Acute effect of static and dynamic stretching on hip dynamic range of motion during instep kicking in professional soccer players

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ACUTE EFFECT OF STATIC AND DYNAMIC STRETCHING ON HIP DYNAMIC RANGE OF MOTION DURING INSTEP KICKING IN PROFESSIONAL SOCCER PLAYERS

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ABSTRACT

Amiri-Khorasani, M, Abu Osman, NA, and Yusof, A. Acute effect of static and dynamic stretching on hip dynamic range of motion during instep kicking in professional soccer players. J Strength Cond Res 25(6): 1647–1652, 2011—The purpose of this study was to examine the effects of static and dynamic stretching within a pre-exercise warm-up on hip dynamic range of motion (DROM) during instep kicking in professional soccer players. The kicking motions of dominant legs were captured from 18 professional adult male soccer players (height: 1.80.38 ± 7.34 cm; mass: 69.77 ± 9.73 kg; age: 19.22 ± 1.83 years) using 4 3-dimensional digital video cameras at 50 Hz. Hip DROM at backward, forward, and follow-through phases (instep kick phases) after different warm-up protocols consisting of static, dynamic, and no-stretching on 3 nonconsecutive test days were captured for analysis. During the backswing phase, there was no difference in DROM after the dynamic stretching compared with the static stretching relative to the no-stretching method. There was a significant difference in DROM after the dynamic stretching compared with the static stretching relative to the no-stretching method during (a) the forward phase with p < 0.03, (b) the follow-through phase with p < 0.01, and (c) all phases with p < 0.01. We concluded that professional soccer players can perform a higher DROM of the hip joint during the instep kick after dynamic stretching incorporated in warm-ups, hence increasing the chances of scoring and injury prevention during soccer games.

KEY WORDS angular displacement, flexibility, kinematics, warm-up

INTRODUCTION

Flexibility refers to the range of motion (ROM) available at a joint, and it plays an important physical role as a general health-related physical fitness component, that is, activities related to daily living and upkeep of an independent lifestyle and especially for the sporting performance (12,21). Flexibility represents the ability to move a joint or a series of joints through a full, unrestricted, pain-free ROM. Gender, age, immoderate adipose tissue, skin, stiff muscle, ligaments, and tendons are factors impacting muscle flexibility and joint ROM (3,34). There are several stretching methods that have been used to achieve and maintain flexibility, including static, ballistic, dynamic, and proprioceptive neuromuscular facilitation (2,6,16). These stretching methods are applied in many different forms, including multiple variations of passive and active techniques (34). Stretching exercise may be performed in both the long-term and short-term. Long-term (chronic) preparation may include a well-developed training program to increase flexibility; the short-term (acute) preparation should include a warm-up to improve performance and flexibility pretraining or precompetition.

The most used method in warm-up routines is static stretching. It has been used because it seems to be easier and safer to apply than the other methods (34). Static stretching is a common method performed by strength and conditioning specialists and athletes to increase muscle length. This type of stretching takes the muscle to its end range and maintains this position for a specified duration (10). However, previous studies show that the acute static stretching method may negatively affect performance outcomes in contrast to dynamic stretching, which most research studies have shown to have a positive effect on performance (14,24,26,28,36). The effect of static stretching, specifically on muscle strength and power production, knee flexion, and extension 1 repetition maximum lifts, leg extension power, vertical jump, sprint speed, and agility have all been reduced in terms of performance shortly after a static stretching warm-up (4,6,9,24,33). In contrast, few studies have shown the positive effect of static stretching, which increases ROM; however,
the studies were restricted to improving flexibility in healthy and injured individuals not in sport performance (34).

In fact, it seems that in most studies, the ROM of joints was measured statically. However, these findings may not be applicable to ROM during dynamic motion in sports. The specificity of sport performance and skill require dynamic capturing of motions during practice. Soccer which is the most popular team sport throughout the world demands a high level of flexibility and dynamic skills. One of these dynamic skills in soccer is the instep kick, which is most important when scoring goals and is widely studied (25,30). An instep kick is performed in well-coordinated intersegment and interjoint motions. The hip joint is one of the important lower body joints used during soccer instep kicking. Angular displacement of the hip joint which can be identified as dynamic range of motion (DROM) is at backswing and forward direction. Its angular displacement or DROM can have an effect on kick outcomes achieved at high ball speed, which is important in soccer kicking, because this gives the goalkeeper less time to react, thus improving one's chances of scoring (11,30).

Therefore, it is important that we identify stretching methods that produce a higher DROM during dynamic and active motions in soccer. The purpose of this study was to investigate the acute effect of static and dynamic stretching on DROM of the hip joint during the instep kick in professional soccer players. We hypothesized that dynamic stretching improves the DROM of the hip joint during the soccer instep kick.

