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Original

Acute effect of three different warm-up protocols on maximal isokinetic strength in young men

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ABSTRACT

Objective: To investigate the acute effect of three different warm-up protocols on a maximal isokinetic strength test.
Methods: Twenty-two male, recreational athletes involved in regular resistance training were evaluated. Subjects performed a maximal isokinetic strength test of the knee extensors in an isokinetic dynamometer after completing a control session or one of the following warm-up protocols using a randomized design: a general warm-up, stretching warm-up, or specific warm-up. The comparison between treatments was completed through Repeated-Measures Analysis of Variance, followed by a Bonferroni "post hoc" test ($p < 0.05$).
Results: The only difference found was the concentric peak moment following the application of the specific warm-up protocol, which was lower than the control session (12.94%; $p < 0.05$). No other differences were noted in eccentric peak movement or total work (concentric + eccentric) parameter after application of any the warm-up protocols within control condition ($p > 0.05$).
Conclusion: The finding of this investigation showed that none of warm-up protocols applied were able to change the total work of maximal isokinetic strength. Thus, our investigation suggests that the general warm-up, stretching warm-up and specific warm-up have had no adverse or improved effectiveness on acute muscle strength capacity.
Keywords: Warm-up; Stretching; Muscular strength; Isokinetic dynamometer.

Efecto agudo de tres diferentes protocolos de calentamiento previo en la fuerza isocinética máxima en hombres jóvenes

RESUMEN

Objetivo: investigar el efecto agudo de tres diferentes protocolos de calentamiento previo en una prueba de fuerza isocinética máxima.
Métodos: Fueron evaluados veintidós hombres, atletas recreacionales de entrenamiento resistido. Los individuos realizaron una prueba de fuerza isocinética máxima de los extensores de la rodilla en un dinamómetro isocinético después de una sesión de control o completar uno de los siguientes protocolos de calentamiento previo de forma aleatoria: calentamiento general, calentamiento a través de estiramiento, o calentamiento específico. La comparación, entre los tratamientos, fue realizada a través de un análisis de varianza de medidas repetidas, seguidas por la prueba de "post hoc" de Bonferroni ($p < 0.05$).
Resultados: La única diferencia encontrada fue en el pico de torque concéntrico después de la aplicación del calentamiento específico, donde se mostró menor que la sesión control (12.94%; $p < 0.05$). No se observaron otras diferencias en los datos en los parámetros de pico de torque excéntrico o en el trabajo total (concéntrico + excéntrico) después de la aplicación de cualquier protocolo de calentamiento comparando con la sesión de control ($p > 0.05$).
Conclusión: Los hallazgos de este estudio mostraron que ninguno de los protocolos de calentamiento utilizados fueron capaces de alterar el trabajo total en la fuerza isocinética máxima. Así, nuestra investigación sugiere que el calentamiento general, calentamiento a través de estiramiento, o calentamiento específico no tuvieron efecto adverso o de mejora en la capacidad de la fuerza muscular máxima de forma aguda.
Palabras clave: Calentamiento; Estiramiento; Fuerza muscular; Dinamómetro isocinético.

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Efeito agudo de três diferentes protocolos de aquecimento prévio sobre a força isocinética máxima em homens jovens

RESUMO

Objetivo: investigar o efeito agudo de três diferentes protocolos de aquecimento prévio em um teste força isocinética máxima.
Métodos: Foram avaliados vinte e dois homens atletas recreacionais de treinamento resistido. Os indivíduos realizaram um teste força isocinética máxima dos extensores do joelho em um dinamômetro isocinético após uma sessão controle ou completar um dos seguintes protocolos de aquecimento prévio de forma randomizada: aquecimento geral, aquecimento através de alongamento, ou aquecimento específico. A comparação, entre os tratamentos, foi realizada através de uma análise de variância de medidas repetidas, seguidas pelo teste de "post hoc" de Bonferroni ($p < 0.05$).
Resultados: A única diferença encontrada foi no pico de torque concêntrico após a aplicação do aquecimento específico, onde se mostrou menor do que a sessão controle (12.94%; p <0.05). Não foram observadas outras diferenças nos dados nos parâmetros de pico de torque excêntrico ou no trabalho total (concêntrico + excêntrico) após a aplicação de qualquer protocolo de aquecimento comparando com a sessão controle (p> 0.05).
Conclusão: Os achados deste estudo mostraram que nenhum dos protocolos de aquecimento aplicados foram capazes de alterar o trabalho total na força isocinética máxima. Assim, a nossa investigação sugere que o aquecimento geral, aquecimento por alongamento e o aquecimento específico não tiveram efeito adverso ou de melhora na capacidade da força muscular máxima de forma aguda.
Palavras chave: Aquecimento; Alongamento; Força muscular; Dinamômetro isocinético.

