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Effect of exercise order on the number of repeats and training volume in the tri-set training method

Efeito da ordem dos exercícios sobre o número de repetições e volume de treino no método de treinamento tri-set

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Abstract – Although the tri-set system is widely adopted by athletes and experienced weight training practitioners aimed at optimizing the metabolic overload, there are still few works in literature on the effect of exercise order manipulation on this training system. Therefore, this work was aimed at investigating the effect of exercise order manipulation on the number of repeats and training volume using the tri-set system for lower limbs. This is a randomized cross-over design study. The experimental group consisted of 14 healthy men (23.53 ± 5.40 years; 24.51 ± 2.96 kg/m²). Subjects were submitted to two experimental sessions at different exercise order for lower limbs: Sequence A: squat on guided bar, leg press 45° and bilateral leg extension; sequence B: bilateral leg extension, leg press 45° and squat on guided bar. Three sets to volitional fatigue in all exercises were performed, with intensity of 75% 1RM. Superiority for sequence B in the total number of repeats (70.14 ± 13 vs 60.93 ± 7.94 repeats, p = 0.004) and total training volume (9129.64 ± 2830.05 vs 8238.29 ± 2354.20 kg, p = 0.014) was observed. Based on the above, the performance of single-joint exercises before multi-joint exercises in the tri-set system adopted for lower limbs induced higher number of repeats and total training volume.

Key words: Adults; Motor performance; Resistance training methods; Weight training.

Resumo – *Embora o sistema tri-set seja amplamente adotado por atletas e praticantes experientes de treinamento com pesos que buscam otimizar a sobrecarga metabólica, a literatura carece de investigações acerca do efeito da manipulação da ordem dos exercícios nesse sistema de treinamento. Sendo assim, objetivou-se investigar o efeito da manipulação da ordem dos exercícios sobre o número de repetições e volume de treino, utilizando o sistema tri-set para membros inferiores. Trata-se de uma pesquisa com delineamento cross-over aleatorizado. O grupo experimental foi composto por 14 homens saudáveis (23,53 ± 5,40 anos; 24,51 ± 2,96 kg/m²). Os avaliados foram submetidos a duas sessões experimentais em diferentes ordens de exercícios para membros inferiores: sequência A: agachamento na barra guiada, leg press 45° e cadeira extensora bilateral; sequência B: cadeira extensora bilateral, leg press 45° e agachamento na barra guiada. Foram executadas três séries até a fadiga voluntária em todos os exercícios, com intensidade de 75% de 1RM. Observou-se superioridade para a sequência B no número total de repetições (70,14 ± 13,00 vs 60,93 ± 7,94 repetições; p = 0,004) e volume total (9129,64 ± 2830,05 vs 8239,29 ± 2354,20 kg; p = 0,014). Diante do exposto, a execução de um exercício monoarticular antes de multiarticulares, no sistema tri-set adotado para membros inferiores, induziu a um maior número de repetições e volume total de treinamento.*

Palavras-chave: *Adultos; Desempenho motor; Métodos de treinamento resistido; Treinamento com pesos.*

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INTRODUCTION

Weight training is prescribed depending on the manipulation of several variables. The modulation of the number of series and repeats, training volume, load intensity, speed and exercise order determines the magnitude of neural and morphological adjustments in skeletal muscle such as increased strength, resistance and cross-sectional area[1].

It has been shown that the magnitude of these adjustments induced by weight training occurs in smaller proportions as the individual increases the number of training sessions[2,3]. Accordingly, periodized manipulation of the training load components is recommended in order to modify the metabolic stress and thus optimize the results of athletes or practitioners[1].

Among the main weight training systems described in literature (drop-set, pre-exhaustion, pyramid, among others), the tri-set method has been widely adopted by athletes and experienced weight training practitioners seeking to optimize the metabolic overload made possible due to the short interval of rest among exercise sessions for the same muscle group[4]. Although the execution order is a variable that affects both acute[5,6] and chronic responses[7-9], in training programs with weights, few studies have investigated the effect of exercise order on muscle performance in the tri-set system. Thus, there is need for further information about this method in order to provide more evidence-based subsidies for coaches to choose the training system that best meets the objectives of their athletes.

