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Relationship between Repetitions and Selected Percentage of One Repetition Maximum in Trained and Untrained Adolescent Subjects

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ABSTRACT

Moraes E, Alves HB, Teixeira AL, Dias MR, Miranda H, Simão R. Relationship between Repetitions and Selected Percentage of One Repetition Maximum in Trained and Untrained Adolescent Subjects. **JEPonline** 2014;17(2):27-35. This study compared 7 males with experience in resistance training (trained group: 14.4 ± 1.3 yrs) to 10 males with no prior experience (untrained group: 14.6 ± 0.8 yrs). The subjects performed maximum repetitions at 80% of one repetition maximum (1RM) until concentric fatigue in the bench press (BP), the lat pull-down (LPD), and the 45º leg press (LP) resistance exercises. The number of repetitions achieved during the LP was greater than during the LPD in both groups (P≤0.05). The number of repetitions for the LP and the LPD were greater than during the BP in both groups (P≤0.05). The number of repetitions was greater in the trained group vs. the untrained group in both the LP and the LPD exercises (P≤0.05). There was no significant difference between the groups (P≥0.05) during the BP exercise. The findings indicate that the number of repetitions achieved at 80% of 1RM in trained and untrained adolescent subjects vary with different resistance exercises.

Key Words: Muscle Strength, Resistance Training, Adolescent Subjects

INTRODUCTION

As long as correct technique and supervision are required, resistance training (RT) is both a safe and effective method to condition children and adolescents (10). In fact, the American Academy of Pediatrics (1) and numerous researchers (14,19,21,31) indicate that RT can improve muscle strength, muscle endurance, body composition, lipid profile, bone mineral density, cardiovascular fitness, and mental health to help reduce the risk of injuries in athletics and recreational activities (29).

The RT prescription for adults usually includes a combination of several of the following variables, such as weekly frequency (12), volume of training (5), number of sets (4), number of repetitions (7), training load (24), rest interval between sets and exercises (22), and exercise order (27). The combination is often defined by the subjects age level, experience, and athletic emphasis on strength, hypertrophy, power, and/or localized muscular endurance (2,13,18,30). For young subjects that include children, RT is usually designed to develop muscle strength, power, and endurance (10) that is appropriate for a specific sport.

Intensity is generally recognized as the primary variable to gain muscle strength (10,13). For children and adolescents, in particular, who are interested in improving their muscle strength, a RT program that consists of 6 to 15 repetitions with 1 to 3 sets is recommended (1,10). Furthermore, the recommendation is linked to a specific load percentage (10) in both children (14) and adults (7) via the one repetition maximum (1RM) to control the intensity of effort.

The association between load percentage and number of repetitions is common (3). But, in adults it has been demonstrated that the number of repetitions achieved using a specific percentage of 1RM may vary depending on the muscle mass involved in resistance exercises (16,17,24,26) and the subjects' training status (17,20). Hoeger et al. (16) analyzed this relationship in adults and concluded that the number of repetitions achieved and percentage of 1RM was different according the resistance exercise. As an example, at 60% of 1RM subjects performed ~34 repetitions in the leg press exercise and ~11 repetitions in the knee flexion exercise. Interestingly, while their study showed that the number of repetitions is associated with the load percentage in adults, it should not be generalized to the adolescent population.

Despite the National Strength Conditioning Association (NASCA) (10) position statement, the recommendations regarding load percentage with certain number of repetitions are differentiated according with fitness status and desired objectives. It is possible that the NASCA position is questionable because: (a) only one study on the topic was referenced; and (b) the study sample was composed only untrained children. Thus, given the differing points of view in the literature, the purpose of this study was twofold. First, this study compared the number of repetitions achieved at 80% of 1RM in adolescents in different resistance exercises. Second, it compared the number of repetitions achieved in trained and untrained subjects.

METHODS

Subjects

Seventeen healthy adolescent men were enrolled in this study. Seven subjects had previous experience in RT for 6 consecutive months with minimum frequency of 3 $d \cdot wk^{-1}$ for 30-min or longer per session (trained group). Ten subjects had no previous experience in RT (untrained group). The descriptive data of the subjects are presented in Table 1. The inclusion criteria were: (a) not using any nutritional supplement; and (b) self-report maturational stage between 3 and 4

stages in the Tanner scale (9). Exclusion criteria included: (a) any limitation that would interfere in the experimental procedures; and (b) a positive answer to one of the questions on the Physical Activity Readiness Questionnaire (PAR-Q) (23).

All subjects were instructed to keep to their daily habits and not to engage in physical exercises 24 hrs prior to the tests. Each subject and his legal guardian read and signed a specific informed consent form. The university institutional review board approved the procedures used in this study.

