performed repetitions in the next sets in each movement compared to three-minute relaxation, and this decrease in repetitions at the end of the sessions was greater.

On the other hand, Willardson et al. indicated that there was a difference between the upper part of the body movement (chest press) and the lower part of the body (squat) as regards the time of rest period between sets [17, 18]. Previous studies that examined rest interval lengths between sets for single exercises demonstrated significant differences in repetition performance and the completed exercise volume. However, results from current studies do not permit inferences regarding necessary rest intervals between sets and exercises for the sustainability of the number of repetitions in course of the sets in different exercises performed in the same training session. We hypothesized that performance would be negatively affected by a shorter rest interval and in exercises performed late in a training session, irrespective of the rest interval and the need to possibly include longer rest intervals between sets at the end of the workout. The limitation of previous studies was the examination of single exercises, whereas the proposed typical resistance sessions consist of multiple exercises for the same muscle groups. Thus, there is a great need for further research to compare the volume completed over an entire resistance exercise session with different rest intervals between sets. Two previously conducted experiments on the influence of rest intervals between sets on the number of repetitions during the upper body resistance exercise have also reported that rest intervals between sets and exercises directly affect the total volume of a training session for the upper body exercises [19, 20]. The results indicated that one-minute rest between sets leads to a reduction in the total training volume and in completion of the number of repetitions in subsequent sets compared to three-minute rest intervals. However, prior research demonstrated greater fatigue resistance to lower-body exercises vs. upper-body exercises [18]. Thus, it is necessary to investigate the effect of rest interval on the number of performed repetitions during a resistance training session which comprises the lower part of the body. Therefore, the present study has investigated one- and three-minute resting on the number of repetitions of six lower part of body movements in well-trained individuals.

MATERIAL AND METHODS

The present study method is semi-experimental. 12 trained male volunteers participated in this study. They had experience in resistance training of at least two years with a mean frequency of three 90-minute sessions per week. Their mean age, height and weight were 22.85 ±1.17 yrs, 175.63 ± 4.6 cm and 75.54 ±4.8 kg, respectively.

PROTOCOL

After completing medical questionnaires and consent forms, the subjects took part in 3 separate sessions with an interval of 48 hours during similar hours of the day (to minimize effects of different times). On the first day, 8 repetitions maximum (8RM) was identified for all movements according to the study method by Miranda et al. [8]. On the second and the third days, participants randomly performed training sessions with two different rest intervals (1 and 3 min). Following the 8-RM assessment, the subjects completed two experimental resistance exercise sessions with either one or three minutes rest between sets and exercises in a randomized crossover design. The training sessions included 6 lower part of body movements which were performed in the same sequence. (1 – squat, 2 – leg press, 3 – leg extension, 4 – leg curl, 5 – standing calf raise, 6 – seated calf raise). The only difference between

two training sessions was the rest period between sets and movements. All movements were performed in 3 sets until exhaustion, whose intensity was equal to 8 maximum repetitions. No pause was allowed between the eccentric and concentric phase of repetitions. The subjects were asked to perform repetitions as well as possible with voluntary velocity. At the beginning of each training session, first participants performed 2 sets of movements (squat) with 12 repetitions whose intensity was 40% 8RM. There was 2-min resting between sets for warm-up. During 2 training sessions with 1 and 3-min resting, the number of performed repetitions in each set and for each movement was recorded.

STATISTICAL ANALYSIS

For each exercise, ANOVA with repeated measures was conducted to compare the number of repetitions in the first and the third set in each resting interval, and when the difference presented was significant, the Tukey's post hoc test was applied for multiple comparisons. The paired student's t-test was used to verify differences in the total number of repetitions for the same exercise between the 1-min and 3-min rest intervals. All statistical analyses were performed using SPSS v.18 (SPSS, Chicago, IL). The significance level was set at $p \leq 0.05$

RESULTS

Table 1. The number of repetitions performed in each set and the total number of repetitions performed in each movement with 1- and 3-min rest intervals

