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Original Article

Shorter static stretching volume does not impair isokinetic muscle strength

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Abstract
Coaches and athletes in warm-up routines for preventing muscle injuries during exercise, and hoping for improving muscle performance commonly incorporate static stretching. However, static stretching exercises usually impairs muscle performance. Although static stretching exercises impair muscle performance, there is a greater variability of the evidence in static stretching induced impairmentswhen the static stretching volume are less than 90 seconds per muscle group. In this sense, this study was designed to compare different static stretching volume on extensor and flexor knee peak torque. Twenty-one physically active men visited the laboratory five times for performing the familiarization process and experimental procedures. In each experimental procedure, the individuals performed an isokinetic testpreceded byactive warm-up and static stretching. The angular velocities of isokinetic tests were 60°/s, 180°/s, and 300°/s. The warm-up routines were: active warm-up on cycle ergometer + no stretching; active warm-up on cycle ergometer + twenty seconds of static stretching; active warm-up on cycle ergometer + forty seconds of static stretching; active warm-up on cycle ergometer + sixty seconds of static stretching. The stretching exercises were performed in knee extensors and knee flexors. No differences were showed between all protocols to knee extension peak torque at angular velocities 60°/s ($F=0.545$, $p=0.653$), 180°/s ($F=0.082$, $p=0.969$), and 300°/s ($F=0.230$, $p=0.875$). Moreover, knee flexion peak torque did not show difference between all protocols at angular velocities 60°/s ($F=0.100$; $p=0.960$), 180°/s ($F=0.036$, $p=0.991$) and 300°/s ($F=0.057$, $p=0.982$). This study provides evidence that static stretching performed until 60 seconds incorporated in warm-up routine did not impair extensor and flexor knee peak torque.
Key Words: Muscle Strength, Performance, Static Stretching.

Introduction

Pre-exercise warm-up are common practice in training routines and had the tendency to be based on individual coaches, trainers and athletes experiences, probably due to limited scientific evidence supporting one protocol over another[1]. However, recently researchers have studied different warm-up protocols on physical performance[2,3,4,5]. Among warm-up protocols utilized on training routines and recent researchers: proprioceptive neuromuscular facilitation[6], dynamic warm-up[7], and traditional static stretching[8] are usually highlighted.
Traditional static stretching involvesmoving a limb until the end of its range of motion or until its point of discomfort[2,9]. It has been demonstrated to be an effective tool to improve flexibility[10], improve muscle performance, and prevent injuries during exercise[11]. However, some studies do not corroborate with the idea that static stretching could improve performance; on the contrary, it could reduce performance[5,8].

Some factors may contribute to the impact of static stretching on muscle performance[8], and among these factors; the duration of static stretching becomes an important variable[2]. Simic et al.[5] showed that shorter static stretching (<45 seconds) performed before the exercise may not be detrimental to muscle performance, but static stretching performed between 45 to 90 seconds could lead to impairments on muscle performance.

As pointed by Behm et al.[2] those volumes used do not reflect a typical static stretching during a resistance training session, also when total static stretching volumes are less than 90 seconds per muscle group, there is a greater variability of the evidence in impairments. In this sense, according to literature pointed that variability in static stretching of shorter duration, the aim of this study was to verify if static stretching could impair muscle strength incorporated in a warm-up routine and if stretching time could influence the magnitude

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of impairments. The initial hypothesis was that 60 seconds of static stretching incorporated to the warm-up routine could impair muscle strength.

Methods

Participants

A randomized controlled trial study design was used. Fourteen trained men (22.05 ±2.09 yrs; 176.0 ±6.7 cm; 75.8 ±8.5 kg; 12.1 ±4.1 %BF) participated in this study. The inclusion criteria were as follow: age ranged from 18 to 25 years, regular physical exercise at least 3 times per week, and no cardiovascular or orthopedic diseases history that would compromise any proposed tests. All participants provided written informed consent before participation and Institutional Review Board at the Catholic University of Brasilia, Brazil approved the protocol (n. 2.497.193 CEP/UCB). All procedures followed with the ethical standards of the Helsinki Declaration.

Protocol

The study was designed to observe if static stretching incorporated in a warm-up routine could acutely influence muscle strength performance and if stretching duration could lead to different findings. All subjects were evaluated immediately after the warm-up routines. Thus, the warm-up consisted in active warm-up (cycling), specific warm-up and static stretching (20, 40, 60 seconds) or control condition (without static stretching). The dependent variables were concentric peak torque at quadriceps extension and hamstring flexion of knee concentric peak torque and independent variables were warm up routines.

