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Beware the Meta-Analysis: Is Multiple Set Training Really Better than Single Set Training for Muscle Hypertrophy?

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ABSTRACT

Fisher J. Beware the Meta-Analysis: Is Multiple Set Training Really Better than Single Set Training for Muscle Hypertrophy? **JEPonline** 2012;15(6):23-30. While many individuals perform resistance training with the purpose of increasing the size of their muscles, reviews have not clarified a training prescription for optimizing hypertrophy. A 2010 meta-analysis concluded that multiple set training resulted in greater hypertrophic gains compared to single set training. However, while the use of meta-analysis in exercise physiology is well documented, there is sufficient reason to be cautious when applying a single statistic acquired by combining multiple studies and the relevant effect sizes (ES). This paper reviews the articles included within the 2010 meta-analysis. In particular, the differences in subject training experience, gender, and clinical condition, the training frequency, the intervention duration, the repetition duration used, and the method of measuring hypertrophy, as well as other variables that appear not to have been considered are discussed in this paper. The substantial limitations in comparing or grouping these articles suggest that the meta-analysis cannot be used to support the conclusion that multiple sets produce greater hypertrophic gains than single set training.

Key Words: Cross-Sectional Area, Dual energy X-Ray Absorptiometry, Resistance

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INTRODUCTION

The size principle suggests that it is not the load lifted but rather the stimulation of maximal number of muscle fibers through progressive recruitment of motor units, which optimizes muscular strength development (3). Indeed, Fisher and colleagues (7) presented evidence that concluded single sets performed to muscular failure provide the same strength gains as multiple sets (7).

Reaching an understanding of the advantages and/or disadvantages of single sets and multiple sets is important. Many people, including recreational gym users as well as professional athletes, perform strength training exercises with the goal of muscular hypertrophy (18), for which the optimal[1] stimulus is still undefined. In 2007, a large review of the strength development literature by Wernbom and colleagues (22), examined the multiple variables that might affect hypertrophic gains. The variables included the length of training period, frequency, load (often, incorrectly stated as intensity), and volume (including sets and repetitions). The authors (22) reported that only a small number of studies had considered the effect of fewer than 3 sets on muscular hypertrophy.

More recently, Krieger (9) published a meta-analysis of single set training versus multiple set training for muscular hypertrophy. The overriding conclusion was that multiple set training is associated with 40% greater hypertrophy-related effect sizes (ES) than single set training. A meta-analysis is a viable quantitative method of overcoming the limitations of statistical power and small sample sizes when performed correctly (22). However, the scientific literature has warned us of the use of meta-analyses in attempting to summarize the results of multiple studies in a single statistic (5,6,19,24). With this in mind, the aim of this paper is to review the articles discussed in Krieger's meta-analysis. The goal is to consider the strengths and limitations of the paper and the practical application.

[1]We should be cautious in using the word "optimal" due to the inter-individual variation between human participants and training stimulus (2).

THE META-ANALYSIS

Krieger (9) clarifies the benefits and needs of a meta-analysis based on small sample sizes. Krieger also detailed his method of literary search and the complexities of calculating ESs for each of the selected studies. However, of primary importance, he failed to discuss some of the major inequalities between the studies. With this in mind, I have summarized each of the articles in the meta-analysis, considering some of the major methodological intricacies that might limit the extent to which Krieger's (9) conclusions can be validated.

Galvão and Taaffe (8)

This study considered the strength and hypertrophic gains of untrained men and women (n=28) aged 65-78 yrs following a 20-wk resistance training (RT) intervention. The participants performed either 1 set or 3 sets of chest press, seated row, triceps extension, biceps curl, leg press, leg curl, and leg extension exercises 2 times per week. The authors reported no significant differences between groups for lean muscle mass measured using dual energy x-ray absorptiometry (DXA). This study also appears to have accurately controlled the training intensity using 8 repetition maximum (RM), specifically stating that the subjects were to increase load progressively to reach muscular failure at 8 repetitions.

Marzolini, Oh, Thomas, and Goodman (10)

The subjects (n=53) in the study by Marzolini et al. (10) were >45 yrs of age with coronary artery disease (CAD). They were divided into 3 groups in which they performed 29 wks of exercise. All groups performed aerobic training (AT) 5 times per week for 5 wks. Then, the AT group continued AT 5 times per week for 24 wks while the two RT groups performed 24 wks 3 times per week AT and 2 times per week RT (either 1 or 3 sets, respectively). The subjects performed 10 exercises starting at 70% 1 RM for 10-15 repetitions that increased by 5 kg when 15 repetitions were performed. Using DXA, the authors reported significantly greater change in lean body mass for the 3-set group (+1.5 kg) compared to the AT group (0.4 kg).

