THE EFFECT OF SINGLE VERSUS MULTIPLE SETS ON STRENGTH

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ABSTRACT. Kelly, S.B., L.E. Brown, J.W. Coburn, S.M. Zinder, L.M. Gardner, and D. Nguyen. The effect of single versus multiple sets on strength. J. Strength Cond. Res. 21(4):1003-1006. 2007.—Research has previously been divided on whether performing resistance training with a single set per training session is as effective for increasing strength as training with multiple sets. The purpose of this study was to determine the effect of single sets versus multiple sets on strength. Forty subjects were randomly assigned into 1 of 3 groups: control (C; n = 8), single set (SS; n = 14), or multiple sets (MS; n = 18) to perform 8 maximal knee extensions at 60°·s⁻¹ on a Biodex System 3 isokinetic dynamometer twice a week for 8 weeks. The SS group performed 1 set while the MS group performed 3 sets. All groups were pre-, mid- (4 weeks), and posttested at 60°·s⁻¹. Strength was expressed as peak torque (PT). A 3 × 3 × 2 (time × group × sex) mixed factor repeated measures analysis of variance (AN-OVA) revealed no interaction involving sex, but there was an interaction of group by time. The MS group exhibited a significant (p < 0.05) increase in PT (pre = 171.39 ± 61.98 Nm; mid = 193.08 ± 66.23 Nm) between the pretest and the midtest while the SS group (pre = 163.45 ± 56.37 Nm; mid = 172.60 ± 61.78 Nm) and C groups (pre = 135.99 ± 54.31 Nm; mid = 127.66 ± 53.12 Nm) did not change. Strength did not change between the midtest and the posttest for any group. It was concluded that performing 3 sets of resistance exercise was more effective than performing a single set for increasing peak torque. These results seem to indicate that for increasing strength of the quadriceps, performing multiple sets is superior to performing a single set of resistance exercise.

Key Words. isokinetic, velocity, peak torque, single set, multiple sets

INTRODUCTION

The topic of the optimal amount of sets of resistance exercise one should perform when training in order to maximize strength gains has been one of great debate (12). The research is divergent; limited research demonstrates that performing a single set of a resistance training exercise is as effective (10, 14, 24) or even more effective (19) than performing multiple sets for strength gains while the predominant amount of research has demonstrated greater strength gains as a result of increased sets (3, 11, 13, 15, 17, 20).

Further, there has been a plethora of literature advocating either single set training (6, 8, 18) or multiple set training (2, 5, 21, 22) as the preferred method for increasing strength through resistance training. The issue has become a major point of contention among researchers. Reasons for the disparity in the literature have been suggested in Rhea's 2003 meta-analysis. It was speculated that small sample sizes in individual studies, which result in low statistical power, may have contributed to lack of significance between single set and multiple set protocols. Additionally, Rhea et al. questioned methodological control in some studies, stating that some neglect to control for variables such as periodization or training intensity. Thus, it can be difficult to accurately decipher differences or trends in data when simply examining the p values.

More research with various protocols is required to more accurately describe the dose/response relationship for resistance training. Previous literature examining the effect of various volumes on strength has yielded conflicting results (12). As the body of research continues to grow, an answer to the question of increasing volume, or sets of resistance exercise, for strength gain should become clearer.

The purpose of the current study was to examine differences between single sets and multiple sets in strength developed over an 8-week training period on an isokinetic dynamometer. There have been numerous strength training protocols employed in attempting to answer the single versus multiple set question, however, none of the previous research has examined the issue with isokinetic testing and training. The fact that the training was isokinetic, theoretically allowed for maximal effort to be given on each repetition throughout the entire range of motion (25), creating a training environment in which each repetition was as difficult to perform as the preceding and subsequent repetitions. It was expected that both groups participating in the training protocols would significantly increase isokinetic strength from pretest to posttest when compared to a control group. Furthermore, based on the bulk of the literature (3, 11, 13, 15, 17, 20), it was hypothesized that the group trained with multiple sets would demonstrate a significantly greater strength increase than the group trained with a single set.

