A PREVIOUS HAMSTRING INJURY AFFECTS LIMB DOMINANCE IN SOCCER KICKING

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The objective of this study was to study if the influence of limb dominance on kicking is affected by a previous hamstring injury to either limb. Forty-five players (26 females and 19 males) belonging to elite soccer teams volunteered to take part in the study. They performed 5 instep soccer kicks with either limb into a target 7m away. Differences were found across limb dominance for the uninjured group in peak linear velocities, hip flexion velocity, knee angle at ball impact, and hip moments. A previous injury prevented the rapid extension of the hamstring muscle fibres, being more predominant in the non-dominant limb. Thus the effects of a previous hamstring injury must be taken into account while dealing with the kicking technique, and the location of the injury on the dominant or non-dominant limb is equally important.

KEY WORDS: inverse dynamics, motion analysis, kinematics, kinetics.

INTRODUCTION: Studies on European soccer accounted injuries to the hamstrings contributed to 37% of all muscles injuries (Ekstrand, Hägglund, & Waldén, 2011). 22% of players sustained at least one hamstring injury during a season and the number of hamstring strain injuries increasing annually by 4% (Ekstrand, Waldén, & Hägglund, 2016). The dominant leg accounts for a greater frequency of lesions – 54.4% vs 36.5% in the non-dominant leg (Noya, 2015), but no significant differences were observed in the number of hamstring injuries between the dominant and the non-dominant leg (Freckleton & Pizzari, 2013). The hamstring muscle strain-type injury is considered to be a multifactorial problem, and the factors of age and previous hamstring injury must be considered alongside any other risk factors being examined (Navarro et al., 2015). The hamstring muscle complex is known to be affected by the kicking skill (Navandar et al., 2015; Navandar, Gulino, Antonio, & Navarro, 2013), and various investigations have shown that limb dominance also influenced it (Navandar et al., 2016; Nunome, Ikegami, Kozakai, Apriantono, & Sano, 2006). However, no study has looked at the combined effect of limb dominance and previous hamstring injury on the kicking skill. Therefore, the objective of this study was to ascertain if the influence of limb dominance on kicking is affected by a previous hamstring injury to either limb.

METHODS: Participants: Forty-five elite soccer players (females: n = 26, age = 22.15 ± 4.50 years, weight = 60.71 ± 9.48 kg; males: n = 19, age = 21.16 ± 2.00 years, weight = 71.46 ± 6.22 kg) participated in the study. Players were asked about their preferred leg, playing position and previous injury history in a questionnaire prior to the data capture session. Only players having suffered a grade 1, 2 or 3 hamstring injury which caused them to miss the subsequent match in the last two years were considered as "previously injured". All players who were injured had suffered a unilateral injury (females: injured in dominant limb = 6, injured in non-dominant limb = 4, uninjured = 16; males: injured in dominant limb = 3, injured in non-dominant limb = 1, uninjured = 15).

Data capture: Twenty-four retro-reflective markers (diameter = 14 mm) were attached to the anatomical landmarks of each participant's body, and 4 markers being attached to the ball. In a procedure similar to Navandar et al. (2016), a 6 camera Vicon Motion Capture System at 250Hz and a Kistler Force Platform at 1000 Hz were used to capture static and dynamic data in laboratory conditions, on FIFA approved artificial turf which was placed on the laboratory floor with the force plated being clearly marked out. In the dynamic capture, the players were instructed to kick the stationary ball with their dominant and non-dominant legs at a 1m x 1m target 7m away, as hard as possible using the instep soccer kick, while placing their support leg on a force platform. Kicks were recorded until 5 kicks were performed with each leg meeting the above criteria. Ball velocities were calculated and the trial containing the median value of ball velocity for each limb was selected for further analysis.

Data Processing: A standard inverse dynamics procedure was used to calculate the kinetic and kinematic variables of the kicking and support limb, with the kicking motion being divided into the backswing, leg cocking, leg acceleration and follow through phases (Lees, 2013).