		Repetitions (mean ± standard deviation)			
Exercise	Rest Interval	First Set	Second Set	Third Set	Total
Squat	1 Minute	8.18 ±0.75 ‡#	6.45 ±0.52 *	4.72 ±0.41	19.45 ±0.66 £
	3 Minute	8.0 ±0.0 ‡	7.8 ±0.52	6/5 ±0.44	22.3 ±0.75
Leg press	1 Minute	5.17 ±1.44 ‡#	4.09 ±0.67	3.54 ±0.77	12.9 ±1.2 £
	3 Minute	6.9 ±0.47 ‡#	5.42 ±0.68	4.84 ±1.08	17.16 ±0.85
Leg extension	1 Minute	4 ±1.33 ‡	3.54 ±0.74 *	2.09 ±1.05	9.63 ±0.97 £
	3 Minute	5.95 ±1.2 ‡	5 ±0.82	4.72 ±0.7	9/63 ±0.97
Leg curl	1 Minute	5.38 ±0.5 ‡#	4 ±0.86	3.72 ±0.41	13.1 ±0.7 £
	3 Minute	6.4 ±0.75	6.23± 0.45	5.95 ±0.99	18.58 ±0.5
Standing calf raise	1 Minute	5.1 ±0.78 ‡#	3.72 ±0.83	3.54 ±1.08	12.36 ±1.02 £
	3 Minute	6.28 ±1.22 ‡	5.82 ±0.94 *	4.58 ±0.94	16.68 ±0.91
Seated calf raise	1 Minute	4.27 ±0.64 ‡	3.6 ±1.2	2.9 ±0.83	10.77 ±0.14 £
	3 Minute	5.8 ±1.23 ‡	5.2 ±0.86	4.65 ±0.5	15.65 ±0.6

#: Significant difference between the first and the second sets at 1-min rest intervals

‡: Significant difference between the first and the third sets at 1-min rest intervals

*: Significant difference between the second and the third sets at 1-min rest intervals

£:Significant difference between the total number of repetitions between the two rest intervals

The results of this research are presented in Table 1. In this study, it has been identified that the total number of performed repetitions in all movements in 1-min resting interval (Fig. 1) is significantly less than 3-min rest interval ($p \leq 0.05$). Moreover, the results show that there is a difference between the number of performed repetitions in 3 sets in each of 1- and 3-min rest interval. In case of 1-min rest interval, there is a significant difference between the performed repetitions in the first and the second [illegible] for squat movement, leg press, leg curl and standing calf raise ($p \leq 0.05$), while, it has been identified that in both resting situations the number of the performed repetitions in the third set was significantly lower than in the first set in all movements, except leg curl, which has no difference in the 3-min rest interval ($p > 0.05$). Moreover, the results indicate a significant decrease in the number of performed repetitions between the second and the third set in the squat movement and leg extension at 1-min rest interval ($p > 0.05$); while in the case of 3-min rest interval, this reduction is observed only in the standing calf raise movement ($p > 0.05$).

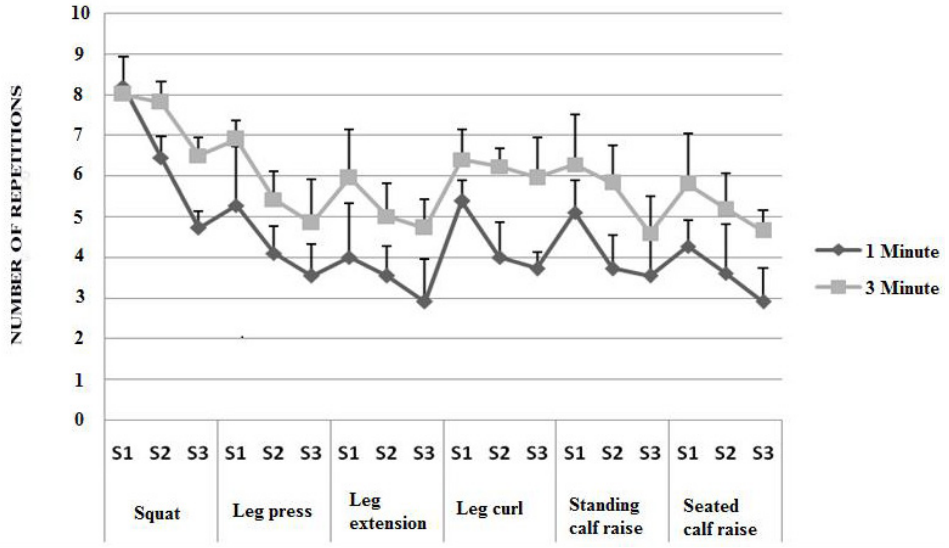

Fig. 1. The number of repetitions performed in each set with 1- and 3-minute rest intervals. S1: the first set; S2: the second set; S3: the third set

DISCUSSION

The main finding of this study was that the number of performed repetitions in 1-min rest interval compared to the 3-min rest interval was lower. By comparing these two factors, it is clear that the training volume (the number of repetitions) is decreased in the second and the third set in each of movement. The finding that the rest interval length between sets and movement affects the number of repetitions performed during one training session correlated to previous studies [7, 10, 13, 14, 15, 16, 17, 18, 21, 22, 23] which investigated the effect of rest interval on performed repetitions in one movement (squat or chest press).

