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The Optimal Waiting Time for Hamstring Peak Power after a Warm-Up Program with Static Stretching

B. Meric Bingul

University of Kocaeli, School of Physical Education and Sport, 41360, Kocaeli, Turkey
E-mail: bergunmeric@gmail.com

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ABSTRACT The purpose of the present study is investigation of an ideal waiting time for hamstring muscle peak torque after the warm up program with static stretching exercises. The thirteen male students from Kocaeli University, School of Physical Education and Sport Department participated to this study voluntarily. Five different warm-up protocols were randomly applied to the subjects. The first protocol was five minutes jogging and the second was five minutes jogging with static stretching. The other protocols were five minutes jogging with static stretching + three minutes, six minutes and nine minutes waiting times. Following each warm-up session, the subjects' hamstring muscle peak torque was tested on a Biodex system III dynamometer at angular velocities of 60 degree/second. Repeated measures of variance (ANOVA) in SPSS program were used to compare the data obtained from the five protocols. As a result of the study, the warm-up session that consisted of static stretching exercises has negative effects on hamstring peak power. However, this negative effect disappeared after the six minutes waiting time ($p<0.05$).

INTRODUCTION

Muscle stretching is a type of exercise and used as a part of a warm-up that tenses the soft tissue structures to enable greater mobility, leading to an increase in joint range of motion and flexibility (Murphy et al. 2010; Daneshmandy et al. 2011; Melo et al. 2014). However there are still questions about correct influence of stretching to utilize it in relation to the physical performance. While some studies in the literature indicated that static stretching has no negative effect on strength performance (Clark et al. 2014; Ribeiro et al. 2014), some other studies informed that it causes loss of force (Nelson et al. 2005; Kistler et al. 2010; Pasqua et al. 2014). This loss stems from mechanical and neural factors. The mechanical factors are changes in the viscoelastic properties of the musculotendinous unit (Janot et al. 2007) and temporary loss of muscular stiffness after stretching. In addition, neural factors are low neuromuscular activation, which decreases the motor unit activation and alters reflex sensitivity (Janot et al. 2007; Cagno et al. 2010). Although, most of the studies have found acute decreases in strength after stretching and that such decreases seem to be more prominent, the longer the stretching protocol, the number of exercises and sets, and the duration of each set, in general, exceeded the ranges normally recommended in the literature (Rubini et al. 2007). It has been suggested that static stretching routines should be avoided before practice or competition (Cagno et al. 2010). Besides, some studies state that decreases in strength can be eliminated by doing aerobic activities before and after static stretching (Murphy et al. 2010) or in combination with dynamic stretching (Morrin and Redding 2013). However, the negative effects of static stretching can be removed with a certain amount of waiting time. The detrimental effect of stretching on subsequent muscle performance dissipates over time. Torres et al. (2008) indicate that a 5 minutes-period or longer after upper body stretching may allow the body to dissipate any negative effects. Brandenburg et al. (2007) examined the effects of static stretching on counter movement jump performance and they found that the performance started to decrease after static stretching exercises and continued for 24 minutes. It is recommended to leave some recovery time to eliminate this negative effect after static stretching exercises (Torres et al. 2008).The purpose of the study is to explore an ideal waiting time for hamstring muscle peak torque after the warm up exercises with static stretching.

Address for correspondence:
Dr. Bergün Meriç Bingül
University of Kocaeli
School of Physical Education and Sport
Telephone: +902623033658
Fax: +902623033603
E-mail: bergunmeric@gmail.com

MATERIAL AND METHODS

Participants

The thirteen male students (mean ± SD age = 18.04±0.77 years; weight = 62.35± 6.48 kg; height = 1.73±0.06 m; training experiences= 5.46±2.52 years) at Kocaeli University, School of Physical Education and Sport Department, who had some football background, voluntarily participated in the study. The subjects had no significant history of recent major lower limb injury or disease.

Procedures

The study was conducted consistent with the recommendations of the Declaration of Helsinki. The subjects were informed about the risks and benefits of the study. During the period of the study, the subjects followed a normal diet. The day before the test, the subjects stayed away from alcohol, caffeine and ergogenic aids.

