

ACUTE EFFECT OF DIFFERENT STRETCHING METHODS ON THE STRENGTH PERFORMANCE IN SUCCESSIVE SERIES

EFEITO AGUDO DE DIFERENTES MÉTODOS DE ALONGAMENTO SOBRE O DESEMPENHO DA FORÇA EM SÉRIES SUCESSIVAS

Daniel Vieira Braña Côrtes de Souza¹, Arthur Coimbra Santana¹, Kleberon Barbosa Meireles¹ and Eurico Peixoto César¹

¹Universidade Presidente Antônio Carlos, Barbacena-MG, Brasil.

RESUMO

Ainda não há consenso sobre a utilização de alongamentos antes de exercícios de força em séries sucessivas. Sendo assim, o objetivo foi verificar o efeito agudo de dois métodos de alongamento sobre o desempenho da força no exercício supino reto. Indivíduos treinados realizaram 3 séries de 8 a 10-RM no supino reto imediatamente após o alongamento estático (AE), Facilitação Neuromuscular Proprioceptiva (FNP) ou condição controle. Foi encontrada queda significativa das repetições na segunda e terceira séries em comparação à primeira em todas as condições. Não houve diferença significativa no número de repetições ou no volume total entre as condições com e sem alongamento. O AE e a FNP não causaram impacto negativo no desempenho da força, podendo, assim, serem utilizados previamente a esse exercício.

Palavras-chave: Contração isotônica. Exercício de alongamento muscular. Força muscular. Treinamento de resistência.

ABSTRACT

There is still no consensus about the use of stretching before strength exercises in successive series. Thus, the aim was to verify the acute effect of two stretching methods on the strength performance in the bench press exercise. Trained subjects performed 3 sets of 8 to 10-RM in the bench press immediately after the static stretching (SS), Proprioceptive Neuromuscular Facilitation (PNF) or control condition. There was a significant decrease in repetitions in the second and third series compared to the first for all conditions. There was no significant difference in the number of repetitions or total volume between the conditions with and without stretching. The SS and PNF induced no negative effect on strength performance and can be used prior to this exercise.

Keywords: Isotonic contraction. Muscle stretching exercises. Muscle strength. Resistance training.

Introduction

Stretching exercises are commonly prescribed before a physical exercise session with the aim of increasing flexibility levels¹, reducing the incidence of injuries² and late muscle pain³, and improving performance in subsequent physical activity⁴⁻⁶. However, with the exception of the influence on range of motion (ROM) levels⁷⁻¹¹, controversies remain about the influence of stretching on the other factors mentioned¹²⁻¹⁴.

Though widely investigated, there are still debates about the acute effect of different stretching methods on strength and power performance, especially in exercises with successive series. Most studies point out a decrease in strength performance after static stretching routines^{15,16} and proprioceptive neuromuscular facilitation (PNF)^{17,18}. However, other authors evidence that these stretching methods have no effect on strength levels^{4,19,20}. There are also studies that have identified improvements in performance^{5,6}, but they are more scarce. Frequently, such discrepancies in obtained results are attributed to different stretching volumes used, the characteristics of the subjects (trained or untrained) and the way performance is measured, with dynamic, isometric contractions in single or multiple series.

Recently, Ryan et al.²¹ proposed the dose-response relationship for the effects of stretching on strength production. He showed that the greater the volume of stretching employed, the greater the chances of deleterious effect on performance. In addition, it has been evidenced that stretching routines can promote changes in the length-tension curve (angle-torque) of the muscle-tendon unit, which would affect strength production differently in exercises performed in a dynamic or isometric way, with the latter being more susceptible to negative effects¹⁴.

Two major mechanisms have been suggested to explain the strength deficit promoted by stretching routines: the neural mechanism, which reduces the sensitivity of intrafusal fibers, reduces muscle activation (EMG) and autogenic inhibition and reciprocal inhibition reflex mechanisms, and the structural mechanism, suggesting a reduction of the passive tension and the musculotendinous stiffness^{22,23}. However, evidence points to the absence of observance of reflex mechanisms after stretching routines²⁴.

The acute effect of different stretching techniques on strength performance in the bench press exercise has been the subject of investigation by some authors^{4,15,20}. However, although the use of multiple series is often suggested for strength development²⁵, only one study investigated this condition, verifying the acute effect of static stretching on bench press performance¹⁹. In that study, four static stretching exercises with single sets of 30 s were used, and no decrease in strength performance was observed. However, as far as it is known, no authors have verified the acute effect of different stretching methods (static and PNF) on strength performance in multi-series bench press exercise.

