See discussions, stats, and author profiles for this publication at: https://www.researchgate.net/publication/311858533

Manuscript clarification: Dose-Response of 1, 3, and 5 Sets of Resistance Exercise on Strength, Local Muscular Endurance, and...

Article in The Journal of Strength and Conditioning Research · January 2017

CITATION
1

READS
5,225

4 authors, including:

Paulo Gentil
Universidade Federal de Goiás
70 PUBLICATIONS 536 CITATIONS

James Fisher
Southampton Solent University
47 PUBLICATIONS 175 CITATIONS

James Steele
Southampton Solent University
61 PUBLICATIONS 220 CITATIONS

Some of the authors of this publication are also working on these related projects:

- Sprint Biomechanics View project
- The Dynamic Spinal Posture View project

All content following this page was uploaded by Paulo Gentil on 23 December 2016.

The user has requested enhancement of the downloaded file. All in-text references underlined in blue are added to the original document and are linked to publications on ResearchGate, letting you access and read them immediately.
MANUSCRIPT CLARIFICATION

DOSE-RESPONSE OF 1, 3, AND 5 SETS OF RESISTANCE EXERCISE ON STRENGTH, LOCAL MUSCULAR ENDURANCE, AND HYPERTROPHY

To the Editor:

We read with interest a recent article by Radaelli et al. (3) titled “Dose-response of 1, 3, and 5 sets of resistance exercise on strength, local muscular endurance, and hypertrophy” and would like to congratulate the authors for conducting this complex and interesting study. However, we noted a number of issues that are worthy of clarification.

Concerning the methods, an apparent terminology mistake arises when authors state that all groups performed sets to concentric failure and then state that “the training resistance was increased by 5–10% for the next session when subjects were able to perform more than 12 repetitions in all sets of an exercise.” It has been previously reported that if young men perform 12 repetitions to concentric failure in the bench press and rest for 3 minutes, they will be able to perform around 8 repetitions at the same load in the next set (4). This suggests that participants were likely not training to concentric failure. Table 1 shows values of volume load more than 3 times greater for the 3 sets group and more than 5 times greater for the 5 sets group, in comparison with the 1 set group. This suggests that repetitions were kept constant without load reductions between sets, reinforcing that sets may be not have been performed to concentric failure (4–7).

Knowing if the participants were really performing repetitions to concentric failure is important for interpreting the results, as previous study reported significant differences between performing 1 set to “self-determined” repetition maximum and “real” concentric failure in well-trained participants (1). Moreover, clarification is also important to allow the correct replication of the study by other researchers and its application by coaches and athletes who wants to follow the authors’ recommendations.

We might also consider the statistical analyses performed. In viewing Table 1, it seems evident that the preintervention values were very different between groups, with the 1 set group generally showing lower values than the other groups. For example, the 5 sets group had a preintervention value almost 40% higher than the 1 set group in the bench press, which causes us to question the use of analysis of variance (ANOVA) (in fact, authors cannot make statements about “strength gains” based on ANOVA results, as the test does not indicate this). When calculating the percent increases, results were similar among groups performing 1, 3, or 5 sets: bench press—13.49, 17.30, and 11.16%; lat pull-down—18.65, 12.00, 16.58%; shoulder press—22.47, 23.68, 35.18%; leg press—15.71, 15.48, and 12.89%. So we have strong reasons to question the statistical method used and to suppose that the differences reported would not exist if the comparison were performed with a procedure that take in account the initial values, such as analysis of covariance. This supposition is reinforced by the fact ANOVA resulted in no difference in the leg press, which is the only exercise where the initial values were not so discrepant between groups.

It is important to note that this little (or even null) difference occurs at the expense of 200–400% increases in training volume and duration! Therefore, since lack of time is the most common cited barrier for exercise adoption and that increasing the number of sets from 1 to 3 has been shown to promote a large drop-out rate (2), one should be cautious before recommending a minimum of 3 sets per exercise as it can interfere with adherence without bringing justifiable results.

We thank the authors and editorial board for their efforts with this publication but we believe that it is important to consider these clarifications with regard to terminology and methods as which might affect outcomes and interfere with the reproduction of the study protocol.

Paolo Gentil1
James Fisher2
James Steele2
Antonio Arruda3

1 College of Physical Education and Dance, Federal University of Goiania, GO, Brazil
2 Center for Health Exercise and Sport Science, Southampton Solent University, East Park Terrace, Southampton, United Kingdom
3 Human Performance Laboratory, University of Petrolina, Petrolina, PE, Brazil

REFERENCES


Journal of Strength and Conditioning Research
© 2015 National Strength and Conditioning Association
In Response:

We thank Dr. Gentil for his interest in our research. We will address his questions and comments in the order presented in his letter to the editor.

A training zone of 8–12 repetition maximum (RM) was chosen because it allows for day-to-day variation in strength when performing sets to failure. A training zone also allows progression of the resistance for a specific exercise. When all sets of an exercise are performed at the upper range of the repetitions in the training zone, the resistance is increased. In our study, when a subject could perform 12 or more repetitions in all sets of an exercise, the resistance was increased 5–10% for that exercise in the next training session. The increase in resistance decreased the number of repetitions in each set to concentric failure to the lower end of the training zone. Dr. Gentil in his letter references a study indicating “that if young men perform 12 repetitions to concentric failure in the bench press and rest for 3 minutes, they will be able to perform around 8 repetitions at the same load in the next set (6).” He interprets this to mean that when the resistance was increased 5–10%, the participants were then likely not training to concentric failure. As stated above, when the resistance was increased, the number of repetitions decreased to the lower end of the training zone, but sets were still performed to concentric failure. Additionally, in the study referenced by Dr. Gentil, when 12 repetitions to concentric failure were performed in the next set, 8 repetitions to concentric failure were performed. Thus, both sets were performed to concentric failure, but with a different number of repetitions per set and both sets were performed in an 8–12RM training zone. It is also important to note that other studies contradict the results of the study referenced by Dr. Gentil. For example, it has also been reported that weight trained athletes (American football players) in the bench press and squat can perform 10 repetitions per set in 3 successive sets with 3 minutes rest between sets using a 10RM resistance (3). We agree with Dr. Gentil that generally in successive sets to failure at the same resistance, the number of repetitions per set decreases, but the sets can still be performed to concentric failure, which was the case in our study.

