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Acute effect of different stretching methods on isometric muscle strength

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ABSTRACT. This study investigated the acute effect of static stretching methods (SS) and proprioceptive neuromuscular facilitation (PNF) on the static muscle strength (SMS). Eleven young male subjects with strength training experience, performed 3 tests with a 48h interval between them, randomly selected, where each one subject carried out all procedures: a) hand grip without stretching; b) hand grip preceded by static stretching of wrist flexors muscles; c) hand grip preceded by PNF stretching of wrist flexors muscles. The Shapiro-Wilk test verified the normality of data, and a one-way ANOVA with repeated measures, followed by Tukey's post hoc test, evaluated the differences between the groups. The significance was set at $p < 0.05$. Significant differences were detected between control and static stretching protocols (35.4±11.30 vs. 30.2±9.18 kg N^{-1}; $p < 0.05$). The same was observed between control and PNF stretching protocols (35.4±11.30 vs. 29.1±10.05 kg N^{-1}; $p < 0.01$). However, no statistical difference was found for static and FNP stretching protocols (30.2±9.18 vs. 29.1±10.05 kg N^{-1}; $p > 0.05$). In conclusion, both stretching methods had caused negative effects on isometric strength, reducing its levels.

Keywords: muscle stretching exercises, muscle strength dynamometer and hand.

Efeito agudo de diferentes métodos de alongamento sobre a força muscular isométrica

RESUMO. O presente estudo objetivou investigar o efeito agudo dos métodos de alongamento estático (AE) e facilitação neuromuscular proprioceptiva (FNP) sobre a força muscular estática (FME). Foram realizados, em 11 homens jovens com experiência prévia em treinamento de força, três testes com intervalo de 48h entre a aplicação dos mesmos, selecionados aleatoriamente, fazendo com que cada sujeito realizasse todas as técnicas, em rodízio: a) teste de preensão manual sem alongamento; b) teste de preensão manual precedido por alongamento estático dos músculos flexores de punho; c) teste de preensão manual precedido por FNP dos músculos flexores de punho. O teste de *Shapiro-Wilk* foi realizado para avaliar a normalidade dos dados e a *one-way* Anova com medida repetida, seguida por *post-hoc* de Tukey para análise das diferenças entre grupos. A significância adotada foi alpha $p < 0,05$. Conforme os resultados, entre os protocolos SA e AE, foram encontradas diferenças significativas na produção de força isométrica (35,4±11,30 vs. 30,2±9,18 kg N^{-1}; $p < 0,05$). Entre SA e FNP, também foram encontradas diferenças significativas (35,4±11,30 vs. 29,1±10,05 kg N^{-1}; $p < 0,001$). Todavia, diferenças significativas não foram observadas entre AE e FNP (30,2±9,18 vs. 29,1±10,05 kg N^{-1}; $p > 0,05$). Os métodos de AE e FNP provocam efeito agudo sobre a FME reduzindo os níveis desta capacidade física.

Palavras-chave: exercícios de alongamento muscular, dinamômetro de força muscular e força da mão.

Introduction

Throughout history, several myths and non-scientific postulates on the activities involving stretching, especially its application before, during warm-up or cool down as a contributing factor for physical performance and reduced risks of injury (JAMTVEDT et al., 2010; SEKIR et al., 2010). However, this hypothesis seems to be controversial since recent publications question the conventional use of pre-exercise stretching (CRAMER et al., 2004; RUBINI et al., 2007). In addition to the prophylactic capacity discussed (COSTA et al., 2013; GLEIM; MCHUGH, 1997; THACKER et al., 2004), the argument of improving the performance also supports its practice. Although some studies have not found a relationship between this type of sport and drop in physical performance

(BRADLEY et al., 2007; CHRISTENSEN; NORDSTROM, 2008), there are others that demonstrated that its use before exercising appears to bring negative impacts on the performance, especially when the activity requires high demand for production of muscle strength (COSTA e SILVA et al., 2012; CRAMER et al., 2004; FOWLES et al., 2000; NELSON et al., 2005; SHRIER, 1999; RUBINI et al., 2007; WINCHESTER et al., 2009).