Ribeiro et al.[10] analyzed the effect of exercise order manipulation for the pectoral muscle group in the tri-set system in trained men and found higher number of repeats and training volume when single-joint exercises were performed before multi-joint exercises. Considering the difference between number of repeats performed for upper and lower limbs with the same relative load[11], it is possible that the exercise order influences the number of repeats differently between limbs. In this perspective, the aim of this study was to investigate the effect of exercise order manipulation on the number of repeats and training volume using the tri-set system for lower limbs.

METHODOLOGICAL PROCEDURES

The experimental group consisted of 14 subjects (23.53 ± 5.4 years; 24.51 ± 2.96 kg/m^2) with previous experience in weight training (1.8 ± 1.1 years) and no previous history of surgery or any musculoskeletal involvement of hip, knee and ankle.

The sample size analysis was performed using the G * Power 3.1 software. Based on a previous analysis, power of 0.80; $\alpha = 0.05$; correlation coefficient of 0.5; sphericity violation correction of 1 and effect size of 0.50 were adopted, according to procedures suggested by Beck [12]. Based on these values, a minimum sample of 12 subjects was calculated. Furthermore, it was estimated that the size of the selected sample (n = 14) was sufficient to provide statistical power of 88.1%.

All participants read and signed the free and informed consent form after being informed of the benefits and risks related to their participation in the research. The study was approved by the Ethics Research Committee of the University where the study was developed under protocol No. 023/2011.

Experimental design

This is a cross-over randomized design study. The volunteers were submitted to nine experimental sessions with minimum 72-hour intervals. For the performance of sessions, participants were instructed not to perform any kind of moderate to vigorous physical activity and do not drink any beverage containing caffeine 24 hours preceding the performance of protocols. In the first session, the following procedures were applied: anamnesis, anthropometric measurements and familiarization session with protocols. In the second, third and fourth session, one repetition maximum (1RM) in squat on guided bar, leg press 45° and bilateral leg extension tests were performed, respectively. The three subsequent sessions were designed to 1RM retest for obtaining load reliability. We chose to perform 1RM tests on separate days in order to minimize possible interference in results. Subsequently, participants underwent two random experimental sessions in the tri-set system at different orders of lower limb exercises in sequence A (SA) starting from multi-joint exercises to single-joint exercises (squat on guided bar, leg press 45° and bilateral leg extension) and sequence B (SB) starting from single-joint exercises to multi-joint exercises (bilateral leg extension, leg press 45° and squat on guided bar). All exercises were performed at intensity of 75% of 1RM. Both in the performance of 1RM test as in experimental sessions (SA and SB), volunteers were instructed to carry out the eccentric and concentric phases in about two seconds.

Anthropometric measurements

Body mass assessment was performed using a digital scale (Welmy®), with precision of 100 grams and height using a portable stadiometer (Welmy®), with accuracy of 0.1 cm. Body mass index (BMI) was calculated as the ratio of body weight in kilograms (kg) by squared height in meters (m). The skinfolds technique (Lange® calipers) was used to estimate body density[13]. From this, relative fat was estimated using the equation of Siri[14] and the absolute body fat (kg) was subtracted from body mass to obtain the lean body mass (kg).

1RM tests

The 1RM test was used as an indicator of maximum force. Whereas subjects with over 24 weeks of weight training experience, two 1RM testing sessions for the same exercise show reliable results[15], in this study, two sessions were used for each exercise.

Initially, warm-up exercise was performed of eight repeats with 50% of the load that would be used in the first attempt. After one minute, subjects were instructed to try to perform two repeats with the load imposed, with three attempts. The rest period between each attempt was three to five minutes. The 1RM value was considered when the individual could perform only one repetition. If the subject performed two repeats or could not perform any repetition, a new attempt was carried out with the necessary load adjustment. The 1RM tests showed good reproducibility in squat exercises in guided bar (r = 0.94), leg press 45° (r = 0.94) and bilateral extensor (r = 0.96). Furthermore, the variation coefficient for these three exercises was 23.12%, 21.54% and 20.43%, respectively.

