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Electromyography Assessments of the Vastus Medialis Muscle during Soccer Instep Kicking between Dynamic and Static Stretching

by
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The purpose of this study was to examine the effects of static and dynamic stretching within a pre-exercise warm-up on vastus medialis muscle activity during instep kicking and ball velocity in soccer players. The kicking motions of dominant legs were captured from using six synchronized high-speed infra-red cameras at 200 Hz and Electromyography at 100 Hz. There was significant difference in vastus medialis activity after dynamic stretching relative to no stretching condition (0.12 ± 0.06 mV) versus static stretching relative to no stretching condition (-0.21 ± 0.10 mV) with p < 0.001). In addition, there was also a significant difference in ball velocity after dynamic stretching relative to no stretching condition (4.53 ± 2.10 m/s) versus static stretching relative to no stretching condition (-1.48 ± 2.43 m/s) with p < 0.003. We concluded that dynamic stretching during the warm-up, as compared to static stretching, is probably more effective as preparation for optimal muscle activity and finally have high ball velocity which is required in soccer.
Key words: s*tretching, muscle activity, ball velocity, soccer instep kick*

Introduction

It is a usual exercise (rephrase) to perform a warm-up before athletic activity because it has been shown to improve performance and potentially reduce the risk of injury (Bishope, 2007). It is over a wide area accepted exercise for warm-up routines to be composed of moderate-intensity aerobic exercise and stretching exercises (Houlgh et al., 2009). Traditionally, Static stretching is a technique that is often incorporated into many warm-up routines (Hedric, 2000) because it is known to increase the range of movement about the joint (Cross and Worrell et al., 1999), which is advantageous to athletes who require higher levels of flexibility. It also has been suggested that static stretching before athletic activities can help prevent injuries (Cross and Worrell et al., 1999; Hartig and Henderson, 1999). However, most recent researches have showed that static stretching can have a negative effect on athletic performance by inducing short-term strength (Cornwell et al., 2001; Fowles et al., 2003), power (Behm et al., 2001; Cornwell et al., 2001; Young and Behm, 2003; Bradley et al., 2007), agility (Little and Williams, 2006) and speed (Little and Williams, 2006; Fletcher et al., 2007) deficits; as a result, a number of researchers have suggested that static stretching should be avoided during warm-up routines (Cornwell et al., 2001; Bradley et al., 2007).

Dynamic stretching is another technique that has become very popular in sport (Hedric, 2000). Recent studies have demonstrated that dynamic stretching

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Table 1

Different warm up protocols and testing program during 2 non-continuous days

	First day						Second day					
group	4 min	jogging	Kicking	Stretching	2 min rest	kicking	4 min	jogging	Kicking	Stretching	2 min rest	kicking
1	+		+	Static	+	+	+		+	Dynamic	+	+
2	+		+	Dynamic	+	+	+		+	Static	+	+

can improve power output during concentric resistance contractions (Yamaguchi et al., 2007), sprint running time (Fletcher et al., 2004), vertical jump, and performance (Cornwell et al., 2001; Little and Williams, 2006). This suggests that the inclusion of dynamic stretching in a warm-up may supply a practical option to static stretching (Fredrick and Szymanski, 2001).

Despite, there are some researches in soccer that have investigated the acute effects of stretching on different performance tasks, such as, acceleration, maximal speed, vertical jump, agility (Little and Williams, 2006; Amiri-Khorasani, 2010b), but, to date, there is little if any research which investigated the acute effects of static and dynamic stretching on soccer skills, such as instep kick which is main offensive action during soccer game (Amiri-Khorasani et al., 2009; Amiri-Khorasani et al., 2010a). Vastus medialis as a knee extensor is one of the most engaged muscles during soccer instep kicking to have high ball velocity which also is good index of well coordinate action during soccer instep kicking (Kellis and Katis, 2007).

The main objective of this study is to investigate the acute effect of dynamic and static stretching on vastus medialis activity (VMA) during instep kicking and also on ball velocity (BV). We hypothesized that dynamic stretching would demonstrate significantly the increase in VMA during soccer instep kick and BV compared to static stretching protocol.

