THE EFFECT OF DIRECT KICKING FORCE ON ANTERIOR TibIAL TRANSLATION FROM SOCCER BALL IN HEALTHY KNEES

YUKIO URABE, KOSUKE TANAKA, SENTARO KOSHIDA and KOJI MIYASHITA

Abstract

Anterior cruciate ligament (ACL) is the first restraint against anterior tibial translation (ATT) in the knee joint. Previous studies suggested that knee joint laxity might be increased by the repeated stress imposed on the knee joint. The purpose of this study was to demonstrate the effect of the repeated soccer ball kicking actions on the ATT in healthy knees. Forty female collegiate students volunteered for this study. KT-2000 knee arthrometer was used to measure ATT before and after the task. The findings demonstrated that the repeated kicking actions had no significant effect on the ATT in healthy knees. The maximum knee extension angle on the striking side was greater than the supporting side (p<0.05). Significant correlations between mean anterior translation and maximum knee extension angle were observed on both sides (p<0.05). The kicking force on a soccer ball resulted in no increase in the knee laxity.

Key word: 1. Anterior tibial translation, 2. Knee joint laxity, 3. Anterior cruciate ligament

INTRODUCTION

Non-contacting anterior cruciate ligament (ACL) injury was one of the most serious problems facing all athletes. Since ACL injury usually requires surgical treatment, or prolonged, intensive rehabilitation, the mechanism of ACL injury needs to be well studied in order for prevention\textsuperscript{1,2}. The ACL injury is usually caused by a single traumatic stress during stopping, changing directions, cutting, or jump landing during sports activities. However, the repeated stress imposed on ACL may also cause injury resulting from the increased ligament laxity in the knee joints. Previous studies suggested that sustaining exercises might increase ligament laxity in knee joints\textsuperscript{2-4}. The increase of ligament laxity after one hour of sports activity is also demonstrated in ACL-reconstructed knees\textsuperscript{2}.

Non-contacting ACL injury occurs more frequently in female soccer players who kicked the ball repeatedly during practices and/or games. Such repeated mechanical stress imposed on knee ligaments by the kicking motion may be associated with a greater ACL injury incidence among female soccer players. Therefore, the purpose of this study was to determine the effect of the kicking actions on ACL laxity in healthy females. We hypothesized that the repeated force would increase the anterior tibial translation (ATT) in knee joint of healthy females.

METHODS

Forty female collegiate students volunteered to participate in the study. The mean age (±SD) was 21.6±2.0 years. The standing height was 157.9±4.9 cm. The body weight was 51.3±4.3 kg. All subjects did not have prior pathological knee problems.

The ATT was measured bilaterally by KT-2000 knee arthrometer (MEDmetric Co. San Diego, CA, USA) before and after the study. Subjects were placed in spine position with knee flexion angle at 20°. Anterior shear force of 134N was applied to their knee joints.

To establish consistency in the experiment, one examiner was selected based on intra-examiner’s repeatability of the measurement. Six candidates performed the ATT measurements in ten subjects. Intra-class correlation coefficient (ICC) was calculated to assess intra-examiner’s repeatability. The results showed ICC (2, 1) = 0.67, and ICC (1, 1) = 0.72 (range; from 0.58 to 0.82). The examiner who

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showed ICC(1,1)=0.82 was used for this study.

A 280g weight (SD=20g) soccer ball was used for the study. Subjects were instructed to kick a soccer ball at maximum effort every 15 seconds. All subjects kicked the soccer ball 50 times within 15 minutes. Subjects chose which knee to kick based on their preference. Kinematics’ motion data was collected using Ilas-200 high-speed camera (Detect Co., Japan) Maximum knee extension angle was analyzed using the original software (Detect Co., Japan) The distance of the ball traveled was also recorded.

The mean value, standard deviation, and side-to-side difference in ATT were compared before and after the task. The ligament laxity measurements and the maximum knee extension angle were compared before and after using paired t-test. The Pearson’s correlation coefficient was used to compare the side-to-side difference before and after the task. Statistical significance was defined as alpha level of less than .05 in this study.

RESULTS

The kicking maneuver was performed by right leg in 37 subjects and left leg in 3 subjects. Table 1 compared the difference in ATT between the kicking side and the supporting side before and after the task. The mean value of ATT on the striking side was 5.81 mm before and 6.37 mm after the task. The results showed the increase of 0.56 mm in ATT after the task. However, this difference was not statistically significant. The mean values of ATT on the supporting side were 5.77 mm before and 6.34 mm after the task where the increase of 0.57 mm was observed. However, the difference was also not statistically significant.