Introduction

To help prepare for competitive sports and physical activities, warm-up routines are regularly engaged as a pre-exercise feature of many competitive and recreational athletes.[1-3] It has been suggested that muscle performance can be enhanced by performing a WU routine via various mechanisms including decreased resistance of muscle and joints, increased rate of metabolic reaction, higher release of oxygen, increased rate of nerve conduction and increased blood flow to working muscles.[4] However, the WU programme must be accomplished with caution and not involve high demand, otherwise it may cause detrimental effects[5]. Moreover, it is routinely accepted that pre-exercise WU will reduce the risk of injury and alleviate symptoms of muscle soreness.[6,7]

Among the different WU protocols performed prior to exercise there are three techniques that are traditionally utilized: the general warm-up (GEWU), the stretching exercise warm-up (SEWU), and the specific warm-up (SPWU). GEWU involves routines of relative low intensity aerobic activity; SEWU is a common technique in which the subjects use static stretch exercises; and the SPWU would incorporate exercises of variable specificity that simulates the same movement as the subsequent activity or test. It is widely accepted that pre-exercise WU tend to reflect the experiences of individual coaches and/or athletes. However, there is a paucity of published research that examine the effects of WU,[8] and more specifically published research that analyses the exact mechanisms and specific outcomes associated with various modes of WU.[9] In this regard, the American College of Sport Medicine (ACSM)[10] has indicated that more controlled studies are needed to substantiate the effectiveness of WU protocols. Controlled studies have tested the effect of WU protocols on muscle performance, such as, GEWU,[8,12,14,15] SEWU[1-3,11] and SPWU.[4,5,13,16]

Although the scientific literature explains the benefits of a WU on the muscle performance, conflicting result have emerged from within this body of literature. Furthermore, another interesting question raised is which one among these different forms of WU protocols (general, stretching and specific), would be more effective at improving muscle performance? Therefore, the main goal of this study was to investigate the acute effect of three different warm-up protocols on a maximal isokinetic strength test.

Methods

Subjects

Twenty-two male, recreational athletes (age: 24 ± 3 year; height: 188 ± 7 cm; weight: 88 ± 11kg; body fat: 12 ± 3%) who were involved in regular resistance training for more than two years volunteered for this study. All research participants declared that they were not consuming any ergogenic aids. The participants were requested to abstain from any sort of training for 48 hours prior to the beginning of this study. Research Ethics were submitted and approved by governing institution (protocol: 1256.181.11.11).

Experimental Design

Prior to performing the test protocols, all subjects underwent a familiarization session in the first visit to the laboratory, where they were acquainted with the test procedures associated with each the WU protocols and muscular strength test by isokinetic dynamometer. The experimental protocol required participants to commit to a further four visits to the laboratory, with each visit following a 48-hour rest period. On the second visit to the laboratory, a control condition session was conducted without any form of WU. From the third, fourth and fifth visits a randomized design was taken to avoid any carry over effect. Where participants completed one of the three WU protocols: GEWU; SEWU; SPWU; prior to the maximal isokinetic strength test (Fig 1). Between each of the WU protocols and isokinetic strength test, a 60-sec rest period was allowed.[15,17]

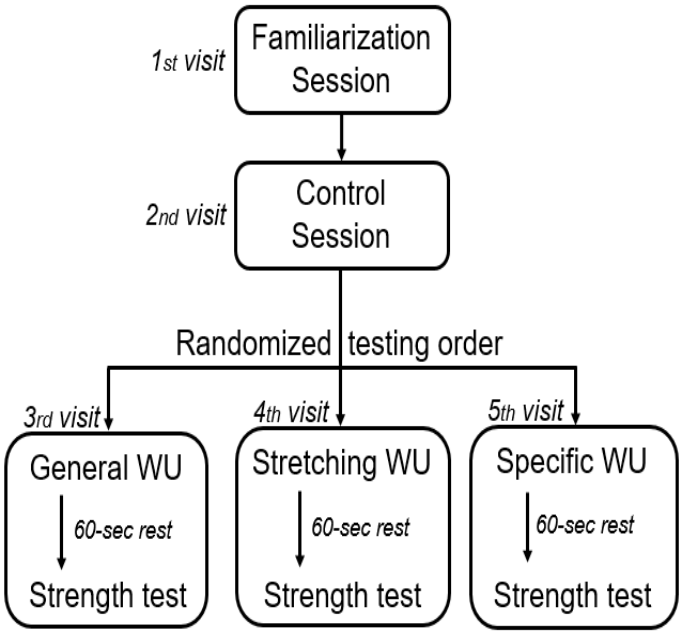

Figure 1. Experimental Design.