Before the intervention, all the subjects underwent a clinical evaluation by laboratory physician, composed by a resting electrocardiogram, blood pressure measurement, cardiovascular risks analyses, and specific anamneses. After approved by the clinician, subjects underwent to the laboratory four times to be tested after four different warm-up routines at the same time of the days. Extension and flexion knee peak torque were evaluated by dynamic isokinetic test. All procedures were carried out at Laboratory of Physical Evaluation - LAFIT - at the Catholic University of Brasilia – UCB, that has temperature and humidity controls.

Warm-up routines: All the subjects were informed to avoid any physical exercise 24 hours before any test. Before all isokinetic testing and stretching protocols, each subject completed a 5-minute general active warm-up at 25-50W on a stationary cycle ergometer (Monark, Ergomedic828E)[12]. After that, static stretch (20, 40 or 60 seconds) were in random order in different days, the same as the control session, characterized for no prior Acute Static Stretch (NPASS). Each subject performed an unassisted static stretching exercise (PASS) spending the specific time for the session (20, 40 and 60 seconds) at the middle point of discomfort composed for two exercises aimed to stretches quadriceps and hamstring muscle groups according to order as followed:

1) Hip flexion with knee extension – Dorsal decubitus, with a specific tensor helps ("Theraband®"), achieving the middle point of discomfort angle with no pain, keeping the hip on the floor and knee in extension, stretching posterior leg muscle;
2) Knee flexion - In stand position, keep the knee in a flexion position, with no pain, holding the feet with the same side hand.

Only at the first visit after general warm-up (cycling at 50W), a specific warm-upwas performed, also used as a familiarization session at an isokinetic dynamometer, composed by 5 repetitions at all angular velocities in descending order (300°•s^{-1}, 180°•s^{-1} e 60°•s^{-1}).

Quadriceps and Hamstring peak torque: The Biodex System 3 isokinetic dynamometer (Biodex Medical Systems Inc., Shirley, NY, 2002) was used to measure the right knee extension and flexion concentric muscular isokinetic performance. The angular velocities (AV) 60°•s^{-1}, 180°•s^{-1}, 300°•s^{-1} were inserted in ascending order, rest time applied between AV was 1 min. Each visit consisted of 5 repetitions at 60°•s^{-1}, 5 at 180°•s^{-1} as well as 20 repetitions at 300°•s^{-1}. The lateral femoral epicondyle of each subject was used as biological axis and then aligned with the dynamometer axis in sitting position with the trunk at 85° flexion. After seated in the dynamometer chair, each subject was fitted in maximum stabilization (trunk, hip, and leg) in attempt to minimize the cooperation of different muscular groups those specific used for extending or flexing the knee. Ranged of Motion (ROM) was setting in 70°, and an experienced examiner on the procedures conducted tests. Before the tests, the limb weight was measured by the dynamometer to calculate to correct the gravity force. All procedures were adopted according to the manufacturer manual. Furthermore, all subjects were encouraged by verbal through all tests[12].

Statistical Analysis

Data normality was evaluated by Shapiro-wilk test. After that, one-way ANOVA with repeated measure was carried out with the Bonferroni post hoc analyses for Peak Torque (PT) through statistical Package for the Social Sciences for Windows, version 21.0 (SPSS 21.0). The significance level adopted for all comparisons were α0.05.

Results

There were not significant differences between stretching protocols in warm-up routines to knee extension peak torque at angular velocities 60°/s (F=3.394, p=0.057), 180°/s (F=0.385, p=0.766), and 300°/s (F=0.375, p=0.773). In addition, knee flexion peak torque at angular velocities 60°/s (F=0.820, p=0.510), 180°/s (F=0.073, p=0.973), and 300°/s (F=0.973, p=0.440) did not show significant differences between stretching protocols in warm-up routines (table 1).

Table 1. Peak torque at angular velocity $60°•s^{-1}$, $180°•s^{-1}$, $300°•s^{-1}$ ($N•m^{-1}$) in different stretching volumes.