Five different warm-up protocols were randomly performed on nonconsecutive days (Fig. 1). The first protocol was a general warm-up that consisted of 5 minutes jogging (GWU), and the second consisted of GWU with static stretching (GWU+SS). The other protocols were GWU with static stretching + 3 minutes (GWU+SS+3 min), 6 minutes (GWU+SS+6 min) and 9 minutes waiting time (GWU+SS+9 min). In the static stretching protocol, 3 different exercises (Table 1) were worked out with two sets in 30 seconds for each muscle group. Resting time was decided as 12 seconds between the sets. The study took place over a session of 5 days and at the same time of the day. Following each warm-up session, the hamstring muscle peak torque was measured by using isokinetic dynamometer.

Measurement of Hamstring Muscle Power

Isokinetic measurement of concentric/concentric hamstring peak torque (PT) was measured using a Biodex System 3 isokinetic dynamometer (Biodex Medical Systems, Inc., Shirly, NY). This system has been previously described to produce valid and reliable measurements of torque and position (Chaouachi et al. 2010). The peak torques were taken in which the isokinetic dynamometer was set to an angular velocity of 60 degrees/second for the dominant leg. The subjects were seated in the dynamometer with their back in a neutral position. The non-dominant leg was placed on an adjustable pad and after a warm-up session, they were asked to move their legs forwards using maximal effort against the accommodating resistance at a

Table 1: Static stretching exercises

1. Static stretch seated	The subjects sat on the floor with one leg stretched straight out and the other bent out of the way. They rotated the straight leg inwards and leaned forward at the hips to feel a stretch under the thigh.
2. Flex and extend hamstring stretch	The subjects flexed their legs and bent forward from their knee joint, kept the back straight and extended their leg.
3. Forward Bend With Rounded Back	The subjects sat on the floor, extending both legs straight out in front of them, legs together. They folded the torso over thighs, gently rounding the back but keeping the legs straight.

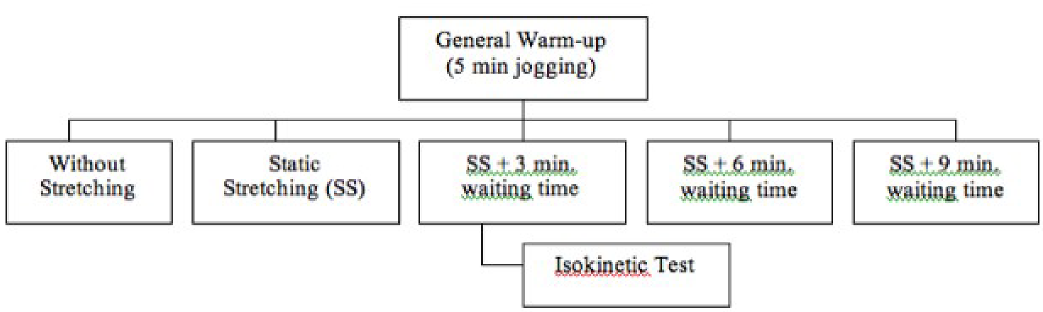

Fig. 1. A summary of the experimental method

present speed and for three number of test repetitions. Peak torque of the flexor muscle group data was collected for evaluation.

Statistical Analysis

Descriptive statistics (mean ± SD) were formulated for the following variables: age, height, body and weight. Thus, the data was collected. The hamstring muscle peak torque performance was analyzed. Repeated measures of variance in SPSS (version 17.0) program were used to compare the data obtained from the 5 protocols. When a significant F value was achieved, post-hoc comparisons were accomplished via a Least Significant Difference (LSD) test to identify specific differences between WU conditions. The priori level of significance was set at 5 percent ($p<0.05$).

RESULTS

As a result of the study, according to the repeated measures of variance test results, the warming up session that consisted of static stretching exercises had a negative effect on hamstring muscle peak torque performance and it was calculated 4.87 percent reductions ($p= 0.001$) in the performance. However, this negative effect disappeared after the six minutes waiting time ($F= 18.44$, $p< 0.001$). It was observed that increments of 4.90 percent occurred after 6 minutes waiting time ($p= 0.002$) and increments of 3.99 percent after 9 minutes ($p= 0.003$) from the baseline (Fig. 2).

