The Different Intensity of Maximum Strength Enhancement in Young Males After Ten Weeks of Weightlifting Training

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Abstract

The number of sets in resistance training program which required to produce maximal strength gain were still controversial. We examined the changes in maximal strength between groups with different weight training workouts in the present study. 22 untrained young males were divided into three groups randomly, each group perform a different sets of weightlifting squats; the groups did one set, three sets, six sets, respectively; all groups used 8 repetitions at maximum weight, for each; all groups lifted weight two times per week, and the study lasted ten weeks. The 1 repetition maximum of each subject was tested at the beginning of the training period, at the 4th week, the 7th week and at the 10th week. The result showed there were no significantly differences in 1 repetition maximum between the three groups after ten weeks of training. It could be conclude that, in untrained individuals, there were no difference in maximum strength, regardless of whether they practiced one set, or for multiple sets of exercises.

Keywords: Resistance training, Set, 1RM

Introduction

Strength training is a fundamental training method for professional athletes, but anyone can use strength training to cultivate muscular strength, lean body weight, and bone density. According to Powers and Howley’s study[1], in order to improve strength, weight training must employ the overload principle by periodically increasing the amount of weight/resistance; this method was called progressive resistance exercise (PRE), the concept of PREs is the basis for most weight training programs. Many resistance training workouts are structured around exercise intensity, “sets,” “and “reps,”. For a given exercise within a workout, the number of “sets” is the number of sequences of exercise, and the “reps” is the number of repetitions within each set. “Intensity” refers to the weight lifted and may be expressed in terms of the “repetitions maximum”(RM), where 1RM is the greatest weight that can be lifted one time with good form. Rest days between workouts seem critical for optimal strength improvement; a training schedule of three or two days per week is usually recommended [2]. One of the most controversial issues of strength training is the number of sets required to produce optimal strength gains. Historically, it has often been claimed that multiple sets produced maximal strength gains; various studies have produced different claims. Starkey et al. [3] compared the effects of different volumes of high-intensity resistance training on isometric torque and muscle thickness, and concluded that one set of high-intensity resistance training was as effective as three sets for increasing isometric torque and muscle thickness in previously untrained adults. Carpinelli and Otto [4] found limited scientific evidence to support the idea that a greater volume of exercise elicits greater increases in strength or muscle hypertrophy. Rhea [5] reported that three sets of training are superior to one set for eliciting maximal strength gains. Similarly, a study by Schlumberger [6] showed that three-set strength training produced better strength gains than single-set strength training in women who had basic experience in resistance training. According to our interviews with several coaches, athletes always perform more than six sets resistance training. However, to the best of our knowledge, no studies have compared the results of one set to the results of more than four sets [4]. The present study was aimed to investigate that the effects of muscle strength changes in different sets of weightlift training within ten weeks.

Materials and methods

Subjects

22 untrained male volunteers of Shanghai University of Sports junior students, all age 19±1 years old, randomly drew straws and were divided into three groups (S1, S3, S6) according to the results of that random draw. The information of the subjects showed on Table 1. from Table 1, it can be seen that there were no significant differences of height and weight between the three groups of subjects before training, and that
there were no significant differences of weight after 10 weeks of training.

The first group did one set of dynamic resistance exercises (S1) workout, the second group did three sets (S3), and the third group did six sets (S6). Each repetition followed a cycle: lifting barbells from a squat putting barbells to shoulders, squatting down from a standing posture until knee joints formed right angles, then resuming a standing position. Each set had eight repetitions at maximum weight, i.e. 8RM. All subjects trained two times per week, over a period of 10 weeks.

**Training schedule**

Before the training program began, each subject’s baseline 1RM was tested. Each subject’s training was conducted with a weight denoted 8RM, equal to 80% of that subject’s 1RM. After four weeks of training, each subject’s 1RM was re-tested, and training continued with the updated value. After the seventh week of training, each subject’s 1RM was re-tested, and training continued using an updated 8RM. After 10 week of training, each subject’s 1RM was re-tested.

**The testing of 1RM:**

For each subject, the exact weight used for 1RM was discovered by following test. First, the subject did warm-up exercises for five to ten minutes. Then, a starting weight was selected that was close to, but below, the subject’s maximum lifting capacity. The subject lifted this starting weight twice with correct form, and then rested for two to three minutes. The weight was increased by an increment of variable size, and the subject lifted the new weight until the subject could only lift the weight once with correct form. The increment was one, or two, or five kilograms.

**The estimate of 8 RM weight:**

In general, for every reduction of 2.5% from 1RM, the individual can probably do one more repetition [7]; therefore, this research assumed that each subject would be able to lift 80% of his 1RM weight for eight repetitions with correct form.

**Statistical method:**

The data was evaluated by means of repeated measurement analysis of variance (ANOVA). When the ANOVA resulted in a significant F value (p < 0.05), the difference between groups was located with the Newman-Keul test; a Paired-t-test was used to determine differences between means within each group. Values are reported as means±SD. The Statistical Product and Service Solutions (SPSS11.5) software package was used.