Mcbride, Blaak, and Triplett-Mcbride (11)

Fifteen males and 13 females completed a 12-wk RT intervention assigned to a single set, multiple set (M-6), and a control group. The single set group performed 1 set of bicep curl, chest-fly, and leg press 2 times per week for a 10 RM and 6 RM, respectively. The subjects in the multiple set group performed 6 sets of bicep curl and leg press, and 3 sets of chest-fly exercise 2 times per week at 10 RM and 6 RM. Both groups also completed abdominal sit-ups and lower back extensions on both days to 15 RM with a single set, performing 1 set of each while the multiple set intervention consisted of 3 sets of each. The control group did not exercise. Lean body mass was measured using DXA. The authors reported no significant differences between or within the groups.

Munn, Herbert, Hancock, and Gandevia (12)

Subjects in the Munn et al. study included 115 untrained (21 males and 94 females) with a mean age of 20.6 ± 6.1 yrs. The training intervention lasted 6-7 wks, and each previously untrained subject completed 18 training sessions in either a 1-set or a 3-set slow (3 sec concentric: 3 sec eccentric), or a 1-set or a 3-set fast (1 sec concentric: 1 sec eccentric) training groups. The primary aim was to consider the effects of contraction speed. Each participant trained only 1 arm in an elbow flexion exercise for 6-8 RM. No significant differences between the groups were reported in the subjects' arm circumference (as measured by a tape measure).

Ostrowski, Wilson, Weatherby, Murphy, and Lyttle (13)

Ostrowski et al. considered the effect of training volume on hormonal output and muscular size and function in trained subjects over a 10-week training intervention. Twenty-seven males aged 19 and 44 yrs were assigned to 3-sets, 6-sets, or 12-sets of exercise 4 times per week. Various exercises were performed on different days described as: (a) Day 1, squat, leg press, leg extension, stiff-legged deadlift, leg curl, and single-leg curl; (b) Day 2, bench press, incline bench press, decline bench press, shoulder press, upright row, and lateral raise; (c) Day 3, lat pull-down, T-bar pulldown, seated row, calf raise, calf press, and seated calf raise; and Day 4, barbell curl, preacher curl, dumbbell curl, close grip bench press, triceps pushdown, and triceps extension. Volume was controlled as 12 repetitions per set for the first 4 wks, 7 repetitions per set for the next 3 wks, and 9 repetitions per set for the final 3 wks, with each set being described as maximal. Muscle CSA and circumference were measured using ultrasound with no significant differences between the 3-set, 6-set, and 12-set groups.

Rhea, Alvar, Ball, and Burkett (15)

Sixteen trained males aged 21.0 ± 2.0 yrs were randomly assigned to a 1-set training group or a 3-set training group. The subjects trained 3 times per week for 12 weeks with 1 wk of active rest (defined as physical activity without weight training) between weeks 5 and 6. Intensity was controlled by assigning 8-10 RM, 6-8 RM, and 4-6 RM for the first, second, and third training session of each week, respectively. Each training group performed the chest press and leg press for the desired sets and repetitions during each workout. However, in an apparent effort to maintain consistency in training time, the single set group also performed 1 set of 8-12 repetitions for biceps curl, lat pull-down, abdominal crunches, back extensions, and seated rows. Rhea and colleagues (15) stated that “time permitting” the 3-set group also performed 1 set of these exercises. Neither the 1-set nor 3-set group had any significant changes in body composition as measured by whole-body plethysmography (bod-pod) or circumference measures at the chest and mid-thigh using a tape measure.

Rønnestad, Egeland, Kvamme, Refsnes, Kadi, and Raastad (16)

This study used 21 untrained males (19-44 yrs), who were randomly assigned to one of two training groups. They performed 3-sets of lower body exercise and 1-set of upper body exercise (3L-1UB) or 1-set of lower body exercise and 3-sets of upper body exercise (1L-3UB). The subjects trained 3 times per week for 11 weeks by performing leg press, leg extension, leg curl, seated chest press, seated row, lat pull-down, biceps curl, and shoulder press exercises. They were required to use an explosive concentric contraction with a 2-3 sec eccentric phase. The repetitions were controlled as 10 RM for week 1 and week 2, 8 RM for week 3 and week 4, and 7 RM for the remaining 6 weeks. The subjects were provided a protein bar before and an energy drink throughout each workout. T Rønnestad and colleagues (16) reported a significantly greater increase in CSA (measured by magnetic resonance imaging, MRI) for the thigh muscles for the 3L-1UB group compared to the 1L-3UB group. No significant differences were found for upper body muscles between groups. The 3L-1UB group also showed a significantly greater increase in body weight compared to the 1L-3UB group. However, no significant differences were reported for lean body mass measured using DXA.

Starkey, Pollock, Ishida, Welsch, Brechue, Graves, and Feigenbaum (20)

Forty-eight (21 males, 27 females) healthy untrained subjects aged 18-50 yrs were assigned to one of three groups: (1-set, 3-set, or control). Each training group performed bilateral knee-extension and flexion exercises 3 times per week for 14 wks completing either 1-set or 3 sets. Repetition duration was controlled at a count of 2 for concentric contractions, and a count of 4 for eccentric contractions. The 8-12 repetitions were performed until volitional fatigue. Using ultrasound, the authors reported no significant difference between the 1-set and the 3-set training groups in CSA.

