The Acute Effect of Static Stretching of Quadriceps, Hamstrings and Gastrocnemius Muscles on Knee Joint Position Sense in Football Players

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ABSTRACT

Purpose: Everything that impairs joint proprioception system can harm joints. It has been stated that stretching exercises can change properties of the proprioceptive receptors and as a result changes the sensibility of the joints proprioception. Due to fact that static stretching has greater use between athletes, it is necessary to give useful information about the safety of these stretching exercises and their effect on knee joint position sense. Therefore, the purpose of this study was to determine the effect of static stretching of selected muscles around knee on knee joint position sense in football players.

Methods: This study was a quasi-experimental research with pretest and posttest design. In this study, 30 soccer players at the college level, with the mean age of 23.20 ± 1.45 years were selected through purposeful sampling. Before performing stretching exercises and measuring, subjects had 5 minutes warm up on a fixed bike with the same speed. Then, knee joint position sense were measured by electrogoniometer SG150 model and the achieved figures were recorded as pretest record in the record sheet. Then static stretching exercise protocol was applied on the selected muscle and immediately after that, joint position sense was measured. The obtained data were recorded as posttest record. The paired t test was used to compare the mean of pretest to the posttest mean.

Results: The results of the study showed that there is no significant difference between the mean of knee joint position sense before doing static stretching exercises and thereafter (P = 0.13).

Conclusion: According to the results of this study, athletes, trainers and coaches can use the static stretching without fear of negative effects on the proprioception.

1. Introduction

Stretching exercisers are usually done before sport activities in order to improve function and decrease the risk of injury [1]. Coaches and trainers believe that applying stretching protocols before competition reduces injury and improves athletes' performance [2]. Dynamic and static stretching are among common stretching exercises used by the athletes [3]. Since static stretching can increase motion range and reduce risk of musculoskeletal injury, it can be used as a part of warm up program before exercise and competition by many athletes [4]. There is some concern that stretching exercises may in-

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fluence proprioceptive receptors and impair them [5]. Since disorder in proprioception impairs transmission of afferent messages from joint, it can impose too much or inappropriate load on the joint, which as a result, these factors can lead to progressive joint degeneration and continuous failure in balance as well as neuromuscular imbalance [6].

Proprioception is a general term refers to spatial position sense of a joint and its movement, which receives sensory inputs from muscle spindle, tendon, joint, and existing receptors in skin and considering these inputs, it specifies position, direction, intensity, and speed of joint movements [7]. Planning and doing sports exercises depend on athlete's ability to use nonvisual information about joints position. However, different mechanoreceptors have been placed in skin, joint capsule, and connective tissue. It is generally accepted that the greatest and most important determining factor in joint proprioception are receptors, which are placed in muscles and responsible for movement and control of a certain joint [8].

Proprioception is necessary in knee joint for better control of lower limbs while walking, running and doing daily tasks. Brain awareness of knee joint position leads to contribution of muscles around knee. These muscles have an important role in the stability of knee joint and absorb strikes during exercises [9].

Muscle spindles are important part of proprioceptive receptors. Therefore, one of the factors, which may affect the function and precision of this sense are muscles around each joint. While stretching muscles around each joint, the muscle spindles are stimulated and they send sensory inputs to central nervous system and consequently stimulate motor nerve receptors. Thus, stretching exercises can affect muscular receptors and relevant joints proprioception [10].

Björklund and colleagues indicated that stretching exercises of agonist and antagonist muscles can change properties of the muscle spindle and may decrease its sensitivity [5]. In this regard, Streepey and colleagues reported that proprioceptive neuromuscular facilitation (PNF) stretching of hamstrings and quadriceps would decrease knee joint proprioception [2]. However, the results of the studies done by Larsen et al. and Torres et al. revealed that static stretching of hamstrings and quadriceps muscles had no significant effect on knee joint proprioception [11,12]. In a similar study, Ghaffarinejad and colleagues also investigated the acute effect of static stretching of muscles around knee on knee joint position sense and it was determined that stretching exercises improves knee joint position sense at 45 degrees [13].

Few studies have been done on the effect of static stretching of muscles around knee on knee joint position sense , out of which contradictory results have been reported. However, lack of research regarding static stretching effect of hamstrings and quadriceps muscles on knee joint position sense still exists. Despite the abundant use of this stretching among athletes, there are some doubts for its safety use. Therefore, because of the paucity of research, contradictory results, and considering the fact that no study has been carried out on soccer players, the present study aimed to provide sport therapist, coaches, trainers and other individuals with sufficient information by studying the effect of static stretching of quadriceps, hamstrings and gastrocnemius muscles on knee joint position sense in soccer players.