METHODS

Experimental Approach to the Problem
In a within-subject experimental design, professional soccer players conducted 3 different warm-up protocols on 3 nonconsecutive test days within 1 week. Each test day was conducted for >72 hours after a match or hard physical training to minimize the fatiguing effects from previous exercise. The warm-up protocols differed only in the mode of stretching methods used, whereas all other exercises used in the warm-up were identical. The stretching modes used were static, dynamic, and no stretch (Independent variables). Soccer Instep Kicking was captured after each warm-up protocol and hip angular displacement during backward, forward, and follow-through phases (Dependent variables), which is instep kicking were selected for analyzing.

Subjects
Eighteen professional male soccer players (height: mean 180.38 ± 7.34 cm; mass: mean 69.77 ± 9.73 kg; age: mean 19.22 ± 1.83 years) from Iran Premier league, who had no history of major lower limb injury or disease, volunteered to participate in this study. All participants had trained regularly for the premier league teams, and each had >10 years of professional soccer practice (mean 10.00 ± 2.30 years), and they also had a high level of fitness, conditioning, and skills in soccer. The sport center ethics committee of the university gave approval for all procedures. Subjects were informed orally about the procedures they would undergo, and each read and signed a medical questionnaire and an informed consent form.

Procedures
Subjects were divided into 3 groups, and they regularly performed 3 warm-up protocols on 3 noncontinuous days. The protocol was performed in a manner that on the first day, 3 groups performed 1 of the 3 warm-up protocols and on the following days the duties in lieu of doing the stretching method was changed regularly by rotation as shown in Table 1. Finally, the results of all participants in all methods were collected separately, showing that all 18 participants had performed the entire research.

The protocol plan was jogging (low intensity 2-3 METS) for 4 minutes, performing stretching programs (except for the no-stretch protocol), 2 minutes of rest, and eventually 5 soccer instep kicks. Because all participants preferred to kick the ball using their right leg, the right leg was considered the preferred leg. After 2 minutes of rest, players were randomly assigned to

<p>| Table 1. Different warm-up protocols and testing programs during 3 noncontinuous days.* |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|</p>
<table>
<thead>
<tr>
<th>Group</th>
<th>4-min jogging</th>
<th>Stretching</th>
<th>2-min rest</th>
<th>Kicking (5 min)</th>
<th>4-min jogging</th>
<th>Stretching</th>
<th>2-min rest</th>
<th>Kicking (5 min)</th>
<th>4-min jogging</th>
<th>Stretching</th>
<th>2-min rest</th>
<th>Kicking (5 min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>+</td>
<td>No</td>
<td></td>
<td>+</td>
<td>+</td>
<td>Dynamic</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>Static</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>2</td>
<td>+</td>
<td>Static</td>
<td>(4 min)</td>
<td>+</td>
<td>+</td>
<td>No</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>Dynamic</td>
<td>(4 min)</td>
<td>+</td>
</tr>
<tr>
<td>3</td>
<td>+</td>
<td>Dynamic</td>
<td>(4 min)</td>
<td>+</td>
<td>+</td>
<td>Static</td>
<td>(4 min)</td>
<td>+</td>
<td>+</td>
<td>No</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

*+ = activity included.
a series of 5 consecutive maximal velocity instep place kicks of a stationary ball with their dominant limb (no rest was allowed during the 5 kicks). A ball was kicked 11 m toward a target 2 × 2 m in size, in the middle of a goal post; essentially, this corresponds to the penalty kick in soccer. 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 5 soccer ball (mass = 0.435 g) was used for each kicking session, and its inflation was controlled throughout the trials at 700 hPa.

The principal lower extremity muscle groups involved in soccer instep kicking included the gastrocnemius, hamstrings, quadriceps and hip flexors, gluteals, and the adductors. Muscles are also the main force producers to move lower extremity segments during soccer instep kicking. The static stretches used are no. 21 (gastrocnemius), no. 69 (hamstrings, modified with subjects holding their own leg), no. 101 (hip flexor and quadriceps, modified with vertical thigh and trunk alignment), and no. 114 (gluteals)

Described by Alter (1), and the saddle (adductors) described by Hoffman (18). Subjects held the stretch for 15 seconds on each leg before changing immediately to the contralateral side. Subjects were told to stretch until they approached the end of the ROM but within the pain threshold. Subjects performed the dynamic stretches on alternate legs for 30 seconds at a rate of approximately 1 stretch cycle per second or unilaterally for 15 seconds, they then repeated this on the other leg at a rate of approximately 1 stretch cycle per second. The dynamic stretches used involve the quadriceps femoris (quadriiceps); lateral lunge (adductors); hip extensors (gluteals); hamstrings (hamstrings); and plantar flexors (gastrocnemius), described in Yamaguchi and Ishii (35). Subjects were instructed to try and attain the maximal ROM during the 15 seconds of dynamic stretching.

