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The Influence of Active Warming up, with or without Static Stretching, on Muscular Strength in Brazilian Militaries*

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La influencia del calentamiento activo, con o sin estiramiento estático, sobre la fuerza muscular en militares brasileños

L'influence de réchauffement actif, avec ou sans étirement statique, sur la force musculaire des militaires brésiliens

A Influência do aquecimento ativo, com e sem alongamento estático, na força muscular de militares brasileiros

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Abstract. The aim of this study was to compare the influence of active warm-up with or without static stretching on torque values generated in equipment isokinetic to knee joint. It was a cross-section study, comparative, which evaluated the maximum strength of knee extensors and flexors on an isokinetic dynamometer at the speed of 60°/s. Twelve (12) military were evaluated, all sex male, with average age group of 25 years old ±2.5; in relation to a body mass and stature, the average values and standard deviation were 75 ± 7.5 Kg e 1.71 ± 0.1 m. Significant differences were observed on peak torque values of the knee extensors (p=0.034), knee flexors (p=0.028) and maximum peak torque values of knee flexors (p=0.034) between the tests preceded by warm-up with static stretching and the ones preceded by warm-up without stretching. There was no significant difference to maximum peak torque values of knee extensors (p=0.071). It can be understood that the active warm-up with static stretching before the maximum strength test on the isokinetic (60°/s) promotes an increasing on peak torque values of knee extensors and flexors as much as in the average values as in the maximum ones, in absolute terms, although the maximum peak torque of the extensors have not exhibited significant differences.

Keywords: knee extensors; knee flexors; maximum peak torque; strength test; warm-up.

Resumen. La propuesta de este estudio fue comparar la influencia del calentamiento activo con y sin estiramiento estático en los valores de torque generados en el equipo isocinético para la articulación de la rodilla. Se trata de un estudio transversal, comparativo, que evaluó la fuerza máxima de los extensores y flexores de la rodilla en un dinamómetro isocinético a la velocidad de 60°/s. Se evaluaron doce militares, todos del sexo masculino, con una edad media de 25 ± 2,5 años. En relación con la masa corporal y la estatura, los valores de la media y la desviación estándar fueron: 75±7,5 kg y 1,71±0,1 m. Se observaron diferencias significativas en los valores del pico medio de par de los extensores de la rodilla (p=0,034), flexores de la rodilla (p=0,028) y valores del pico máximo de torque de los flexores de la rodilla (p=0,034) entre las pruebas precedidas de calentamiento con estiramiento estático y aquellas precedidas de calentamiento sin estiramiento. No hubo diferencia significativa en los valores del pico máximo de torque de los extensores de la rodilla (p=0,071). Se puede concluir que el calentamiento activo con estiramiento estático antes de la prueba de fuerza máxima en el isocinético (60º/s) promueve un aumento en los valores del pico de torque de los extensores y flexores de la rodilla tanto en los valores medios como máximos, en términos absolutos, aunque el pico de par máximo de los extensores no haya presentado diferencias significativas.

Palabras clave: calentamiento; estiramiento estático; extensores de rodilla; flexores de rodilla; pico de torque; prueba de fuerza máxima.

Résumé. L'objectif de cette étude était de comparer l'influence de chauffage actif avec et sans étirement statique les valeurs de couple générées équipement isocinétique pour articulation du genou. Cette étude comparative a été une transversale, qui a évalué la puissance maximale des fléchisseurs et extenseurs du genou sur un dynamomètre isocinétique à 60°/s. Nous avons évalué 12 soldats, tous des hommes, d'âge moyen 25±2,5ans; poids corporel relatif et de la hauteur, les valeurs moyennes et d'écart type était de 75±7,5kg et 1,71±0,1m. Il y avait des différences significatives dans les valeurs de couple maximales moyennes de extenseurs du genou (p=0,034), fléchisseurs du genou (p=0,028) et les valeurs de couple maximal des fléchisseurs du genou (p=0,034) entre les tests précédée par chauffage avec étirage statique et ceux précédés par chauffage sans étirement. Il n'y avait pas de différence significative dans les valeurs du couple de pointe maximale des extenseurs du genou (p=0,071). On peut conclure que le chauffage actif avec étirement statique avant le test de force maximale dans le isocinétique (60°/s) favorise une augmentation de couple de pointe de extenseurs des genoux et des fléchisseurs dans les deux valeurs moyennes comme un maximum, en termes absolue, bien que le couple de pointe maximum de la extenseurs ne présentait pas de différences significatives.

