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Research Article

Different Load Distributions Affect Subjective Scales and Repetitions Performed After a Single Resistance Training Session in Well-Trained Men

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Abstract

The purpose of the present study was to evaluate the acute subjective responses to a single RT session with continuous- and grouped-sets distributions in resistance-trained men. There were three sessions in a crossover/random fashion.

On the first session, all subjects were familiarized and their biceps curl 10RM load was determined. The sessions were randomized for continuous- or grouped-sets distributions. For continuous-sets, 8 sets of 10RM were performed sequentially, while for grouped-sets, they performed two blocks of 4 sets of 10RM with 12-min of rest between blocks. Two minutes of rest was given between sets. Volume load and maximal number of repetitions were measured in both distributions. Rating of perceived exertion (RPE) was recorded 10 minutes after the 8th set for each distribution. Affective response was recorded before and 10 minutes after each distribution. Repetitions in reserve (RIR) were recorded after each set for each distribution. Results demonstrated a progressive reduction in the maximal number of repetitions performed during continuous-sets ($P<0.05$). However, for grouped-sets, there was a progressive reduction in the maximal number of repetitions performed from the 1st to the 4th set ($P<0.05$), and from the 5th to the 8th set ($P<0.05$), and a significantly greater volume load for continuous-sets vs. grouped-sets (3292±809 kgf vs. 3692±891 kgf; $P<0.001$, respectively). Also, there was significantly greater RPE for continuous-sets vs. grouped-sets (9.37±1.06AU vs. 8.12±1.96AU; $P=0.026$). There were not differences in RIR between both distributions, while AR showed a reduction for both distributions (continuous-sets pre 3.31±1.92 vs. post 0.37±2.55; $P=0.001$), and grouped-sets (pre 3.37±1.50 vs. post 0.62±2.72; $P=0.006$). These findings demonstrate that grouped-sets allow more repetitions and greater volume load. However, continuous-sets distribution produces greater RPE but similar RIR when compared to grouped-sets, while both distributions negatively affect AR after a RT session.

Introduction

Subjective scales are commonly used in resistance training (RT) programs to monitor exercise intensity, level of effort, training load, or progression [1]. Studies have shown that subjective scales are sensitive to changes in the acute variables of strength and to different populations [2,3], and could be used as an additional factor controlling loads applied in both clinical and exercise settings [4,5]. There are several different subjective scales available in the scientific literature aiming to control training load or exercise (i.e. rate of perceived exertion (RPE), repetitions in reserve (RIR), and affective response to exercise (AR)).

Several methods can be proposed to manipulate load and sets (i.e. superset, compound sets, etc.) [6]. These methods are based on increasing rest between sets and exercises, changing the exercise order or muscle groups [7]. A method called continuous-sets is common in RT programs [8] and consists of performing all sets of each exercise sequentially. According to previous research, performing continuous-sets may alter muscle activation [9], level of neuromuscular fatigue [10], or transient muscle swelling in the prime movers [11]. Additionally, performing multiple sets continuously to muscle failure decreases the number of repetitions, and consequently, reduces the mechanical/metabolic stimulus to muscle adaptation [12]. In contrast, grouped-sets consists of performing a number of sets for a specific muscle group, then changing the muscle group for other sets, then returning to the first muscle group [12-29]. Both methods are commonly used in RT programs, however, to the best of our knowledge there are few studies comparing these different distributions using different subjective responses [4,30]. Also, it would be interesting to evaluate how manipulation of some RT methods impact subjective perception of effort.

Therefore, the purpose of the present study was to evaluate the acute subjective responses to a single RT session with continuous- vs, grouped-sets distribution in resistance-trained men. It was hypothesized that there would be a reduction in the maximal number of repetitions performed for continuous-sets when compared to grouped-sets distribution. Additionally, it was expected that there would be a high session rate of perceived exertion, low repetitions in reserve, and a reduction in the AR for continuous-sets when compared to grouped-sets distribution [2,3,31-34].