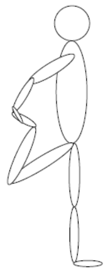
Material & Methods

Six adult male college soccer players (height: mean 180.38, ± 7.34 cm; mass: mean 69.77, ± 9.73 kg; age: mean 19.22, ± 1.83 years), who had no history of major lower limb injury or disease, volunteered to participate in this study after providing their informed consent. All procedures were approved by the sport center committee of university. Subjects were required to report to the laboratory to read and sign a medical questionnaire and an informed consent.

Subjects were divided into 2 groups, then they regularly performed two warm up protocols in 2 non-continuous days. The experimental protocol was conducted according to experimental protocol of previous researches (Wallmann et al., 2005; Wallmann et al., 2008; Amiri-Khorasani et al., 2010b). Therefore, this protocol performed in a manner that in the first day, two groups did one of the two warm up protocols and in the following day the stretching method was changed regularly by rotational way as presented in Table 1. Finally, results of all participants in all methods were collected separately, showing that all six participants had performed the whole stretching protocol (static and dynamic stretching).

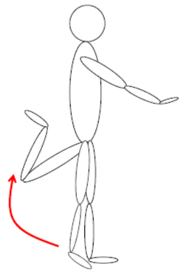
The test protocol included jogging for 4 minutes, 5 soccer instep kicks, performing stretching programs, 2 minutes rest and eventually 5 soccer instep kicks respectively. Since all participants chose to kick the ball using their right leg, the right leg was considered to be dominant. The players were randomly assigned to a series of five maximal velocity instep place kicks of a stationary ball with dominant limb, according to Amiri-Khorasani et al. (2010a) suggestion. A ball was kicked 3 m towards a target 1 × 1 m in size. To minimize movement in the frontal plane, the participants were restricted to a 3 m straight run-up from a position directly behind the ball at an approach angle of 0°. A FIFA-approved size five soccer ball (mass = 0.435 g) was be used for each kicking session and its inflation was controlled throughout the trials and kept at 700 hPa.

Static Stretching



The subject flexed one knee and raised his heel to his buttocks. The subject slightly flexed his supporting leg, exhaled, and grasped his raised foot with one hand. The subject inhaled and slowly pulled his heel toward his buttocks without over compressing the knee.

Dynamic stretching



The subject contracted his hamstrings intentionally and flexed his knee joint so that his heel touched his buttock.

Figure 1

The procedures for static and dynamic stretching of quadriceps groups muscles

The principal muscle group used in this motion (quadriceps) was stretched. The static and dynamic stretching procedures were explained by Little and Williams (2006) and a stretching program was proposed by Yamaguchi and Ishii (2005), as illustrated in Figure 1.

Six synchronized high-speed infra-red cameras (Vicon MX-F20) were used to capture limb motion at 200Hz. Once positioned the cameras into the appropriate location (performance area), then the cameras were calibrated to define their own volume origin. A motion capture software (Vicon Nexus 1.2) was used to digitize body landmarks, including the bony anatomical landmarks of the right and left anterior superior iliac spine, posterior superior iliac spine, mid-way between the posterior superior iliac spines, lateral epicondyle of knee, thigh; over the lower lateral ⅓ surface of the thigh, lateral malleolus, shank; over the lower ⅓ of the shank, over the second metatarsal head, and calcaneous. The EMG signals recorded by Mega Electronics Telemetric Electromyography unit (MESPSC 4000) consisting of a signal conditioner with an amplifier gain of 1000X, and a common mode rejection ratio greater than 120 dB. A converting plate for A/D 12 bits signal was used to convert the analog to digital signals, with a sampling frequency of 1000 Hz for each channel and an input range of 5 mV. The EMG signal was digitally filtered using a high-pass, fourth-order, zero lag Butterworth filter with a 5 Hz cutoff frequency, followed by a moving root-mean-square (RMS) filter.

Surface EMG signals from vastus medialis, 20% of the distance from the medial knee joint line to the ASIS; were recorded from pre-gelled silver-silver/chloride bipolar surface electrodes (Medicotest A/S, Rugmaken, Denmark). Bipolar surface electrodes of EMG device were placed according to anatomic location of muscles, longitudinally through the muscle. After the skin was shaved, abraded with skin preparation gel and cleaned with alcohol wipes to reduce skin impedance, bipolar surface electrodes of EMG device were placed over each muscle belly in line with the direction of the fibers with a center to center distance of approximately 2.5 cm according to anatomic location of muscles. A single ground electrode was placed over the anterior tibial spine.