Considering these circumstances and gaps presented in the literature, the present study aims to verify the acute effect of two different stretching methods on submaximal dynamic strength performance and on total volume (sum of the product of the number of repetitions and load in kg in each series) in bench press exercise performed in three successive series.

Methods

Participants

The sample consisted of 10 apparently healthy young adult men (30 ± 5.4 years old, 79 ± 9.1 kg and 178 ± 0.7 cm), involved in regular resistance training sessions for at least one year. The study excluded participants who reported any lesions, surgery in the joints required for the experimental procedures and/or use of anabolic drugs that, according to literature reviews, seem to interfere with the results of the tests related to strength performance²⁶⁻²⁸.

The study participants were invited at Presidente Antônio Carlos University, Barbacena campus, MG.

Procedures

Before the study started, the participants were invited to sign a free and informed consent form containing all procedures involved in the study, and a photographic registration authorization during the conduction of any procedures related to the investigation. A copy of both documents was sent to each participant. Both procedures are in compliance with the ethical standards set forth by the National Health Council (Resolution 196/96). The present study was submitted to and approved by the research ethics committee of Presidente Antônio Carlos University - UNIPAC under CAAE registry: 48921115.5.0000.5156 in October 2015.

The study consisted of six visits interspersed with at least two and at most five days between them. The initial three visits were intended to familiarize the participants with the experimental procedures and to determine the load associated with the performance of 8-10 repetition maximum (RM).

At the first visit, the participants underwent an anthropometric measures protocol for morphological characterization of the sample. They were then subjected to the test to determine the load equivalent to 8-10 RM in the bench press exercise. Procedures referring to the participants' familiarization with the stretching protocols were performed right after this test. At the next two visits, participants were subjected to the same test for determination of reliability and typical measurement error (TME).

The remaining three visits corresponded to the experimental and control situations, distributed in a randomized manner. The participants were instructed not to perform any vigorous physical activity within the 48 hours prior to the tests, which were always performed at the same time of the day.

Experimental and Control Conditions

Of the three visits that represent the experimental and control conditions, two were intended to intervention by means of a previous stimulus with static stretching (SS) or proprioceptive neuromuscular facilitation (PNF), and one without any intervention, serving as control (CON).

Initially, in the experimental conditions, the individuals were subjected to the two different stretching methods that were constituted by three successive series. Considering the total duration of stretching used during the studies that reported deleterious effects on strength performance, the present study adopted a routine with a total duration of 90 seconds per muscle group. Each series comprehended two stretching exercises without interval between them. The interval between each series was 30 seconds. In the condition that involved the application of SS, in each exercise, the participants were subjected to slow and gradual passive mobilization, sustained for 30 s at the point of discomfort reported by the subjects. During the PNF condition, the following procedure was adopted. The initial 5 seconds were intended to perform a maximal voluntary isometric contraction, and the final 25 seconds to static stretching. Immediately after the end of the stretching routine, the subjects did three successive series of bench press with predicted loads for 8-10 RM, with a 2-minute interval between series. In the CON condition, the subjects performed the same procedures, except for the stretching routine. No warm-up routines were applied, since they can be considered as confounding variables. Figure 1 illustrates the experimental procedures described above.