Data Analysis: Kinematic and kinetic variables in the sagittal plane, and normalized phases of kicking were compared in a 3-way ANOVA with the independent factors being limb dominance, previous injury and sex. When a significant effect was observed between the ANOVA levels, multiple comparisons were performed with the Bonferroni correction, and the results were interpreted with 95% confidence intervals (CIs) and effect sizes (as partial η^2 values). The threshold values for small, medium and large effect sizes were set as 0.01, 0.06 and 0.14 respectively (Cohen, 1992; Richardson, 2011).

RESULTS AND DISCUSSION: Differences in the peak linear velocities between the dominant and non-dominant limb were found only for the uninjured group, and not for the injured group (Table 1). Previous studies have consistently stated the superiority of the dominant limb in linear velocities (Nunome et al., 2006). However, a previous injury prevented large differences from occurring. These differences can be explained on the sequence of velocities, which follow a proximal to distal sequence (Lees & Nolan, 1998), and the differences that occur at the different phases of the kick.

Table 1
Comparison of peak linear velocities

		Ball Velocity (m/s)	Toe velocity (m/s)	Ankle velocity (m/s)	Knee Velocity (m/s)
Uninjured group	ND	23.97 ± 3.40**	19.15 ± 2.48**	15.85 ± 1.77**	8.74 ± 1.04**
	D	26.75 ± 2.74**	21.08 ± 2.29**	17.19 ± 1.67**	9.53 ± 0.91**
Injured group	ND	24.00 ± 2.00	19.00 ± 2.55	16.00 ± 1.41	8.80 ± 0.84
	D	25.44 ± 2.74	20.11 ± 1.76	16.44 ± 1.33	9.00 ± 0.87

*ND: Non-dominant limb kick, D: dominant limb kick. * Significant difference between the two groups with p < 0.05, ** Significant difference between the two groups with p < 0.001.*

Table 2
Peak moments of the hip

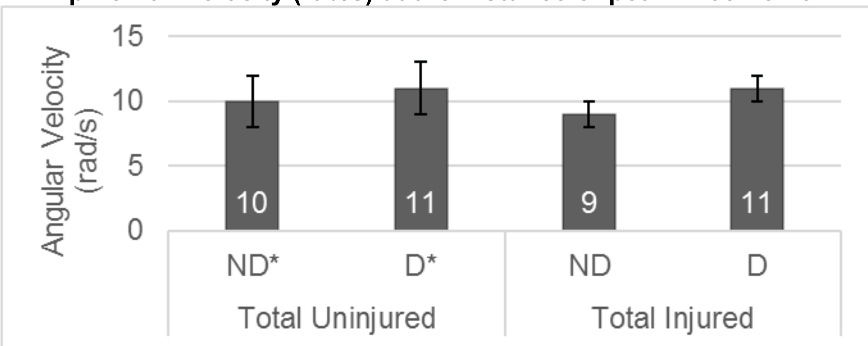
		Peak Flexion moment Backswing (Nm/kg)	Peak Extension Moment Follow Through (Nm/kg)
Uninjured group	Non-Dominant	3.62 ± 1.02*	-2.95 ± 1.12*
	Dominant	4.03 ± 0.74*	-3.69 ± 0.92*
Injured group	Non-Dominant	3.80 ± 0.45	-2.80 ± 0.84
	Dominant	4.44 ± 1.13	-3.78 ± 1.20