Mots-clés: chauffage; couple de pointe; essai de résistance maximale; étirage statique; extenseurs du genou; fléchisseurs des genoux.

Resumo. A proposta deste estudo foi comparar a influência do aquecimento ativo com e sem alongamento estático nos valores de torque gerados equipamento isocinético para a articulação do joelho. Trata-se de um estudo transversal, comparativo, que avaliou a força máxima dos extensores e flexores do joelho em um dinamômetro isocinético na velocidade de 60°/s. Foram avaliados 12 militares, todos do sexo masculino, com idade média de 25±2,5 anos; em relação a massa corporal e estatura os valores da média e desvio padrão foram: 75±7,5Kg e 1,71±0,1m. Foram observadas diferenças significativas nos valores do pico médio de torque dos extensores do joelho (p=0,034), flexores do joelho (p=0,028) e valores do pico máximo de torque dos flexores do joelho (p=0,034) entre os testes precedidos de aquecimento com alongamento estático e aqueles precedidos de aquecimento sem alongamento. Não houve diferença significativa para os valores do pico máximo de torque dos extensores do joelho (p=0,071). Pode-se concluir que o aquecimento ativo com alongamento estático antes do teste de força máxima no isocinético (60º/s) promove um aumento nos valores do pico de torque dos extensores e flexores do joelho tanto nos valores médios quanto máximos, em termos absolutos, embora o pico de torque máximo dos extensores não tenha apresentado diferenças significativas.

Palavras chave: alongamento estático; aquecimento; extensores de joelho; flexores de joelho; pico de torque; teste de força máximo.

Introduction

Physical fitness is, by definition, the set of attributes and characteristics that people have or develop by the regular practice of physical activity or exercise. These characteristics have an important connection with physical fitness components, such as cardiorespiratory capacity, body composition and muscular fitness, preventing diseases and promoting life quality (American College of Sports Medicine [ACSM], 2013).

The developing of muscular fitness focusing on the promotion of health, can enhance bone mass, musculotendinous integrity and the incapacity to execute everyday activities among others (ACSM, 2013; Kraemer, Fleck & Deschenes, 2012). Tests to evaluate the muscular fitness are necessary in the beginning of the treatment period or in screening evaluation. The computerized isokinetic dynamometer has been largely applied in several studies (Dias et al., 2004; Rothstein, Lamb, & Mayhew, 1987; Sole, Hamrén, Milosavljevic, Nicholson, & Sullivan, 2007), because of its capacity to measure, in a quantitative way, the physical parameters of muscular function in different joints.

When performing physical exercise, such as the maximum muscular strength test, there is a branch that recommends the performance of active warm-up (AW) which is composed by general warm-up, stretching and specific warm-up related to the sport or task to be done (Brown, et al., 2003; Kraemer et al., 2012). This structure of AW allows a safer practice to achieve the goal of preparing the individual to the physiological efficiency stage similar to the main work of the training session (Bompa, de Oliveira, & Franciscon, 2002). On the other hand, there are authors who suppress stretching exercises on AW, before de performance of exercises of potency and strength.

Reinforcing the variety of conceptions in relation to the structure of the AW and recommendations, there are studies that already tested the muscular strength using different stretching methods such as warm-up, causing performance drops on maximum strength (Brentano, Rodrigues, & Kruel, 2008; Endlich et al., 2009; Tricoli & Paulo, 2012). Other studies did not find any significant difference in maximum strength when performing the warm-up along with static stretching (de Albuquerque, Maschio, Gruber, de Souza, & Hernandez, 2011; Simão, Giacomini, Dornelles, Marramom, & Viveiros, 2003).