Methods

Subjects

The sample size was justified by a priori power analysis based on a pilot study conducted previously, based on a significance level of 5% and a power of 80% derived from the rate of perceived exertion of individuals with the same characteristics used in the present study [35]. Sixteen physically active men volunteered for this study (age 27 ± 6 years, total body mass 81.8 ± 7.8 kg, height 174 ± 5 cm, biceps curl 10RM 61 ± 11 kgf). All subjects were regularly engaged in a RT program for more than one year and were familiar with hypertrophy-type training and the standing biceps curl exercise. Subjects had no previous surgery and history of injury with residual symptoms within the last year on their upper limbs. The University research ethics committee approved this study (#67/2016), and all subjects read and signed an approved informed consent document.

Procedures

Subjects were instructed not to perform any RT for 48 hours prior to each of three testing sessions. All tests were randomized and counterbalanced across subjects and experimental conditions. In the first session, upper limb dominance and anthropometric measures were taken. All subjects were right-arm dominant based on their preferred arm to write. Then, subjects were instructed in the proper technique for the biceps curl exercise (BC). For BC, all subjects were positioned standing in front of a cable-pulley machine and were instructed to use a supinated grip on a straight bar. They lifted the bar from complete elbow extension to complete elbow flexion (concentric phase), then returned to full elbow extension (eccentric phase). All subjects underwent 10RM testing (according to guidelines established by the National Strength and Conditioning Association [NSCA] [36]) to determine individual initial training loads. Three to five minutes rest were used between attempts. All subjects were familiarized with all subjective scales: (1) rate of perceived exertion (RPE), (2) affective response to exercise (AR), and (3) repetitions in reserve (RIR). Standard instructions and anchoring procedures for each scale were explained during the familiarization session.

Two sessions were randomly assigned for each subject and experimental conditions (Figure 1). For continuous-sets, subjects performed eight sets of 10RM with two minutes inter-set rest. For grouped-sets, they performed two blocks of 4 sets of 10RM, with 12-min rest between blocks (interval time to perform 4 sets of 10RM). All sets were executed to concentric failure (10RM) with two minutes inter-set rest. RIR was recorded after each set. Additionally, RPE and AR were recorded after the eighth set of each condition.

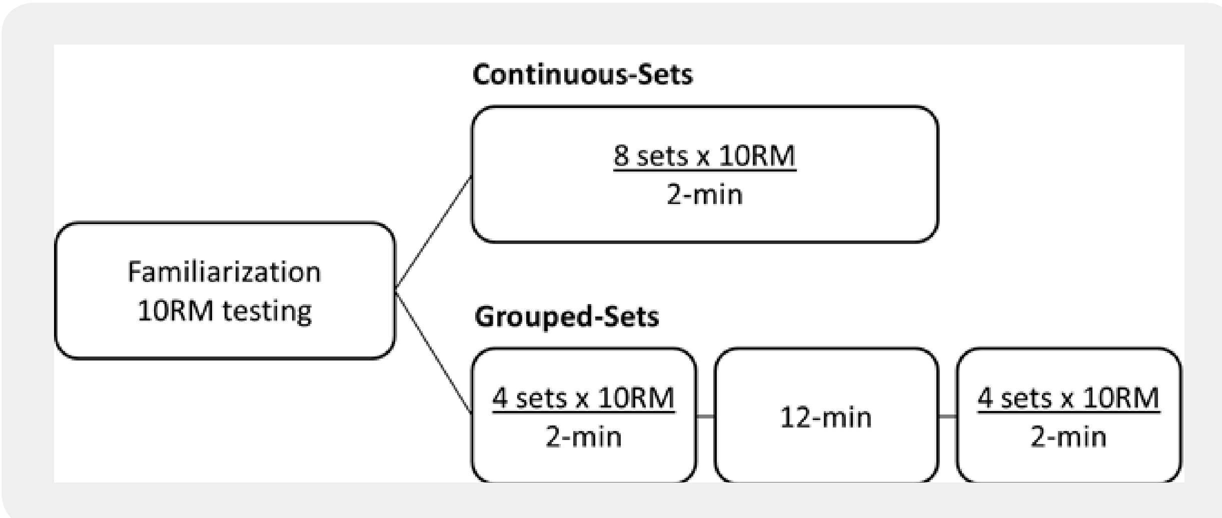

Figure 1: *Design of the experimental procedures*

Measurements

Maximal Number of Repetitions and Volume Load (VL)

The maximal number of repetitions of each set was counted for each distribution. Volume load (VL) was calculated by the following formula: VL = Σ sets (number of repetitions x 10RM load) [37].