DISCUSSION

The results of many studies (Bradley et al. 2007; Pagaduan et al. 2012; Haddad et al. 2013; Babault et al. 2014; Costa e Silva et al. 2014) have manifested how static stretching affects the force performance negatively, especially stretching just before exercise which might cause temporary strength deficits. Negative acute effects of static stretching on maximal muscular performance tend to diminish with reduction of stretch duration (Simic et al. 2013). Some studies have concluded that no losses in strength are observed when durations are properly set. For instance, Rossi et al. (2010) indicated that stretching duration (60 x 30) did not appear to be a major influencing factor for the current strength reductions and recommended coaches and athletes to avoid flexibility training consisting of stretching repetitions of 30 seconds or longer prior to competitions. In addition, Ayala et al. (2012) found that short (2 x 30s per muscle group) pre-exercise active-static lower-limb stretching routine did not elicit stretching-induce reductions in knee flexor and knee extensor isokinetic concentric and eccentric strength.

Kay and Blazevich (2012) suggest the detrimental effects of static stretch are mainly limited

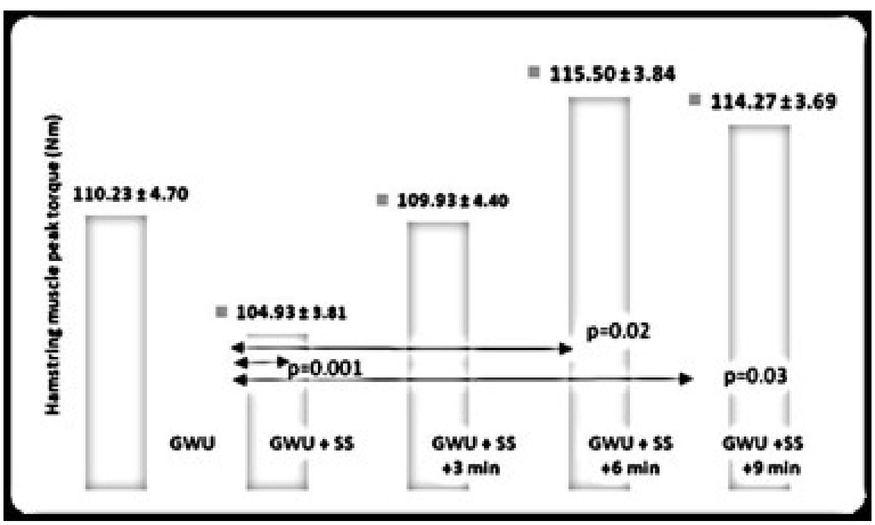

Fig. 2. Mean + standard deviation of hamstring muscle peak torque (Nm)

to longer durations (>60 s), which may not be typically used during pre-exercise routines in clinical, healthy, or athletic populations. Shorter durations of stretch (<60 s) can be performed in a pre-exercise routine without compromising maximal muscle performance. In another study, the peak force performance, decreased after 30 s and 60 s of quadriceps static stretching (8.5% and 16.0%, respectively), was reported for young adults (Siatras et al. 2008). Gonçalves et al. (2013) studied with the quadriceps muscle, which was stretched (knee flexion) for three sets of 30 s with 30 s rest intervals and the researchers found that a small amount of stretching of an agonist muscle (quadriceps) did not affect peak force, and peak rate of force development.

In the present study, a decrease of 4.87 percent was found in hamstring muscle peak power although the duration of stretching (2 x 30s per exercises) was not too long. This detrimental effect might be due to training with flexor muscle group (hamstring). Kay and Blazevich (2012) indicated that the knee flexors (82%) seemed to be more regularly influenced by stretch compared with the knee extensors (64%) and plantar flexors (62%). Two mechanisms have been proposed to explain the muscle strength deficit mediated by stretching: a) a structural mechanism involving changes in the muscle-tendon unit stiffness and compliance and b) a neural mechanism involving a decrease in muscle activation. A stiffer muscle-tendon unit would be more efficient during the initial transmission of force, thereby, increasing the rate of force development (Gonçalves et al. 2013), Nelson et al. (2005) suggested that increased muscular compliance as a result of stretching might mean the muscle would go through a greater period of unloaded shortening before taking up slack sufficiently to transfer the generated force to the bone. It is also possible that the recovery period between the end of the warm-up period and the start of the fitness test will influence performance (Thompsen et al. 2007). There were different waiting times to obtain good performance in the literature. Chaouachi et al. (2010) studied the effect of warm-ups involving static or dynamic stretching on agility, sprinting, and jumping performance in trained individuals. They applied static stretching, an adequate warm-up and dynamic sport-specific activities to trained individuals with at least 5 or more minutes of recovery before their sport activity. Besides, Torres et al. (2008) indicate that the negative effects of static stretching leave the body after 5 minutes or longer. Bradley et al. (2007) suggest that if static stretching is essential before an event, coaches and athletes should ensure that stretching occurs at least 15 minutes prior performance. The neural activation recovers approximately 15 minutes after a static stretch. The literature seems to indicate that the neural effects are more transient (of shorter duration) or play a smaller or insignificant disruptive role than viscoelastic properties in static-stretch induced impairments (Behm and Chaouachi 2011). Mizuno et al. (2014) found that, the maximal voluntary contractions torque was significantly decreased immediately after, and 5 minutes after the static 5 minutes stretching intervention compared with the pre-intervention value ($p < 0.05$), and this change recovered within 10 minutes. Their results suggest that the deficits of static stretching are disbled in a short time after static stretching.

