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Muscle Tightness as One of the Physical Factors that Affect Kicking Motion

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Abstract. [Purpose] The aim of this study was to analyze the effect of muscle tightness and joint range of motion on the kicking motion based on measurements of physical functions obtained by a medical check and simple analysis of kicking motion. [Subjects] The subjects of this study were 21 senior high school students who belonged to a soccer club. [Methods] We measured the tightness of the iliopsoas, quadriceps, hamstrings, and triceps surae, and the angle of external rotation of the hip joint in the upright position. Also, images in the sagittal plane were taken of the kicking motion. [Results and Conclusion] A tendency was observed of muscle tightness in the quadriceps and triceps surae, affecting the kicking motion. The angle of external rotation of the hip joint in the upright position also affected kicking motion by decreasing anterior inclination of the lower supporting leg and backward shift of the upper trunk at the time of foot impact on the ball.
Key words: Muscle tightness, Sport injury, Soccer

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INTRODUCTION

For the kicking motion in soccer, strong correlations have been reported between leg extension power and ball speed and between hip joint flexion force and ball speed[1]. In many studies, kicking motion has been analyzed using 3D motion analyzers or high speed cameras, while a few studies have been conducted using evaluations made at the playing field.

It is said that due to the characteristics of the game, the kicking motion represents about 50% of the fundamental skills used during soccer games, and among them instep kicks and inside kicks are much more frequently used than others. Regarding the relationship between physical functions and occurrence of injury, it has been reported that tightness of the iliopsoas, adductors, hamstrings, and quadriceps are among the factors that affect the occurrence of injuries at tendon insertion sites[2]. Many studies have described a possible relationship between the occurrence of sport injuries and low muscle flexibility in youths in their growing period, but only a few have evaluated the association with sport motions.

In this study, we evaluated the factors of muscle tightness that affect the kicking motion, based on measurements of muscle tightness obtained in a medical check at the playing field and on a simple analysis of the kicking motion.

SUBJECTS

Twenty-one high school students who belonged to a top-class soccer team, which has competed at the national level were enrolled in this study. They signed a consent form after a thorough oral explanation about the significance, purpose, and method of the study, following our receipt of approval from the teacher responsible for the team. They had an average age of 16.5±0.9 years, height of 170.1±6.1 cm, and weight of 61.4±8.3 kg, and history of play of 8.5±1.7 years.

METHODS

Referring to a previous study[3], four muscle tightness tests, which are thought to be relevant to soccer, were performed in this study. For the muscle tightness tests, hip flexion angle of one leg with the other leg bent toward the abdomen and held by the arms (Ilio), the straight leg raising angle (SLR), the angle of knee flexion in the prone position (Quad), and the maximum dorsiflexion angle of the ankle with the knee extended in the standing position (Gastro) were measured for both of the legs to evaluate of the iliopsoas, hamstrings, quadriceps, and triceps surae, respectively (Fig. 1). The averages of the right and left legs were used as the representative values. In addition, the angle of external rotation of the hip joint in the upright position was measured using the hip joint method of Tokyo University's General Joint Laxity Test[3].

We had each subject kick the ball using an inside kick aiming at a net which was set at 11 m ahead with maximum power three times. No restriction was set on the run up. Images were taken in the sagittal plane at a right angle to the direction of the shoot. A digital camera EX-FC100 (Casio computer Co., Ltd.) was set on a tripod 5 meters away from the ball at the height of 90 cm and the images were taken at 210 fps.