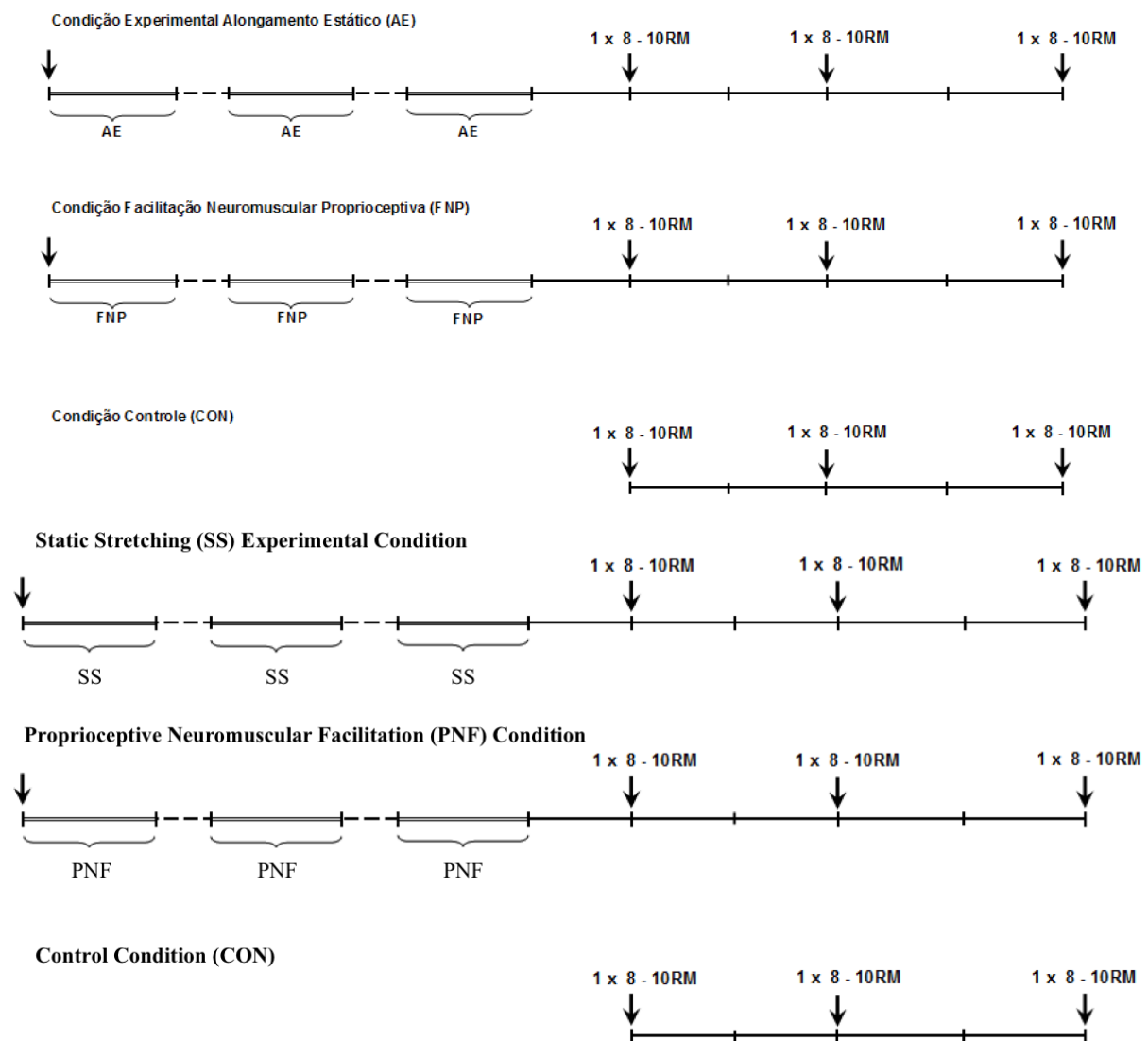


Figure 1. Study experimental design.

Source: The authors.

The participants were subjected to two stretching exercises for the pectoralis major and triceps brachii muscles. In the first, sitting on a bench, the participant maintained the abduction of the shoulders with lateral rotation, with a flexion of the elbows and the hands positioned in the occipital region. Then, the researcher carried out, slowly and gradually, the horizontal abduction movement of the shoulders (Figure 2A). In the second exercise, the participant maintained the elbow flexion with the abduction and lateral rotation of the shoulder, and the hand was directed to the contralateral scapular region. The investigator then performed the abduction of the shoulder to the limit point of discomfort reported by the subject (Figure 2B).

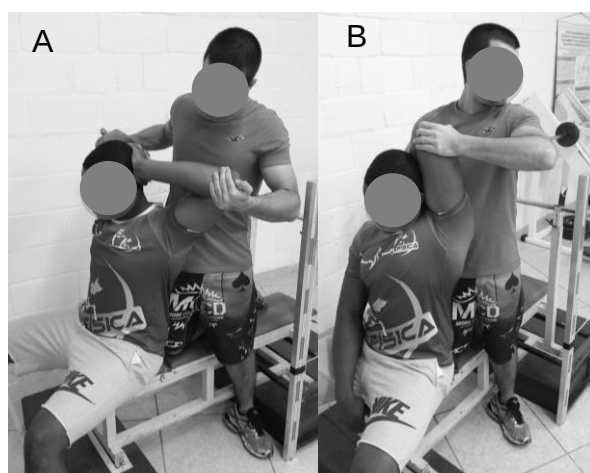


Figure 2. Stretching routines for Pectoralis Major (A) and Triceps Brachii(B).

Source: The authors.