Willardson and Burkett [17] investigated the effect of three relaxation intervals (1 minute, 2 minute, 5 minute) on the number of performed repetitions in 4 sets whose intensity was 8RM in two movements (chest press and squat) with 5-min rest time between the two movements. Their results indicated that there

was a significant decrease in performed repetitions in the squat movement in the 1 and 2-minute rest interval situation in comparison to the 5-minute rest interval, while no differences were observed between 1 and 2-min rest intervals. Nevertheless, there was a significant difference in the chest press movement in each rest interval.

Also Mirzaei et al. [15] investigated the effect of three various resting intervals on sustainability of the squat movement repetitions in consequent sets with intensity of 60–90% of 1RM. Their results indicated that there was a meaningful difference between the first and the forth set in both of the training intensities. Nevertheless, there was a significant difference in the capability to keep repetitions between rest intervals (90 seconds and 40 seconds) and (150 seconds and 240 seconds). Moreover, significant differences were not observed as regards the sustainability of repetitions between 90-second and 150-second resting intervals. The limitation of that study and similar studies [2, 7, 10, 12, 13, 14, 16, 17, 18] is that they investigate the effects of rest intervals in only one movement.

In this study, the effects of two rest intervals on performed repetitions in a resistance training session composed of the lower part of body movements has been investigated.

The obtained results correlated with research results by Miranda et al. [19], who studied the effects of 1 and 3-min rest intervals on the numbers of performed repetitions during one resistance training session in the upper body. In Miranda's et al. studies, 14 trained males performed five upper part of body movements with 8 RM intensity during two resistance training sessions (1-min rest interval session and 3-min rest interval session). Their results indicated that in all movements the total number of performed repetitions decreased when there was 1-minute resting period between the sets and applied movements. Moreover, in both rest intervals, the number of performed repetitions in the second and the third sets was lower than in the first set. Also, in Miranda's et al. studies, it was observed that in both situations of rest intervals there was a greater decrease in the number of movement repetitions at the end of the training session. The same results have been observed in our study.

It seems that the sequence of movement performance is effective on the number of repetitions. In this regard, Miranda et al. [20], Simão et al. [23], and Richmond and Godard [2] reported that the numbers of repetitions in consequent sets of movement decreased; similarly, the numbers of performed repetitions at the end of a resistance training session decreased. In intense and boring training conditions, many mechanisms interfere. Some key factors in decreasing muscle performance include: gathering H ions (H^+), mineral phosphate (H_2PO_4) and decreasing phosphocreatine (PCr), which confuses the contraction stimulant procedure [24]. In scientific aspects, sufficient rest periods between weight training sets are necessary to compensate disadvantageous effects of fatigue and facilitating muscular recovery. Likewise, it has been proved that intense training simulates muscular peripheral fatigue and this factor decreases skeleton muscle potential to provide active tension [13]. Studies indicated that the ability of neuromuscular actions recovery, the tension of active muscles and metabolism haemostats are related to time [25].

In weight training, when the applied load quantity was at a medium level and training continued until fatigue, muscles use anaerobic glycolysis to support energy required for contraction. This causes accumulation of hydrogen ions, decreasing pH and accumulation of lactic acid in these muscle fibres [24].

Increasing hydrogen ions and acidifying environment decrease the calcium level in myofibril, which delays the inductive connection in calcium and troponin adherence. On the other hand, increasing hydrogen ions prevent phosphofructokinase actions (anaerobic glycolysis enzyme) and lead to slow glycolysis pathway route. Also, this factor prevents ATP production to support contraction energy [24] so it decreases performance and the number of performed repetitions in the subsequent set. Therefore, these factors can be another possible reason for performance drop or decrease. The results of the current study showed that longer intervals allow the sustainability of the number of repetitions in sets and subsequent exercises performed in the same training session. Also, the number of repetitions to failure in successive sets decreases regardless of the length of the rest periods between sets and exercise. However, it seems that this reduction is smaller in exercises performed at the beginning vs. at the end of the session, especially when using 3-minute vs. 1-minute rest interval between sets.

CONCLUSIONS

The results of the present study indicated that excessive fatigue while performing a movement causes a decrease in the number of performed repetitions during next movement sets and also decreases the training volume during the sequence of movements especially in shorter rest intervals. Therefore, it is recommended that sufficient recovery (minimum 3 minutes) between resistance training sets be established to keep the subsequent set at a higher level until one can establish optimal response in relation to increasing muscle strength and mass.

Considering the importance of the effects of rest intervals on the resistance training volume, it is recommended that future researchers investigate the effects of various rest intervals on the training volume during a resistance training session, especially a training session which is composed of a combination of the upper and the lower body exercises.

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