Four digital video cameras (Panasonic NV-GS60, Japan) were used to capture limb motion at 50 Hz. All 4 video cameras were adjusted so that the reference point was the penalty point, and they were equally spaced to ensure that the spacing between 2 consecutive cameras covers an angle of 90°.
from the penalty point. An external audio refer to football impact sound was used to synchronize the 4 video cameras. The calibration frame with 16 calibration points that covers a 1.5-
m-long, 1.5-m-wide, 1.5-m-high space was used to calibrate the space in which subjects performed the instep kicking. Reflective spherical markers (1 mm in diameter) were fixed securely by a single investigator onto the lateral side of the bony anatomical landmarks of the right and left legs, including the fifth metatarsal head, the heel, the lateral malleolus, the lateral epicondyle of the knee, the lateral greater trochanter and the center of the ball. Peak Motus version 9 videographic data acquisition system (Peak Performance, Englewood, CO, USA) was used to manually digitize the video records of the calibration frames and subjects' performances. This software also was used to estimate 3-D coordinates of 10 body landmarks and the center of the soccer ball for each trial from the dominant leg toe-off to at least 10 frames after the soccer ball left the kicking foot. Finally, 1 kick could be selected with a good football impact and adequate center of goal targeting for final analyzing. Hip angular displacements during backswing, forward, and follow-through phases identified by Lees (22) were selected as dependent variables and also analyzed as DROM. There are, therefore, 3 variables during soccer instep kicking which are DROM of the hip joint during (a) the backswing phase, which starts from the dominant leg toe-off until start flexion of the hip joint, (b) forward phase which starts from hip flexion after backswing phase until impact with the ball, and (c) follow-through phase, which started impact with the ball until the end of hip flexion and start of hip extension.

Statistical Analyses
The effect of different stretching methods on DROM of the hip joint in all players was determined using 1-way analysis of variance 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. Test–retest reliability values for the testing order of tests intraclass correlation reliability (ICCRs) were \( \geq 0.97 \), effect size was \( \geq 0.89 \), and power was \( \geq 0.99 \).

RESULTS
The results for the DROM or angular displacement of the hip joint after the different warm-up procedures are presented in Figures 1–3.

Within-group analysis showed no significant difference in DROM after the dynamic stretching (2.59 ± 4.67°) compared with the static stretching (0.35 ± 2.197°) relative to the no-stretching group during the backswing phase. There was, on the other hand, a significant \( (p < 0.03) \) difference in DROM after the dynamic stretching (3.35 ± 6.36°) compared with the static stretching (−1.35 ± 7.86°) relative to the no-stretching group during the forward phase (Figure 1). There was, in addition, a significant \( (p < 0.01) \) difference in DROM after the dynamic stretching (2.42 ± 3.14°) compared with the static stretching (−0.68 ± 8.76°) relative to the no-stretching group during the follow-through phase (Figure 2). According to the whole phases (total DROM), there was a significant \( (p < 0.01) \) difference in DROM after the dynamic stretching (8.38 ± 795°) compared with the static stretching (−1.67 ± 9.59°) relative to the no-stretching group during whole phases (Figure 3).

DISCUSSION
The purpose of this study was to compare the effect of static and dynamic stretching methods, during warm-up on the hip DROM during the instep kick in professional soccer players. The findings of this study showed that significant increase in hip joint DROM after the dynamic stretching compared to static stretching during the (a) forward phase, (b) follow-through phase, and (c) all soccer instep kicking phases.

The present finding showed that there was no significant difference between dynamic and static stretching on hip DROM during the backswing phase. It seems that the reasons behind DROM are twofold: optimal agonist contracted muscle, which results from the movement of the segment around the joint creates more DROM or angular displacement and also optimum antagonist muscle (muscle to be stretched), which limits segment movement to the opposite
direction. During the backswing phase, according to the literature, the kicking leg moves backward, with the hip extending up to 29°; how supported by hip extensors as agonist muscles and limited by hip flexors as antagonist muscles, with a velocity of 171.9–286.5° s⁻¹ (23,29). In addition, as a result of the backward movement of the shank, the angular velocity of the thigh is almost minimal at the same time that the shank velocity is negative. During the initial part of the forward swing phase, the angular velocity of the thigh is positive ~286–401° s⁻¹, whereas a negative shank angular velocity ~286–401° s⁻¹ is observed (20,22). This is because of the immediate forward movement of the thigh as long as the shank moves backward. Depending on the role of the hip and the thigh during the backswing phase, it seems that hip extensors do not generate maximal energy to move the thigh backward around the hip joint. According to previous studies (5,7,15,28,35), which showed that dynamic stretching positively affected the target muscle and because of production of greater force and power than in static stretching and based on hip and thigh function during the backswing phase, it could be that different stretching methods did not have a determinant role in affecting hip extensors to move the thigh for more DROM around the hip joint, because hip extensors did not produce high force to move quickly.