Repetition maximum test

At the initial visit, the subjects indicated which load they believed was the one corresponding to the performance of 8-10 RM. If the load did not match the stipulated number of repetitions, new attempts were made by adjusting it to two pounds more or less. The attempts ended when the subject was able to complete the minimum number of eight and the maximum of 10 repetitions within the criteria pre-established by the researchers. A maximum of five attempts was made per visit to identify the load (kg). The interval between attempts was five minutes. At the two subsequent visits, the initial load for the test was that obtained at the previous visit.

Each individual was positioned on the weight bench in dorsal decubitus position, with knee and hip joints flexed, parallel lower limbs, and feet resting on the support provided by the equipment. The position of the hands was standardized according to the bar's first dividing lines. With the help of the researchers, the movement was started so that participants held the bar with their elbows fully extended, forming a perpendicular angle between the arm and the trunk (Figure 3A). The execution started by the eccentric phase, characterized by the flexion of the elbows to the 90° angle (Figure 3B). To maintain this alignment, two supports with adjustable height were used on each side of the equipment, connected by an elastic tube just below the participant's arm. At the touch of the arms on the elastic, the concentric phase of the exercise began immediately, being characterized by the extension of the elbow joint and its return to the position of full extension of the elbows (Figure 3C).



Figure 3. Position adopted on the weight bench in different phases of the exercise: initial position (A), eccentric phase (B) and concentric phase (C).

Source: The authors.

In order to encourage maximum performance during the tests, verbal stimuli were directed to the subjects in all series of exercises on the weight bench.

Statistical analysis

The descriptive analysis of the load and repetition variables were expressed as mean and standard deviation. The conceptual assumptions for the use of parametric statistical tests were tested. The presence of normal distribution was tested using the Shapiro-Wilk test.

The reliability of number of repetition and load (kg) measures in the 8-10 RM tests was verified through the intraclass correlation coefficient (ICC) with the pairs of number of repetitions and load measures between visits 2 and 3, thus resulting in the stability of the measures. In addition, the typical measurement error (TME) was calculated, which corresponds to the standard deviation of the differences obtained between the pairs of measures, divided by the square root of two^{29,30}. In order to verify the degree of agreement between these variables at visits 2 and 3, the Bland & Altman analysis³¹ was used.

To find possible differences between the experimental and control conditions for the number of repetitions, the Two-way ANOVA was employed. To verify possible differences in the total volume (sum of the product of the number of repetitions and loads in each of the series under each condition) between the conditions, a One-way ANOVA was applied. When significant differences were identified, the Bonferroni post hoc test was used.

For all statistical analyses, the SPSS software (17.0 for Windows®, IBM Corporation, New York, USA) was used. The results were considered statistically significant when $P \leq 0.05$.

Results

The reliability of the measures of all dependent variables of the present study was verified through the ICC, the TME and the Bland & Altman test. These values were: load ($R = 0.998$; $P = 0.01$; strong; TME 0.94 kg/0.01% and Bias = -1.34); repetitions ($R = 0.856$, $P = 0.05$, moderate; TME 0.6 kg/0.08% and Bias = 0.1). As it is possible to see, all measures presented a high degree of association and agreement, and low associated error value.

A Two-way ANOVA was performed to verify the condition/time interaction, which showed a significant difference only in the time factor ($P = 0.001$) for number of repetitions. There was no condition/time interaction ($P=0.449$) for total volume between conditions.

To identify in which series of the experimental and control conditions there was difference, a One-Way ANOVA was carried out. In the stretching conditions (SS and PNF), there was a significant decrease in the number of repetitions performed in the second ($P = 0.028$ and $P = 0.006$) and in the third ($P = 0.0001$ and $P = 0.002$) series in relation to the first one, respectively. There was also a significant drop in the third series ($P = 0.0001$ and $P = 0.007$) in comparison with the second one in the stretching conditions (SS and PNF). For the control condition, a significant decrease was observed only in the number of repetitions performed in the second ($P = 0.0001$) and in the third ($P = 0.002$) series in relation to the first one, but without difference between the second and the third series ($P = 0.249$) (Figure 4).