Procedures

During the control sessions, participants did not perform any sort of WU protocol, a 3.5-minute period of seated rest was imposed before participants underwent the strength test.[17] The GEWU protocol was conducted on a treadmill (Moviment TR 200) for 10 min at a velocity equivalent to 70% of subjects predicted heart rate (220 – age)[8], utilizing a heart rate monitor (RS800cx; Polar Electro). The stretching exercise used in the SEWU protocol required participants to stretch their quadriceps femoris muscles of their dominant leg. Two sets of 30-sec stretches, with a 30-sec rest interval between each set, were performed with submaximal intensity[17]. The SPWU protocol was conducted on the same isokinetic dynamometer as the strength test. This SPWU protocol involved a single set of 15 submaximal knee extension movements performed at an intensity level of 50-55%[13,18] of the maximal strength test obtained during the control session at angular velocity of 60°/s.

Maximal voluntary contraction test

The data drawn from the maximal isokinetic strength test was measured using a dynamometer (Cybex - NORM™). The test was conducted in a sitting position, the free end of the mechanical lever of the dynamometer was secured 5 cm above the lateral malleolus and the axis of rotation of the dynamometer was aligned with lateral femoral epicondyle. The test consisted of one maximal voluntary contraction of knee extension (concentric followed by eccentric movement) measured at 30°/s[15], at a range of motion (ROM) of 100°. The isokinetic parameters used in this study were the concentric and eccentric peak moment (PM) and the total work (TW) of single maximal contraction (concentric + eccentric).

Statistical analysis

Results are reported as descriptive statistics (Mean ± Standard Deviation). Data normality was tested by the Shapiro-Wilk homoscedasticity test (Bartlett criterion). The comparison between treatments was completed through Repeated-Measures ANOVA, followed by a Bonferroni "post hoc" test ($p < 0.05$). Statistical procedures were completed according to the parameters of the IBM SPSS Statistics 20 package.

Results

The concentric PM produced followed by SPWU was lower than control session ($p < 0.05$); 239.25 ± 31.44 and 274.80 ± 38.98 N·m, respectively. No other differences were noted in the concentric PM. Regarding the eccentric PM and TW parameters, there were no differences observed after the application of either WU protocol or after the control sessions, nor even differences among the WU protocols ($p > 0.05$) (Fig 2).