The physical strength is one of the major components of fitness and health and can be evaluated by different protocols (ACSM, 2009; ACSM, 2011) and in diverse body segments. In this way, activities involving the handling of objects require a great development of strength of flexor and extensor muscles of the wrist joint (KUH et al., 2005). For representation, regarding the test, measure and evaluation, the handgrip is a parameter easily obtained, because it uses simple resources, without considerable cost and has a good predictive ability, besides viability for selection in programs and researches on physical and sporting activities (VISNAPUU; JURIMAE, 2007).

As for the relationship between stretching and isometric strength, few studies had evaluated the acute effect on small muscle groups (COSTA E SILVA et al., 2012; CARDOZO et al., 2006; KNUDSON; NOFFAL, 2005), because most researches on healthy populations had used large muscle groups (BEHM et al., 2006; GOMES et al.; 2011; MAREK et al., 2005; NELSON et al., 2005; OGURA et al., 2007; UNICK et al., 2005; YAMAGUCHI et al., 2006). Knudson and Noffal (2005) reported that despite the negative effects found in their study, and those already described in literature, the static stretching method for convention and easy application, seems to be the most spread in fitness centers and sporting environments in general (BEHM et al., 2006; BRADLEY et al., 2007; MAREK et al., 2005; NELSON et al., 2005; OGURA et al., 2007; VOIGT et al., 2011). Nevertheless, the proprioceptive neuromuscular facilitation (PNF) is also frequently included in heating prior to several physical and sporting activities

Knowledge gaps are observed between comparisons of different methods for stretching wrist flexors (static vs. PNF) and their impact on isometric strength, as well as with individuals with strength training experience. Thus, the present study aimed to investigate the acute effect of static stretching method (SS) and proprioceptive neuromuscular facilitation (PNF) on the static muscle strength (SMS).

Material and methods

Sample

Male subjects (N = 11) with strength training experience and similar physical characteristics (Table 1) have accepted to take part of this research by signing the Consent Form, according to the Resolution 196/96 of the National Health Council. The research project was approved by the Research Ethics Committee of the Federal Rural University of Rio de Janeiro (protocol # 006771). The following inclusion criteria were used: strength training experience (for at least 2 years); physically active; aged between 18 and 30 years; without clinical problems, tested and released by medical record; and exclusion criteria were: limitation or injury to strength work; history of upper limb injuries; hyper- or hypomobility; smoking habit.

Table 1. Descriptive analysis of anthropometric characteristics of the sample.

Variable	Mean ±SE	Min-Max	CI (Low-Up)	CV (%)
Age (years)	22.5±2.20	20-27	20.97-23.93	9.83
Weight (kg)	73.4±2.53	70-78	71.74-75.14	3.45
Height (cm)	175±5.21	166-184	171.76-178.77	2.98
BMI	23.9±1.08	22.4-25.9	23.20-24.66	4.54

SD=standard deviation; IC= confidence interval; (Low-Up)= lower and upper endpoints; CV= coefficient of variation; BMI=body mass índex.

Procedure

Four visits were conducted on nonconsecutive days, always by the morning around 8:00 am at the Laboratory of Exercise Physiology and Human Performance of the Rural Federal University of Rio de Janeiro (LFDH/UFRRJ). Before the tests, data of relative humidity, room temperature and body temperature of the subjects were noted. On the first visit, the subjects signed the Consent Form, and were submitted to anthropometric assessment of body mass, height, and body mass index (BMI). The height was taken with participants standing barefoot on a stadiometer (*Sanny*, 0.1 cm, Brazil). The body weight was measured with a digital scale (*Plenna*, 0.1 kg, USA). The BMI was calculated by the equation: body weight height^{-2}. It was also conducted a familiarization with the maximal isometric strength test using a hand grip (*Jamar* 5030JI, USA). The body temperature was measured by a forehead digital thermometer (*Microlife* MIT-FR1DMI, USA). From the second to the fourth visit the sample (n = 11) was submitted to three experimental protocols, randomly selected: a) maximal isometric strength test without stretching (WS); b) maximal isometric strength test preceded by static stretching of wrist flexor muscles (SS); c) maximal isometric strength test preceded by PNF of wrist flexor muscles (PNF). The protocol intervals were 48 hours.