Table 1. The difference in anterior tibial translation (ATT) on the striking side before and after the task and the difference of ATT on the supporting leg before and after the task

<table>
<thead>
<tr>
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<th>Before</th>
<th>After</th>
<th>Differences</th>
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<tr>
<td>Strike</td>
<td>5.81±1.95</td>
<td>6.37±2.12</td>
<td>0.56</td>
</tr>
<tr>
<td>Support</td>
<td>5.77±1.91</td>
<td>6.34±2.10</td>
<td>0.57</td>
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</tbody>
</table>

The difference in ATT between the kicking and the supporting knees (side-to-side difference) was 0.89 mm (SD=0.96 mm) before the task and 1.12 mm (SD=1.01 mm) after the task. The side-to-side difference was not significant before and after the tasks. The maximum knee extension angle during the striking maneuver was 14.1±5.3° (mean±SD) on the striking side and 11.7±4.2° on the supporting side. Greater maximum knee extension was observed on the striking side (p<0.01) A significant correlation between the mean ATT and the maximum knee extension angle was found in this study (p<0.05).

The correlation between maximum knee extension angle and differences of ATT on the kicking knee before and after tasks were shown in Figure 1 and

Figure 1. The colleration between maximum knee extension angle and the difference of ATT on the striking side before and after the task

Figure 2. The colleration between maximum knee extension angle on the supporting knee and the difference of ATT on the supporting leg before and after the task
ATT (after-before)

Figure 3. The colleration between the distance of ball flight and the difference of anterior tibial translation on the kicking leg before and after the task

2. A significant correlation with coefficient variance of 0.826 was observed on the kicking knee (p < 0.01). The supporting knee, the coefficient variance was 0.943, and the correlation was statistically significant (p < 0.01). The mean distance of the soccer ball flight was 17.2 ± 3.9 m (mean ± SD). A significant correlation was found between the distance of ball traveled and the difference of ATT on the striking knee before and after the task (Figure 3).

DISCUSSION

Kirkley et al. [4] found 0.74 mm changes in tibial anterior translation, and the knee laxity was increased after 15 minutes of treadmill running at the speed of 5 miles per hour. However, the kicking action did not increase ATT. Previously, we obtained the similar result with treadmill running task [5]. This current study showed the differences of 0.56 mm on the kicking side and 0.57 mm on the supporting side after the task. Although kicking a soccer ball could produce vigorous impact on subjects’ knees, the type of force imposed on knees may be different from treadmill running tasks.

Our study indicates maximum knee extension angle during the kicking action were significantly correlated with anterior tibia translation after the task. The greater force produced by kicking a soccer ball may impose greater stress on ACL. This may lead to a creep phenomenon to ACL. The maximum isometric quadriiceps femoris muscle contraction task at a knee angle of 20° leads to an increase in ATT [6]. However, the kicking actions, performed at approximately knee angle of 70 degree, caused no effect on ATT in the knee. Kicking a soccer ball at maximum effort increased great maximum knee extension angle. According to the result, the degree of impact force produced by kicking a soccer ball may be related to the changes of ATT. We illustrated the scheme of possible mechanism for the increase of ATT in Table 2. Our result did not show significant ATT changes after the kicking action. However, maximum knee extension angle was correlated with the increase of the ATT.

Table 2. The possible mechanism for the change of ACL tensile strength by repeated stress

<table>
<thead>
<tr>
<th>The change of mechanical properties of ACL is one of the risk factors...</th>
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<tbody>
<tr>
<td>Tensile strength of ACL is reduced by sports activity</td>
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<tr>
<td>ACL is exposed to repetitive anterior share force by striking a soccer ball</td>
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<tr>
<td>Increase anterior tibial translation</td>
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</table>
CONCLUSIONS

No significant difference in ATT after kicking a soccer ball was observed. Maximum knee extension angle on the kicking side was greater than the supporting side. Significant correlations between mean anterior translation and maximum knee extension angle were observed in both knees. Future investigations are needed to identify a continuous or repeated force that may increase ligament laxity. This study is useful as a reference for future studies.

REFERENCES