	EXT PT ($N•m^{-1}$) Mean ± SD			FLX PT (($N•m^{-1}$) Mean ± SD		
Stretching time	60°/s	180°/s	300°/s	60°/s	180°/s	300°/s
NPASS	239.15 ± 25.56	170.17 ± 23.49	133.18 ± 18.74	133.13 ± 18.94	102.02 ± 12.10	88.86 ± 10.58
20 seconds	224.89 ± 32.11	171.21 ± 25.01	131.94 ± 19.16	129.09 ± 18.79	101.41 ± 16.65	85.80 ± 15.58
40 seconds	234.56 ± 32.03	170.77 ± 25.56	134.39 ± 19.42	132.96 ± 19.91	102.67 ± 14.73	88.11 ± 13.74
60 seconds	229,11 ± 28,95	168.80 ± 23,85	132.23 ± 16.70	130.20 ± 15.28	101.70 ± 14.06	88.21 ± 12.13

PT = Peak Torque; EXT = Extension; FLX = Flexion; NPASS = No prior Acute Static Stretch.

Discussion

The main finding of the present study was that static stretching incorporated to warm-up routine did not reduce extension and flexion knee strength. We had hypothesized that 60 seconds of static stretching in warm-up routine could impair extensor and flexor knee strength. However, static stretching independent of the volume was not able to impair isokinetic muscle performance evaluated from peak torque. Results about the impact of static stretching on muscle performance show divergences and could be dependent on factors like stretching duration and intensity[2].

Some studies have indicated that static stretching could affect negatively muscle strength[14,15]. In this sense, Serra et al.[8] showed that independent of training status, static stretching reduced load lifted on 1RM test, and the static stretching performed was 3 sets of the 30 seconds to each muscle tested. In this same line, Sekir et al.[16] reported that after static stretching exercises to quadriceps and hamstring, the quadriceps and hamstring muscle strength were reduced in concentric and eccentric contractions at 60°/s and 180°/s, the total time of static stretching was 6 ± 1 minute. However, our results contrast with studies showed, these contrasts may be explained by different stretching volumes adopted, in both studies, Serra et al.[8] and Sekir et al.[16], the total stretching time was greater than 90 seconds to each muscle tested. While in our protocol, each subject performed only 20, 40 or 60 seconds to each muscle.

In this sense, Behm et al.[2] reported in a systematic review that static stretching time greater than 90 seconds could impair muscle performance. However, these impairments do not always occur if the stretching time is less than 90 seconds. In this line, Beedle et al.[17] showed that 45 seconds of static stretching to quadriceps and hamstring did not impair load lifted on leg press 1RM test compared to dynamic stretching and a non-stretching day. Moreover, Simic et al.[5] in a meta-analysis showed that shorter stretch tended to reducethe negative acute effect of static stretching on maximal muscle strength. Thus, it is possible to note that stretching time influence muscle strength impairments and could partially explain our results.

Moreover, another point that may be mentioned is stretching intensity[18]. In our protocol, static stretching was performed at the middle point of discomfort and did not show strength impairments. Although Ogura et al.[19] reported that sixty seconds of static stretching to hamstring until the maximal point of length without feeling pain or discomfort showed lower hamstring maximal voluntary contraction of knee flexion than thirty seconds of hamstring static stretching and control condition, that are contrary to our results. Winke et al.[20] reported that a total time of three minutes of static stretching taken to the point of discomfort did not affect peak eccentric and concentric torque production in the knee flexors at 60°/s and 210°/s. Thus, it is possible to note that although stretching has a high volume, if it performed at moderate intensity may not have strength impairments.
This inconsistency appears to be related to warm-up routine. In our and Winke et al.[20] studies warm-up routines include active and specific warm-up on a cycle ergometer, while Ogura et al.[19] study was made only static stretching before the test. In this line, Pinto et al.[21] investigated the effect of static stretching duration on vertical jump performance, the authors avoided a specific warm-up, because it may minimize tissue cooling, maximize central nervous system, muscle fiber conduction time and muscle contractile performance, that could impact on results[5]. Although this hypothesis was not tested to muscle strength is notable that some studies reported that a dynamic and active warm-up could improve strength performance[22,23], because it could increase intracellular Ca^{2+}, cross-bridge cycling[22] and decrease muscle stiffness[24].

Although our study has limitations, such as, the absence control of stretching intensity, and active warm-up condition by a more precise way. Our data suggest that static stretching at the middle point of discomfort until sixty seconds may be incorporate in a warm up routine, without knee muscle strength impairments. However, this data would be useful for muscular isokinetic assessment due to time spend on it.

This bearing must be better explored, mainly investigating its influence on other muscular variables as power and total work as well as injuries risks.

Conclusion

The study suggests that static stretching until sixty seconds incorporated in a warm-up routine does not impair knee muscle strength. Therefore, static stretching until sixty seconds may be incorporated in warm-up routine by coaches without impairments in muscle strength.

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