METHODS

Experimental Approach to the Problem

The focus of the current study was the dose/response relationship in resistance training. No attempt to equate volume among groups was made. Each group was assigned a different volume of the same exercise over the same period of time, and the strength data which resulted were examined.

Subjects

Forty subjects (Table 1) voluntarily participated in the study. All subjects were free of any knee pathology for the past year. The majority of subjects were kinesiology students; thus, it is expected that most participants had
some level of resistance training experience. Subjects were randomly assigned to 1 of 3 groups: control (C), single set (SS), or multiple set (MS). It was asked that each subject volunteering had not performed lower body resistance exercises for the past 2 months, and that they continued to abstain from lower body extraneous strength exercise throughout the course of the study. Each subject was required to read and sign an informed consent form approved by the University Human Subjects Institutional Review Board.

**Procedures**

Prior to testing, each subject was weighed on a Health-O-Meter digital scale (Shelton, CT) and performed a 5-minute warm-up on a Monark 868 cycle ergometer (Varberg, Sweden) at a comfortable cadence and workload. Subjects were positioned on the isokinetic dynamometer with straps placed over each shoulder, around the waist, and over each thigh to ensure isolation of the knee extensors. They were then verbally instructed to perform a practice set of 4-6 submaximal repetitions. After a 1-minute rest, the pretesting began, consisting of 1 set of 6 maximal effort concentric knee extensions at 60°·s⁻¹ with the right leg.

Participants in the training groups were trained in sets of 8 repetitions twice a week for 8 weeks for a total of 15 training sessions (with midtesting replacing the second training session of the fourth week) with the right leg. The training protocol was identical to the testing protocol in terms of instructions given to the subject and subjects’ position on the machine. Following their cycle warm-up, subjects performed either 1 set (SS group) or 3 sets (MS group) of 8 repetitions at 60°·s⁻¹ with 1 minute rest between sets. Subjects were permitted to miss no more than 2 nonconsecutive training days. More than 2 missed training days or 2 consecutive missed days resulted in dismissal from the study.

Following the fourth (mid) and eighth (post) week of training (3–5 days), subjects were retested. The midtesting and posttesting procedures were identical to those of the prettest day. Isokinetic testing and training were done on a Biodex System 3 isokinetic dynamometer, which has been shown to be highly reliable by Brown et al. (4). All data from the Biodex were sampled at 2000 Hz by custom LabView (version 7.0) software, which collected torque, position, and velocity. Data were analyzed using SPSS software (version 14.0; SPSS, Inc., Chicago, IL).

**Statistical Analyses**

There were no differences in demographic data of the subjects by group (Table 1). A 3 × 3 × 2 (group × time × sex) mixed factor repeated measures analysis of variance (ANOVA) was used to analyze peak torque. There was no interaction of sex and time so the groups were collapsed for gender. A 2-way interaction was seen for time by group. This was followed up with 3 simple ANOVAs for time for each group.

![Peak Torque at 60°·s⁻¹](image)

**RESULTS**

The multiple set group significantly (p < .05) increased peak torque at 60°·s⁻¹ (pre = 171.39 ± 61.98 Nm; mid = 201.40 ± 77.67 Nm) between the pretest and midtest. There was no difference between the midtest and posttest. The single set group and control group demonstrated no improvements between any time of testing (Figure 1).

**DISCUSSION**

The purpose of this study was to examine the effect of single versus multiple sets on strength (demonstrated as peak torque) of the quadriceps over 8 weeks of isokinetic training. Our results demonstrated that performing 3 sets of isokinetic knee extension exercises twice a week was superior to performing 1 set for increasing strength at the training velocity. The multiple set group demonstrated a significant increase in peak torque at the training speed from pretest to midtest and from pretest to posttest while the control and single set groups did not. This seems to be congruent with the bulk of the literature on exercise volume, where performing more total work results in increased results (11, 15, 20, 22).