In the present study, after the 6 minutes waiting time, the negative effects of static stretching disappeared and when it was compared to the baseline, increments of 4.90 percent occurred in the peak power of the hamstring muscle ($p<0.05$). The results were similar for the waiting time of 9 minutes (3.99 %).

CONCLUSION

The present study and the literature confirm that the relationships between warm-up, performance and interval time exist. For an ideal hamstring muscle peak torque performance, as indicated in the literature, stretching duration, the number of exercises and sets, and the duration of each set are remarkable and complete 6 minutes waiting time at least is also suggested before strength performance.

RECOMMENDATIONS

It is recommended not to choose static stretching exercises prior performances that require hamstring muscle strength. If required, it should be given at least 6 minutes waiting time before performance to allow disappearance of its negative effects.

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REFERENCES

Ayala F, Sainz de Barandas P, De Ste Croix M, Santonja F 2012. Efecto agudo del estiramiento activo sobre la fuerza y potencia de la flexión y extensión de rodilla. *Revista Andaluza de Medicina del Deporte,* 5(4): 127-133.

Babault N, Bazine W, Deley G, Paizis C, Lattier G 2014. Acute effects of static stretching on isokinetic torque production are directly related to the initial flexibility level. *International Journal of Sports Physiology Performance*, 2: 121-126.

Behm DG, Chaouachi A 2011. A review of the acute effects of static and dynamic stretching on performance. *European Journal of Applied Physiology,* 111: 2633-2651.

Bradley PS, Olsen PD, Portas MD 2007. The effect of static, ballistic, and proprioceptive neuromuscular facilitation stretching on vertical jump performance. *Journal of Strength and Conditioning Research,* 21(1): 223-226.

Brandenburg J, Pitney WA, Luebbers PE 2007. Time course of changes in vertical jumping ability after static stretching. *International Journal of Sports Physiology and Performance,* 2: 170-181.

Cagno A, Baldari C, Battaglia C, Gallotta MC, Videira M, Piazza M, Guidetti L 2010. Pre-exercise static stretching effect on leaping performance in elite rhythmic gymnasts. *Journal of Strength and Conditioning Research*, 24(8): 1995-2000.

Chaouachi A, Castagna C, Chtara M, Brughelli M, Turki O, Gally O, Chamari K, Behm DG 2010. Effect of warm-ups involving static or dynamic stretching on agility, sprinting, and jumping performance in trained individuals. *Journal of Strength and Conditioning Research,* 24: 2001-2011.

Clark L, O'leary CB, Hong J, Cockard M 2014. Lockard M 2014. The acute effects of stretching on presynaptic inhibition and peak power. *Journal of Sports Medicine Physical Fitness,* 54(5): 605-610.

Costa e Silva GVL, Silveira ALB, Masi F, Bentes CM, Cirilo de Sousa MS, Novaes JS 2014. Acute effect of different methods on isometric muscle strength, *Maringá*, 36(1): 51-57.

Daneshmandy H, Atri AE, Ghasemi A, Rahmani P 2011. The effects of PNF and static stretching on knee ROM of amputee athletes. *Brazilian Journal of Biomotricity,* 5(4): 255-262.