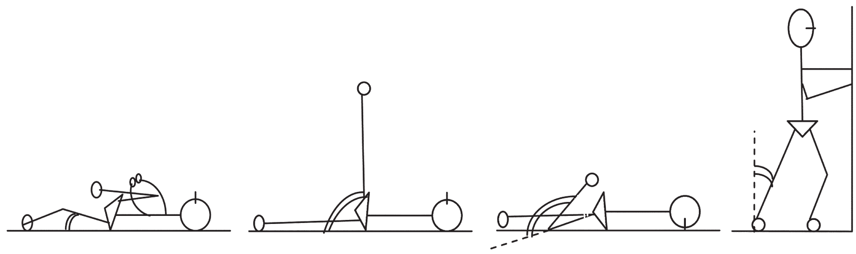

Fig. 1. Muscle tightness tests

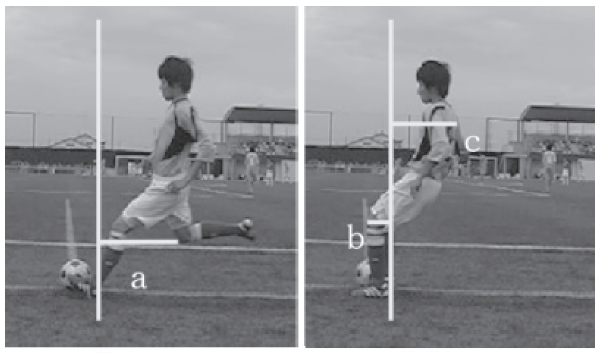

Fig. 2. Measurement of distances during the kicking motion
a: distance between the perpendicular line to the ground that passes through the heel of the supporting leg and the forefront surface of the knee of the kicking leg
b: distance between the perpendicular line to the ground that passes through the heel of the supporting leg and the forefront surface of the knee of the supporting leg
c: distance between the perpendicular line to the ground that passes through the heel of the supporting leg and the backmost surface of the upper trunk

For the analyses of the motion, Media Blend (DKH Co., Ltd.) was used and the three shoots were analyzed. During the kicking motion, four points were defined to represent the process: "Toe off", when the toe of the kicking leg leaves the ground; "Heel contact", when the heel of the support leg contacts the ground; "Foot flat", when the sole of the supporting leg contacts the ground; and "Ball impact", when the kicking leg contacts the ball.

Using the images captured in the sagittal plane, the following three distances were measured: "distance a", the distance at the time of Heel contact between the perpendicular line to the ground that passes through the heel of the supporting leg and the forefront surface of the knee of the kicking leg; "distance b", the distance at the time of Ball impact between the perpendicular line to the ground that passes through the heel of the supporting leg and the forefront surface of the knee of the supporting leg; and "distance c", the distance at the time of Ball impact between the perpendicular line that passes through the heel of the supporting leg and the backmost surface of the upper trunk (Fig. 2). These distances show the characteristics which are supposed to cause some disorders in kicking motion: "a" − swing range of the kicking leg, "b" − anterior inclination of the supporting leg, "c" − posterior transition of the upper trunk.

In order to evaluate the factors of muscle tightness that affect the distances a, b, and c in the kicking motion, multiple regression analyses were performed with each measured distance as the dependent variable and measurements of the tightness of lower leg muscles and degree of external rotation of the hip joint as explanatory variables. The analyses were performed using stepwise selection of explanatory variables considering F values.

Statistical analyses were performed using SPSS Statistics 17.0.

Table 1. Results of the measurements

	Average ± SD
Distance a (cm)	71.8 ± 8.40
Distance b (cm)	19.1 ± 6.84
Distance c (cm)	44.2 ± 11.7
SLR (degrees)	66.7 ± 6.29
Quad (degrees)	138.4 ± 4.44
Ilio (degrees)	11.9 ± 5.31
Gastro (degrees)	31.6 ± 4.94
Hip external rotation (degrees)	144.4 ± 15.4

RESULTS

The results of the measurements are listed in Table 1.

The multiple regression analyses showed the effect of muscle tightness on “distance a” was not significant in ANOVA, with an R^2 of 0.21, which was considered to be a poor fit (Table 2). However, muscle tightness was shown in the ANOVA to have a significant effect on “distance b” and “distance c” (Tables 3, 4).

DISCUSSION

In the kicking motion, it is expected that tightness of the muscles in the anterior aspect of the thigh can lead to restriction in the range of extension motion of the hip joint, which can cause compensatory motions including excessive extension of the lumbar region or abduction or external rotation of the hip joint at the time of backswing. If these compensatory motions are repeated, the subjects are at risk of lumbar spondylolysis or groin pain syndrome. However, in this present study, the kicking motion analysis in the sagittal plane did not explain the effect of muscle tightness on the distance of the backswing of the kicking leg at the time of Heel contact. Motion analyses were performed only in the sagittal plane in this study, because we were aiming to contribute to injury prevention, from the aspect of physical motion, through simple image taking at the playing field. Since kicking motion naturally accompanies body rotation, the rotation function of the hip joint is also important for the kicking motion. Besides, among various physical functions that may affect kicking motion, we only focused on muscle tightness. Evaluation of other physical functions remains a future issue.

