Relationship between the Percentage of 1RM and the Number of Repetitions for the Prescription of Strength Training Programs

Rodrigo Pereira 1,4, Fabrício Madureira 1, Claudio Scorcine 1, Aurea Mineiro 1, Wanessa Ysis 1, Dilmar Pinto Guedes Jr 1,2,3

1Universidade Metropolitana de Santos/ Santos-SP/ Brasil, 2Centro de Estudos de Fisiologia do Exercício e Treinamento/ São Paulo-SP/ Brasil, 3Universidade Santa Cecilia/ Santos-SP/ Brasil, 4Faculdade da Praia Grande/Praia Grande-SP/ Brasil

ABSTRACT

Pereira R, Madureira F, Scorcine C, Mineiro A, Ysis W, Pinto D, Guedes Jr DP. Relationship between the Percentage of 1RM and the Number of Repetitions for the Prescription of Strength Training Programs. JEPonline 2016;19:3:42-49. The purpose of the study was to investigate the number of repetitions per set at 80% of 1RM, considering different groups in gender, level of physical fitness, upper and lower limbs, exercises, equipment of different brands, age (adolescent and adult), and motivation. The sample consisted of 78 volunteers (36 men and 42 women) who underwent tests in six different types of exercises supervised by expert coaches. For each exercise, the 1RM test was conducted according to Kraemer et al. guidelines, then 80% of the 1RM load was calculated, and the maximum of correct repetitions was performed. The results do not agree with the findings reported in the literature. Therefore, we suggest caution in prescribing training programs that follow these parameters. One must consider some important variables to avoid underestimating or overestimating the relationship between % of 1RM and the number of repetitions.

Keywords: Strength Training, Maximum Load, Percent, Prescription
INTRODUCTION

Strength training (ST) produces muscle hypertrophy (29,30), which results in an increase in muscle strength, power, and endurance. In 2009, the American College of Sports Medicine (21) recommended ST to improve physical fitness and functional capability of athletes and non-athletes. Some of the methodological variables for prescription include load (intensity), the number of repetitions and sets, the rest interval between sets and sessions, the sequence of exercises, the speed of performance, and the weekly frequency. Load is directly related to the effects of ST, and it is usually based on percentages of one repetition maximum (1RM) (1,6,11,19,23) The 1RM test is usually regarded as the gold standard for assessing the dynamic maximum strength by using percentage values of maximum strength to determine training zone (6).

Some authors have suggested estimates for the expected number of maximum repetitions (RM) for a given percentage of 1RM (2,6,8,9,17). However, there is not a consensus in the literature on such estimates (7,9,27). In any strength training program it is important that the prediction of the workload is based on validated guidelines, especially since this is one of the most important variables for a successful training routine (6). Several studies have analyzed the relationship between percentage of 1RM and the number of repetitions performed with consideration given to: exercises (18), physical fitness (9,26), upper and lower limbs (13,28), and characteristics of muscle fiber composition (4). Publications considering variables such as gender, equipment brands with distinct biomechanical characteristics, and age have yet to be investigated.

The purpose of this study was to investigate the number of repetitions per set at 80% of 1RM, different genders, level of physical fitness, upper and lower limbs, exercises, different equipment brands, age (adolescent and adult), and level of motivation.

METHODS

Subjects

Seventy eight subjects (36 men, 42 women) with a age of 23.17 ± 7.78 yrs performed six different exercises: (a) 14 men and 14 women performed tests on the Leg Press machine; (b) 5 men and 12 women performed tests on the Lying Leg Curl; (c) 7 men and 16 women performed tests on the Seated Leg Curl; (d) 8 men and 20 women performed the Seated Row test; (e) 21 men and 27 women performed on the Front Lat Pulldown machine; and (f) 23 men and 19 women on the Bench Press. All exercises were supervised by expert coaches.

Procedures

The 1RM test was performed for each exercise according to the guidelines by Kraemer et al. (10). Once the 1RM loads were determined, 80% of 1RM was calculated by having the subjects perform as many repetitions as possible while maintaining the correct range of motion. The tests were performed in 2 d with an interval of 48 hrs between them, and the exercises were alternated for upper and lower limbs, with different muscle groups each day. For each test some variables were evaluated by groups of beginners and trained individuals, age and gender, different equipment brands (biomechanics), upper and lower limbs, and with and without motivation.
The subjects signed an informed consent form and delivered a medical certificate in order to determine their overall health conditions. The survey was conducted at the Faculdade de Educação Física de Santos / Universidade Metropolitana de Santos (FEFIS/UNIMES), and the tests were performed in two gyms on the college premises.

Statistical Analyses
The distribution of results was assessed using the Shapiro-Wilk test for normality and the analysis of quantile-quantile plots in order to determined if the variables were distributed similarly to the normal curve. The Student’s t-test was used to compare the literature suggestion of the number of repetitions of 1RM at 80% and the data found in this study. The significance level was set at P≤0.05.