Experimental sessions

Before the protocol execution, volunteers performed warm-up exercise with eight repeats with approximately 50% of 1RM in the first tri-set exercise. One minute after, the individual performed the exercise protocol in accordance with the sequence determined by simple randomization.

Although there is no recommendation of exercise intensity for the tri-set system, it was decided to adopt intensity recommended for traditional training[1] aiming muscular hypertrophy. Thus, the intensity determined for both sequences was 75% 1RM. Participants performed the three tri-set exercises with displacement and preparation interval ranging from 5 to 8 seconds and also performed three exercise series to voluntary fatigue with three-minute interval between them.

Verbal encouragement was provided during all exercises in both experimental protocols, recording only repeats that completed a movement cycle. The total volume was determined by the sum of the number of repeats performed for each tri-set series multiplied by the load lifted in kg. After the completion of each series of the tri-set system, the CR-10 ratings of perceived exertion (RPE) proposed by Borg[16] and adapted by Foster et al.[17] was presented to volunteers, who were requested to indicate the number that best represented the effort made.

Statistical analysis

Initially, the Shapiro-Wilk test was used to confirm data normality, and then the "t" test for paired samples was used for comparisons between sequences (SA and SB) in relation to the total number of repeats and total volume. ANOVA for repeated measures with two factors was used for comparisons between the three series and sequences (SA and SB) in the number of repeats and workload. If the Mauchly sphericity test was violated, the Greenhouse-Geisser correction was applied. When the F test identified effect and / or interaction, the *post hoc* Bonferroni test was used to find differences between means. To complement analysis, the effect size (η^2) was presented. Intraclass correlation coefficient was used to analyze reproducibility among 1RM sessions. The chi-square test was used to compare RPE between sequences A and B in the three series. For data analysis, the statistical package SPSS version 22.0 was used, adopting significance level of $p < 0.05$.

RESULTS

Anthropometric and 1RM characteristics of subjects are presented in Table 1.

Table 1. Characteristics of subjects (n = 14)

Variables	Mean ± SD	Minimum-Maximum
Age (years)	23.53 ± 5.40	19.09-38.93
Height (m)	1.79 ± 0.08	1.65-1.93
Body mass (kg)	79.12 ± 12.16	61.60-99.00
BMI (kg/m²)	24.51 ± 2.96	19.23-30.30
Relative fat (%)	15.15 ± 5.87	5.64-24.21
Absolute fat (kg)	12.42 ± 6.13	3.57-23.96
Lean mass (kg)	66.69 ± 7.94	51.64-76.78
1RM squat on guided bar (kg)	120.57 ± 27.88	80-180
1RM Leg Press 45° (kg)	340.36 ± 73.34	240-480
1RM bilateral leg extension (kg)	97.71 ± 19.97	60-130

BMI, body mass index; 1RM, repetition maximum; SD, standard deviation

Figure 1 shows the number of total repeats of exercises between different sequences, and SB values were significantly higher ($p = 0.004$).