Rating of Perceived Exertion (RPE)

The RPE was assessed with a CR-10 scale using the recommendations of Sweet *et al.,* [38]. Subjects were asked to use an arbitrary unit (AU) on the scale to rate their overall effort for each distribution. A rating of 0 was associated with no effort and a rating of 10 was associated with maximal effort and the most stressful exercise ever performed. After each experimental condition all subjects answered the following question based on CR-10 scale: "How was your workout?" (Figure 2a)

Affective Response (AR)

The AR was assessed with a bipolar numeric scale ranging from +5 (very well) and -5 (very bad) with zero corresponding to "neutral". Subjects were asked to provide their emotional state before and after all sets in both distributions [39] (Figure 2b).

Repetitions in Reserve (RIR)

The RIR was assessed by a scale proposed by Zourdos *et al.*, [40] specifically designed to measure the effort after each set for both distributions. Subjects were asked to provide how many repetitions they felt it was possible to perform at the end of each set for both distributions (Figure 2c).

(a)

Rating	Descriptor
0	Rest
1	Very, Very easy
2	Easy
3	Moderate
4	Somewhat hard
5	Hard
6	-
7	Very hard
8	-
8	-
10	Maximal

(b)

Rating	Descriptor
+5	Very well
+4	-
+3	Well
+2	-
+1	Somewhat well
0	Neutral
-1	Somewhat bad
-2	-
-3	Bad
-4	-
-5	Very bad

(c)

Rating	Descriptor
10	Maximum effort
9	1 repetition remaining
8	2 repetitions remaining
7	3 repetitions remaining
5-6	4-6 repetitions remaining
3-4	Light effort
1-2	Little to no effort

Figure 2: *Subjective scales: (a) rate of perceived exertion, (b) affective response to exercise, and (c) repetitions in reserve.*

Statistical Analyses

Normality and homogeneity of variance were confirmed with the Shapiro-Wilk and Levene's tests, respectively. A paired t-test was used to test differences in the RPE and volume load. A 2x2 repeated-measures ANOVA (distribution x time) was used to test differences in the AR. A 2x8 repeated-measures ANOVA (distribution x sets) was used to test differences in the RIR. Post-hoc comparisons were performed with a Bonferroni correction. Furthermore, the magnitudes of the differences were examined using the standardized differences based on Cohen's d by means of effect sizes (d). The d results were qualitatively interpreted using the following criteria: <0.35 trivial; 0.35-0.80 small; 0.80-1.50 moderate; and >1.5 large, for recreationally trained subjects [41]. An alpha of 0.05 was used to determine statistical significance.

Results

Maximal Number of Repetitions

There was a progressive reduction in the maximal number of repetitions performed during continuous-sets (P<0.05; d=0.96 [small effect]; Δ%=49%). However, for grouped-sets, there was a progressive reduction in the maximal number of repetitions performed from the 1st to the 4th set (P<0.05; d=0.81 [small effect]; Δ%=36%), and from the 5th to the 8th set, with no difference between 1st and 5th set (P<0.05; d=0.93 [small effect]; Δ%=55.6%) (Table 1).