2. Materials and Methods:

This study is a quasi-experimental research in which the effect of static stretching of quadriceps, hamstrings, and gastrocnemius muscles on knee joint position sense in soccer players was measured through pretest and posttest. Thirty student soccer player aged 18 to 25 years were selected through purposeful sampling. They did exercise at least three sessions a week over the past three years. In order to exclude the probable variables with negative influence, we tried to select players with homogenous weight and height as well as normal BMI (18 to 25). Furthermore, none of the subjects experienced the following problems: record of surgery, neurological and musculoskeletal disorders in lower limbs, record of ligament injury and meniscus of knee [14].

Methods of Data Collection and Design Performance

After obtaining consent of subjects to participate in the research, the subjects completed the consent form as well as data collection form, including demographic information and sports record. The measurements of the study were done at the laboratory of corrective movements and sports pathology, University of Tehran. Before starting the research, the subject were studied regarding their height, weight, and lower limbs abnormalities. Since there are some reports on similarities of joint position sense between the dominant and non-dominant limbs [15,16], only the knee of the dominant foot was used for assessment. In order to determine the dominant foot, tests of shooting foot and going up the stairs was used. Furthermore, considering that the highest efficacy of

muscle spindles (as main proprioceptive receptors) is in middle range of joint movement [17], the target angle for measuring position sense of knee joint should be in the this range (40-80 degrees flexion) [11]. In this study, reconstruction method of 45 degrees angle of knee flexion was used. At first, prior to pretest and stretching exercises, in order to prevent probable damages and providing more applicable results, the subjects were asked to pedal on a fixed gear bicycle with predetermined and fixed speed for 5 minutes in order to warm up.

Method of Pretest and Posttest

After warm up, the subject sat in a chair for measuring knee joint position sense. The chair height was selected in a manner that the sole of subject did not touch the ground. Then, arms of electrogoniometer were attached to knee joint in specified places by land markers. Knee joint position sense was measured by electrogoniometer, SG150 (manufactured by Biometrics LTD, England), which has high validity and reliability and is used in many researches [18, 19, 20, 21]. The reliability of this instrument for measuring knee joint position sense in sitting position is (ICC = 0.86) [22]. In order to perform the test, each subject wore sport shorts and had no other cover for his lower limbs. Each subject was in a free standing position and 4 skin markers were stuck on outer side of the limb in 4 points. To specify required markers, at first greater trochanter of femur was touched and then head of the greater trochanter was attached to the middle part of outer joint line of knee.

The first marker was stuck at the upper one-fourth of this line, second marker on the neck of fibula and the third marker on upper part of outer ankle. Then the subject sat on a chair knee at 90-degree angle and the fourth marker was stuck at upper part of popliteal fold along with outer edge of patella. Fixed arm of electrogoniometer was placed along with greater trochanter and upper part of popliteal fold and its motor arm was placed along with upper head of fibula and outer ankle (Figure 1). The places markers stuck were based on studies of Lafortune and colleagues [23], Cappozzo and colleagues [24], Lamoreu [25], and Tully and Stillman [26].

Figure 1. Subject position on chair and place where markers and electrogoniometer are attached.

At first, the subject was asked to move his foot from 90 degrees of flexion to 45 degrees of flexion 3 times with open eyes and actively at an approximate speed of 10 degrees per second and hold it for 5 seconds. To remove visual intervention during measuring, the eyes of the subjects were closed by sleep mask and he was asked to keep his head straight and fixed. After 7 seconds, he was asked to move his leg actively up to the intended angle and reconstruct the said angle with the desired speed and declared that with the word "arrived".

The difference between angle reached by the subject and the target one was estimated with absolute error. Each movement was repeated 3 times and finally mean of 3 obtained error angles was considered as the main record for every movement and the achieved results was recorded as pretest record. The subjects got prepared for reassessment immediately after doing stretching exercises. And the same procedure was carried out in posttest.

The data in pretest and posttest were analyzed by SPSS software, version 18 (manufactured by IBM). The normal distribution of data were studied by Kolmogorov–Smirnov test. The data were analyzed by paired t test. The level of significance was 0.05.

Method of static stretching

In the present study, the muscles stretched were quadriceps, hamstrings, and gastrocnemius. The static stretching protocol used in this study for each muscle included 30 stretching for 30 seconds and then 15 seconds rest was prescribed between each stretching. For homologizing stretching, the subjects were asked to stretch the joint calmly and carefully with control and up to the pressure pain threshold [11]. The mean of the stretching time, including stretching and the rest is 2 minutes and 15 seconds and total period of each stretching session was 6 minutes and 45 seconds.