The mechanics of collision between the foot and ball has been identified by Lees (2003). By considering the mechanics, the resultant ball velocity can be expressed as:

$$V_{\mathrm{ball}} = V_{\mathrm{foot}} \cdot \frac{[M] \cdot [1+e]}{[M+m]}$$

where V is the velocity of the ball and foot ball foot respectively, [M] is the effective striking mass of the leg, while m is the mass of the ball and e is the coefficient of restitution. The term e relates to the quality of ball impact. This index can have a functional effect on the resultant ball velocity produced by kicking. However, estimated values of the effective striking mass, M, have been reported to vary considerably (from 1 to 4 kg) in the literature (Asami and Nolte, 1983; Plagenhof, 1971; Togari,

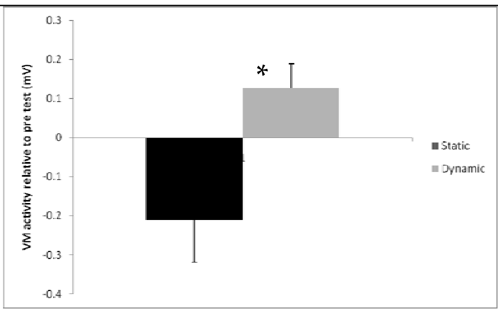


Figure 2
Vastus medialis activity (VMA) relative to the pre test. Significant changes in the VMA between the static and dynamic stretching methods (p < 0.003) during soccer instep kicking

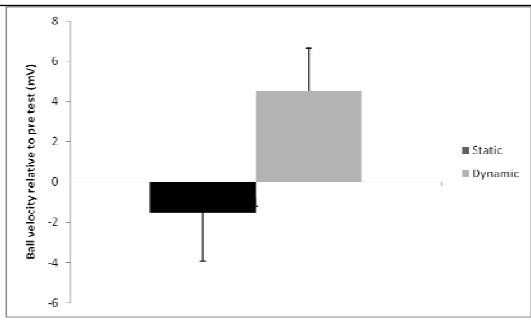


Figure 3
Ball velocity (BV) relative to the pre test. Significant changes in the BV between the static and dynamic stretching methods (p < 0.008) during soccer instep kicking

1972).This makes it difficult to directly estimate the ball impact quality from the above formula. Thus, in the present study, the quality of ball impact was indirectly evaluated by estimating the relationship between the toe linear velocity immediately before ball impact and the initial ball velocity.

The effect of different stretching methods on VMA and BV was determined using one-way analysis of variance (ANOVA) for repeated - measures. A significance level of $p \leq 0.05$ was considered statistically significant for this analysis. When justified, paired t-tests were performed to confirm significant changes within each condition.

Result

The results of the soccer instep kick after the different stretching procedures are presented in Figures 2 and 3.

There was significant difference in VMA after dynamic stretching relative to no stretching condition (0.12 ± 0.06 mV) versus static stretching relative to no stretching condition (-0.21 ± 0.10 mV) with $p < 0.001$ (Figure 2). In addition, there was also significant difference in BV after dynamic stretching relative to no stretching condition (4.53 ± 2.10 m.s^{-1}) versus static stretching relative to no stretching condition (-1.48 ± 2.43 m.s^{-1}) with $p < 0.003$ (Figure 3).

Discussion

The present study demonstrated that BV was significantly reduced after static stretching relative to no stretching condition compared with dynamic stretching. Results from the EMG analysis indicated that static stretching caused a significant reduction in EMG activity. Therefore, there was a significant increase in EMG activity after dynamic stretching compared with static stretching, indicating an increased neuromuscular response to the dynamic stretching. This finding which illustrated in Figure 2 supports those of Cramer et al. (2005; 2006) and Marek et al. (2005) and propose that dynamic stretching raises muscle activation (EMG amplitude) more than static stretching. They reported that static stretching reduced VL and RF muscles activation (EMG amplitude). Unfortunately, there is not many similar studies to compare findings, however, the finding that dynamic stretching improved BV coincides with previous research that has reported improvements in muscular performance in leg extension power (Yamaguchi and Ishii, 2005), 50-m sprint time (Fletcher et al., 2007), and agility performance (Little and Williams, 2006; Amiri-Khorasani et al., 2010) after dynamic stretching.