Inside this context, with diversity of conceptions and results, it can be perceived the lack of study comparing the influence of static stretching on WA structure before the muscular strength test, mainly in a isokinetic dynamometer or weight training equipment (Kraemer et al., 2012). In this sense, this study aimed to compare the influence of active warm-up with and without static stretching on torque values generated in isokinetic equipment to keen joint.

Methodology

This is a cross-sectional and comparative study that evaluated the maximum strength of knee extensors and flexors on an isokinetic dynamometer at the speed of 60°/s. Twelve (12) militaries from Brazilian Army were selected by convenience. The following criteria were considered: 12 months of minimum experience performing strength training and age between 20 and 30. As exclusion criteria were considered: previous history of joint, bone or muscle injury on lower members and missing any of the scheduled testing.

This study was approved by the Ethical Committee in Research according to CAAE: 55948016.1.0000.5289. All participants signed an informed consent term.

Experimental Procedures

The participants were assigned into one group and performed the testes in a "cross-over" format. To do that, it was necessary to attend the laboratory in three distinct moments (M1, M2 and M3), according to shown in figure 1. M1 had the goal to measure the height and body mass. In M2, the subjects performed the warm-up composed by: general warm-up, active static stretching and specific stretching before the maximum strength on the isokinetic. The time kept among the experimental moments was set to avoid the possibility of the carry-over effect between the moment two and three (ACSM, 2013; Kraemer, Fleck & Deschenes, 2012).

The general warm-up was composed by a light 05 minutes running, knee elevation and heel elevation. To the static stretching, tow series of 20 seconds were performed on the following muscle groups: knee flexors and extensors, adductors, glutes and sural triceps. The specific warming-up was held on the same Biodex©, through isokinetic protocol with concentric contractions (CON/CON), performing 10 repetitions on the extension and flexion of the knees identical to the test, but with mild intensity.

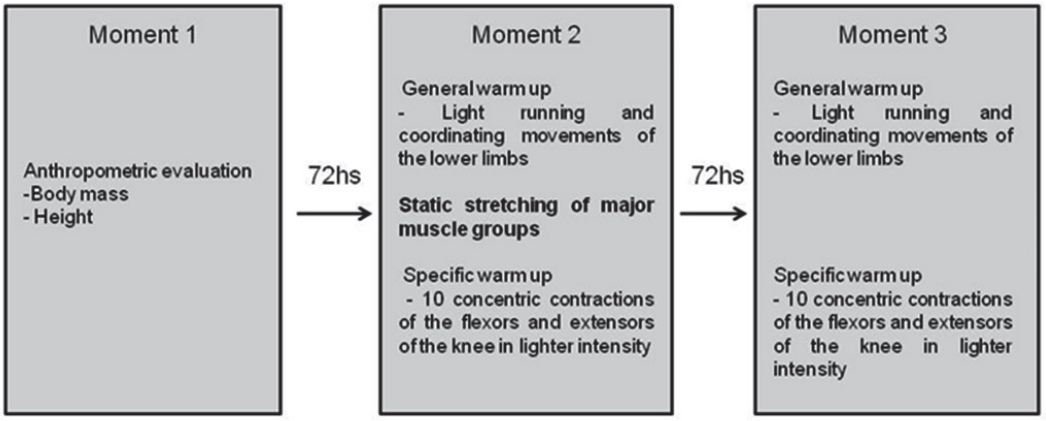

Figure 1. Flowchart with the moments in which the evaluations were performed.
Source: prepared by the authors.

On M3 was performed the warm-up consisting of the same form of the procedures realized on M2 without the static active stretching before the maximum strength test on the isokinetic dynamometer Biodex©, as it can be seen in figure 2.