Table 1: *Mean ± standard deviation of the maximal number of repetitions, RPE, RIR, and AR evaluated in each set for continuous- and grouped-sets during Biceps Curl Exercise.*

Dependent Variable	Pre-Test	Post-Test	Sets								Total Reps.
			1	2	3	4	5	6	7	8	
Continuous-Sets (Max. Repetitions)			10±0	9.3±1.3	7.4±1.8	5.6±1.6	5.6±1.5	5.7±1.3	5.3±1.3	5.1±1.0	53±7
RIR (A.U)	--	--	8.8±0.7	9.4±0.7	9.9±0.3	10±0	10±0	10±0	10±0	10±0	--
RPE (A.U)	--	9.4±1.1	--	--	--	--	--	--	--	--	--
AR (A.U)	3.3±1.9	0.4±2.6	--	--	--	--	--	--	--	--	--
Grouped-Sets (Max. Repetitions)			10±0	9.8±0.5	8.0±1.6	6.4±1.8	9.9±0.3*	6.4±2.0	5.4±1.7	4.4±1.4	60±7*
RIR (A.U)	--	--	8.7±0.8	9.4±0.6	9.9±0.3	10±0	9.5±0.6	10±0.1	10±0	10±0	--
RPE (A.U)	--	8.1±2.0	--	--	--	--	--	--	--	--	--
AR (A.U)	3.4±1.5	0.6±2.7	--	--	--	--	--	--	--	--	--

*Significant difference between conditions from the corresponding set, P<0.001.

RPE – rating of perceived exertion; RIR – repetitions in reserve; AR – affective response.

Volume Load

There was a greater Volume load for grouped-sets when compared to continuous-sets (3692±891kgf vs. 3292±809kgf, respectively; P<0.001; d=0.46 [small effect]; Δ%=10.8%). Rating of Perceived Exertion: There was a significant in the RPE between distributions (continuous-sets 9.37±1.06 AU vs. grouped-sets 8.12±1.96 AU; P=0.026; d=0.79 [small effect]; Δ%=13.3%) (Table 1).

Affective Response

There were not significant differences between distributions (Table 1). There was a reduction in AR in both continuous-sets (pre-distribution: 3.31±1.92 vs. post-distribution: 0.37±2.55; P=0.001, d=1.30 [moderate effect]; Δ%=88.8%), and grouped-sets (pre-distribution: 3.37±1.50 vs. post-distribution: 0.62±2.72; P=0.006, d=1.25 [moderate effect]; Δ%=81.6%).

Repetitions in Reserve

There were not differences in RIR between both distributions. However, from 1st to the 4th set both distributions presented an increase in RIR (Continuous-sets: P<0.05, d=2.42 [large effect]; Δ%=15%; grouped-sets: P<0.05, d=2.29 [large effect]; Δ%=14.9%) (Table 1).

Discussion

To the authors' knowledge, this was the first study to evaluate the acute subjective responses to a single RT session with continuous- vs. grouped-sets distributions in resistance-trained men. It was hypothesized to be a reduction in the maximal number of repetitions performed in continuous-set when compared to grouped-sets distribution. The most important results of the present study were (a) a greater maximal number of repetitions and volume load after grouped-sets when compared to continuous-sets, and (b) a higher value of RPE after a continuous-sets distribution.

Several studies have demonstrated a progressive decrease in the maximal number of repetitions with continuous-sets, even when long inter-set rest intervals are used [31-34]. Willardson and Burkett [34], Scudese *et al.,* [32], and Ratamess *et al.,* [31] reported a reduction in the maximal number of repetitions performed during the bench press exercise (80%1RM, 3RM, and estimated 10RM, respectively) from the 1st to 5th set with 2 minutes rest between sets. The reduction in the maximal number of repetitions observed in previous studies was similar to our results in both conditions (continuous-sets: 49%, and grouped-sets: 43%). However, based on the characteristics of grouped-sets in our study, a higher volume load was observed (~10%) when a longer rest interval between blocks of sets was used. This result is in accordance with previous studies that demonstrated a time-efficient strategy with the use of alternate exercises aiming to sustain the maximal number of repetitions over multiple sets [10,23,42-45]. It is well accepted that a combination of central and peripheral fatigue is responsible for the reduction in strength over multiple sets [1], and the rest interval is the main acute variable responsible for removing this deleterious effect [29,46].