LIMITATIONS

Krieger (9) states in his method section that one of his inclusion criteria was that the studies must make a "comparison of single to multiple sets per exercise, with all other variables being equivalent." Therefore, it was especially interesting to find the inclusion of a research study that did not consider single-set training (13). The statement of other variables being equivalent is also a concern. The inclusion of research manuscripts with trained subjects (13,15) and untrained subjects (8,10-12,15,20) is an important limitation. In fact, although it is difficult to be certain of the magnitude of any change relative to "other" variables, the potential adaptation to training is likely to decrease during the transition from the untrained subject to the trained subject (4). We might certainly consider that the trained subject is closer to their genetic potential than the untrained subject. However, Krieger elected to group all data, rather than consider trained and untrained subjects separately. We might also consider the age and gender differences between the subjects, especially since some studies state "trained males aged ~21 yrs (12,15) and other studies identify untrained males and females between 65 and 78 yrs of age (8). The inclusion of a study in which the subjects have been diagnosed with CAD (10) seems to add an additional limitation to the overall grouping of such research, especially with evidence showing an interaction between hormones such as testosterone and CAD (21). In this regard, researchers have paid particular attention to hormones associated with protein synthesis and hypertrophy, including testosterone (1,17). While research papers might still be inconclusive (14), the authors of these papers should be careful of including studies that might bias the results.

It should be pointed out that the meta-analysis included studies that varied in duration from 7-24 wks, with frequencies from 2-4 times per week. Some studies included AT in the intervention (10) while others varied from training 1 limb with isolated exercises (12,20) to a plethora of different isolated and compound exercises (11,13,16). Ultimately, this inclusion of isolated and multi-joint exercises limits the accuracy and degree to which the findings can be fully accepted. Repetition duration (often incorrectly cited as velocity or speed) varied in the following ways: 3 sec concentric: 3 sec eccentric and 1 sec concentric: 1 sec eccentric (12), explosive concentric and 2-3 sec eccentric (16), and 2 sec concentric: 4 sec eccentric (20). In addition, the number of repetitions the subjects performed often varied between studies, including 6-8 RM (12), 8-12 repetitions (20), and 10-15 repetitions (10) as well as within the studies, changing throughout the intervention (11,13,16).

The effect sizes for hypertrophy were calculated from different measurements that included DXA (8,10,11,16), ultrasound (13,20), whole body air plethysmography (bod-pod) (15), MRI (16), and a tape measure (12,15). While Krieger (9) states that a calculation of standardized ESs from different methods of measurement can be performed, it is reasonable to conclude that this variability in measurement can produce different results unrelated to the purpose of the comparisons. Without question, each method has its own unique validity and reliability. For example Rønnestad et al. (16) reported an increase in CSA of the thigh using an MRI, while DXA measurements reported no change in lean body mass. It would be interesting to know whether the software used with the MRI differentiated between fatty infiltrations or other "non-muscle" volume, causing an increased measure in CSA that was not supported by DXA.

As a final concern, 1 of the 8 studies provided the subjects with nutritional supplementation (16) that along with most other between study differences failed to be mentioned by Krieger (9). In short, then, when the variables between the studies are considered, it is necessary to be cautious of a practical conclusion that suggests simply that multiple sets of exercise result in greater hypertrophy than a single set. Hence, the following might be asked: How many times per week should subjects train? How many exercises should the subjects perform for each muscle and in total? How many repetitions should the subjects complete? Should the subjects train to muscular failure/repetition maximum?

What repetition duration should they use? Should they include aerobic training? Should the subjects expect the same results for upper and lower body muscles?

CONCLUSIONS

Researchers should be careful of meta-analysis that provides a single statistic proving something that no empirical study within that meta-analysis is able to support. Hence, as the famous quotation states "There are lies, damned lies and statistics." In light of this point, of the eight articles addressed in Krieger's (9) meta-analysis, he himself clarified that only two of the articles supported that multiple set training provided greater hypertrophic gains (10,16). Of the two articles, one reported significantly greater change in lean body mass for a 3-set group compared to an AT group, with the only significant difference for lean body mass between the 1-set and the 3-set groups being the lean mass of the leg (10). The second article used to support this statement considered 3L-1UB training compared to 1L-3UB training (16). The authors reported a significantly greater CSA in the thigh for the 3L-1UB group. The same was not true for the upper body CSA for the 1L-3UB group. At best these two articles suggest that for untrained subjects multiple set training might increase hypertrophy beyond that of single set training in lower body muscles. But, it is better to be hesitant in concluding anything more than this.

Ultimately, while Krieger's (9) published paper, attempting to summarize such a complex area, is very important, exercise physiologists should be careful not to become so burdened with quantitative analysis that they lose sight of the practice and realities of strength training. Future researchers might support that multiple set training is more beneficial than single set training for muscular hypertrophy. Until then, Krieger's meta-analysis that compares such a complexity of participants, training methods, and measurements of hypertrophy is challenged by the limitations that postpone if not prevent exercise physiologists from supporting such a simple conclusion.

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