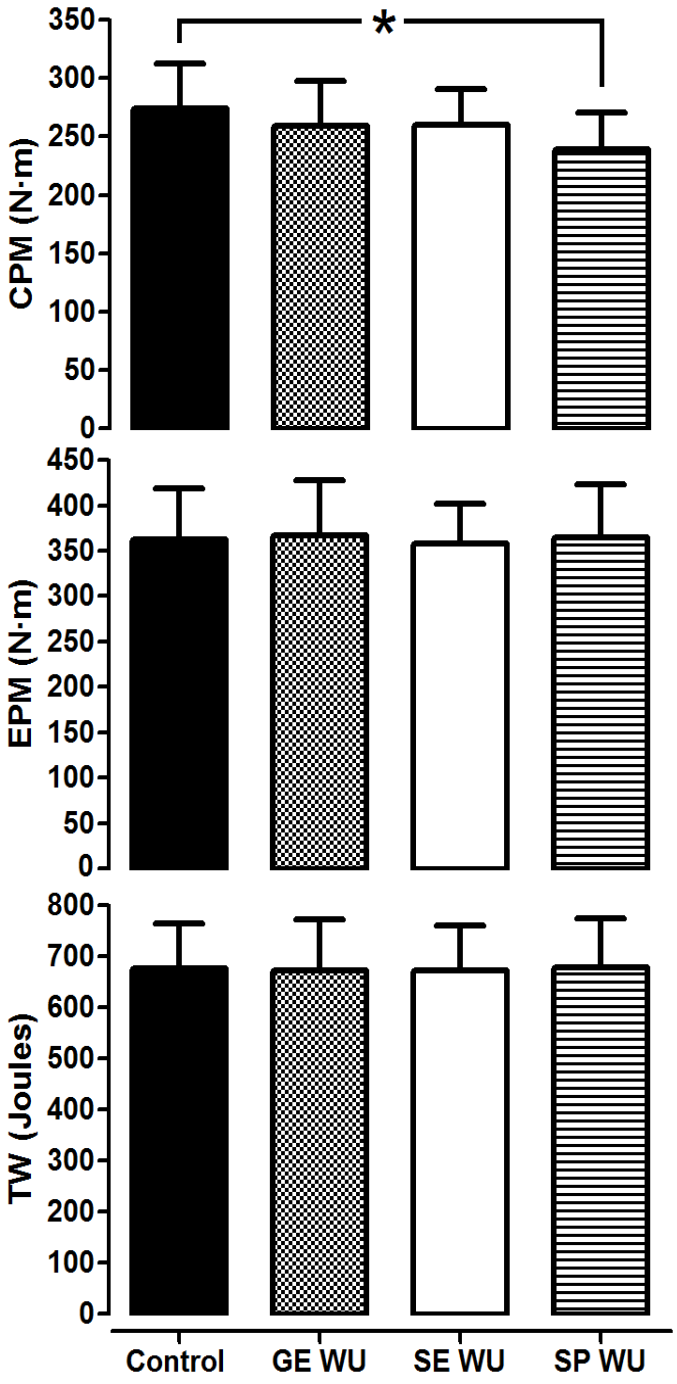

Figure 2. Acute effects of different warm-up protocols on maximal voluntary contraction test. Values shown as mean ± SD. * denotes statistically significant difference ($p < 0.05$). TW: total work); GEWU: general warm-up; SPWU: specific warm-up; EPM: eccentric peak moment; CPM: concentric peak moment.

Discussion

The data from this demonstrates that when the maximal isokinetic strength test is performed 60-sec after an application of SPWU, the concentric PM may actually decrease. However, the results also showed that none of the WU routines revealed to be more effective on strength tests than the control condition. Moreover, this research also demonstrates that the same result is achieved when compared the eccentric PM and the TW isokinetic parameters from each of the WU protocols (Fig 2). These findings suggest that claims made in landmark texts[4,5] regarding a WU routine enhance muscle performance have not been replicated in this study. In addition, the concentric PM data of the present study support the affirmation of Ayala et al.,[5] that WU programme must be performed with caution; otherwise it may cause detrimental effects on strength.

Fermino et al.,[12] applied two different protocols of WU before performing a strength test (10-RM) on leg press, leg extension and leg curl machines. They used GEWU (20 min of low-intensity aerobic on a treadmill) and SPWU (20 repetitions on leg press machine at 50% of 1-RM). Most important, Fermino and colleagues[12] did not find any differences on muscle strength after both WU protocols and concluded that regardless of the type of WU routine there was no noticeable increase in muscle performance. Lastly, Fermino et al.,[13] carried out another study where they applied a SPWU (15 repetition with 50% of 1-RM) and SEWU (two sets of 20-sec with submaximal intensity) before a strength test performed on a leg curl machine. In this instance, the authors[13] again concluded that there was no difference on the

acute effect of maximal strength after both WU strategies. Similarly, Arruda et al,[18] tested the effect of SPWU (15 repetition at 55% of 1-RM) and SEWU (four different stretches of 20-sec with maximal intensity) on 10-RM in a peck deck machine. In this study, the authors[18] concluded that the SPWU protocol had neither a positive nor negative effect on the number of repetition completed; however, the SEWU was sufficient to negatively affect muscular performance.

It goes without saying that it is with great caution that we compare the current investigation with the studies cited above. The studies mentioned above did not measure the concentric and eccentric PM, yet even with consideration of this fact, none of the aforementioned studies have been able to associate any of the WU protocols with an increase in muscular performance. Our investigation reaffirms these conclusions, as neither of the WU protocols (general, stretching or specific) were able to improve the TW parameter of 1-RM on isokinetic dynamometer. Although, the WU protocols of our investigation are similar to those studies[12,13,18], we must acknowledge that there are clear limitations when comparing the muscle performance test. The preceding research measured maximal repetition on conventional machines while our investigation used an isokinetic dynamometer. Another limitation worth nothing is that none of the three preceding studies involved a control condition and consequently could only compare the effect that each WU protocols had on muscle performance. Interestingly, the study of Arruda and colleges[18] was the only one which found a decrease in muscle performance after SEWU; however, this can be explained by the intensity of the stretching used. While our investigation and the study of Fermino and colleges[13] used submaximal intensity, Arruda and colleges[18] used maximal intensity of discomfort. A recent study,[17] tested two protocols of static stretching exercise on maximal strength with different intensity of discomfort taken at ROM during stretching (maximal and submaximal). This study[17] concluded that the stretching performed at maximal intensity decreases the muscle strength. Sa et al[19], suggested that more intensive stretching protocols have produced detrimental effects on muscle performance due to decreases in neural activation by the Golgi tendon reflex, changes in viscoelastic properties of muscle-tendon units and the arrangement of muscle fibres.