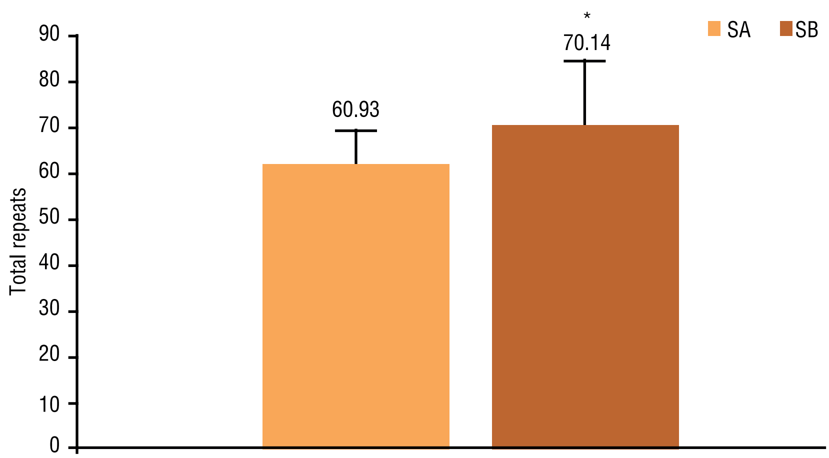

Figure 1. Comparison of the total number of repeats for SA (SA = squat on guided bar, leg press 45º and bilateral leg extension) and SB (SB = bilateral leg extension, leg press 45 ° and squat on guided bar) (n = 14). Data were expressed as mean and SD. * P < 0.05 significant difference between sequences.

The comparison between the average number of repeats of each exercise between sequences is shown in Figure 2. Significant values were found in exercises squat on guided bar (SA > SB, $p < 0.001$) and bilateral leg extension (SB > SA; $p < 0.001$).

Table 2 shows the comparison of the number of repeats and workload between conditions and series. There was a significant effect of exercise series on the number of repeats ($F = 31.30$; $p < 0.001$) and workload ($F = 20.02$, $p < 0.001$); in addition, a significant effect of sequence on the number of repeats was observed ($F = 4.82$; $p = 0.03$). Greater number of repeats in the second and third series for SB was found (p = 0.043; p = 0.037, respectively). The comparison between number of repeats in exercise series identified similar behavior between sequences, in which there was a decrease in the number of repeats in the third series in relation to the first series ($p < 0.05$), and a decrease in the third series in relation to the second series was also observed.

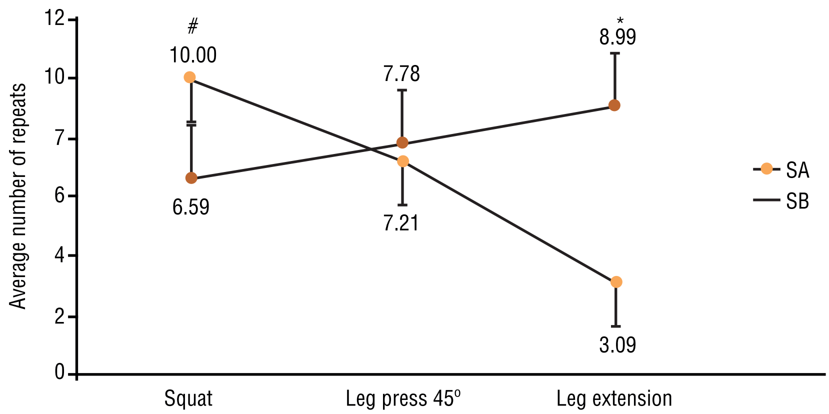

Figure 2. Average number of repeats in exercises squat on guided bar, leg press 45 ° and bilateral leg extension in SA and SB (n = 14). Values are expressed as mean and SD. * $p < 0.05$ vs SA; # $p < 0.05$ vs SB.

Table 2. Influence of exercise order on the number of repeats and work volume in the tri-set system for lower limbs.

			ANOVA			
	SA	SB	Effect	F	p	(η^2)
Repeat						
1st series	23. 86 ± 3.67	25.57 ± 3.65	Series	31.30	< 0.001	0.546
2nd series	19.86 ± 3.41$^{\#}$	23.79 ± 5.98*	Seq	4.82	0.03	0.156
3rd series	17.21 ± 2.75$^{\#¥}$	20.79 ± 5.42$^{\#¥*}$	Series x Seq	1.35	0.26	0.050
Volume (kg)						
1st series	3197.36 ± 1063.10	3268.71 ± 907.14	Series	20.02	< 0.001	0.435
2nd series	2667.07 ± 713.32$^{\#}$	3048.00 ± 1012.45	Seq	0.81	0.37	0.030
3rd series	2374.86 ± 734.83$^{\#¥}$	2812.93 ± 1033.05	Series x Seq	1.88	1.75	0.068

