Kinematics Analysis of Lower Extremity Joints During Side Step Cutting Maneuver Related to Anterior Cruciate Ligament Injury in Soccer Players

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Abstract: The aim of current research was to investigate kinematics of lower extremity during side step cutting maneuver related to anterior cruciate ligament (ACL) injury in different male and female soccer positions. Therefore, 18 male and 18 female soccer players were tested for side step cutting maneuver. Kinematics variables (hip and knee flexion and knee valgus) were captured by one camera at 50 Hz from male and female defenders, midfielders and strikers. Current findings showed that there is a significant difference (p=0.05) in knee valgus between all male and female players and also between each of their positions, but there were no significant differences (p=0.05) between hip flexion and also in knee flexion between all male and female and their positions. Authors concluded that female soccer players probably have more ACL injury potential as compared to male players due to their higher knee valgus.

Key words: Side Step Cutting Maneuver %ACL Injury %Kinematics %Knee %Soccer

INTRODUCTION

Researching on understanding anterior cruciate ligament (ACL) injury risk mechanisms is an field of huge interest because of the raised ACL injury risk in males and females [1-5]. Furthermore, in different sports, gender plays important role in the ACL injury risk. Researchers reported that females to be at huge risk for ACL injury than their male duplicates in basketball and soccer [1, 6]. More recent studies has demonstrated that the rate of ACL injury is still higher in female soccer and basketball athletes than in male soccer and basketball athletes; however, the rate of ACL injury is significantly greater in female soccer athletes as compared to female basketball athletes [7]. According to these results, female soccer athletes come into view to be at highest risk for enduring an ACL injury. To better understand potential risk factors for ACL injury, it is influential to concentrate study on those individuals who are at the greatest ACL injury risk, such as female soccer athletes to better deduce potential of ACL injury risk factors.

Previous studies reported that one of the main ACL injury risk factor is side step cutting maneuver, especially in male and female players [1-3] in soccer which is most popular sport team throughout the world [8, 7]. Therefore, the aim of current study was to investigate kinematics of knee and hip flexion and knee valgus during side step cut maneuver in different male and female soccer positions.

MATERIALS AND METHODS

Participants: Eighteen male and eighteen female soccer players who had no history of major lower limb injury or disease volunteered to participate in this study. The university institutional review board gave approval for all procedures. Participants were required to report to our research laboratory to read and sign a medical questionnaire and an informed consent.

Procedures: Subjects performed a 10-min adequate warm-up before maneuver capturing. The side-step cutting maneuver involved three meters running to target place and then plant the foot of their dominant leg on the target place and cut 35-55° toward either their contra lateral or the ipsilateral side, depending upon the light direction. The subjects were instructed to point the foot of the planted (dominant) leg forward before making a cut.

Measures: Three digital video cameras (Canon VIXIA HF M500, Japan) were used to capture limb motion at 50 Hz.
All three video cameras adjusted the reference point as the side step cutting maneuver point and were placed equally spaced to ensure the spacing between two consecutive cameras covers an angle of 90° from the landing point. An external light was used to synchronize the three video cameras. At end, all video records of landing were digitized manually by motion analysis system (SkillSpector version 1.3.2, Denmark) according to their attached markers which included lateral side of the bony anatomical landmarks of the right and left legs: the lateral malleolus (ankle), the lateral epicondyle of the femur (knee), the lateral greater trochanter (hip), anterior superior iliac spine, the middle of superior surface of the femur, the middle of superior surface of the tibia and the medial epicondyle of the femur. Some important kinematics parameters of hip and knee joints during landing were selected for analyses. This study focused on lower extremity, so it investigated the minimum hip flexion angle, minimum knee flexion angle and maximum knee valgus angle from initial contact with plant leg until its foot was off.

**Statistical Analysis:** The MANOVA for repeated-measures was used to determine the effects of gender on kinematics of side step cutting maneuver. When justified, paired t-tests were performed to confirm significant changes within each condition. The Bonferroni adjustment was then carried out to confirm the significant differences. A significance level of \( p = 0.05 \) was considered for this analysis.

**RESULTS**

Participants’ characteristics demonstrated in Table 1. Female soccer players (11.9 ± 8.9 deg) showed significantly greater knee valgus against male soccer players (4.7 ± 7.3 deg) \((p < 0.05)\), as presented in Figure 1.

