EFFECT OF PREVIOUS HAMSTRING INJURY AND LIMB DOMINANCE ON KICKING BIOMECHANICS IN ELITE FEMALE SOCCER PLAYERS

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The hamstring injury is one of the most common injuries occurring in soccer. The purpose of this study was to identify the effect of a previous hamstring injury and limb dominance on the kicking pattern of elite female soccer players. 14 players belonging to a top first division soccer team volunteered to take part in the study. They were asked about their injury history and leg dominance in a questionnaire, and they performed 5 instep soccer kicks with either limb into a target 7m away. The results showed that limb dominance had no effect on the kicking pattern in elite players. Significant differences were found in the maximum hip angular velocity while kicking with a previously injured limb as compared to a previously uninjured limb. This indicates that rehabilitation programs probably should treat the injury differently in female soccer players.

KEY WORDS: inverse dynamics, motion analysis.

INTRODUCTION: Epidemiological injury studies assessing these sports consistently rank hamstring strain injuries as one of the most prevalent factors resulting in missed playing time by soccer players. A ten year study on European soccer found that injuries to the hamstrings contributing to 37% of them (Ekstrand, Hägglund, & Waldén, 2011). On an average, 18 days and 3–3.5 matches are missed per hamstring strain in a soccer player(Petersen & Holmich, 2005). The hamstring strain also tends to have a high rate of re-injury(Freckleton & Pizzari, 2013; Petersen & Holmich, 2005). Over two seasons of professional soccer in England, sprinting and shooting were the first and the third most common causes of a non-contact hamstring injury (Woods et al., 2004).
Studies done on athletes indicate that hamstring muscle strain injuries most commonly occur during maximal or sub-maximal sprinting (Lee, Reid, Elliott, & Lloyd, 2009). In sports such as soccer, the hamstring muscle complex can also potentially get loaded during activities such as kicking which could possibly lead to anomalies in the biomechanical kicking pattern.
Many of these studies involving professional soccer players have been based on evaluating their strength with players being seated and using the isokinetic machine(Fousekis, Tsepis, & Vagenas, 2010; Greig & Siegler, 2009), or performing certain exercises (Arnason, Andersen, Holme, Engebretsen, & Bahr, 2008).
However, no study has studied the influence of a previous injury to the hamstring muscle complex on the kicking action in female soccer players. Although the influence of limb dominance was done on the maximal instep soccer kick (Dorge, Andersen, Sorensen, & Simonsen, 2002), this hasn't been studied on elite female soccer players, and moreover the effect in combination with a previous hamstring injury hasn't been investigated either.
Keeping the above the aims of the study was to study the difference in the biomechanical pattern of kicking on artificial grass, between players previously injured and uninjured while kicking with their dominant and non-dominant legs. The hypothesis was that a previous hamstring injury affects the kicking pattern as previously found with male soccer players (Navandar, Gulino, Antonio, & Navarro, 2013).

METHODS: Participants: 14 elite soccer players belonging to a top first division team in the Spanish women's league volunteered to take part in the study. Players with a clinically diagnosed hamstring injury in the preceding and current season, which caused them to miss a competitive or friendly game, were considered as "having a previous injury history" (n = 4).

Among the sample of players selected, all the injured players had a unilateral hamstring injury.

Experimental setup: A 6 camera Vicon Motion Capture System (Oxford Metrics Ltd., United Kingdom) was used to capture data at 250Hz. This was synchronized with a Kistler Force Platform (Kistler Group, Switzerland), capturing data at 1000Hz. The data was captured in laboratory conditions, on artificial grass. Players used boots appropriate for the playing surface for the study.

The capture was divided into a static capture and a dynamic capture. 24 retro-reflective markers with a diameter of 14 mm were attached to the anatomical landmarks of each participant's body. A FIFA approved standard ball was used for the study, with four markers being placed on the ball, two at diametrically opposite ends (markers B1 and B2), and two markers placed on the circumferential midpoints between B1 and B2.

A static capture preceded a ten minute warm up, following which the players were instructed to kick the stationary ball with their dominant and non-dominant legs at a target 7m away, as hard as possible using the instep soccer kick, such that their support leg was placed on one of the platforms. 5 kicks were performed with each leg. The ball velocities of the kicks were calculated using the midpoint of the four markers, and the trial containing the medial ball velocity was selected for either limb for further analysis.

Data Processing: Joint centres were determined at the hip, knee and ankle, and the kicking leg was modelled as a link-segment model composed of the foot, shank, and thigh. A local co-ordinate system was defined at each segment, such that the longitudinal axis was the Z (the positive direction being from the distal to proximal segment), the antero-posterior axis being X, and Y being mutually perpendicular to both (such that the right hand rule was observed).