In contrast to the backswing phase, during the forward phase, the dynamic method showed a higher DROM compared to the static stretching method. During the forward phase compared to the backswing phase, the hip starts to flex (reaching values of 20° at speeds of up to 745° s⁻¹ (23,29). Therefore, it is clear that the thigh moves faster during the forward phase than during the backswing phase, because hip flexors as agonist muscle produce higher forces than because of quick thigh movements and also in more DROM around the hip joint. Dynamic stretching compared to static stretching probably affected hip flexors to perform a faster motion and more angular displacement. Furthermore, this significant difference between dynamic and static stretching relative to no-stretching also provides evidence during the follow-through phase. It seems that the role of the thigh during the follow-through is similar with that during the forward phase.

We suggest that the main reason for the positive effect of dynamic stretching on DROM of the hip joint is its effect on agonist muscles rather than on antagonist muscles. Agonist muscles (hip flexors) produce more force after dynamic stretching compared to after static stretching and are therefore able to move the segment (thigh) around the hip joint and increase the DROM. Previous studies also support our finding that dynamic stretching positively affects hip DROM compared to static stretching. Previously, 2 hypotheses have been proposed for the static stretching-induced decrease in performances (4,8,27,31): (a) mechanical factors involving the viscoelastic properties of the muscle that may affect the muscle's length–tension relationship and (b) neural factors such as decreased muscle activation or altered reflex sensitivity. Recent studies (27,31) have suggested that the primary mechanism underlying the stretching-induced decreases in force is related to increased muscle compliance that may alter the muscle length–tension relationship, increased sarcomere shortening distance and velocity, and decreased force production because of the force–velocity relationship. A stretching-induced change in the length–tension relationship may also account for the negative effect on agility performance. On the other hand, it seems that the positive acute effect of dynamic stretching is the result of some level of postactivation potentiation (PAP) (17). Postactivation potentiation is prevalently defined as the temporary increase in muscle contractile performance after a previous “conditioning” contractile activity (32). Postactivation potentiation may raise the rate constant of crossbridge attachments (19), which in turn may enable a greater number of crossbridges to form, resulting in an increase in force production (3). Faigenbaum et al. (13) and Yamaguchi and Ishii (35) hypothesized that the increases in force output after dynamic stretching were caused by an intensification of neuromuscular function, and they hinted that the dynamic stretching had a PAP effect on performance.

In summary, this study examined the acute effects of 2 different stretching methods during warm-up on the DROM of the hip joint during instep kicking in professional soccer players. Unique to this investigation, the warm-up protocols, which included dynamic stretching, enhanced the DROM to a greater degree than did static stretching alone. The possible reasons for these observations are as follows: (1) a positive effect of dynamic stretching on agonist muscles by allowing a greater number of crossbridges to form, resulting in an increase in force production, (2) effect on antagonist muscle (stretched muscle) by a motion similar to the main motion to move around the joint in more angular displacement compared to static stretching. Static stretching, on the other hand, when performed routinely during soccer pretraining and precompetition warm-up, does not appear to be detrimental to subsequent DROM of the hip joint. However, the benefits of using static stretching in a warm-up remains questionable.

**PRACTICAL APPLICATIONS**

A higher DROM in soccer seems to have a positive impact on angular velocity of lower extremity joints during whole phases of instep kicking especially in the forward and follow-through phases. Dynamic stretching during warm-ups, as compared to static stretching, is probably most effective as a preparation for the DROM required in sports such as soccer. It seems that dynamic stretching is more useful and optimal than static stretching for dynamic motions that needs more DROM around the joints. Consequently, the present finding suggests to coaches who train professional soccer teams that dynamic stretching produces more and maximal benefit and optimum muscular function to perform DROM during active
movements as compared to static stretching, especially in skills such as soccer instep kicking. This in turn will produce high ball velocity and increase one’s chances of scoring a goal. Injuries related to lack of ROM may also be prevented with dynamic stretching. In active sports, coaches and trainers should use the DROM analysis and make appropriate modifications to the training to maximize the performance.

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REFERENCES