RESULTS
The results are presented in Tables 1 to 6. All variables are expressed as mean ± standard deviation.

Table 1. Description of the Average and Standard Deviation of Repetitions Performed on Different Exercises at 80% of 1RM, Compared to 10 Repetitions as Suggested in the Literature.

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Bench Press</th>
<th>Seated Row</th>
<th>Lat Pulldown</th>
<th>Leg Press</th>
<th>Seated Leg Curl</th>
<th>Lying Leg Curl</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10.5 ± 4.6</td>
<td>7.8 ± 3.8*</td>
<td>11.8 ± 5.7*</td>
<td>17 ± 8.5*</td>
<td>9.8 ± 3.3</td>
<td>9.7 ± 3.7</td>
</tr>
</tbody>
</table>

Data are shown as mean ± SD; *Indicates significant difference, P≤0.05

Table 2. Comparison of Two Exercises With Different Age Groups, Regarding the Number of Repetitions Performed at 80% of 1RM, Compared to 10 Repetitions as Suggested in the Literature.

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Adolescent</th>
<th>Adult</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bench Press</td>
<td>13.2 ± 4.9*</td>
<td>9.3 ± 4</td>
</tr>
<tr>
<td>Leg Press</td>
<td>19.8 ± 9.3*</td>
<td>15.3 ± 7.7*</td>
</tr>
</tbody>
</table>

Data are shown as mean ± SD; *Indicates significant difference, P≤0.05

Table 3. Comparison of the Number of Repetitions Performed by Beginners and Advanced at 80% of 1RM, Compared to 10 Repetitions as Suggested in the Literature.

<table>
<thead>
<tr>
<th>Group</th>
<th>Bench Press</th>
<th>Row</th>
<th>Pulldown</th>
<th>Leg Press</th>
<th>Seated Leg Curl</th>
<th>Lying Leg Curl</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beginner</td>
<td>10.6 ± 4.9</td>
<td>7.6 ± 4.1</td>
<td>11.8 ± 6.6</td>
<td>17.6 ± 8.4</td>
<td>10.1 ± 3.2</td>
<td>9.7 ± 4.4</td>
</tr>
<tr>
<td>Trained</td>
<td>10.5 ± 4.0</td>
<td>8.1 ± 3.5*</td>
<td>11.9 ± 3.9*</td>
<td>15.1 ± 9.1*</td>
<td>9.4 ± 3.2</td>
<td>9.5 ± 2.9</td>
</tr>
</tbody>
</table>

Data are shown as mean ± SD; *Indicates significant difference, P≤0.05

Table 4. Comparison of the Results With and Without Motivation for the Number of Repetitions at 80% of 1RM, Compared with 10 Repetitions as Suggested in the Literature.

<table>
<thead>
<tr>
<th>Group</th>
<th>Bench Press</th>
<th>Row</th>
<th>Pulldown</th>
<th>Leg Press</th>
<th>Seated Leg Curl</th>
<th>Lying Leg Curl</th>
</tr>
</thead>
<tbody>
<tr>
<td>WM</td>
<td>11.3 ± 4.9</td>
<td>9.7 ± 3.1</td>
<td>12.3 ± 3.8</td>
<td>18.6 ± 8.6</td>
<td>9.8 ± 3.0</td>
<td>10.9 ± 3.0</td>
</tr>
<tr>
<td>WOM</td>
<td>9.6 ± 4.5</td>
<td>5.4 ± 3.6*</td>
<td>11.4 ± 6.4*</td>
<td>14.8 ± 8.4*</td>
<td>10 ± 7.0</td>
<td>7.5 ± 4.2</td>
</tr>
</tbody>
</table>

WM = With Motivation; WOM = Without Motivation; Data are shown as mean ± SD. *Indicates significant, P≤0.05
Table 5. Comparison of Upper and Lower Limbs on the Number of Repetitions Performed for Each Limb at 80% of 1RM, Compared to 10 Repetitions as Suggested in the Literature.

<table>
<thead>
<tr>
<th>Upper Limb</th>
<th>Lower Limb</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.06 ± 4.9</td>
<td>11.58 ± 5.85*</td>
</tr>
</tbody>
</table>

Data are shown as mean ± SD. *Indicates significant, P≤0.05

Table 6. Comparison between Gender Regarding the Number of Repetitions Performed at 80% of 1RM, When Compared to 10 Repetitions as Suggested in the Literature.