**Results**

Table 1 The heights and weight of subjects before and after training

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>height (cm)</th>
<th>weight (kg, before training)</th>
<th>weight (kg, after training)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>7</td>
<td>170.4±5.7</td>
<td>61.2±5.9</td>
<td>60.0±8.9</td>
</tr>
<tr>
<td>S3</td>
<td>7</td>
<td>173.3±3.7</td>
<td>62.3±4.6</td>
<td>62.1±6.4</td>
</tr>
<tr>
<td>S6</td>
<td>8</td>
<td>173.1±3.5</td>
<td>62.5±8.9</td>
<td>61.7±8.1</td>
</tr>
</tbody>
</table>

Table 2  Barbell squat 1RM before and after training (kg, mean±SD)

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>After 4 weeks</th>
<th>After 7 weeks</th>
<th>After 10 weeks</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>106.4±18.4</td>
<td>127.1±17.5 #</td>
<td>152.1±20.7 #</td>
<td>169.2±25.1 #</td>
<td>between groups 0.342</td>
</tr>
<tr>
<td>S3</td>
<td>117.1±16.7</td>
<td>134.2±10.9 #</td>
<td>165.0±14.7 #</td>
<td>182.1±15.7 #</td>
<td>within group 0.000</td>
</tr>
<tr>
<td>S6</td>
<td>105.6±9.42</td>
<td>121.2±12.4 #</td>
<td>153.1±18.3 #</td>
<td>176.2±19.7 #</td>
<td></td>
</tr>
</tbody>
</table>

( P was from R-M ANOVA. # significant difference compared with baseline · p<0.01 · paired-t-test.)

Table 3 Percentage increase of barbell squat 1RM before and after training (% , mean±SD)

<table>
<thead>
<tr>
<th></th>
<th>After 4 weeks</th>
<th>After 7 weeks</th>
<th>After 10 weeks</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>20.3±9.9</td>
<td>44.3±14.8 #</td>
<td>60.2±14.2 #</td>
<td>between groups 0.879</td>
</tr>
<tr>
<td>S3</td>
<td>15.7±10.2</td>
<td>41.9±10.6 #</td>
<td>56.8±12.5 #</td>
<td>within groups 0.000</td>
</tr>
<tr>
<td>S6</td>
<td>15.0±10.1</td>
<td>42.1±19.2 #</td>
<td>63.5±19.9 #</td>
<td></td>
</tr>
</tbody>
</table>

( P was from R-M ANOVA. # significant difference compared with the 4th week · p<0.01 · paired-t-test.)

**Change of the absolute value of barbell squat 1RM before and after training**

After 10 weeks of barbell squat training, all subjects showed increased 1RM values; within all three groups, these increases were statistically significant. However, between groups (S1, S3, S6), there was no significant difference in 1RM (Table 2).

**Change of the percent increase of barbell squat 1RM before and after training**
Different subjects began from different baseline 1RM values. Percentages were calculated to overcome these variations. Table 3 shows the percentage values of improvement after four, seven, and ten weeks. At each stage, the difference between most recent 1RM and baseline 1RM was divided by the baseline 1RM, and the resulting quotient was multiplied by 100 percent to produce the percentage.

Table 3 indicate that after adjustment for the variations in baseline 1RM, improvement in 1RM showed no statistically significant differences between any of the three groups (S1, S3, S6).

Discussion

The result of this study indicated that, after ten weeks, all subjects in all groups showed more than 55% improvement in 1RM. However, even though all subjects exercised with equal intensity, and each group used a different number of sets per workout, there were no statistically significant differences between improvements for different groups. Whereas some opinion in the literature suggest that a large number of sets will produce a large increase in strength, our findings indicate that a single set per workout was just as effective as six sets per workout. This means that for the untrained participants, over the course of ten weeks, the number of sets per workout was not a limiting factor for maximum strength gains in the lower limbs.

Dynamic resistance training been used widely in strength training program. Howley and Franks recommended that resistance training programs primarily intended to develop strength should use between 1 ~ 5-RM per set; they further recommended that training to develop strength and muscle size should use between 6 to 12-RM per set; and training to develop local muscle endurance should use between 20 to 50 repetitions at 60% 1-RM or less per set [7]. Furthermore, Howley and Franks attributed the strength increase after resistance training to neural and muscular adaptations during training; they wrote that neural adaptations dominate early in training, and that untrained individuals a must train for at least 4 weeks before a measurable change in muscle size can be observed [7]. The present study examined a ten-weeks training period at a training intensity of 8RM, therefore, we consider neural adaptations to have been the dominant cause of the 1RM increase in all subjects.

Several studies [8-9] have reported that different types of muscle fibers are recruited at different exercise intensity levels: in low-intensity exercise (40% VO₂max) most of the fibers that are activated are type I, whereas during high-intensity exercise (75% and 100% VO₂max) both type I and type II fibers are recruited. For resistance training, exercise intensity is determined by the weight (RM). High-intensity training (at least 75% VO₂max) activates all muscle fibers.

It is generally accepted that neural adaptations after resistance training include increases in neural drive. Those increases include: increases in the magnitudes of efferent neural output from the CNS to active muscle fibers, and increases in motor unit firing rates. However, motor unit synchronization, learning, and coordination come from the specificity of the training adaptation [10-11]. The only obvious relationship between the number of exercise sets and these factors is the learning of the action. Our results indicated that training intensity, but not number of training sets, contributed to the neural adaptations produced by ten-week weight training program.

In this study, the maximum low-limb strength levels of the untrained individuals, increased after ten weeks of resistance training, regardless of whether the subjects practiced single set or multiple sets. This indicates that an untrained participant in a resistance training program could efficiently increase muscular strength by a single-set training protocol. This is important for individuals who desire the health and fitness benefits associated with a well-rounded physical fitness program but who cannot spare the time required by multiple-set resistance training programs. However, for the trained individuals, research on the number of sets to produce optimal strength gains are required.

References


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