Hand grip test

The handling of isometric dynamometer for hand grip (*Jamar* 5030JI, USA) was performed with the dominant hand and the arm should be extended along the body in a neutral position (pronation/supination) according to Knudson and Nofall (2005). Values were obtained after performing a maximal handgrip.

Static stretching protocol

The protocol SS consisted of a single series of 30 seconds of static stretching for wrist flexor muscles, with a range motion to the point of discomfort. The stretching was performed passively and the position adopted consisted of shoulder flexion at 90º and elbow extension with hand in prone position.

PNF Stretching Protocol

The stretching protocol for the PNF method was performed using the technique *Scientific Stretching for Sports* (SSS). Volunteers had stretched the wrist flexor muscles up to the range of motion to promote discomfort, and kept for 10 seconds. Afterwards they were requested to perform an isometric contraction of muscles against the resistance promoted by the evaluator. After 10 seconds of contraction, subjects have relaxed the muscles, when the evaluator undertaken a passive stretching for 10 seconds. This described protocol has in total 30 seconds of duration.

Statistical analysis

The statistical analysis was carried out using the software *Graph Pad Prisma* 5.0 for Windows. The Shapiro-Wilk test was performed to evaluate the normality of the quantitative data, assumption met for all variables, suggesting the use of the parametric one-way ANOVA (WS x SS x PNF) followed by a Tukey's post hoc test for analyzing differences between groups to determine the treatment effects on the dependent variable (maximal handgrip strength). The calculation of changes in the SMS after experimental treatments was carried out through the effect size (difference between the experimental and control mean values, divided by the control standard-deviation), proposed by Rhea (2004). The significance level adopted was $p < 0.05$.

Results

The Table 2 lists the values of body temperature of participants between the different visit days.

In the Table 3 is presented the behavior of environmental variables during the visits.

Table 2. Behavior of body temperature during the experimental days.

	Mean ±SD	Min-Max	CI (Low-Up)	CV (%)	
Body temperature (°C)					
1st visit	35.2±0.29	34.6-35.7	35.0-35.3	0.84	
2nd visit	35.1±0.40	34.1-35.5	34.7-35.3	1.17	p=0.15
3rd visit	35.3±0.31	34.9-35.9	35.1-35.5	0.89	

SD=standard deviation; CI= confidence interval; (Low-Up)=lower and upper endpoints; CV= coefficient of variation; BMI=body mass index; The value of *p* indicates no significant differences between experimental days.

Table 3. Behavior of environmental variables during the experimental days.

	1st visit	2nd visit	3rd visit	Mean±SD
Environmental conditions				
RT (°C)	25.5	23.9	24.4	24.6±0.82
RU (%)	55.6	62.6	48.9	55.7±6.85

RT= room temperature; RH= relative humidity; SD=standard deviation.

Significant differences were detected between the protocols WS and SS ($p < 0.05$) in the production of isometric strength (35.4±11.30 vs. 30.2±9.18 kg N^{-1}). Between the WS and PNF statistical differences were also verified ($p < 0.001$) (35.4±11.30 vs. 29.1±10.05 kg N^{-1}). However, there was no significant difference ($p > 0.05$) between SS and PNF (30.2±9.18 vs. 29.1±10.05 kg N^{-1}) (Figure 1).