Another study,[15] tested the concentric and eccentric PM and TW parameters by an isokinetic dynamometer (Cybex) with one maximal contraction test of knee extension at 30°/s following either a GEWU (10 min of low-intensity aerobic on a ergometric cycling), SEWU (4 sets of 30-sec at submaximal intensity), combined WU protocols (GEWU + SEWU), or control condition. There were no differences observed in the concentric PM, eccentric PM or TW parameters recorded after each WU protocol. Moreover, there was also no noticeable difference between any of the WU protocols when compared with control condition. The maximal isokinetic strength of our investigation and above mentioned study[15] were equal, and the results relating to the isokinetic parameters after GEWU and SEWU were the same. Similarly, there are other studies that tested the acute effect of different WU protocols (GEWU, SEWU and SPWU;[14,20] GEWU and SPWU[16]) on muscular strength that did not find any changes.

The data of our investigation and previously cited studies demonstrates that WU protocols did not affect the maximal muscle strength. Moreover, the data from concentric PM recorded after a SPWU and the results of Arruda et al[18], confirm the suggestion of Ayala and colleges[5] that a poorly performed WU programme may cause detrimental effects on strength production. In addition, other studies[21,22] have concluded that previously performed aerobic exercises can also decrease muscle strength. In addition to these other studies[23,24] have concluded that WU exercises do not offer the presumed benefit of injury reduction. Clearly there is an obvious void in the literature addressing WU routines. More specifically there is a lack of investigation of injury prevention outcomes, a widely accepted canon for using WU exercises is the prevention of injuries however this is not supported by any investigation[9]. Given these findings, the practice of WU routines is not a reasonable intervention when a maximal strength contraction is required.

In conclusion, the finding of the present investigation demonstrated that a SPWU may cause significant decrease in the concentric PM of the quadriceps. On the other hand, the eccentric PM and TW parameters were not affected by any sort of WU protocols applied in this study. Thus, our investigation suggests that GEWU, SEWU or SPWU have no adverse or effectiveness on acute muscle strength capacity.

Authotship. All the authors have intellectually contributed to the development of the study, assume responsibility for its content and also agree with the definitive version of the article. **Acknowledgements.** The authors thank the subjects who participated in this study and also thank Dr Edilson Thiele.. **Provenance and peer review.** Not commissioned; externally peer reviewed. **Ethical Responsabilities.** *Protection of individuals and animals:* The authors declare that the conducted procedures met the ethical standards of the responsible committee on human experimentation of the World Medical Association and the Declaration of Helsinki . *Confidentiality:* The authors are responsible for following the protocols established by their respective healthcare centers for accessing data from medical records for performing this type of publication in order to conduct research/dissemination for the community. *Privacy:* The authors declare no patient data appear in this article.