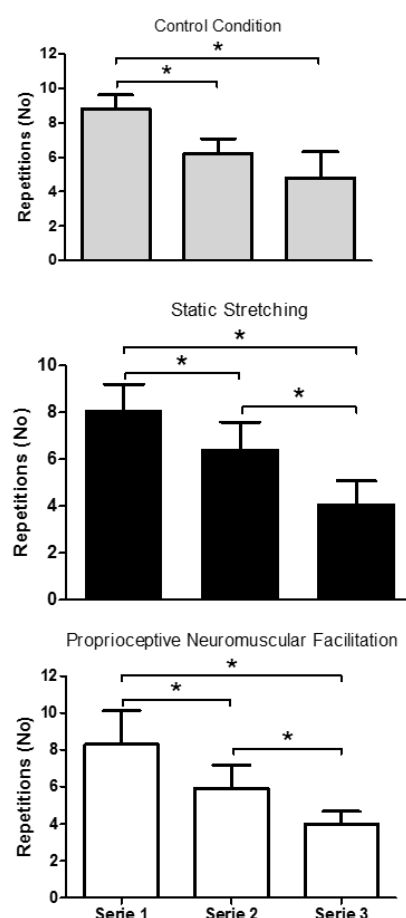


Figure 4. Comparison of the number of repetitions performed in each series for the three conditions, separately.

Source: The authors

There was significant difference in the total volume of the series only in the SS conditions ($P = 0.04$) and PNF ($P = 0.02$) between the first and the third series. There was no significant difference between the volume of the series in the control ($p = 0.07$).

No significant difference was observed between the number of repetitions or the total volume (load x repetitions) in the comparison between the three conditions. Figure 5 represents the number of repetitions performed by each subject for the two experimental and control conditions.

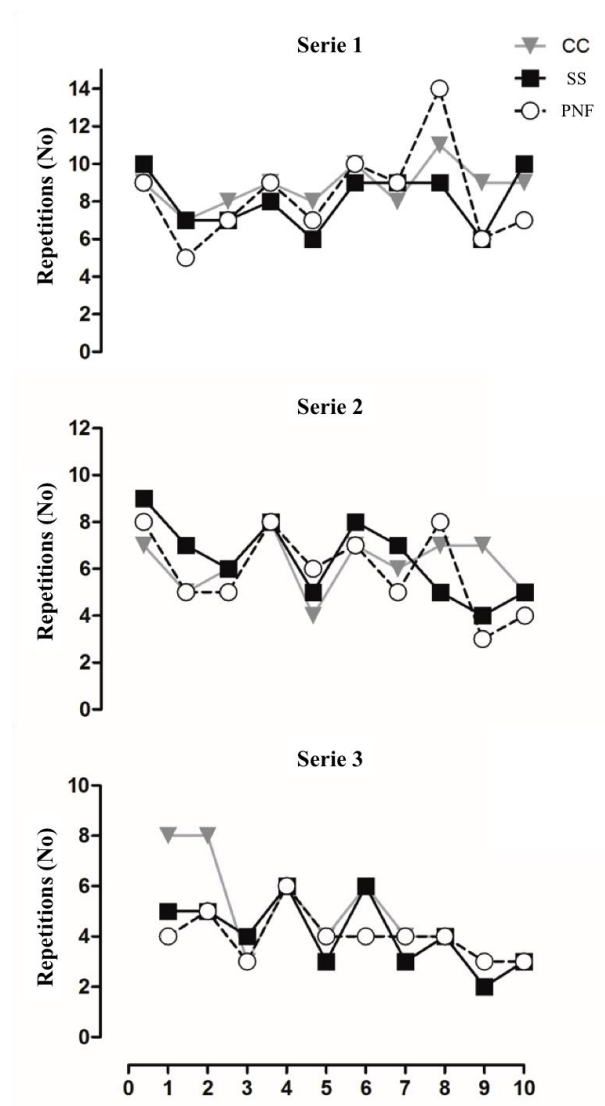


Figure 5. Comparison between the number of repetitions performed by each subject in each series in the three conditions investigated.

Source: The authors.

Discussion

The results of the present study indicate that different stretching methods performed prior to dynamic muscular actions do not affect significantly the production of strength in the upper limbs exerted in successive series when compared to the control group.

Many studies have reported a decline in strength performance after the use of different stretching methods (e.g. static and PNF). Generally, the deleterious effects of stretching on strength are linked to changes in the viscoelastic properties of the muscle-tendon unit, which promote a reduction in passive tension and stiffness³², and/or a reduction in muscle activation²², making the transfer of strength from the muscle to the tendon more difficult. In addition, autogenic inhibition and reciprocal inhibition reflex mechanisms are postulated hypotheses to explain the reduction in muscle contraction capacity, especially when PNF is used. However, Mitchell et al.²⁴ could not observe these mechanisms after PNF, and report

that, although the GTO can inhibit muscle contraction, its effects cease immediately after muscle relaxation following isometric contraction.