Number of repeats and work volume observed in each series for sequence A (SA = squat on guided bar, leg press 45° and bilateral leg extension) and sequence B (SB = bilateral leg extension, leg press 45 ° and squat on guided bar) (n = 14). Values are expressed as mean and SD. $^{\#}$ $p < 0.05$ *vs* 1st series; ¥ $p < 0.05$ *vs* 2nd series; * $P < 0.05$ *vs* SA. Seq = Sequence

Regarding the volume behavior between sequences and series, there is a greater work volume in all series for SB; however, without statistical significance. The comparison of volume among series identified a different behavior between sequences, in which a decrease in volume of SA in the second and third series in relation to the first series ($p < 0.05$) was observed, while in SB, no significant decrease in volume in the second and third series compared to the first series was observed. As for the total volume, a significantly greater volume for SB (p = 0.014) was observed in Figure 3.

In relation to RPE data between sequences in the three series, similar values were observed (1st series; p = 0.86; 2nd series, p = 0.60; 3rd series; p = 0.73).

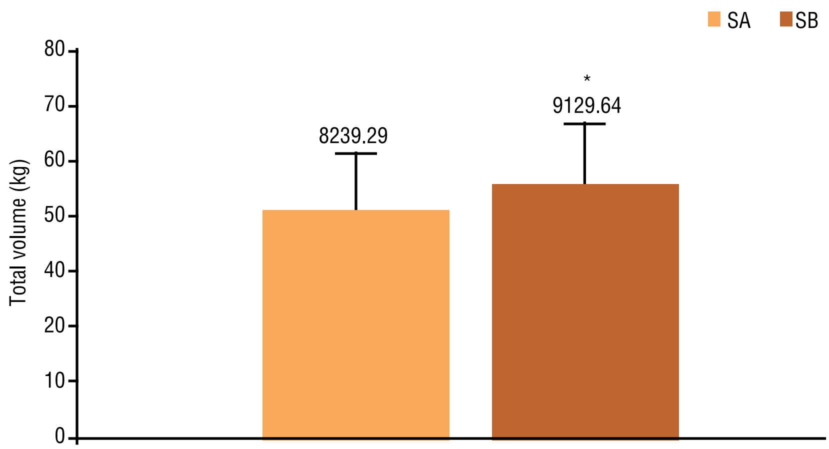

Figure 3. Comparison of total volume between SA (SA = squat on guided bar, leg press 45° and bilateral leg extension) and SB (SB = bilateral leg extension, leg press 45 ° and squat on guided bar) (n = 14). Data were expressed as mean and SD. * $P < 0.05$ significant difference between sequences.

DISCUSSION

This study aimed to investigate the effect of lower limb exercise order manipulation on the number of repeats and training volume using the tri-set system. When comparing to the performance of different exercise orders, it was found that performing single-joint exercises early in the session induces the performance of greater number of repeats and thus higher total volume in relation to the sequence that starts with multi-joint exercises.

The results for the number of repeats of this study corroborate those observed by Ribeiro et al.[10], in which higher performance in the number of repeats in the tri-set system was found when single-joint exercises were performed before multi-joint exercises. Furthermore, analysis stratified for exercises showed that exercises performed at the end of the tri-set system (bilateral leg extension and squat on guided bar) had lower number of repeats ($p < 0.05$), which was expected, since this reduction in performance is mainly associated to accumulated fatigue and decreased exercise performance[5,18,19].

Similar behavior was observed in the number of repeats of the third series in both sequences. This is probably due to the accumulated fatigue resulting from the first and second series, which led to a reduction in the ability to generate force, providing a significant decrease in the number of repeats in all exercises of subsequent series [18]. Although data on this behavior in the tri-set system are scarce, studies involving the traditional system also demonstrated the effect of fatigue and decreased performance over the exercise series[5,19-23].

In a systematic review, Simão et al.[24] recently reported that the training volume is optimized when multi-joint exercises of lower and upper limbs are performed at the beginning of the session. One possible explanation for these results is the fact that accumulated fatigue even partial of smaller muscle groups tend to cause losses in the total volume[1]. However, these results should not be extrapolated to other training systems, as demonstrated in this investigation.