The microtrauma caused mainly by the eccentric action, combined with by products from anaerobic glycolysis and the accumulation of calcium within the sarcoplasmic reticulum, may inhibit excitation-contraction coupling temporarily, thus impairing volume load and peak force [47,48]. Previous studies have indicated that an increase in the rest interval between sets promotes removal of byproducts from the glycolytic system, restores adenosine triphosphate and phosphocreatine, and increases intracellular pH [19,29,49]. Therefore, grouped-sets presented higher volume load when compared to continuous-sets, and maintenance of the maximal number of repetitions across multiple sets.

Additionally, it was expected that a high RPE, low RIR, and a reduction in AR for continuous-sets when compared to grouped-sets [2,3,31-34], however these hypotheses were not confirmed by our results. The RIR after each set was similar between conditions even when the maximal number of repetitions was much smaller than the target number of repetitions (10RM). This effect might be explained by the high sense of effort after muscular failure (muscle fatigue) in each set in both conditions. Therefore, RIR seemed to be more affected by muscular failure than the absolute number of repetitions in each set.

Results of the present study, demonstrated a higher session RPE after continuous-sets when compared to grouped-sets (9.4 A.U vs 8.1 A.U., respectively). Tiggermann *et al.,* [1] proposed that the afferent signals from muscles, joints, and skin are combined in an activity recall when RPE is reported. Since all training variables were maintained constant, except the load distribution, the greater rest interval between the 4th and 5th sets in grouped-sets might have resulted in less perception of effort. In this way, our results did not corroborate previous studies [50-54]. No differences were observed by changing exercise order [52,53] or rest interval length [46,48]. Overall, results of this study suggest that grouped-sets allow more repetitions to be performed, and have similar subjective responses in resistance trained men.

Finally, the findings of the present study are not in accordance with previous studies investigating the AR to RT [2,3]. Arent *et al.,* [2] found a positive AR after a resistance training session for major muscle groups at 70% of 10RM when compared to 40 or 100% of 10RM. Bellezza *et al.,* [3] observed an increase in AR after a RT session at 80 to 100% of 10RM. We observed a decrease in the affective response following both conditions. This might be related to differences in training volume, exercise intensity, or exercise order [1]. Our aim was to compare different set distributions in a RT session targeting the elbow flexors. This is similar to split routines where experienced lifters train no more than 2-3 muscle groups in a single session. However, previous studies investigated novice subjects using sub-maximal loads (70 and 80% of 10RM) and full body routines [2,3]. Since, exercise adherence has been related to the affective response to exercise [30], periods with reduced loads or different set distributions might be important to the experienced lifter.

Conclusion

Our results suggest that grouped-sets allow more repetitions in a single RT session; and higher volume load when compared to continuous-sets. Continuous-sets produce a higher RPE, and similar RIR when compared to grouped-sets, and both distributions negatively affect AR.

Conflicts of Interest

All authors have no conflict of interests.

Bibliography

1. Tiggemann, C. L., Pinto, R. S. & Kruel, L. F. M. (2010). A percepção de esforço no treinamento de força. *Revista Brasileira de Medicina do Esporte, 16*(4), 301-309.

2. Arent, S. M., Landers, D. M., Matt, K. S. & Etnier, J. L. (2005). Dose-response and mechanistic issues in the resistance training and affect relationship. *Journal of Sport & Exercise Psychology, 27*(1), 92-110.

3. Bellezza, P. A., Hall, E. E., Miller, P. C. & Bixby, W. R. (2009). The influence of exercise order on blood lactate, perceptual, and affective responses. *Journal of Strength and Conditioning Research, 23*(1), 203-208.

4. Egan, A. D., Winchester, J. B., Foster, C. & McGuigan, M. R. (2006). Using session RPE to monitor different methods of resistance training. *Journal of Sports Science and Medicine, 5*(2), 289-295.