** Significant difference between the dominant and non-dominant limb kicks with p < 0.05.*

The end of the backswing phase is defined as the instance when the hip reaches peak extension angle (Lees, 2013), and a peak flexion moment (defined in literature as the soccer paradox (Lees, Asai, Bull-Andersen, Nunome, & Sterzing, 2010)). At this instance, in the uninjured group, the dominant limb kicks have a greater hip flexion moment as compared to non-dominant limb kicks (Table 2). However, this difference is not seen in the previously injured group, with the values being slightly higher (small and medium differences in values

between injured (partial η^2 =0.01) and uninjured group (partial η^2 =0.06)). Thus, previously injured players applied a greater moment in order to restrict the hip extension, when the hamstring muscle fibres were, theoretically, the shortest in length.
This was followed by a greater hip flexion velocity in the dominant limbs for the uninjured group at the end of the leg cocking phase (Figure 1). It is in this phase when the knee continues to flex while the hip begins to flex. Theoretically, the muscle fibres in the hamstring muscle group begin to lengthen, and this lengthening is slower in the previously injured group in the non-dominant limb (partial η^2 = 0.06, p = 0.03). It is in this phase when the knee reaches a peak velocity, and due to this inhibition of rapid lengthening in the leg cocking phase, this difference across limb dominance is seen only in the uninjured group.

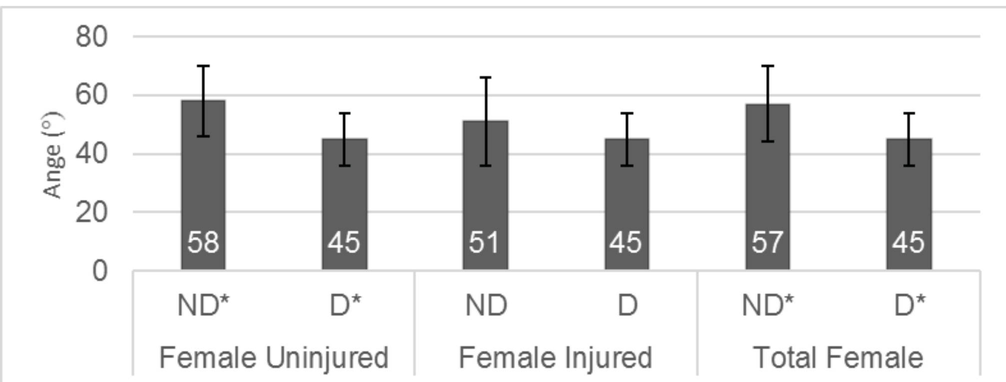
Figure 1
Hip flexion velocity (rad/s) at the instance of peak knee flexion



*ND: Non-dominant limb kick, D: dominant limb kick. * Significant difference between the dominant and non-dominant limb groups only in the uninjured limb with p < 0.05.*

Looking at female kicks alone at the instance of ball impact, a greater knee flexion angle was observed in the non-dominant limb kicks (Figure 2), which facilitated a better transfer of momentum leading to higher ball velocities (Navandar et al., 2016). However, if one were to group them further based on previous injury, this difference is seen only in the uninjured group. Previously injured female soccer players have a lower knee flexion angle at ball impact in the non-dominant limb, restricting the extension of hamstring muscle fibres (the knee extends and the hip flexes in this phase). However, this does not translate to higher ball velocities in the injured, non-dominant limb kicks for females, and this could be due to the angle of the ankle at ball impact which determines its quality.

Figure 2
Comparison of knee flexion angle (º) at ball impact in female soccer players



ND: Non-dominant limb kick, D: dominant limb kick. Significant differences between the dominant and non-dominant limb groups only in the uninjured limb with p < 0.05.

Finally, in the follow through phase a difference across limb dominance is seen for the uninjured group in the peak hip extension moment (Table 2), which is reached when the hip reaches a maximum flexion angle. This phase corresponds to one where the fibres are lengthened to a peak, and this is affected in the previously injured limbs.

CONCLUSIONS: Differences were found between the dominant and non-dominant limb kicks. However, these differences were affected by the presence of a previous injury to the hamstring muscle group, especially in phases where the hamstring muscles were lengthening. Coaches, rehabilitators and biomechanists must take this into account while dealing with a player who has previously injured his hamstrings, as it appears to affect the non-dominant limb more than the dominant limb.

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