Corroborating the findings of this study, Ribeiro et al.[10] investigated the effect of the order of pectoral exercises on the training volume in the tri-set method and observed total volume significantly higher for the sequence that started the session with single-joint exercises before multi-joint exercises. Based on information available in literature along with the results of this study, it is believed that the exercise order influences the number of repeats and total volume differently according to the training system adopted; however, the mechanisms responsible for this influence are not yet fully elucidated.

When analyzed the subjective perceived effort, the results of this study showed no differences between sequences in the tri-set system ($p > 0.05$), corroborating data from literature, which show that exercise order manipulation has no influence on RPE in the traditional system[22,25,26]. This behavior can be explained by the performance of exercises to voluntary fatigue that concomitantly to verbal stimulation, induced individuals to obtain similar results in SA and SB.

This study provides results that can contribute to the prescription of weight training for individuals using the tri-set system in their training sessions, as a relationship between total training volume and myofibrillar hypertrophy has been observed in literature[27-30]. However, this study has some limitations that should be mentioned such as the bias in the control of the movement performance speed, use of exercise for lower limbs only and absence of evaluation of hormonal and biochemical variables. Therefore, further studies should be performed to analyze the metabolic mechanisms involved, as well as to investigate the use of this system in other muscle groups.

CONCLUSIONS

According to data shown in this study, in the tri-set system adopted, performing single-joint exercises before multi-joint exercises led to higher number of repeats and total training volume.

REFERENCES

1. Ratamess N, Alvar B, Evetoch T, Housh T, Kliber W, Kraemer W, et al. Progression models in resistance training for healthy adults. Med Sci Sports Exerc 2009;41(3):687–708.
2. Maior AS, Alves A. A contribuição dos fatores neurais em fases iniciais do treinamento de força muscular: uma revisão bibliográfica. Motriz 2003;9(3):161–8.
3. Wernbom M, Augustsson J, Thomeé R. The influence of frequency, intensity, volume and mode of strength training on whole muscle cross-sectional area in humans. Sport Med 2007;37(3):225–64.
4. Uchida MC, Aoki MS, Navarro F, Tessutti VD, Bacurau RF, Bacurau P. Efeito de diferentes protocolos de treinamento de força sobre parâmetros morfofuncionais , hormonais e imunológicos. Rev Bras Med Esporte 2006;12(1):21–6.
5. Spreuwenberg L, Kraemer W, Spiering B, Volek J, Hatfield D, Silvestre R, et al. Influence of exercise order in a resistance-training exercise session. J Strength Cond Res 2006;20(1):141–4.