Although there is a growing body of evidence advocating the use of dynamic stretching, investigators have often considered as to the potential mechanisms for their observations (Hough et al., 2009). Some have ascribed to the increases in performance to increased neuromuscular activity (Bishop, 2007; Hough et al., 2009), despite the fact that this has not been reported in soccer instep kick. In this study, EMG activity was significantly greater after dynamic stretching compared with static stretching, indicating an increase in muscle activation after dynamic stretching. This finding may provide a mechanistic basis for the increase and improved performance during the instep kick after dynamic stretching.

It is seems that the static stretching may have caused some neurological impairment resulting in decreased muscle activation (Hough et al., 2009). This suggestion is supported by previous research in which significant reductions in EMG activity of the quadriceps (Marek et al., 2005) and triceps surae (Cornwell et al., 2001) have been reported after static stretching. Fowles et al. (2000) reported a number of factors which may cause such a reduction in muscle activation, including the Golgi tendon reflex, the mechanoreceptor (type III afferent), and the nociceptor pain feedback (type IV afferent) responses. In an assay to clarify the neural mechanisms underlying the stretching-induced reduce force production; Herda et al. (2008) proposed that it is as a result of a temporary impairment of gamma loop role. In addition, Cramer et al. (2005) proposed that a central nervous system mechanism probably accountable for the stretching-induced decrement in isokinetic peak torque production and EMG amplitude of the stretched leg.

It is also possible that the static stretching may have caused an increase in the viscoelastic properties of the muscular tendon unit (MTU) after stretching, which has been hypothesized to alter the force-relaxation properties within a muscle (Fowles et al. et al., 2000; Cornwell et al., 2001; Cramer et al., 2004; Hough et al., 2009), thereby decreasing its force-generating capacity. In addition, BV reduction after static stretching may have been attributed to decreases in the hardness of the MTU. Several investigators have purposed which decrements in stiffness of the MTU after stretching maybe responsible for reductions in muscular strength (Kokkonen et al., 1998) and force (Rosenbaum and Hennig, 1995). Wilson et al. (1994) hypothesized that a stiffer MTU enhances force production by improving the length-tension and force-velocity relationships of the MTU.

The increase in EMG after dynamic stretching suggests that neuromuscular mechanisms were also responsible for the subsequent increased VMA and finally BV. A short period of activity has been demonstrated to induce acute alterations that improve neuromuscular function in terms of mechanical and electrical output (Bishop, 2003; Hough et al., 2009). In the recent research, the increased EMG activity after dynamic stretching may represent an increase in the number of active neurons per motor units recruited to facilitate motor unit activation through neuromuscular propagation. In addition, post activation potentiation (PAP) probably was caused by the muscular activity involved in the dynamic stretching exercises in the present study. PAP is known to be improved through performance of maximum voluntary contractions of the target muscle (Gossen and Sale, 2000). The mechanisms responsible for PAP include increased phosphorylation of myosin regulatory light release from the sarcoplasmic chains and increased Ca^{2+} reticulum causing increases in muscular force (Behm et al., 2004; Herda et al., 2008; Hough et al., 2009).

It seems that VMA decreased after static stretching due to neurological impairment, but increased after dynamic stretching because of PAP which creates more force production. It appears to be that vastus medialis muscle after dynamic stretching can produce more force than static stretching. These produced forces create more knee joint moment which produce more shank angular velocity and subsequently it transmit by foot to ball. Finally, we have higher ball velocity after dynamic stretching than static stretching.

Conclusion

Dynamic stretching showed that its acute effect as compared to static stretching is probably most effective and useful as preparation for the soccer instep kicking with increasing Vastus medialis activity and finally ball velocity. Therefore, this higher muscle activation cause more forces production and subsequently more moments. The increase in moment will raise the angular velocity which is transmitted to the toe and then the ball which results in higher ball velocity. It seems that dynamic stretching is more useful and optimal than static stretching because of more force production for dynamic motions. Findings of this result suggest to coaches, trainers, physical educators and other persons who are responsible to prepare their players muscle during warm up with stretching exercise to use dynamic stretching instead of static stretching. If they like to use static stretching, we suggest them to perform dynamic stretching after static stretching.

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