Gonçalves R, Gurjão AL, Filho JC, Farinatti PDE, Gobbi LT, Gobbi S 2013. The acute effects of static stretching on peak force, peak rate of force development and muscle activity during single- and multiple-joint actions in older women. *Journal of Sports Sciences*, 31(7): 690-698.

Haddad M, Dridi A, Moktar C, Chaouachi A, Wong DP, Behm D, Chamari K 2013. Static stretching can impair explosive performance for at least 24 hours. *Journal of Strength and Conditioning Research,* 28(1): 140-146.

Janot JM, Lance CD, Corey R 2007. Pre-exercise stretching and performance. *IDEA Fitness Journal*, 44(8): 40-42.

Kay AD, Blazevich AJ 2012. Effect of acute static stretch on maximal muscle performance: A systematic review. *Medicine. Science in Sports and Exercise,* 44(1): 154–164.

Kistler BM, Walsh MS, Horn TS, Cox RH 2010. The acute effects of static stretching on the sprint performance of collegiate men in the 60- and 100-m dash after a dynamic warm-up. *Journal of Strength and Conditioning Research,* 24(9): 2280-2284.

Melo LTM, Vasconcelos RS, Teles LMSA, Porto LM, Maia JA, Abdon APV 2014. Evaluation of passive stretching in the hamstrings flexibility of who practice exercises. *International Journal of Sports Science,* 4(2): 67-71.

Mizuno T, Matsumoto M, Umemura Y 2014. Stretching-induced deficit of maximal isometric torque is restored within 10 minutes. *Journal of Strength and Conditioning Research,* 28(1): 147–153.

Morais de Oliveira AL, Greco CC, Molina R, Denadai BS 2012. The rate of force development obtained at early contraction phase is not influenced by active static stretching. *Journal of Strength and Conditioning Research*, 26(8): 2174–2179.

Morrin N, Redding E 2013. Acute effects of warm-up stretch protocols on balance, vertical jump height, and range of motion in dancers. *Journal of Dance Medicine and Science,* 17(1): 34-40.

Murphy JR, Di Santo MC, Alkanani T, Behm DG 2010. Aerobic activity before and following short duration static stretching improves range of motion and performance vs. a traditional warm-up. *Applied Physiology, Nutrition, and Metabolism*, 35: 679–690.

Nelson AG, Kokkonen J, Arnall DA 2005. Acute muscle stretching inhibits muscle strength endurance performance. *Journal of Strength and Conditioning Research*, 19(2): 338-43.

Pagaduan JC, Pojskic H, Uzicanin E, Babajic F 2012. Effect of various warm-up protocols on jump performance in college football players. *Journal of Human Kinetic,* 35: 127-132.

Pasqua LA, Okuno NM, Damasceno MV, Lima-Silva AE, Bertuzzi R 2014. Impact of acute static-stretching on the optimal height in drop jumps, *Motriz: Revista de ducação Física,* 20(1): 65-70.

Ribeiro AS, Romanzini M, Dias DF, Ohara D, da Silva DR, Achour AJ, Avelar A, Cyrino ES 2014. Static stretching and performance in multiple sets in the bench press exercise. *Journal of Strength and Conditioning Research,* 28(4): 1158–1163.

Rossi LP, Pereira R, Simäo R, Brandalize M, Gomes ARS 2010. Influence of static stretching duration on quadriceps force development and electromyographic. *Activity Human Movement,* 2(2): 137-143.

Rubini EC, Costa AL, Gomes PS 2007. The effects of stretching on strength performance. *Sports Medicine*, 37(3): 213-224.

Simic L, Sarabon N, Markovic G 2013. Does pre-exercise static stretching inhibit maximal muscular performance? A meta-analytical review *Scandinav Journal of Medicine Science in Sports*, 23: 131–148.

Thompsen AG, Kackley T, Palumbo MA, Faigenbaum AD 2007. Acute effects of different warm-up protocols with and without a weighted vest on jumping performance in athletic women. *Journal of Strength and Conditioning Research,* 21(1): 52-56.

Torres EM, Kraemer WJ, Vingren JL, Volek JS, Hatfield DL, Spiering BA, Ho JY, Fragala MS, Thomas GA, Anderson JM, Häkkinen K, Maresh CM 2008. Effects of stretching on upper-body muscular performance. *Journal of Strength and Conditioning Research*, 22(4): 1279-1285.