6. Bellezza P, Hall E, Miller P, Bixby W. The influence of exercise order on blood lactate, perceptual, and affective responses. J Strength Cond Res 2009;23(1):203–8.
7. Spineti J, De Salles B, Rhea M, Lavigne D, Matta T, Miranda F, et al. Influence of exercise order on maximum strength and muscle volume in nonlinear periodized resistance training. J strength Cond Res 2010;24(11):2962–9.
8. Dias I, De Salles BF, Novaes J, Costa PB, Simão R. Influence of exercise order on maximum strength in untrained young men. J Sci Med Sport 2010;13(1):65–9.
9. Simão R, Spineti J, De Salles BF, Oliveira LF, Matta T, Miranda F, et al. Influence of exercise order on maximum strength and muscle thickness in untrained men. J Sports Sci Med 2010;9(1):1–7.
10. Ribeiro A, Silva D, Nascimento M, Avelar A, Ritti-Dias R, Cyrino E. Effect of the manipulation of exercise order in the tri-set training system. Rev Bras Cineantropom Desempenho Hum 2013;15(5):527–34.
11. Shimano T, Kraemer W, Spiering B, Volek J, Hatfield D, R S. Relationship between the number of repetitions and selected percentages of one repetition maximum in free weight exercises in trained and untrained men. J Strength Cond Res 2006;20(4):819–23.
12. Beck TW. The importance of a priori sample size estimation in strength and conditioning research. J Strength Cond Res 2013;27(8):2323–37.
13. Guedes D. Estudo da gordural corporal através da mensuração dos valores de densidade corporal e da espessura de dobras cutâneas em universitários. Kinesis 1985;1(2):183–212.
14. Siri WE. Body composition from fluid spaces and density. In: Brozek J, Henschel A, editors. Techniques for measuring body composition. Washington DC: National Academy of Science 1961:223-44.
15. Ritti-Dias R, Avelar A, Salvador E, Cyrino E. Influence of previous experience on resistance training on reliability of one-repetition maximum test. J Strength Cond Res 2011;25(5):1418–22.
16. Borg G. Psychophysical bases of perceived exertion. Med Sci Sports Exerc 1982;14(5):377–81.
17. Foster C, Florhaug J a, Franklin J, Gottschall L, Hrovatin L a, Parker S, et al. A new approach to monitoring exercise training. J Strength Cond Res 2001;15(1):109–15.
18. Augustsson J, Thomeé R, Hörnstedt P, Lindblom J, Karlsson J, Grimby G. Effect of pre-exhaustion exercise on lower-extremity muscle activation during a leg press exercise. J Strength Cond Res 2003;17(2):411–6.
19. Simao R, Farinatti P, Polito M, Maior A, Fleck S. Influence of exercise order on the number of repetitions performed and perceived exertion during resistance exercises. J Strength Cond Res 2005;19(1):152–6.
20. Sforzo G, Touey P. Manipulating exercise order affects muscular performance during a resistance exercise training session. J Strength Cond Res 1996;10(1):20–4.
21. Monteiro W, Simão R, Farinatti P. Manipulação na ordem dos exercícios e sua influência sobre número de repetições e percepção subjetiva de esforço em mulheres treinadas. Rev Bras Med Esporte 2005;11(2):146–50.
22. Silva NSL Da, Monteiro WD, Farinatti PDTV. Influência da ordem dos exercícios sobre o número de repetições e percepção subjetiva do esforço em mulheres jovens e idosas. Rev Bras Med Esporte 2009;15(3):219–23.
23. Gil S, Roschel H, Batista M, Ugrinowitsch C, Tricoli V, Barroso R. Efeito da ordem dos exercícios no número de repetições e na percepção subjetiva de esforço em homens treinados em força. Rev Bras Educ Fís Esporte 2011;25(1):127–35.
24. Simão R, De Salles BF, Figueiredo T, Dias I, Willardson JM. Exercise order in resistance training. Sport Med 2012;42(3):251–65.
25. Simão R, Leite RD, Speretta GFF, Maior AS, De Salles BF, Souza Junior TP, et al. Influence of upper-body exercise order on hormonal responses in trained men. Appl Physiol Nutr Metab 2013;38(2):177–81.
26. Farinatti P, Silva N, Monteiro W. Influence of exercise order on the number of repetitions, oxygen uptake, and rate of perceived exertion during strength training in younger and older women. J Strength Cond Res 2013;27(3):776–85.

27. Gotshalk L, Loebel C, Nindl B, Putukin M, Sebastianelli W, Newton R, et al. Hormonal responses of multiset versus single-set heavy-resistance exercise protocols. Can J Appl Physiol 1997;22(3):244–55.
28. Hansen S, Kvorning T, Kjaer M, Sjøgaard G. The effect of short-term strength training on human skeletal muscle: the importance of physiologically elevated hormone levels. Scand J Med Sci Sports 2001;11(6):347–54.
29. West DWD, Burd NA, Tang JE, Moore DR, Staples AW, Holwerda AM, et al. Elevations in ostensibly anabolic hormones with resistance exercise enhance neither training-induced muscle hypertrophy nor strength of the elbow flexors. J Appl Physiol 2010;108(1):60–7.
30. Burd NA, West DWD, Staples AW, Atherton PJ, Baker JM, Moore DR, et al. Low-load high volume resistance exercise stimulates muscle protein synthesis more than high-load low volume resistance exercise in young men. PLoS One 2010;5(8):e12033.

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