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<tr>
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<th>Control M</th>
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<td>Age (yrs)</td>
<td>25.33 ± 1.53</td>
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<td>173.69 ± 7.30</td>
<td>160.00 ± 5.79</td>
<td>176.65 ± 6.23</td>
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<td>Weight (kg)</td>
<td>78.97 ± 14.98</td>
<td>57.02 ± 6.67</td>
<td>84.03 ± 18.26</td>
<td>58.78 ± 9.96</td>
<td>91.12 ± 20.37</td>
<td>75.01 ± 20.81</td>
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The fact that the single set group did not significantly increase strength throughout the course of the study was unexpected. This may serve as more evidence that, although performing a single set of exercise is effective for gaining strength (10, 14, 24), those gains are limited in magnitude, especially when compared to results observed in subjects performing multiple sets (11). The results of this study seem to support previous studies such as Berger (3), Kraemer (11), Kramer et al. (13), Munn et al. (15), Paulsen (17), and Rhea et al. (20), all of which found performing multiple sets of resistance training exercises to be more effective than performing single sets for strength gain. These studies create the scientific foundation for advocating the use of multiple sets as a superior method of resistance training for increasing muscular strength (5, 12, 21, 22). However, these studies are in conflict with the findings of a small portion of the literature (10, 14, 19, 24), that found performing a single set of exercise was as effective as performing multiple sets for strength gain. These few studies provide the support for literature (6, 8, 18) which proposes using a single set of resistance exercise for increasing strength.

Although the literature continues to support multiple set training for strength increases, a select few choose to continue the debate. When examining different protocols, however, it is important to be clear about what one is comparing. Some studies compare protocols in which much different volumes of work are examined (10, 14, 15, 17, 20, 24), while some studies (1, 7, 16, 23) examine various protocols with equal volume. In the studies with different protocols with equal volume, the results showed that performing an equal amount of work yielded equal strength gains. The SS and MS participants in the current study had very different training volumes, which could have heavily influenced strength gains. It is important to note, however, that the relationship between increased volume and increased strength is not linear and not definite (9).

Training status may also affect the response to single versus multiple sets. Generally, studies demonstrating equal strength gains in single and multiple sets use novice or untrained populations (14, 24, 26). Untrained individuals will experience adaptations to even a small stimulus. Therefore, in the early stages of a resistance training program, single sets and multiple sets alike will increase strength. As the duration of the training program increases, increased stimulus will be required to continue increased strength (12).

The training and testing in this study were all performed isokinetically. This is the first known study to employ strictly isokinetic methods. The advantage of isokinetic training is that each repetition is in, theory, maximal in nature. Unlike traditional resistance training, which is necessarily easier in early repetitions and increases in difficulty as the set progresses, isokinetic training makes it possible to perform each repetition at the individual's maximal effort. Thus, it is possible to make every repetition as effective as possible.

There is a need for more research in the area of strength gain through isokinetic training and, in particular, the dose response relationships of such training. Future research may examine the effect of training more times per week, training with different speeds, and cross-training effects on the untrained leg. Additionally, in order to determine the mechanism of the strength increases, muscle hypertrophy, electromyography, and mechanomyography may be examined following training.

**Practical Applications**

This study supports the bulk of the research, which suggests that increasing the volume of work performed in a resistance training program results in increased strength gains (3, 5, 11–13, 15, 17, 20–22). Simply stated, doing more work yields better results. Untrained individuals interested in increasing strength may achieve this goal through a minimal level of volume of work as seen in a single set training program. However, those with more resistance training experience may require greater volume to optimize strength gains. Furthermore, increasing the volume of the program by increasing the number of sets will increase the magnitude and shorten the time for strength gains (13). Strength professionals should understand this principle as well and take the dose/response relationship into account when designing strength protocols.

**References**


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