Table 1 in our article shows the training volume of the 1, 3, and 5 set training groups. Training volume is the product of number of sets × number of repetitions times resistance used. In that, the 3 and 5 set groups did perform more sets than the 1-set group; training volume would be higher in the groups that performed multiple sets. However, Table 2 shows that the 3 and 5 set groups had greater 5RM values both pretraining and posttraining, which would result in greater 8–12RM resistances. Calculation of training volume would be higher in these groups, because of a greater training resistance, even if the number of repetitions per set decreased in successive training sets. Thus, the data in Table 1 do not necessarily indicate that the number of repetitions per set in successive training sets did not decrease.

We agree knowing if sets were performed to concentric failure is important and that “self-determined” RMs would be lower than “tested” RMs. All training sessions in our study were monitored and subjects were instructed to perform sets to concentric failure and given encouragement to do so. Thus, we are confident sets were performed to concentric failure.

We agree that lack of time can be a barrier to exercise adherence. In the study (1) referenced by Dr. Gentil showing a large dropout rate, it is important to put the dropout rate into the context of the study. The subjects in this study were recreational weight trainers and had been performing a 1-set program for a minimum of 1 year. Subjects were divided into 2 groups: 1 group continued with the 1-set program and 1 group started to perform a 3-set program. Thus, the subjects performing the 3-set program had their established training routine changed. This change, in an established training routine, could result in a high dropout rate. A progression for increasing training volume was not used in this study (1). For example, the group performing 3 sets could have performed 2 sets of each exercise for a short period, such as 2 weeks, and then started to perform 3 sets. Progression in training variables is recommended (4), commonly done and lack of progression may affect the dropout rate when changes in training variables are made. Many subjects, including serious fitness enthusiasts and athletes, routinely perform 3 and higher number of sets per exercise in a training session. Thus, multiple-set programs are performed and tolerated by many individuals for long periods of time. Additionally, for some individuals performing multiple-set programs, such as athletes and serious fitness enthusiasts, even if the performance of additional sets results in small strength gains, compared with performing fewer numbers of sets per exercise, these individuals would perform multiple sets to achieve increased strength gains. Nowhere in our study is it stated that 1-set programs are ineffective. We do however state that the multiple-set groups did show greater strength gains than the 1-set group. This result is supported by several meta-
analyses (2,5). For some individuals, a 1-set program may be
what is needed to achieve their desired training goals. While
for others, multiple sets per exercise will be needed to
achieve their desired training goals.

The analysis of variance (ANOVA) test is an appropriate
statistical procedure for our study. Use of an ANOVA
requires the scores for each condition be normally distrib-
uted and have homogeneity of variance, which was the case
for the data in this present study. The ANOVAs on the 5RM
results did show significant ($p \leq 0.05$) group, time, and inter-
action effects for all 4 exercises tested. As stated in the orig-
inal article, if a significant $F$ value was found, the post hoc
test used was a Tukey test and the results showed significant
differences between the training groups as reported.

In the statistical analysis, one consideration is that the
subjects were randomly assigned to the 3 different training
groups. Owing to chance, the 1-set group had lower 5RMs
in 3 of the test exercises. The lower pretesting 5RMs in the
1-set group may have given this training group an advantage
in terms of strength increases with training. In addition to
the ANOVA, effect sizes were calculated and the 5RM effect
sizes generally support the conclusions of the ANOVA. That
is, the effect sizes indicate greater changes in 5RM in the 3
and 5 set groups compared with the 1-set group even in the
leg press where the Tukey post hoc test did not show
a significant difference between training groups. For an
analysis of covariance to increase power against a type II
error, there must be a high correlation between the covariate
and the dependent variable and no correlation between the
covariate and the independent variable. This is not the case
in our study as there should be a high correlation between
initial strength or RM (covariate) and the response to
resistance training (independent variable). Thus, use of an
ANOVA as used was appropriate for our study.

We thank Dr. Gentil for his interest in our study and hope
we have addressed his concerns.

ROBERTO SIMA0

REFERENCES
1. Hass, CJ, Garzarella, L, de Hoyos, D, and Pollock, ML. Single versus
2. Krieger, JW. Single versus multiple sets of resistance exercise: A meta-
3. Kraemer, WJ. A series of studies: The physiological basis for strength
training in American football: Fact over philosophy. J Strength Cond
4. Ratamess, NA, Alvar, BA, Evetoch, TK, Housh, TJ, Kibler, B,
Kraemer, WJ, and Triplett, NT. Progression models in resistance
5. Rhea, MR, Avar, BA, Burkett, LN, and Ball, SD. A meta-analysis to
determine the dose response for strength development. Med Sci Sports
6. Richmond, SR and Godard, MP. The effects of varied rest periods
between sets to failure using the bench press in recreationally trained