References

1. Beedle B, Rytter SJ, Healy RC, Ward TR. Pretesting static and dynamic stretching does not affect maximal strength. J Strength Cond Res. 2008;22(6):1838-43.
2. Costa PB, Ryan ED, Herda TJ, Walter AA, Freitas JM, Sout JR, et al. Acute effects of static stretching on peak torque and the hamstring-to-quadriceps conventional and functional ratios. Scand J Med Sci Sports. 2013;23(1):38-45.
3. Stafilidis S, Tilp M. Effects of short duration static stretching on jump performance, maximum voluntary contraction, and various mechanical and morphological parameters of the muscle–tendon unit of the lower extremities. Eur J Appl Physiol. 2015;115(3):607-17.
4. Lum D. Effects of various warm-up protocol on special judo fitness test performance. J Strength Cond Res. 2019;33(2):459-65.
5. Ayala F, Calderón-López A, Delgado-Gosálbez JC, Parra-Sánchez S, Pomares-Noguera C, Hernández-Sánchez S, et al. Acute effects of three neuromuscular warm-up strategies on several physical performance measures in football players. PloS One. 2017;12(1): e0169660.
6. Nelson AG, Kokkonen J, Arnall DA. Acute muscle stretching inhibits muscle strength endurance performance. J Strength Cond Res. 2005;19(2):338-43.
7. Yamaguchi T, Ishii K. Effects of static stretching for 30 seconds and dynamic stretching on leg extension power. J Strength Cond Res. 2005;19(3):677-83.
8. Andrade DC, Henriquez–Olguín C, Beltran AR, Ramírez MA, Labarca C, Cornejo M, et al. Effects of general, specific and combined warm-up on explosive muscular performance. Biol Sport. 2015;32(2):123-8.
9. McCrary JM, Ackermann BJ, Halaki M. A systematic review of the effects of upper body warm-up on performance and injury. Br J Sports Med. 2015;49(14):935-42.
10. Garber CE, Blissmer B, Deschenes MR, Franklin BA, Lamonte MJ, Lee IM, et al. American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. Med Sci Sport Exerc. 2011;43(7):1334-59.
11. Bacurau RF, Monteiro GA, Ugrinowitsch C, Tricoli V, Cabral LF, Aoki MS. Acute effect of a ballistic and a static stretching exercise bout on flexibility and maximal strength. J Strength Cond Res. 2009;23(1):304-8.
12. Fermino RC, Kotaba C, Santos A, Zen V, Simão R, Polito M, et al. Influência de diferentes aque cimentos no desempenho da força muscular. Rev Bras Físio Exerc. 2004;3(1):249-56.
13. Fermino RC, Winiarski ZH, da Rosa RJ, Lorenci LG, Buso S, Simão R. Influência do aquecimento específico e de alongamento no desempenho da força muscular em 10 repetições máximas. Rev Bras Ci Mov. 2005;13(4):25-32.
14. Nader AN, da Silva AMG, da Rocha HNB, Chaves CPG, Miranda H, Simão R, et al. Influência dos aquecimentos geral e específico na força de membros superiores. Rev Bras Presc Fisiol Exerc. 2009;3(18):517-21.

15. de Albuquerque CV, Maschio JP, Gruber CR, de Souza RM, Hernandez S. Efeito agudo de diferentes formas de aquecimento sobre a força muscular. Fisioter Mov Curitiba. 2011;24(2):221-9.
16. Nicoli AIV, Cordova KO, Barreto AC, Novaes JS. Influência dos diferentes tipos de aquecimento no número de repetições nos exercícios resistidos. Arq Mov. 2007;3(2):42-55.
17. Rodrigues P, Hernandez SG, de Macedo Salgueirosa F, Novack LF, Wassmansdorf R, Wharton L, et al. The influence of two static stretching protocols with different intensities on concentric knee extension strength. Isokinet Exerc Sci. 2017;25(1):41-6.
18. Arruda FL, Faria LB, Silva V, Senna GW, Simão R, Novaes J, et al. A influência do alongamento no rendimento do treinamento de força. Rev Trein Desp. 2006;7(1):1-5.
19. Sá MA, Neto GR, Costa PB, Gomes TM, Bentes CM, Brown AF, et al. Acute effects of different stretching techniques on the number of repetitions in a single lower body resistance training session. J Hum Kinet. 2015;45:177-85.
20. Simão R, Senna G, Leitão N, Arruda R, Priore M, Maior AS, et al. Influência dos diferentes protocolos de aquecimento na capacidade de desenvolver carga máxima no teste de 1RM. Fit Perf J. 2004;3(5):261-5.
21. Haff GG, Stone MH, Warren BJ, Keith R, Johnson RL, Nieman DC, et al. The effect of carbohydrate supplementation on multiple sessions and bouts of resistance exercise. J Strength Cond Res. 1999;13(2):111-7.
22. Schell TC, Wright G, Martino P, Ryder J, Craig BW. Postexercise glucose, insulin, and c-peptide responses to carbohydrate supplementation: running vs. resistance exercise. J Strength Cond Res. 1999;13(4):372-80.
23. Bazett-Jones DM, Winchester JB, McBrice JM. Effect of potentiation and stretching on maximal force, rate of force development, and range of motion. J Strength Cond Res. 2005;19(2):421-6.
24. Fowles JR, Sale DG, MacDougall JD. Reduced strength after passive stretch of the human plantarflexors. J Appl Physiol (1985). 2000;89(3):1179-88.