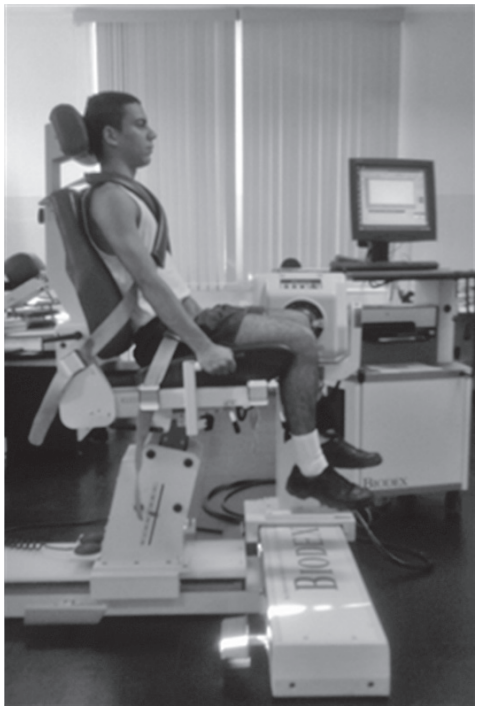

Figure 2. Volunteer positioned to the knee test on the isokinetic dynamometer Biodex®
Source: prepared by the authors.

To evaluate the maximum strength, the CON/CON protocol with 60°/s of speed was used. The participants of the sample, properly dressed, were accommodated according to proper positioning to the evaluation of each joint in sitting position. Volunteers performed three series of five repetitions with ninety seconds of recovering between repetitions and three minutes between the series (Sole et al., 2007; Terreri, Greve, & Amatuzzi, 2001).

During the whole evaluation, the volunteers received verbal incentive from the examiners to perform the greatest force possible. On the end of each test, the gathered data were recorded and stored in the equipment's computer for later analysis.

Instruments and Equipment

To the anthropometric assessment, a digital scale P200M from a leading brand was used, with capacity up to 200 kg, the stadiometer of SANNY brand, ES-2060 model, with measurement capability from 115 to 210 centimeters and tolerance of ± 2 mm. To measure the parameters of muscle function was used a digital dynamometer Biodex System 4 Pro (Biodex Medical System, Shirley, NY, USA) (figure 2). The participants did not have any recent history of joint, bone or muscle injury on lower members.

Statistical Analysis

In this study, the normality test (Shapiro-Wilk) was applied to guide the statistical analysis. Therefore, the data did not show normal behavior ($p \leq 0.05$). The nonparametric test Wilcoxon Signed Ranks Test was used to verify the profile of maximum and average Peak Torque variables of the knee extensors and flexors on the active warm-up structure with and without static stretching. It was used the $p \leq 0.05$.

Results

Significant differences were observed ($p=0.034$) on average peak torque values for: extension movement, when preceded by warming-up with stretching (267 ± 40.52 N·m) and when the warming-up did not include a stretching phase (240.78 ± 46.80 N·m); and for the flexion movement ($p=0.028$) preceded by warming-up with stretching (166.67 ± 44.02 N·m) and the warming-up did not include a stretching phase (147.71 ± 28.64 N·m). In both cases, it was observed higher values for the test preceded by warm-up with static stretching, as outlined in figure 3.

Analyzing the maximum peak torque values, it was not observed significant statistical differences ($p=0.071$) in knee extension when preceded by warm-up with stretching (274.60 ± 42.56 N·m) and when warm-up did not include stretching phase (255.04 ± 50.18 N·m). On the other hand, on flexion movement, the maximum peak torque values came out significantly higher ($p=0.034$) when the test was preceded by warm-up with stretching (172.46 ± 46.11 N·m) than when warm-up did not include stretching phase (154.35 ± 30.07 N·m), as shown in figure 4.

