DIFFERENCES IN THE MECHANICS BETWEEN THE DOMINANT AND NON-DOMINANT PLANT LIMB DURING INSTEP SOCCER KICKING

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INTRODUCTION

Soccer players are expected to be proficient at kicking with both limbs, however, most soccer players display a dominance of kicking ability causing asymmetry between the limbs [1]. This asymmetry in kicking mechanics may have injury implications. While there is some evidence that plant leg mechanics differ between the dominant (DL) and non-dominant (NDL) plant leg during kicking, there is little known about how these differences in mechanics relate to ACL injury risk [2].

Brophy and colleagues reported that female soccer players were more likely to injure their dominant support limb [3]. However, this study was a retrospective analysis of injury rates and did not provide insight about differences in lower extremity biomechanics. In contrast, Clagg and colleagues found that female soccer players exhibited greater knee extension, abduction, and external rotation joint moments in their non-dominant plant limb placing it at higher risk for ACL injury compared to the dominant plant limb [2]. These inconsistencies pose a question as to whether the dominant or non-dominant plant limb is more susceptible to ACL injury during instep soccer kicking of female soccer players.

The purpose of this study was to determine the differences in the mechanics between the dominant and non-dominant plant limb during instep soccer kicking of competitive female soccer athletes. It was hypothesized that the DL would exhibit greater posterior GRF impulse, net knee joint impulses in all three planes and lateral trunk lean.

METHODS

18 female participants were recruited for the study (age 20.7 +/- 2.4 years, height 65.3 +/- 2.2 inches, weight 135 +/- 17.9 lbs). All participants had one year of previous experience in competitive soccer. Competitive soccer was defined as soccer at the level of high school, club, collegiate or Olympic Development Program.

Following a warm-up and familiarization period, participants performed three instep kicks with each leg. The participants were aligned at a 60˚ angle from the direct approach of the ball and were allowed three preparation steps towards the soccer ball. This resulted in 3 kicks at a 60˚ approach angle from the right side of the ball and three kicks at a 60˚ approach angle from the left side of the ball. The participants were told to strike the ball as if they were trying to score a goal.

Three dimensional coordinate locations of a standard full-body marker set were recorded during the kicking trials with an 8 camera Vicon MX motion capture system (VICON, Denver, CO, USA). Labeled 3D trajectory and force plate data were imported into Visual 3D (C-Motion, Inc. Germantown, MD) for analysis of the kinematic and kinetic variables. The kinematic and kinetic data were filtered in Visual 3D using a Butterworth low pass filter at a cutoff frequency of 6 Hz for the kinematic data and 40 Hz for the kinetic data [4]. Custom processing protocols developed in Visual 3D were used to determine AP GRF impulse, knee joint impulse in all three planes, and lateral trunk lean. All variables were calculated between the times of initial plant foot contact (IC) to 50 ms after IC, as this may be a relevant time frame for the study of ACL injury risk [5].
In order to test for significant differences across the non-dominant and dominant limbs a Repeated Measures MANOVA was used with significance set at $p \leq 0.05$. A discriminate analysis was used as a post-hoc test to determine how the individual variables contributed to the difference between limbs.

**RESULTS AND DISCUSSION**

Descriptive statistics for the dependent variables are presented below.

<table>
<thead>
<tr>
<th>Variable</th>
<th>DL Mean (SD)</th>
<th>NDL Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AP GRF Impulse (Nms)</td>
<td>-4.11 (3.73)</td>
<td>1.24 (4.40)</td>
</tr>
<tr>
<td>Net Sagittal Knee Moment Impulse (Nms)</td>
<td>0.00 (0.04)</td>
<td>-0.03 (0.01)</td>
</tr>
<tr>
<td>Net Frontal Knee Moment Impulse (Nms)</td>
<td>0.05 (0.02)</td>
<td>0.02 (0.02)</td>
</tr>
<tr>
<td>Net Transvers Knee Moment Impulse (Nms)</td>
<td>-0.02 (0.01)</td>
<td>-0.02 (0.01)</td>
</tr>
<tr>
<td>Trunk Lean (deg)</td>
<td>-2 (3)</td>
<td>-4 (3)</td>
</tr>
</tbody>
</table>

A significant multivariate main effect of limb was found (Wilks’ $\lambda = 0.348$, $F(5,30) = 11.25$, $p = 0.000$). A discriminant analysis was performed to determine which variables were most responsible for the difference between limbs. This analysis revealed that the net frontal plane knee moment impulse, AP GRF impulse and knee sagittal plane knee moment impulse were the main contributors to the difference between conditions. The structure coefficients were 0.538, 0.493, and 0.424 respectively.

While there were significant differences between DL and NDL, these differences did not support our original hypotheses. We found that the dominant plant limb demonstrated greater values in the mechanics associated with increased ACL injury risk. These results were consistent with the study by Brophy et al. which concluded that female soccer players are statistically more likely to injury their dominant plant limb [3]. On the other hand, our results were contrary to the results of Clagg et al., who found greater “at risk” values in the non-dominant plant limb [3]. Results of the current study may have differed from those of Clagg et al. for several reasons including 1) kicking approach, 2) time frame of data analysis and 3) choice of variables.

While these results were inconsistent with those of Clagg et al. and our original hypotheses; these results are consistent with previous evidence suggesting that athletes may utilize a more protective strategy while performing a less familiar task. It has been found that females with more soccer experiences demonstrated larger knee moments than those exhibited by novice female soccer players [6]. It is possible that in the case of this study, the DL kicking strategy was analogous to the experienced player while the NDL kicking strategy was analogous to the novice player.

**CONCLUSIONS**

There is a difference between the dominant and non-dominant plant limb mechanics within competitive female soccer players. The differences we evident as the dominant plant limb produces greater net AP GRF impulse and knee joint moment impulse in the sagittal and frontal planes, exhibiting mechanics consistent with greater risk of ACL injury. As female soccer players gain experience in a task they may use more aggressive mechanics that place their dominant plant limb at a higher risk of ACL injury.

**REFERENCES**