Gastrocnemius muscle was stretched at standing position so that the subject put his dominant foot backward and bent the other one forward. He passed on his weight on the front foot in order to feel the stretching in the an-

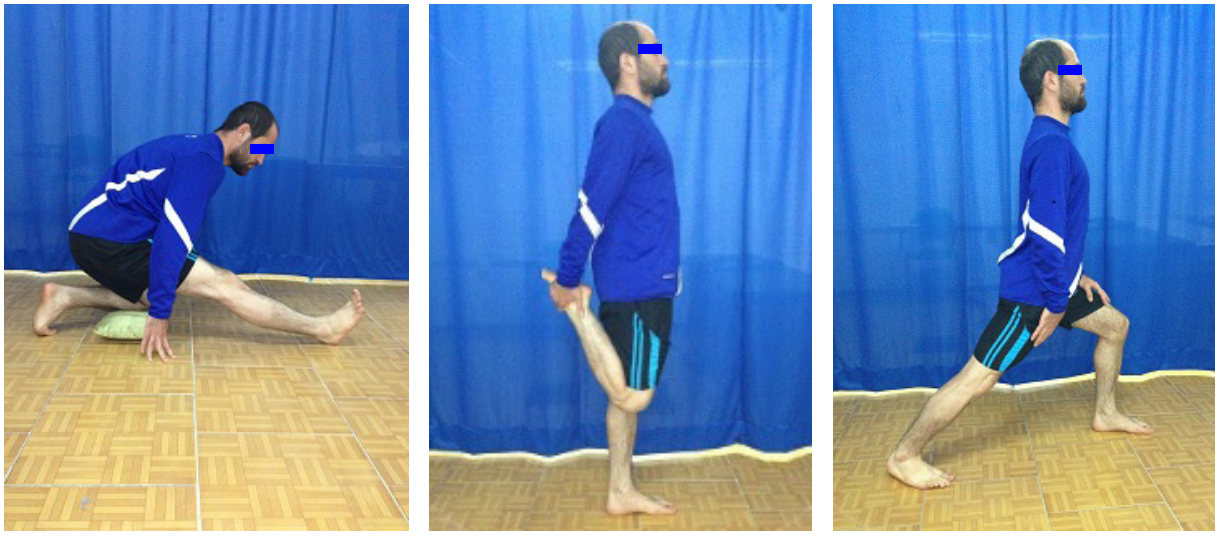

Figure 2. Method of Static Stretching of Quadriceps, Hamstrings and Gastrocnemius Muscles (respectively from left to right)

kle muscle of dominant foot. The heel of the dominant foot should not be raised in this movement.

The stretching of quadriceps muscles is done at a standing position. The subject bents his dominant foot and holds his ankle by hand behind his hip. In this position, he should feel the stretching in quadriceps muscles. Finally, hamstrings muscle stretching was done in Semi-Fowler's position. This was done by putting the knee of non-dominant foot on the ground and the dominant foot was stretched before the body. Then, he was asked to bend his body on the front foot without bending the knee in order to feel stretching in the hamstrings muscles (Figure 2).

3. Results

The mean and deviation of personal particulars of subjects, including age, height, weight, and BMI are mentioned in Table 1.

The results of the study indicated that there is no significant difference between mean of absolute error of knee joint reconstruction before stretching and after static stretching of quadriceps, hamstrings, and gastrocnemius muscles.

4. Discusion

The present study aimed to investigate the effect of static stretching of hamstrings and quadriceps muscles on knee joint position sense of male soccer players. The result revealed that static stretching of selected muscles around knee has no effect on knee joint position sense and cannot considerably change properties of muscle spindle.

The findings of this study corresponds to the findings of other researchers. Björklund and colleagues concluded that static stretching of agonist and antagonist muscles had no effect on knee joint position sense [5]. They assumed that stretching can change the sensitivity of muscle spindles and improve them. Although the joints studied in this research were different from those studied by Björklund and colleagues, our results support findings of Björklund and colleagues, thus, static stretching has probably a similar effect on the position sense of different joints.

One of the reasons stated by Björklund and colleagues for justifying the results of their study was using FASTRAK electromagnetic tracking system, which was not precise enough to measure changes resulting from stretching in the sensitivity of muscle spindle. They also reported reasons like fatigue resulting from doing stretching protocol as one of the probable factors that stops activity of muscle spindles and prevents any changes in the sensitivity of knee joint position sense [5].

In general, fatigue reduces muscle power and brings about disorders in the activity of proprioceptive receptors, especially muscle spindles and Golgi tendon organ and finally, reduces their sensitivity in transmission of the neural messages [29]. Thus, fatigue resulting from static stretching may bring about inefficiency in activity of muscle receptors and affect transmission of proprioception and prohibit change in the sensitivity of knee joint position sense.

Table 1. Anthropometrical properties of subjects (n=30).

Variable	Mean	Standard deviation
Age (years)	23.20	1.45±
Height (cm)	178.29	6.196±
Weight (kg)	71.03	9.74±
BMI (kg/m²)	22.14	1.86±

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In another research, Torres and colleagues (2012) concluded that however static stretching changes the viscoelastic property of muscle spindles, it does not change the performance and information of proprioception [12].