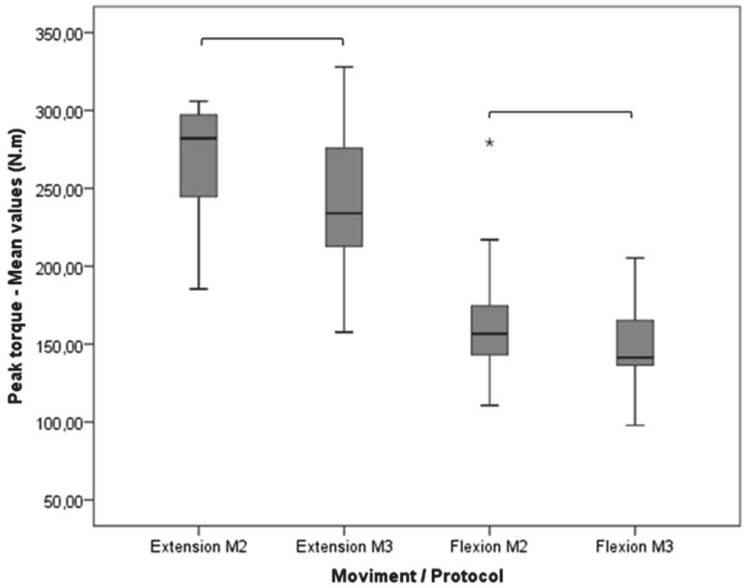

Figure 3. Means values of peak torque (05 repetitions maximum) in extension and flexion preceded by warm-up with static stretching (Extension M2 / Flexion M2) and when the warm-up did not include the phase of the static stretching (Extension M3 / Flexion M3).
Source: prepared by the authors.

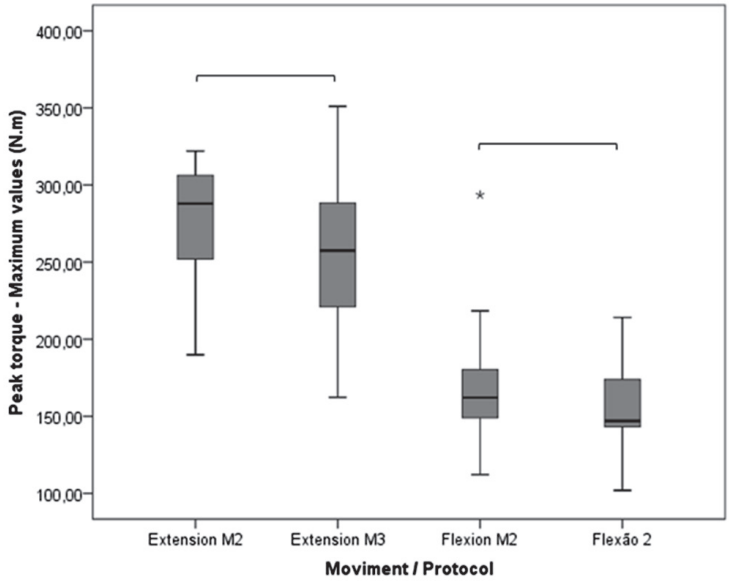

Figure 4. Values of maximum torque peaks (05 repetitions maximum) in extension and flexion preceded by warm-up with static stretching (Extension M2 / Flexion M2) and when the warm-up did not include the phase of the static stretching (Extension M3 / Flexion M3).
Source: prepared by the authors.

Discussion

The present study attempted to determine the influence of active warming-up, with and without static stretching, on isokinetic peak torque of extension and flexion of the knee. Significant differences were observed in average peak torque of knee extensors values (p=0.034), knee flexors (p=0.028) and maximum peak torque of knee flexors values (p=0.034). These results can be physiologically explained, because, even though a few authors (Fowles, Sale, & MacDougall, 2000; Kubo, Kanehisa, Kawakami, & Fukunaga, 2001; Magnusson, 1998; Wilson, Wood, & Elliott, 1991) believe that previous physical warming-up exercises lead to a minor production of muscle strength due to decrease of skeletal muscle rigidity and tendons through viscoelastic changes of the muscle-tendon unit, the performance of specific active warm-up (AW) after static stretching, with the same movements from the maximum strength test in smaller intensities, has the capability to revert the negative effects to strength production (Fowles et al., 2000; Kubo et al., 2001; Wilson et al., 1991), increasing muscle and tendon rigidity, increasing active and passive tension of skeletal muscle (Bompa et al., 2002; Kraemer et al., 2012).

Hence, this warming-up structure is capable of taking advantage of the maintenance or development of joint range and muscle extensibility effects through stretching, collaborating in a bigger total muscle strength production and decreasing the injury risks (Apostolopoulos, Metsios, Flouris, Koutedakis, & Wyon, 2015).