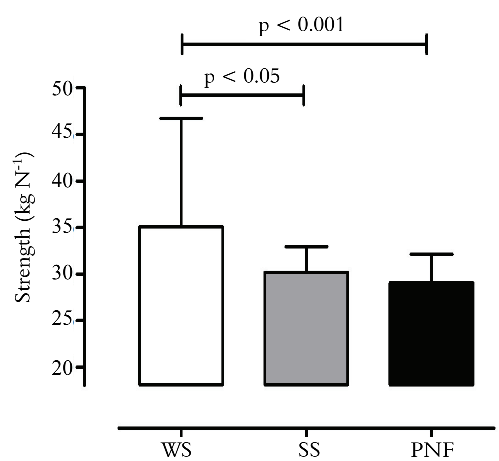

Figure 1. Isometric strength in kg N^{-1} in the maximal handgrip test preceded by different muscle stretching methods. Lines above the bars are the difference between the groups and the values indicate the significance level obtained.

Between the protocols WS vs. SS, the size effect (0.46) demonstrated a small magnitude of change of the SMS. Between the protocols WS vs. PNF, the size effect (0.55) also indicated a small magnitude. Nevertheless, between the protocols SS vs. FNP, the size effect (0.11) pointed out a slight magnitude (Table 4).

Table 4. Effect size and magnitude of change in the static muscle strength between experimental protocols.

	WS vs. SS	WS vs. PNF	SS vs. PNF
Effect size	0.46	0.55	0.11
Magnitude	Small	Small	Slight

WS=without stretching; SS=static stretching; PNF=proprioceptive neuromuscular facilitation.

Discussion

The present study verified the acute effect of different stretching methods (Static Stretching and Proprioceptive Neuromuscular Facilitation) on the production of static muscle strength in kg N^{-1}. As demonstrated in the Figure 1, the results evidenced that the use of stretching for 30 seconds, by both methods, is able to significantly reduce the levels of isometric strength.

Brasileiro et al. (2007) and Perrier et al. (2011) suggested that the flexibility behavior can be influenced by temperature. Thus, the homogeneity of body temperature and environmental conditions between the performance of tests (Tables 2 and 3) has reduced the influence of temperature on flexibility response. The results evidenced that only a stretching series with duration of 30 seconds (SS and PNF) was enough to cause loss in the production of isometric strength. Mean values in the hand grip test were significantly lower when compared with the hand grip test without previous stretching. Costa e Silva et al. (2012) in study with a similar methodological design, verified that the SS acute effects were detrimental to the isometric strength production. Knudson and Nofall (2005) investigated the effect SS on the isometric strength in the hand grip test in 57 young of both sexes, after a linear regression, there was a drop in the log function of 88.8% when tests were performed after 10 series of 10 seconds stretching. In this way, the present study besides corroborating those found by Knudson and Nofall (2005) concerning the use of SS before exercising, also suggested that the stretching by PNF may also generate a significant decrease in the production of isometric strength.

On the other hand, Cardozo et al. (2006) registered no significant loss in the production of isometric strength by up to 90 minutes after three series of SS for wrist flexors in strength training apprentices, with 10 seconds duration each and six seconds interval between them. The authors observed only a downward trend of strength after stretching and assumed that possibly this reduction was not significant ($p = 0.06$) due to the small sample size ($n = 9$).

Studies have shown that different methods and duration of muscle stretching may lead to an acute loss of strength (CRAMER et al., 2004; FOWLES et al., 2000; NELSON et al., 2005, RUBINI et al., 2007; WINCHESTER et al., 2009). This loss may occur owing the changes in viscoelastic properties of the muscle-tendon units, which can generate a reduced passive tension (KUBO et al., 2001; WILSON et al., 1994) and/or decrease in muscle activation (FOWLES et al., 2000). According to our experiment, only 30 seconds stretching by SS and PNF methods were able to reduce the sensitivity of proprioceptors of the muscle, tendon and joint, as also of nociceptors, which are essential mechanisms for protection and organization of structures involved in the human movement (AVELA et al., 1999). However, the proprioceptive responses of muscles and tendons and the activation and passive tension of the muscle, above mentioned, can be only speculated since they were not evaluated in the present study.