5. Haddad, M., Stylianides, G., Djaoui, L., Dellal, A. & Chamari, K. (2017). Session-RPE Method for Training Load Monitoring: Validity, Ecological Usefulness, and Influencing Factors. *Front Integr Neurosci, 11*:612, 1-12.

6. Simão, R., Salles, B. F., Figueiredo, T., Dias, I. & Willardson, J. M. (2012). Exercise order in resistance training. *Sports Med., 42*(3), 251-265.

7. Schoenfeld, B. J. (2011). The use of specialized training techniques to maximize muscle hypertrophy. *Strength Cond J., 33*(4), 60-65.

8. Ciccone, A., Brown, L. E., Coburn, J. W. & Galpin, A. J. (2014). Effects of traditional vs. alternating whole-body strength training on squat performance. *J Strength Cond Res., 28*(9), 2569–2577.

9. Farias, D. A., Willardson, J. M., Paz, G. A., Bezerra, E. S. & Miranda, H. (2017). Maximal strength performance and muscle activation for the bench press and triceps extension exercises adopting dumbbell, barbell, and machine modalities over multiple sets. *J Strength Cond Res, 31*(7), 1879-1887.

10. Paz, G. A., Robbins, D. W., de Oliveira, C. G., Bottaro, M. & Miranda, H. (2017). Volume load and neuromuscular fatigue during an acute bout of agonist-antagonist paired-set vs. traditional-set training. *J Strength Cond Res, 31*(10), 2777-2784.

11. Schoenfeld, B. J. & Contreras, B. (2013). The muscle pump: Potential mechanisms and applications for enhancing hypertrophic adaptations. *Strength Cond J, 0*(0), 1-5.

12. Crewther, B., Cronin, J. & Keogh, J. (2005). Possible stimuli for strength and power adaptation: acute mechanical responses. *Sports Medicine, 35*(11), 967-989.

13. Crewther, B., Cronin, J. & Keogh, J. (2006). Possible stimuli for strength and power adaptation: acute metabolic responses. *Sports Medicine, 36*(1), 65-78.

14. Crewther, B., Keogh, J., Cronin, J. & Cook, C. (2006). Possible stimuli for strength and power adaptation: acute hormonal responses. *Sports Medicine, 36*(3), 215-238.

15. Damas, F., Phillips, S., Vechin, F. C. & Ugrinowitsch, C. (2015). A review of resistance training-induced changes in skeletal muscle protein synthesis and their contribution to hypertrophy. *Sports Medicine, 45*(6), 801-807.

16. Kraemer, W. J. & Ratamess, N. A. (2004). Fundamentals of resistance training: progression and exercise prescription. *Medicine Science Sports Exercise, 36*(4), 674-688.

17. Krieger, J. W. (2009). Single versus multiple sets of resistance exercise: a meta-regression. *Journal of Strength and Conditioning Research, 23*(6), 1890-1901.

18. Krieger, J. W. (2010). Single vs. multiple sets of resistance exercise for muscle hypertrophy: a meta-analysis. *Journal of Strength and Conditioning Research, 24*(4), 1150-1159.

19. Peterson, M. D., Rhea, M. R. & Alvar, B. A. (2004). Maximizing strength development in athletes: a meta-analysis to determine the dose-response relationship. *Journal of Strength and Conditioning Research, 18*(2), 377-382.

20. Ralston, G. W., Kilgore, L., Wyatt, F. B. & Baker, J. S. (2017). The effect of weekly set volume on strength gain: A meta-analysis. *Sports Medicine, 47*(12), 2585-2601.

21. Ratamess, N. A., Alvar, B. A., Evetoch, T. K., Housh, T. J., Ben Kibler, W., Kraemer, W. J. & Triplett, N. T. (2009). American College of Sports Medicine position stand. Progression models in resistance training for healthy adults. *Medicine Science Sports Exercise, 41*(3), 687-708.

22. Rhea, M. R., Alvar, B. A., Burkett, L. N. & Ball, S. D. (2003). A meta-analysis to determine the dose response for strength development. *Medicine & Science in Sports & Exercise, 35*(3), 456-464.