Regarding the decreased forward inclination of the supporting leg and backward shift of the gravity center of the upper trunk at the time of Ball impact, the effects of the triceps surae, quadriceps, and range of motion of hip joint external rotation in the upright position were shown. Sugino et al.[4] performed an examination of male soccer players in elementary and senior high schools and reported that muscle tightness of the quadriceps and triceps surae

Table 2. The effect of muscle tightness on “distance a”

	Partial regression coefficient	Standard partial regression coefficient	95% confidence interval	
			lower limit	upper limit
Intercept	–39.1		–160.0	81.8
Quad	0.76	0.40	–0.10	1.61
Ilio	0.53	0.33	–0.19	1.24

Coefficient of determination R^2=0.21, ANOVA p=0.12. *:p<0.05, **:p<0.01

Table 3. The effect of muscle tightness on “distance b”

	Partial regression coefficient	Standard partial regression coefficient	95% confidence interval	
			lower limit	upper limit
Intercept*	110.8		42.4	179.2
Gastro**	1.33	0.96	0.82	1.84
Quad*	–1.18	–0.77	–1.80	–0.57
Hip external rotation	0.21	0.47	0.04	0.37

Coefficient of determination R^2=0.65, ANOVA p=0.00. *:p<0.05, **:p<0.01

Table 4. The effect of muscle tightness on “distance c”

	Partial regression coefficient	Standard partial regression coefficient	95% confidence interval	
			lower limit	upper limit
Intercept	–77.7		–216.3	60.8
Gastro**	–2.03	–0.86	–3.06	–1.00
Quad*	1.68	0.64	0.44	2.93
Hip external rotation	–0.32	–0.42	–0.65	0.01

Coefficient of determination R^2=0.51, ANOVA p=0.01. *:p<0.05, **:p<0.01

was observed in senior high school students and restriction in the anteflexion of the trunk was observed in elementary school pupils. Takigawa et al.[5] described that soccer players suffering with osteitis pubis tended to have lower values in the symphysis pubic tenderness test, trunk extension, and the angle of external rotation of the hip joint in the upright posture, compared with the average values of university soccer players. In our present study, the results suggest that muscle tightness of the quadriceps and triceps surae is associated with decreased anterior inclination of the lower leg and posterior transition of the gravity center of the upper trunk. We infer that ball impact under such conditions would take place with less flexion of the hip joint. In order to create a greater moment in this condition, the rectus femoris, adductor longus, and iliopsoas would be in action in more stretched positions, which would pose great stress and constitute a risk of hip joint pain at the time of kicking. Besides, stepping-in with the gravity center on the posterior side poses efferent stresses in the quadriceps, and would constitute a risk of injury to the knee extension mechanism.

There is a study that reported that a medical check and stretching instruction improved muscle tightness, which was measured by a method similar to ours[6]. In that study, the reference values of muscle tightness were 70 degrees for the SLR, 135 degrees for the Quad, 15 degrees for the Gastro, and 15 degrees for the Ilio, and the average angle of external rotation of the hip joint was 137.6 degrees[5]. In our subjects, they were 67, 138, 32, and 11 degrees, respectively and the angle of external rotation of the hip joint was 144.4 degrees. Compared with the study mentioned above, there did not seem to be greater muscle tightness or restriction in the range of motion of the joint in our study.

In our present study, muscle tightness of some muscles was shown to affect kicking motion, and muscle tightness is thought to be linked to some chronic disorders. Nakazawa et al.[2] reported that muscle tightness of the iliopsoa, adductors, hamstrings, and quadriceps are related to the occurrence of injuries at tendon insertion sites in junior high school soccer players, and Koga et al.[7] reported that quadriceps tension in patients with Osgood-Schlatter's disease is higher than that of normal subjects. Interventions for muscle tightness are expected to improve muscle tightness associated with the occurrence of injuries. Generally, daily stretching is regarded as desirable for the prevention of sport injuries[6, 8, 9]. Improvements in muscle tightness are expected to affect kicking motion, though it remains to be studied.

There was a limitation to the recording method used in this study. Some studies have analyzed kicking motion[10–12], but there is no common recording method. So in this study, the kicking motion was recorded in an original way. A better way to capture kicking motion is required.

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