This study differs from others in literature considering the size of stretched muscle. Most studies that verified the acute effect of SS on the strength was performed in large muscle groups (GOMES et al., 2011; MCBRIDGE et al., 2007; OGURA et al., 2007;). Ogura et al. (2007) found a drop in performance after stretching for quadriceps and hamstrings muscles in ten male professional soccer players. McBride et al. (2007) also suggested that SS of quadriceps may bring significant reductions in maximum voluntary contraction of knee extensors for moderately active subjects. Gomes et al. (2011) verified that the SS for pectoral muscles may cause a significant loss of strength performance of young men (23.9±4.3 years) with experience in strength training ($n = 15$). Thus, probably the supposed neurophysiological changes related to the length-tension generated by acute stretching (SHRIER, 2004) can occur independent from characteristics of individuals and of size of the stretched muscle. These responses were demonstrated in the present study.

The present data evidenced a negative effect of pre-exercise stretching by static and PNF methods for healthy young subjects with experience in strength training. Cramer et al. (2004) observed that the SS was able to decrease the strength production in a study with a sample made up by 14 moderately active women. The authors used isokinetic dynamometry and found 3.3% loss in the torque peak after quadriceps stretching at 60° s^{-1} and of 2.6% at 240 s^{-1}. Marek et al. (2005) stated that stretching by PNF and static methods led to a reduction in maximal strength (2.8%) in both sexes (10 women and 9 men). Therefore, despite the direct influence of sex on the flexibility (ARAÚJO, 2008), the possible mechanisms stimulated by stretching, seem to occur similarly in men and women. In this way, it can be speculated that the physiological responses found herein may be similar in women.

According to Fowles et al. (2000), counterproductive effects of stretching can remain for up to one hour. Nevertheless, it was used stretching for above normally recommended (13 stretching sessions of 135 seconds), unlike the present study where it was used only one series of

30 seconds for SS and PNF. The ACSM (2011) recommends for flexibility training, the use of 2-4 series of static stretching with support of 10-30 seconds, under the joint amplitude of muscle discomfort, making a total of 60 seconds, and/or 10-30 seconds of insistence by the PNF method. In our study, despite the only 30 seconds of stretching in both methods, a significant loss of performance was observed in strength after stretching. In this context, in relation to the electrical activity of the muscle, not only large volumes of stretching would enable to reduce the activation of motor units. The possible reduced strength after stretching at different insistence times can be partially explained by an autogenic inhibition generated by the stretching owed the activation of Golgi tendon organs (CHALMERS, 2004) which may cause a decrease in the excitability of α-motoneurons (FOWLES et al., 2000).

Sharman et al. (2006) and Funk et al. (2003) examined the gain in flexibility after using different stretching methods and have suggested the PNF as the most effective to increase the range of motion when compared with the SS. The justifications of autogenic inhibition and reciprocal inhibition are well accepted to justify such efficiency (CHALMERS, 2004). The autogenic inhibition refers to a reduced contractile excitability of the stretched muscle, partially ascribed to an inhibition caused by Golgi tendon organs (CHALMERS, 2004). Likewise, through reciprocal inhibition, a voluntary contraction of the antagonist muscle may reduce the levels of strength of the agonist muscle (SHARMAN et al., 2006). Meanwhile, in the present study, no statistical difference could be detected between the methods (SS vs. PNF). The effect size has indicated a small magnitude (Table 4) between SS and PNF protocols, in comparison to WS. But when compared the SS and PNF, this magnitude was only slight (Table 4). Thus, 30 seconds of SS can produce similar effects for isometric strength when compared with PNF, and although the effects had been very small between the different stretching protocols and the control, they were significant on the performance.

Finally our results emphasized that variables as control of hormone levels, sleep, and diet can influence to some extent the results analysis, becoming for lack of control during the study, limiting factors for inferences (SUGANO et al., 2000).

Conclusion

The study based on the sample allowed concluding that SS and PNF methods cause an acute effect on the static muscle strength of muscles involved in the hand grip test, by reducing the levels of this physical ability. Therefore muscle stretching exercises, both by SS and PNF, should not be recommended before activities, especially those that require repetitive vigorous grips, such as the action of hammering, climbing, playing tennis or manipulate objects.

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