23. Robbins, D. W., Young, W. B., Behm, D. G. & Payne, W. R. (2010). Agonist-antagonist paired set resistance training: a brief review. *Journal of Strength and Conditioning Research, 24*(10), 2873-2882.

24. Schoenfeld, B. J. (2010). The mechanisms of muscle hypertrophy and their application to resistance training. *Journal of Strength and Conditioning Research, 24*(10), 2857-2872.

25. Schoenfeld, B. J., Ogborn, D. & Krieger, J. W. (2016). Dose-response relationship between weekly resistance training volume and increases in muscle mass: A systematic review and meta-analysis. *Journal of Sports Science, 35*(11), 1073-1082.

26. Schoenfeld, B. J., Ogborn, D. & Krieger, J. W. (2016). Effects of resistance training frequency on measures of muscle hypertrophy: A systematic review and meta-analysis. *Sports Medicine, 46*(11), 1689-1697.

27. Tan, B. (1993). Manipulating resistance training program variables to optimize maximum strength in men: a review. *Journal of Strength and Conditioning Research, 13*(3), 289-304.

28. Turner, A. (2011). The science and practice of periodization: A brief review. *Strength and Conditioning Journal, 33*(1), 34-46.

29. Willardson, J. M. (2006). A brief review: factors affecting the length of the rest interval between resistance exercise sets. *Journal of Strength and Conditioning Research, 20*(4), 978-984.

30. Parfitt, G. & Hughes, S. (2009). The exercise intensity-affect relationship: Evidence and implications for exercise behaviour. *Journal of Exercise Science & Fitness, 7*(2 (Suppl)), S34-S41.

31. Ratamess, N. A., Falvo, M. J., Mangine, G. T., Hoffman, J. R., Faigenbaum, A. D. & Kang, J. (2007). The effect of rest interval length on metabolic responses to the bench press exercise. *European Journal of Applied Physiol Occupational Physiology, 100*(1), 1-17.

32. Scudese, E., Willardson, J. M., Simao, R., Senna, G., de Salles, B. F. & Miranda, H. (2015). The effect of rest interval length on repetition consistency and perceived exertion during near maximal loaded bench press sets. *Journal of Strength and Conditioning Research, 29*(11), 3079-3083.

33. Willardson, J. M. & Burkett, L. N. (2005). A comparison of 3 different rest intervals on the exercise volume completed during a workout. *Journal of Strength and Conditioning Research, 19*(1), 23-26.

34. Willardson, J. M. & Burkett, L. N. (2006). The effect of rest interval length on bench press performance with heavy vs. light loads. *Journal of Strength and Conditioning Research, 20*(2), 396-399.

35. Eng, J. (2003). Sample size estimation: How many individuals should be studied? *Radiology, 227*(2), 309-313.

36. Brown, L. E. & Weir, J. P. (2001). ASEP Procedures recommendation I: Accurate assessment of muscular strength and power. *Journal of Exercise Physiology, 4*(3), 1-21.

37. Soares, E. G., Brown, L. E., Gomes, W. A., Correa, D. A., Serpa, E. P., Silva, J. J., Marchetti, P. H., *et al.* (2016). Comparison between pre-exhaustion and traditional exercise order on muscle activation and performance in trained men. *Journal of Sports Science and Medicine, 15*(1), 111-117.

38. Sweet, T. W., Foster, C., McGuigan, M. R. & Brice, G. (2004). Quantitation of resistance training using the session rating of perceived exertion method. *Journal of Strength and Conditioning Research, 18*(4), 796-802.

39. Hardy, C. J. & Rejeski, W. J. (1989). Not what, but how one feels: The measurement of affect during exercise. *Journal of Sport & Exercise Psychology, 11*(3), 304-317.

40. Zourdos, M. C., Klemp, A., Dolan, C., *et al.* (2016). Novel resistance training-specific RPE scale measuring repetitions in reserve. *Journal of Strength and Conditioning Research, 30*(1), 267-275.