Inter-segmental angles were calculated using the Euler reference system with the flexion angle being defined as positive. A standard inverse-dynamics approach was used to calculate the forces and internal moments developed by the lower limb joints. Segmental inertial parameters were taken from de Leva (De Leva, 1996). All the calculations were carried out using the VICON BodyBuilder software (VICON; Oxford Metrics Ltd., United Kingdom). The orientations of the joint reaction moments were in accordance with the right hand rule. Data was interpolated near the impact phase in a procedure similar to Nunome et al (2006) and Knudson and Bahamonde (Knudson & Bahamonde, 2001), and all parameters were digitally smoothed by a fourth-order Butterworth filter at 12.5Hz.

The trial was divided into three characteristic time intervals: backswing (BS) (from toe-off of kicking leg (TO) to maximum extension of the hip (MHE)), leg acceleration (LA) (from MHE to ball impact (BI)) and follow through (FT) (from BI to when the 5th metatarsal marker reached the maximum height (MTH)). They were normalized with respect to the total time interval MTH-TO. For data analysis, ball velocities, ground reaction forces, and only sagittal plane kinematic and kinetic variables affected by the hamstring muscle were calculated of the kicking leg. This is because hip and knee flexion/extension joint postures have the greatest influence on hamstring length (Lee et al., 2009). The forces were normalized to the body weight of each subject.

Data Analysis: Two sets of analyses were carried out. A student t-test was used to compare the effect of limb dominance on the variables. A non-parametric Mann Whitney U-test was used to compare the injured and injured groups. A confidence interval of 95% was assumed for the tests.

RESULTS AND DISCUSSION: The kinematic (Table 1) and kinetic variables (Table 2) in this study fall within the range of the values previously reported (Lees, Asai, Andersen, Nunome, & Sterzing, 2010; Lees & Nolan, 1998).

Table 1
Kinematic variables compared on limb dominance and previous injury

	Time intervals %			Ball Vel (m/s)	Peak Angles(°)				Peak AV (rad/s)	
	BS	LA	FT		Hip Extn	Hip Flexn	Max Knee Flexion	Min Knee Flexion	Hip	Knee
Dom	26.58	33.32	40.10	27.52	-18.98	90.48	113.74	4.64	17.22	17.46
ND	24.29	33.72	41.99	25.78	-17.43	91.21	113.55	6.01	16.78	17.27
Uninj	25.63	32.92	41.44	26.74	-18.53	90.95	112.63	4.47	17.46*	17.33
Inj	24.81	37.00	38.19	26.52	-15.69	90.00	119.77	10.08	14.36*	17.61

* significantly different with $p<0.05$

Dom=dominant limb; ND=non-dominant limb; Uninj=uninjured limb; Inj=injured limb; BS= Backswing; LA=Leg acceleration; FT=Follow through; Vel=velocity; Max=maximum; Min=minimum; Extn=extension; Flexn=flexion; AV=Angular Velocity.

Table 2
Kinetic variables compared on limb dominance and previous injury

	Absolute Peak Moments (Nmm)				Peak Reaction Forces (absolute) (N/kg)		
	Hip Flexion	Hip Extension	Knee Extension	Knee Flexion	Ground	Hip	Knee
Dominant	9777.60	10629.21	3244.87	4840.55	2.81	2.41	2.80
Non-Dominant	7353.43	5812.19	2090.65	2902.99	2.66	2.39	3.09
Uninjured	9177.34	8894.03	2804.26	4200.19	2.71	2.40	2.94
Injured	5500.63	5385.03	2137.33	2385.65	2.92	2.41	2.90

Effect of leg dominance: There was no difference between the velocities while kicking with the dominant and non-dominant limb, a finding contrary to that found by Dorge et al. (2002) or Nunome et al. (2006), or in the knee moments as found by Nunome et al. (2006). This could be explained by the fact that they had selected the maximal velocities in their comparisons, while here a median of 5 kicks was selected for analysis. Also their studies contained 7 and 5 highly skilled players respectively, while 14 elite soccer players participated in this study. Elite soccer players must be able to kick the ball with either foot to meet the demands of the professional environment, and this is possibly why such differences in technique between kicking with either limb are not found with players at this level.

Effect of previous injury: The study found no difference between the injured and uninjured limbs with the biomechanical kicking pattern except in maximal hip angular velocity. Perhaps a previous injury inhibits the generation of a higher angular velocity. A similar study carried out with male football players (Navandar et al., 2013) had found mechanical differences in joint moments during kicking between injured and uninjured limbs, and in the time taken for follow through. Taking into account that loads applied during kicking are higher in male players than in female players, we can consider that the hamstring injury therefore has a greater influence in males than in their female counterparts. This is accordance with a recent study carried out by Cross, Gurka, Saliba, Conaway and Hertel (2013) where they showed that male players were 64% more likely to sustain a hamstring strain as compared to women.

CONCLUSION: This study identified the effect of limb dominance and a previous hamstring injury on the kicking in elite female soccer players. A previous injury possibly affects female soccer players differently as compared to male football players, and this could indicate that trainers and rehabilitators must treat the hamstring injury differently in males and females owing to the different effects of the injury on the kicking technique. No significant differences were found between kicking with the dominant or non-dominant limbs considering. Amplifying the number of participants in such a study can give more conclusive results and probably corroborate the findings of this study.

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