Procedures

Anthropometry

The subjects' body weight was assessed using a digital weighing scale (Fillizola®, Brazil). Height was determined using a stadiometer with mm precision (Sanny®, Brazil).

One Repetition Maximum Test (1RM)

Previous studies reported the safety of 1RM test in young population (10). Initially, all the subjects underwent a 2-wk (3 sessions·wk^{-1}) familiarization period, during which the subjects performed the same exercises as used in the 1RM tests. The purpose was to standardize the technique for each exercise. Using a light weight, the sessions were performed with 3 sets of 15 repetitions.

After the familiarization period, the 1RM test was performed in 2 non-consecutive days for the bench press (BP), the machine front lat pull-down (LPD), and the 45º leg press (LP) using a counterbalanced order. Exercises were performed a using RT machine (Riguetto®, High on, Brazil). The 1RM test sessions were separated by 48 to 72 hrs and were used to determine test-retest reliability.

During the 1RM test, each subject had a maximum of 5, 1RM attempts of each exercise with a rest interval of 5 min between attempts with a 10-min recovery period before the start of the 1RM testing of the next exercise. No pause was allowed between the eccentric and concentric phase of a repetition or between repetitions. For a repetition to be successful, a complete range of motion, as is normally defined for the exercise, had to be completed. Excellent day-to-day 1RM reliability for each exercise was shown using this protocol. The 1RM testing on the two occasions showed intraclass correlation coefficients: (a) in the trained group of r = 0.99 for the BP; r = 0.99 for the LPD; and r = 0.97 for the LP; and (b) in the untrained group of r = 0.98 for the BP; r = 0.96 for the LPD; and r = 0.94 for the LP. Additionally, a paired Student's *t* test showed no significant difference between the two occasions in the 1RM tests in both groups.

The following is a brief description of the range of motion used to define a successful repetition for each exercise: BP, moving the bar from a chest touch to a fully extended elbows position; LPD, moving the bar from a chest touch to a fully extended elbows position; and LP, starting with the knees at an 90º angle and fully extending the knees. To minimize error during the 1RM tests, the following strategies were adopted (28): (a) standardized instructions regarding the testing procedure were given to the subjects before the test; (b) the subjects received standardized instructions on specific exercise technique; (c) verbal encouragement was provided during the testing procedure; and (d) the mass of all weights and bars used was determined using a precision scale.

Experimental Session

After 48 to 72 hrs of 1RM tests, the subjects underwent an experimental session that consisted of 1 set of maximum repetitions possible (i.e., until concentric failure) in each exercise at 80% of 1RM with a 10-min rest interval between the exercises. All subjects performed the exercises in the same

order used in the 1RM test. Two minutes prior to the experimental session, each subject performed a specific warm-up in each exercise with 10 repetitions at 40% of 1RM. The velocity of movement was self-selected, but no pause was allowed between the eccentric and concentric phases in all exercises. Repetitions that did not match the technical standards required were not considered. An experienced RT professional conducted all tests sessions.

Statistical Analyses

The Shapiro-Wilk normality test and a homoscedasticity test (Levene's test) were used to analyze the distribution of the data. All variables presented a normal distribution and equality of variance. An independent sample *t* test was used to compare the baseline variables between groups. A two (trained group vs. untrained group) by three (exercises) ANOVA's and Tukey's *post-hoc* test were used to compare the number of repetitions achieved. Statistical significance was set at $P \leq 0.05$. The SPSS statistical package version 19.0 (SPSS Inc., Chicago, USA) was used for all statistical analysis.

RESULTS

Table 1 presents the descriptive data of the subjects. No significant differences were obtained in the age, weight, and height between groups. The load of 1RM was greater only in the trained group only in 45° LP exercise (P=0.032). The number of repetitions achieved in trained group was significantly greater in LP (19.1 ± 4.1) than LPD (14.7 ± 1.5) (P=0.02) and greater in LPD than BP (10.3 ± 1.1) (P=0.01). This also occurred in the untrained group (LP: 14.9 ± 3.9 greater than LPD: 11.3 ± 2.2, P=0.02); (LPD greater than BP: 9.0 ± 2.0, P=0.03). As the comparison between groups, the number of repetitions in trained group was greater in the LPD (P=0.01) and the LP (P=0.04) exercises than the untrained group (Table 2).

Table 1. Descriptive Data (Mean ± SD) of the Subjects.