41. Rhea, M. R. (2004). Determining the magnitude of treatment effects in strength training research through the use of the effect size. *Journal of Strength and Conditioning Research, 18*(4), 918-920.

42. Maia, M. F., Paz, G. A., Miranda, H., Lima, V., Bentes, C. M., Novaes, J. S. & Willardson, J. M. (2015). Maximal repetition performance, rating of perceived exertion, and muscle fatigue during paired set training performed with different rest intervals. *Journal of Exercise Science & Fitness, 13*(2), 104-110.

43. Maia, M. F., Willardson, J. M., Paz, G. A. & Miranda, H. (2014). Effects of different rest intervals between antagonist paired sets on repetition performance and muscle activation. *Journal of Strength and Conditioning Research, 28*(9), 2529–2535.

44. Robbins, D. W., Young, W. B., Behm, D. G. & Payne, W. R. (2010). The effect of a complex agonist and antagonist resistance training protocol on volume load, power output, electromyographic responses, and efficiency. *Journal of Strength and Conditioning Research, 24*(7), 1782-1789.

45. Robbins, D. W., Young, W. B., Behm, D. G., Payne, W. R. & Klimstra, M. D. (2010). Physical performance and electromyographic responses to an acute bout of paired set strength training versus traditional strength training. *Journal of Strength and Conditioning Research, 24*(5), 1237-1245.

46. Willardson, J. M. (2008). A brief review: How much rest between sets? *Strength and Conditioning Journal, 30*(3), 44-50.

47. Ament, W. & Verkerke, G. J. (2009). Exercise and fatigue. *Sports Medicine, 39*(5), 389-422.

48. Walker, S., Davis, L., Avela, J. & Hakkinen, K. (2012). Neuromuscular fatigue during dynamic maximal strength and hypertrophic resistance loadings. *Journal of Electromyography and Kinesiology, 22*(3), 356-362.

49. Salles, B. F., Simão, R., Miranda, F., Novaes, J. S., Lemos, A. & Willardson, J. M. (2009). Rest interval between sets in strength training. *Sports Medicine, 39*(9), 765-777.

50. Corder, K. P., Potteiger, J. A., Nau, K. L., Figoni, S. E. & Hershberger, S. L. (2000). Effects of active and passive recovery conditions on blood lactate, rating of perceived exertion, and performance during resistance exercise. *Journal of Strength and Conditioning Research, 14,* 151-156.

51. Monteiro, W., Simão, R. & Farinatti, P. (2005). Manipulation of exercise order and its influence on the number of repetitions and effort subjective perception in trained women. *Revista Brasileira de Medicina do Esporte, 11*(2), 143-146.

52. Pincivero, D. M., Gear, W. S., Moyna, N. M. & Robertson, R. J. (1999). The effects of rest interval on quadriceps torque and perceived exertion in healthy males. *Journal of Sports Medicine and Physical Fitness, 39*(4), 294-299.

53. Simão, R., Farinatti, P. T., Polito, M. D., Viveiros, L. & Fleck, S. J. (2007). Influence of exercise order on the number of repetitions performed and perceived exertion during resistance exercise in women. *Journal of Strength and Conditioning Research, 21*(1), 23-28.

54. Spreuwenberg, L. P., Kraemer, W. J., Spiering, B. A., Volek, J. S., Hatfield, D. L., Silvestre, R., *et al.* (2006). Influence of exercise order in a resistance-training exercise session. *Journal of Strength and Conditioning Research, 20*(1), 141-144.

55. Helms, E. R., Cronin, J., Storey, A. & Zourdos, M. C. (2016). Application of the repetitions in reserve-based rating of perceived exertion scale for resistance training. *Strength and Conditioning Journal, 38*(4), 42-49.

56. Zourdos, M. C., Jo, E., Khamoui, A. V., Lee, S. R., Park, B. S., Ormsbee, M. J., *et al.* (2015). Modified daily undulating periodization model produces greater performance than a traditional configuration in powerlifters. *The Journal of Strength & Conditioning Research, 30*(3), 784-791.