<table>
<thead>
<tr>
<th>Group</th>
<th>Bench Press</th>
<th>Row</th>
<th>Pulldown</th>
<th>Leg Press</th>
<th>Seated Leg Curl</th>
<th>Lying Leg Curl</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>10.5 ± 4.9</td>
<td>10.6 ± 2.2</td>
<td>10.9 ± 4.7</td>
<td>20.2 ± 8.9</td>
<td>11.2 ± 3.9</td>
<td>9.4 ± 5.4</td>
</tr>
<tr>
<td>Women</td>
<td>10.6 ± 4.5</td>
<td>7 ± 2.2*</td>
<td>12.5 ± 6.1*</td>
<td>13.5 ± 6.8*</td>
<td>9.25 ± 3.1</td>
<td>10.3 ± 2.8</td>
</tr>
</tbody>
</table>

Data are shown as mean ± SD. *Indicates significant, P≤0.05

DISCUSSION

When comparing the suggested 10 repetitions to what the subjects achieved with the load at 80% of 1RM, the following results were found. For the beginners, a statistical difference was found on the leg press test between 10RM and the maximum repetitions achieved (7 repetitions). On the other exercises no significant differences were found. As for the trained subjects, no significant differences for any of the exercises were found.

In regards to the bench press test, some different results were found depending on which variable was considered. If taken into account the total number of subjects evaluated in this experiment, the results corroborate the work of Hoeger et al. (7) that recommends 10RM when using 80% of 1RM. However, when the groups were analyzed separately by age group, the results found in young subjects overestimated the Hoeger and colleagues (7).

Reynolds et al. (22), found results of 75.65% of 1RM to complete 10 RM on the bench press. In the study by Ramalho et al. (3), subjects performed 7 ± 1.4 repetitions at 80% of 1RM. Simão et al. (26) observed an average of 9.2 ± 1.3 repetitions when their subjects were tested at 80% of 1RM in the bench press. In another study, Filho et al. (5) used the same procedure in relation to 1RM tests and maximum number of repetitions, however, the intensity adopted in the maximum number of test repetitions was 85% of the maximum load. The results were approximately six repetitions, which similar to studies that have addressed this issue and approximate intensity values (5,15,20,26).

McArdle et al. (16) state that the percentage of 68% of the 1RM is 10RM for untrained subjects and 79% for trained subjects. In the present study, significant differences were found for lower limbs as compared to standards found in the literature. Simão et al. (26), observed that when using loads in the squat exercise with a reference value of 80% of the load achieved in the 1RM test, an increased number of repetitions were found (20 ± 7).

The results are consistent with those observed by Hoeger et al. (7) in the leg press test, where results related to the number of repetitions was 19 ± 9. Reynolds et al. (22) found the value of 70.1% of 1RM as the appropriate percentage to complete 10RM.
Shimano et al. (25), found variations between different exercises on the number of repetitions performed with the same intensity. In their study, eight trained subjects and eight untrained subjects completed 1RM tests in the bench press, biceps curls, and squats and, then, were instructed to perform as many repetitions as possible with loads of 60%, 80%, and 90% of the 1RM. Although training skills had no influence on the difference in the number of repetitions, the amount of muscle mass involved in the squat tests enable an increased number of repetitions compared to the other exercises in all intensities.

In the current study, when the subjects were separated by gender, a difference was observed for the female subjects in the following exercises: seated row (3 repetitions), front Lat pulldown (2.51 repetitions), and leg press (3.5 repetitions). In the male subjects, a difference was observed only in the leg press test (10.24 repetitions). When the tests were divided into lower and upper limbs, significant differences were found with the lower limbs.

Significant differences were found in the group with motivation during the front Lat pulldown and leg press tests, while the group without motivation showed significant differences on the leg press and seated row. In the seated row, the number of repetitions was lower than 10. There are only a few studies on the motivation variable in the literature.

A difference was found among the adults and adolescents in the leg press machine. In the teenagers, differences were observed in the bench press and leg press tests. Analyzing the group as a whole, considering only the exercise, differences were observed in seated row, front Lat pulldown, and leg press tests.

Libardi et al. (12) compared the hemodynamic and metabolic responses to the subjective perceived during the 1RM and 10RM tests on 14 trained male subjects, aged between 18 and 28. The results showed that the values of maximum load in 10RM tests accounted for 70.6% of the maximum load values achieved in 1RM tests. As evidenced by some authors, there are many variables that point towards results that oppose those found in the literature (7,14,25). Among these, the speed of performance and the range of motion have a direct influence on the number of repetitions (24).

CONCLUSION

While the results in the present study are in agreement with the findings described in the literature, some of the findings are in conflict with the literature. The findings suggest that variables such as exercise, gender, current physical fitness level, age, body segment, and level of motivation should be given special consideration in the prescription of loads when developing ST programs, particularly in regards to the relationship between percentage of 1RM and number of repetitions. This appears necessary to avoid the underestimation or the overestimation of the training load in accordance with individual objectives.
ACKNOWLEDGEMENTS
The authors would like to thank the volunteers who participated in the study.

Address for correspondence: Rodrigo Pereira, Universidade Metropolitana de Santos / Santos-SP / Brasil, Faculdade da Praia Grande / Praia Grande-SP / Brasil, Email: r.pereirads@hotmail.com

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