The study of Brentano et al. (2008), involving 10 trained men, investigated the maximum strength of knee flexors in an isokinetic with this sample, performing in different moments general warming-up, general warming-up and static warming-up, general warming-up and proprioceptive neuromuscular facilitation (PNF), before the maximum strength force test at the speed of 60, 90 and 120°/s. This did not show a significant difference on the peak torque between the warm-up performed with general warm-up (GW) and the warm-up performed with general warm-up and static stretching (SS) on the concentric phase (GW = 150.0 ± 22.9 N·m vs SS = 150.8 ± 21.0 N·m) and eccentric (GW = 179.2 ± 18.7 N·m vs SS = 182.4 ± 24.5 N·m) preceding the maximum strength test at the speed of 60°/s. It is believed that these results are justified by other studies (Grego, & Manffra, 2009; Simic, Sarabon, & Markovic, 2013), which identified that the maximum capability of strength production depends upon the volume of stretching. When the duration of the stretching by muscle is lower than 45 seconds, the decreasing of this capability is softened as was demonstrated within this study.

Contrary to the findings of this study, Tricoli and Paulo (2012) investigated the acute effect of static stretching exercises on maximum strength performance. The sample of this study was composed by eleven young adults, that performed the test at a maximum repetition (1MR) of knee extensors and flexors at the Leg Press 45° device, under two distinct warming-up conditions: general warm-up with and without static stretching and specific warm-up preceding the referred test. The average results achieved at the 1MR test, with warming up including static stretching (Maximum Strength = 391.7 ± 86.5 N), was significantly smaller when compared to warming-up without static stretching (Maximum Strength = 405.5 ± 89.1 N).

It is believed that these results were different from those found in this study, since the task of performing a maximum repetition demands less time of active locomotor system and greater

need of recruitment of muscle fibers and active and passive tension of skeletal muscle if compared to tasks with more repetitions, such as the task of performing five repetitions maximum.

In this study, significantly differences were not observed to the values of peak torque of the knee extensors ($p = 0.071$). The study of de Albuquerque et al. (2011), with a sample made of 16 young female adults, compared the influence of different types of warm-up previous a muscle test of knee extensors, of the dominant leg, at a speed of 30°/s in a isokinetic equipment. The first group performed a warm-up with static stretching, the second performed the warm-up with aerobic exercise in a cycloergometer and the third group performed the combination of warm-up with static stretching and, one minute later, performed the same aerobic exercise before the maximum strength test. The authors did not observe any significant differences between groups in relation to maximum peak torque to the knee extensors on the concentric and eccentric phases ($p \geq 0.05$). Although, there were some disagreement regarding to the speed of test execution and the number of maximum repetitions. This result discrepancy may have occurred, because the protocol used by de Albuquerque et al. (2011) was of 1MR in the concentric and eccentric phase of knee extensors, at a speed of 30°/s only on the dominant leg and the sample made of young female adults, considering that the present study the protocol was concentric/concentric of 5MR at a speed of 60°/s and the sample composed by young male adults. It is believed that the greater number of maximum repetition preceded by a specific warming-up allowed a great recruitment of the muscle-tendinous units and, as consequence, a greater expression of maximum strength.

Another important factor that reinforce the results found in this study is that the general warm-up has the purpose of increase the functions and capabilities of work to optimize the functioning of metabolic process with elevation of the blood flow and body temperature (Bompa et al., 2002), with the beneficial effects of general warm-up, the active static stretching is able to better stimulate the main mechanisms responsible for the articular amplitude and muscle extensibility with the proprioceptors of the musculoskeletal system, muscle fuse, Golgi tendon organs and the active and passive muscle tensions (Apostolopoulos et al., 2015).

It can be cited as limitations of this study: the age of the studied group, the sample size and the specificity of the speed chosen to the test (60°/s). According to the variety of studies with different methodologies, different results and few studies that have verified the influence of different stretching techniques on the active warm-up structure in this study, it is important to perform more studies to consolidate the recommendations in relation to this study object.

Conclusion

It can be concluded that the active warm-up with static stretching before the maximum strength test on the isokinetic (60°/s) promotes an increasing on peak torque values of knee extensors and flexors as much as in the average values as in the maximum ones, in absolute terms, although the maximum peak torque of the extensors have not showed significant differences. It is believed that the performing of specific stretching previous to the maximum strength test on the isokinetic protocols enhances the increasing of active and passive muscle tension in better conditions to express maximum strength.

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