As far as we know, only three studies have verified the effect of different stretching methods (SS and PNF) on performance in the bench press exercise^{17,18,20}. Among those, only two used multiple series. In Franco et al.¹⁸, the authors found a significant drop in the maximum number of repetitions at 85% of 1-RM in three bench press series after the use of static stretching (1 x 40 s) and PNF methods. Besides, only the group that performed PNF had a decrease in total volume (product of number of repetitions per load in kg). In Gomes et al.¹⁷, in turn, only the group that performed PNF obtained a decrease in bench press performance at different intensities (40, 60 and 80% of 1-RM) compared to the control group. The results of both differ from those presented in the present study, in which no significant difference in performance was identified as to conditions with stretching in relation to the control. However, although the number of repetitions reduced similarly in the comparison between the series for the three conditions tested (SS, PNF and CC), only in conditions with stretching a decrease in the number of repetitions was observed, comparing the third and the second series. This fact indicates that, at least in the time main effect, the control condition showed better performance than the conditions with stretching did.

Most studies on this theme suggest that stretching exercises promote a decrease in strength performance. Recent reviews point to the influence of the amount of stretching employed, type of muscle performance measured (e.g. dynamic or static) and the subjects' training level^{14,33,34}. In general terms, it is known that stretching volume presents a dose-response effect²¹. Indeed, a recent review on the matter has shown a tendency to reduce the negative effects of stretching on strength when shorter routines are employed. Simic et al.¹⁴ reported that for routines with <45 s, the negative effect was 3.2% (trivial effect), and in volumes with >90 s, the decrease in performance was 6.1% (likely negative effect). It should be emphasized that these analyses refer to the studies that investigated maximum strength (1-RM), which is different from the one investigated in the present study.

Another factor that deserves attention is the type of contraction (isometric or dynamic) used in the strength test. Simic et al.¹⁴ reported significantly greater negative effects ($P = 0.012$) when isometric tests were used as a measure of strength. This fact can be explained by the change in the length/tension ratio (torque-angle) that static stretching promotes in the muscle-tendon unit³⁵. Since the reduced stiffness of the muscle-tendon unit and the increased resting length of the sarcomere after static stretching will require the muscle to operate at a greater length to exert the same level of tension before stretching³⁶ in isometric tests, the muscle would be operating at a shorter length after the stretching routine, which would prevent its best performance.

Corroborating this claim, some authors have reported a drop in strength performance after static stretching when the muscle is tested in an isometric way^{32,37}. Weir et al.³² subjected 15 women to 5 x 120 s of static stretching in the triceps surae muscle and found a 7% drop in maximal isometric strength (MIS) performance at 20° of dorsiflexion. However, when the dorsiflexion angle was adjusted to 26°, promoting an increase in length and greater tension in that muscle, no deleterious effects on MIS was found. Similarly, McHugh et al.³⁷ tested the MIS in the knee flexors of 10 men, at six different angles, before and after a 6 x 90 s static stretching routine, and reported a decrease in performance only for the positions in which the muscle was shorter in length, but a significant increase in strength with the muscle in a more elongated position. Moreover, some authors suggest that a more compliant muscle may be useful in the performance of exercises in which contraction time is prolonged and involve the elongation-shortening cycle (ESC), which would increase the capacity of the muscle-tendon unit to store elastic energy³⁸. This is corroborated by Molacek et al.²⁰, who

found no significant change in the performance of bench press after 40 or 150 s of static stretching. Because in the present study a dynamic test was applied, which involved prolonged contractions, these dynamic and ESC characteristics have possibly caused the possible negative effects on strength to be suppressed.

The debate about the influence of an individual's training level and its relationship with the deleterious effect of stretching on strength remains. Some authors have suggested that trained individuals or athletes are less susceptible to a decrease in strength performance after stretching exercises and that untrained subjects would be affected more^{33,39}. Nevertheless, Serra et al.¹⁶ verified the effect of three sets of 30 s of static stretching on maximal strength (1-RM) in different exercises in trained and untrained subjects and found similar declines in performance after stretching for both groups. In the present study, the participants were trained in counter-resistance exercise for over a year and all were very familiar with the bench press exercise. Since there is evidence that point, though with exceptions, training level as a factor that influences the effect of stretching on performance, it can be suggested that the training status of the participants in the present study is one of the factors responsible for the absence of deleterious effect on strength.

No significant interaction was observed between the three conditions tested, indicating that different stretching methods (static and PNF), with a 90-s volume per muscle group applied in trained individuals, are not likely to affect negatively strength performance in the bench press exercise.