Variables	Trained Group	Untrained Group	P
Age (yrs)	14.4 ± 1.3	14.6 ± 0.8	.742
Weight (kg)	67.1 ± 9.2	64.8 ± 7.0	.553
Height (cm)	166.0 ± 6.4	168.7 ± 9.1	.515
1RM load (kg)			
Bench Press	43.9 ± 13.8	40.8 ± 14.4	.668
Lat Pull-Down	63.4 ± 12.2	59.3 ± 10.1	.477
45° Leg Press	395.7 ± 87.3	265.4 ± 70.1	.032

Table 2. Comparison of the Number of Repetitions Achieved at 80% of 1RM between the Trained Group and the Untrained Group.

Exercise	Trained Group (n = 7)	Untrained Group (n = 10)
Bench Press	10.3 ± 1.1	9.0 ± 2.0
Lat Pull-Down	14.7 ± 1.5*	11.3 ± 2.2*‡
45º Leg Press	19.1 ± 4.1*†	14.9 ± 3.9*†‡

*Significant difference (P≤0.05) to BP in the same group. †Significant difference (P≤0.05) to LPD in the same group. ‡Significant difference (P≤0.05) between groups in the same exercise.

DISCUSSION

The purpose of the present study was to compare: (a) the number of repetitions achieved at 80% of 1RM in different resistance exercises in adolescents; and (b) the number of repetitions achieved in trained and untrained subjects. The results show that adolescent subjects achieved different number of repetitions with the same load percentage between different resistance exercises independently of training status. In addition, the trained group achieved greater number of repetitions in the LP and LPD exercises than did the untrained group. According to the results, we cannot assert that a given number of repetitions are always associated with the same 1RM percentage in adolescents. The present study is in agreement with Faigenbaum et al. (11) who examined the association between the 1RM percentage and the number of repetitions in BP and LP exercises in untrained children. Their results show significant differences between the number of repetitions achieved in same percentage of 1RM (50 and 75% of 1RM).

Generally, the recommendations for adults cannot be followed by children and adolescents. This appears mainly to be due to differences in response to RT related to growth and maturation that characterizes adolescents (10). According to some authors (8,15), muscle activation in children and adolescents is not complete and, therefore, is lower when compared to adults. Moreover, with regards to the size principle of motor unit recruitment, children are less able than adults in the activation of type II fast-twitch muscle fibers to fatigue in voluntary contractions. This mechanism is believed to have some influence on muscle fatigue and maximum repetitions in children and adolescents compared to adults. But, in the present study, we observed that similar results were found in both adults and adolescents, where the number of repetitions achieved using a specific percentage of 1RM varied depending on the muscle mass involved in the exercise (16,17,24,26) and the subjects' training status (17,20).

Although speculative, it is possible that the fatigue threshold to a given percentage of 1RM may vary from one muscle group to another, possibly in relation to the muscle mass involved in each exercise. It might also be noted that by examining the data collected in the present study that the repetitions performed in a given RT exercise varied among individuals sufficiently to influence the expected adaptations with training. The repetitions achieved at an individual level relate to different stimulus zones (2,13). Thus, the same relative intensity in the same exercise would probably lead to the development of different physical qualities in individuals belonging to the group experienced (i.e., if there was continuity in the training). Thus, what has been proposed by Faigenbaum et al. (11) seems the most appropriate prescription of RT in children. The authors suggest that the intensity must be found for a given area of repetitions and not related to the percentage of 1RM.

The NASCA recommendations regarding RT for children and adolescents indicate different load percentages for different fitness levels (10). The recommendation for children (i.e., novice) is 50 to 70% of 1RM, 1 to 2 sets performed at 10 to 15 repetitions. Based on the study of Faigenbaum and colleagues (11), at 50% of 1RM, children have achieved 87 and 39 repetitions in the BP and LP exercises, respectively. Thus, the intensity that is suggested may be below the capacity of a child, which does not appear as a sufficient intensity to generate a stimulus.

In the present study, it is important to point out that the initial movement of the LP and BP exercises resulted from the eccentric muscle contraction while the initial phase of the LPD exercise required concentric muscle contraction. This difference in the initial position created difficulties for some subjects who had to overcome the initial inertia of moving the load with the proper technique. Therefore, it is possible that the load of 1RM in LPD may have been underestimated.

It can be observed that the RT prescription across the percentage of 1RM has limitations, given that the number of repetitions reached within a certain percentage of 1RM can be influenced by muscle group and training status. Therefore, it is reasonable that the results of this study have practical application in the prescription of RT for teenagers since the number of repetitions is not always associated with a percentage of 1RM.

CONCLUSIONS

The results of the current study show that the number of repetitions achieved at 80% of 1RM are different between different resistance exercises and can be influenced by the training status in adolescents. Therefore, the percentage of maximum load should be used with caution when creating the RT prescription for this population.

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