![Table 1: Participants characteristics](image)

**Table 1:** Participants characteristics

<table>
<thead>
<tr>
<th>Character</th>
<th>Male (Mean ± SD)</th>
<th>Female (Mean ± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (cm)</td>
<td>184 ± 5.8</td>
<td>168 ± 6.1</td>
</tr>
<tr>
<td>Mass (kg)</td>
<td>83 ± 4.6</td>
<td>61 ± 4.9</td>
</tr>
<tr>
<td>Age (yrs)</td>
<td>27.5 ± 5.2</td>
<td>27.6 ± 3.9</td>
</tr>
</tbody>
</table>

![Fig. 1: Kinematics analysis of knee valgus in different soccer positions during side step cutting.](image)

There were no significant differences \((p > 0.05)\) in knee valgus between defenders, midfielders and strikers in male and female, separately. Female players showed significant higher knee valgus in female (a) defenders, (b) midfielders and (c) strikers versus defenders, midfielders and strikers in male players, respectively \((p < 0.05)\).

![Fig. 2: Kinematics analysis of knee flexion in different soccer positions during side step cutting.](image)

There were no significant differences \((p > 0.05)\) in knee flexion between defenders, midfielders and strikers in male and female, separately. In addition, there were no significant differences \((p > 0.05)\) between male and female in each different position.
Fig. 3: Kinematics analysis of hip flexion in different soccer positions during side step cutting. There were no significant differences (p>0.05) in hip flexion between defenders, midfielders and strikers in male and female, separately. In addition, there were no significant differences (p>0.05) between male and female in each different position.

On the other hand, there were no significant differences (p >0.05) in hip and knee flexion between male (31.4 ± 7.2 and 31.7 ± 6.6 deg, respectively) and female soccer players (32.5 ± 7.4 and 32.3 ± 8.5 deg, respectively) (Figures 2 and 3). As illustrated in Figure 1, there were no significant differences in knee valgus between defenders, midfielders and strikers in male and female, separately. On the other hand, female players showed greater knee valgus in each position against each soccer positions in male players (p < 0.05). There were no significant differences in hip and knee flexion between male and female players in different position (Figures 2 and 3).

**DISCUSSION**

Sagittal and frontal planes kinematics differences between male and female soccer players were captured at the hip and knee for the side step cutting maneuver. Similar to the findings of McLean et al. [10] hip flexion angles throughout stance of the side step cutting maneuver were smaller in female subjects than in male subjects, but not significantly (p>0.05). With respect to the knee, no differences between genders were achieved and this agrees with previous side step cutting maneuver studies [11-13].

It must be noted that flexion angle differences between genders do vary throughout the literature, with other studies reporting different results. In consist to our results, Pollard et al. [12] found no hip flexion significant differences (p>0.05) between genders and with respect to the knee, McLean et al. [10] and Malinzak et al. [14] determined that female athletes perform the side step cutting maneuver with less knee flexion than male athletes. Although flexion angle results vary across cutting studies, cutting with less hip or knee flexion can place an individual in a more erect posture. Small flexion angles have been shown to generate higher impact forces [15, 16] and therefore the reduced hip flexion angles in female athletes might possibly increase knee joint loadings and thereby place the ACL at a greater risk of injury. With regard to the previous researches, the findings of this study may validate that greater knee valgus is intrinsic to all female athletes; therefore, knee valgus may increase the risk in female athletes.

In summary, the aim of current study was to investigate kinematics analysis of hip and knee joint during side step cutting maneuver in male and female defenders, midfielders and strikers. Current finding showed only significant differences (p=0.05) on knee valgus in male and female soccer players and also in their different positions. Although, female showed less hip and knee flexion against male soccer players, but there were no significant differences (p>0.05) between male and female and also between each of their positions.

According to current result, we concluded that it seems that different positions have not main effect on kinematics of side step cutting maneuver but the gender could be able to affect it. Therefore, it seems that coaches, trainers, fitness coaches and physicians should redesign their training to improve their players’ ability during side step cutting maneuver with less knee valgus and higher knee and hip flexion for more force observation. In addition, it seems that, greater knee valgus angle has higher potential for ACL injury.

**ACKNOWLEDGMENT**

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