However, when comparing the number of repetitions between the series separately by tested condition, only those that used stretching presented significant difference between the second and the third series. However, this difference was not observed for the control condition.

Conclusions

As a suggestion, further studies should investigate the effect of different stretching methods in successive series for different exercises, in addition to verifying whether a subject's training level stands as an intervening factor for the outcome.

References

1. Ford P, McChesney J. Duration of maintained hamstring ROM following termination of three stretching protocols. *J Sport Rehabil* 2007;16(1):18–27.
2. McHugh MP, Connolly DA, Eston RG, Kremenik IJ, Nicholas SJ, Gleim GW. The role of passive muscle stiffness in symptoms of exercise-induced muscle damage. *Am J Sports Med* 1999;27(5):594–599.
3. Apostolopoulos N, Metsios GS, Flouris AD, Koutedakis Y, Wyon MA. The relevance of stretch intensity and position—a systematic review. *Front Psychol* 2015;6:1128.
4. César EP, Souza DVBC, Santos TM, Gomes PSC. Efeito agudo de diferentes rotinas de alongamento estático sobre o salto com contramovimento. *Rev Educ Física UEM* 2015;26(2):279–288.
5. Beedle BB, Rytter SJ, Healy RC, Ward TR. Pretesting static and dynamic stretching does not affect maximal strength. *J Strength Cond Res* 2008;22(6):1838–1843.
6. Amiri-Khorasani M, Abu Osman NA, Yusof A. Acute effect of static and dynamic stretching on hip dynamic range of motion during instep kicking in professional soccer players. *J Strength Cond Res* 2011;25(6):1647–1652.
7. Odunaiya N, Hamzat T, Ajayi O. The effects of static stretch duration on the flexibility of hamstring muscles. *African J Biomed Res* 2005;8(2):79–82.
8. Bandy WD, Irion JM, Briggler M. The effect of time and frequency of static stretching on flexibility of the hamstring muscles. *Phys Ther* 1997;77(10):1090–1096.