Generally, proprioception information is not only limited to muscle receptors (Golgi tendon organ and muscle spindles), joint receptors as well as skin receptors have a role in transmission of these information. Although the results of the study of Torres and colleagues revealed that static stretching had no effect on proprioception of joints, but they believe that stretching exercises may have fundamental changes on the sensitivity of muscle receptors. However, information transmitted via other sources of proprioception such as skin receptors and joint receptors help maintain proprioception information at normal level [12].

On the other hand, in the study of Larsen and colleagues in which the acute effect of quadriceps, hamstrings and gastrocnemius muscles on proprioception of knee joint was investigated, the results revealed that acute stretching had no effect on the proprioception of knee joint sense. In this study, it was assumed that the stretching may influence the proprioception of knee joint. In order to justify their results they stated that knee joint proprioception was not measured immediately after static stretching, and there was a 6-7 minutes pause and during this pause the effect may have faded away and the registered record was not exact [12]. In the current study after static stretching, there was a 1-2 minutes pause for installing electrogoniometer on knee joint, this pause may affect the results and the static effect may have faded away. But since in Torres and colleagues study the proprioception was measured in 2 times –immediately and one hour after stretching – by Biodex and the results did not show any change in knee joint position sense, therefore, this pause did not have a considerable effect on the results. It should be also mentioned that the results of the present study is compatible with the findings of Larsen and colleagues, then again in their study, the relative error of constructing target angle of knee joint was measured while in the present study and other researches of the aforementioned person, the absolute error was used.

As mentioned by Torres et al. and Larsen et al., one of the other reasons for inefficacy of static stretching on knee joint position sense may be due to the protocol of static stretching. The duration of stretching in the present study (30 seconds) may not be enough to change particulars of proprioception receptors. It is determined that 30 seconds stretching is enough for increasing movement range [30, 31]. However, the duration needed for changing sensitivity of proprioception receptors is not specified yet.

The nature of inactivity of static stretching is another-reason thta probably affects the results of the present study [32]. The inactivity of static stretching means that contrary to dynamic stretching, muscle contraction is not used to increase flexibility of muscles and the stretched muscle can be used by lateral force such as gravity force, other organs or someone else. Some studies have been done in this field; the obtained results indicated that no electrical activity in muscle has been recorded during static stretching by electromyography. Therefore, the researchers reported that the static stretching has no effect

Table 2. Comparison of precision error in knee joint position sense in pre-test and post-test.

Position sense error	Mean of error ±Standard deviation	Difference of errors mean (degree)	t	df	p
Pre-test	1.92±3.00				
Post-test	3.53±1.63				
		0.54	-1.52	29	0.13

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on proprioception receptors of the muscles, which transmit neural messages [33].

Another factor, which probably affects the result of this study is the prolong nature of static stretching in which the muscle-tendon unit is stretched. In static stretching, the muscle is stretched for 10 to 90 seconds; some researchers believe that due to the prolong duration of static stretching, the muscle spindles accord with these conditions and their activity stopped [34, 35].

On the other hand, the results of the present study is incompatible with the findings of Ghaffarinejad and colleagues. The result of their study showed that static stretching of selected muscles around knee improves knee joint position sense [13]. They stated that static stretching improves sensitivity of muscle spindles and transmission of neural messages to central nervous system. It seems that the contradictory results of the present study with findings of Ghaffarinejad and colleagues is due to different methods of measuring knee joint position sense after static stretching.

In the present study, the position sense in quadriceps, hamstrings, and gastrocnemius muscles was generally measured after stretching, but in the study of Ghaffarinejad and colleagues the joint position sense in each muscle was measured separately. Thus, position sense in the study of Ghaffarinejad and colleagues was measured without considering the rest ing time after 1.5 minutes of static stretching, but in this study, the knee joint position sense was measured after 4.5 minutes of static stretching. The duration of rest period between the sets in the said research was 30 seconds, but the duration in the current study was 15 seconds.

Hence, with reference to the mentioned cases, probably the fatigue resulting from stretching which was more in present study compared to the study of Ghaffarinejad and colleagues was probably one of the reasons for contradictory findings in two studies. This fatigue stops the activity of muscle spindles and does not bring about changes in sensitivity of knee joint position sense.

In competitive sports, which exorbitant sum of money are spent to employ the athletes, any kind of injury, especially in sensitive sport competitions can make these athletes incapable of participation, can incur a loss for sports club and can make the athletes withdraw from sports competition. Therefore, trainers and coaches must have sufficient information concerning the best methods for warm up in order to reach maximum function and to reduce injuries. According to the results of the present study, we can conclude that static stretching has no unfavorable effect on knee joint position sense and it is considered a safe stretch. Hence, athletes and trainers can use this stretch without any concern for its negative effects on proprioception.

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