9. Bandy WD, Irion JM, Briggler M. The effect of static stretch and dynamic range of motion training on the flexibility of the hamstring muscles. *J Orthop Sports Phys Ther* 1998;27(4):295-300.
10. Davis DS, Ashby PE, McCale KL, McQuain JA, Wine JM. The effectiveness of 3 stretching techniques on hamstring flexibility using consistent stretching parameters. *J Strength Cond Res* 2005;19(1):27-32.
11. Spennoga SG, Uhl TL, Arnold BL, Gansneder BM. Duration of Maintained Hamstring Flexibility after a One-Time, Modified Hold-Relax Stretching Protocol. *J Athl Train* 2001;36(1):44-48.
12. Small K, Mc Naughton L, Matthews M. A systematic review into the efficacy of static stretching as part of a warm-up for the prevention of exercise-related injury. *Res Sports Med* 2008;16(3):213-231.
13. McHugh MP, Cosgrave CH. To stretch or not to stretch: The role of stretching in injury prevention and performance. *Scand J Med Sci Sport* 2010;20(2):169-181.
14. Simic L, Sarabon N, Markovic G. Does pre-exercise static stretching inhibit maximal muscular performance? A meta-analytical review. *Scand J Med Sci Sport* 2013;23(2):131-148.
15. Leone DCPG, Pezarat P, Valamatos MJ, Fernandes O, Freitas S, Moraes AC. Upper body force production after a low-volume static and dynamic stretching. *Eur J Sport Sci* 2014;14(1):69-75.
16. Serra AJ, Silva JA, Marcolongo AA, Manchini MT, Oliveira JVA, Santos LFN, et al. Experience in Resistance Training Does Not Prevent Reduction in Muscle Strength Evoked by Passive Static Stretching. *J Strength Cond Res* 2013;27(8):2304-2308.
17. Gomes TM, Simão R, Marques MC, Costa PB, da Silva Novaes J. Acute effects of two different stretching methods on local muscular endurance performance. *J Strength Cond Res* 2011;25(3):745-752.
18. Franco BBL, Signorelli GRG, Trajano GS, Oliveira CG. Acute effects of different stretching exercises on muscular endurance. *J Strength Cond Res* 2008;22:1832-1837.
19. Ribeiro AS, Romanzini M, Dias DF, Ohara D, Pereira da Silva DR, Júnior AA, et al. Static Stretching and Performance in Multiple-Sets in the Bench Press Exercise. *J Strength Cond Res* 2013;28(4):1158-1163.
20. Molacek Z, Conley D, Evetovich T, Hinnerichs K, Hinnerichs. Effects of low- and high-volume stretching on bench press performance in collegiate football players. *J Strength Cond Res* 2010;24(3):711-6.
21. Ryan ED, Beck TW, Herda TJ, Hull HR, Hartman MJ, Stout JR, et al. Do practical durations of stretching alter muscle strength? A dose-response study. *Med Sci Sports Exerc* 2008;40(8):1529-1537.
22. Trajano GS, Seitz L, Nosaka K, Blazevich AJ. Contribution of central vs. peripheral factors to the force loss induced by passive stretch of the human plantar flexors. *J Appl Physiol* 2013;115(2):212-218.
23. Fowles JR, Sale DG, MacDougall JD. Reduced strength after passive stretch of the human plantarflexors. *J Appl Physiol* 2000;89(3):1179-1188.
24. Mitchell UH, Myrer JW, Hopkins JT, Hunter I, Feland JB, Hilton SC. Neurophysiological Reflex Mechanisms' Lack of Contribution to the Success of PNF Stretches. *J Sport Rehabil* 2009;18(3):343-357.
25. Tobalina JC, Calleja-González J, De Santos RM, Fernández-López JR, Arteaga-Ayarza A. The effect of basketball footwear on the vertical ground reaction force during the landing phase of drop jumps. *Rev Psicol del Deporte* 2013;22(1):179-182.
26. Clarkson PM, Thompson HS. *Drugs and Sport*. *Sport Med* 1997;24(6):366-384.
27. Cooper R, Naclerio F, Allgrove J, Jimenez A. Creatine supplementation with specific view to exercise/sports performance: an update. *J Int Societ Sport Nutr* 2012;20;9(1):33.
28. Campbell B, Kreider RB, Ziegenfuss T, La Bounty P, Roberts M, Burke D, et al. International Society of Sports Nutrition position stand: protein and exercise. *J Int Societ Sport Nutr* 2007;26(4):8.
29. Atkinson G, Nevill AM. Statistical methods for assessing measurement error (reliability) in variables relevant to sports medicine. *Sport Med* 1998;26(4):217-238.
30. Hopkins WG. Measures of reliability in sports medicine and science. *Sports Med*. 2000;30(1):1-15.
31. Martin Bland J, Altman D. Statistical Methods for Assessing Agreement Between Two Methods of Clinical Measurement. *Lancet* 1986;327(8476):307-310.
32. Weir DE, Tingley J, Elder GCB. Acute passive stretching alters the mechanical properties of human plantar flexors and the optimal angle for maximal voluntary contraction. *Eur J Appl Physiol* 2005;93(5-6):614-623.
33. Behm DG, Chaouachi A. A review of the acute effects of static and dynamic stretching on performance. *Eur J Appl Physiol* 2011;111(11):2633-2651.
34. Kay AD, Blazevich AJ. Effect of acute static stretch on maximal muscle performance: A systematic review. *Med Sci Sports Exerc* 2012;44(1):154-164.
35. Herda TJJ, Cramer TJJ, Ryan EED, McHugh MPM, Stout JJJ. Acute effects of static versus dynamic stretching on isometric peak torque, electromyography, and mechanomyography of the biceps femoris muscle. *J Strength Cond Res* 2008;22(3):809-817.
36. Nelson AG, Guillory ANK, Cornwell A, Kokkonen J. Inhibition of Maximal Voluntary Isokinetic. *J Strength Cond Res* 2001;15(2):241-246.
37. McHugh MP, Nesse M. Effect of stretching on strength loss and pain after eccentric exercise. *Med Sci Sports Exerc* 2008;40(3):566-573.

38. Bosco C, Tarkka I, Komi P V. Effect of elastic energy and myoelectrical potentiation of triceps surae during stretch-shortening cycle exercise. *Int J Sport Med* 1982;3(3):137-140.
39. Unick J, Kieffer HS, Cheesman W, Feeney A. The acute effects of static and ballistic stretching on vertical jump performance in trained women. *J Strength Cond Res* 2005;19(1):206-212.

Received on Sep, 18, 2016.

Reviewed on Nov, 04, 2016.

Accepted on Jan, 23, 2017.

Author address: Daniel Vieira Braña Côrtes de Souza. Rodovia MG 338, Km 12, Colônia Rodrigo Silva Barbacena - MG, CEP: 36201-143 BRAZIL - E-mail: danieldesouza@unipac.br