GENDER EFFECTS ON LIMB DOMINANCE IN KICKING BIOMECHANICS IN ELITE SOCCER PLAYERS

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The objective of this study was to study the effect of gender on the limb dominance in kicking in soccer players. Forty-five players (twenty-six females and nineteen 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. Female soccer players had a lesser flexed knee at ball impact in the non-dominant limb which contributed to lower ball velocities in the toe and subsequently in the ball. Both genders had a shorter backswing with the non-dominant limb, but this difference was made up in the follow through for males and in the subsequent phases for females. Working on bilateral symmetry and coordination would help improve kicking with the non-dominant limb, especially in females.

KEY WORDS: INVERSE DYNAMICS, MOTION ANALYSIS, KINEMATICS.

INTRODUCTION: Although professional soccer players are required to be skilful with either limb (Starosta, 1988) , kicking is an asymmetric task (Nunome, Ikegami, Kozakai, Apriantono, & Sano, 2006). Therefore, the preparation of soccer players should develop a left-right symmetry in shooting (Starosta, 1988). Differences on the kicking technique between the dominant and non-dominant limb produce a greater ball speed when kicking with the dominant limb (Nunome et al., 2006). However, these findings have been reported in small sample sizes of non-professional and semi-professional male soccer players kicking on the laboratory floor. Previous studies have indicated that higher the skill level (Nunome et al., 2006) and maturity (Katis, Kellis, & Lees, 2015), the better the co-ordination for both limbs. To our knowledge, only one study has examined the dominant and non-dominant limb kicking in non-professional female soccer players (Barfield, Kirkendall, & Yu, 2002). Research is lacking to see if these differences exist in elite professional soccer players of either gender. Thus the objective of this study was to study the effect of gender on the limb dominance in kicking in soccer players.

METHODS: Participants: 45 elite soccer players (19 males and 26 females) participated in the study. The female players belonged to two top first division teams in the Spanish women's league (*Primera Division Feménina*), while the men's team consisted of reserve team players of a first division club who played in the third division (2ª B) of Spanish football. Players were asked about their preferred leg, playing position and playing experience in a questionnaire prior to the data capture session.

Data capture: A single session data capture session was used to capture the data. In a procedure similar to Navandar et al. (2015), a 6 camera Vicon Motion Capture System (Oxford Metrics Ltd., United Kingdom) at 250Hz was used. The data was captured in laboratory conditions, on FIFA approved artificial turf. 24 retro-reflective markers with a diameter of 14 mm being attached to the anatomical landmarks of each participant's body, and 4 markers being attached to the ball (Navandar et al., 2015). 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. 5 kicks were performed with each leg. The trial containing the median value of ball velocity among the 5 kicks was selected for either limb for further analysis.

Data Processing: 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 and inter-segmental angles were calculated (Lees, 2013) with the flexion angle being defined as positive. Data was interpolated near the impact phase and then smoothed using a Woltring filter (Woltring, 1985) with a MSE of $4mm^2$ in a procedure previously explained in literature (Reid, Elliott, & Alderson, 2007). The kick was divided into four characteristic phases as shown in Figure 1 (Lees, 2013).

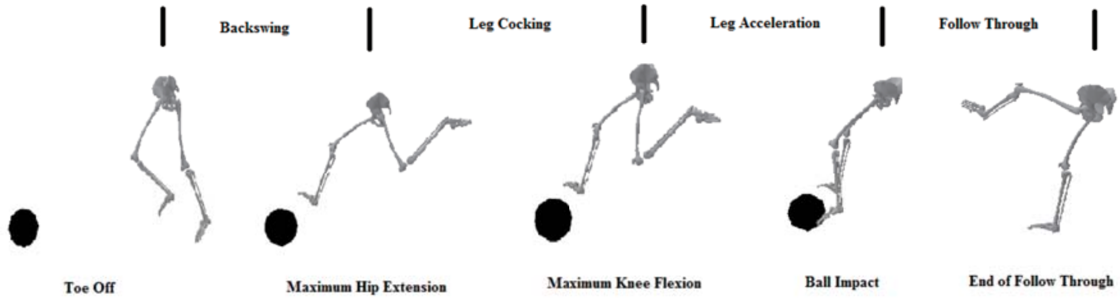

Figure 1: The different phases in kicking and the characteristic time instances

Data Analysis: Peak ball, toe and ankle velocities, normalized phases of kicking, peak hip extension angle and peak hip flexion velocity, peak knee flexion angle and angular velocity, hip and knee angles and angular velocities in the sagittal plane at ball impact were compared in a 2-way ANOVA independent factors being gender and limb dominance and adjustments made using Bonferroni corrections. A confidence interval of 95% was determined for the study. The statistical analysis was carried out using SPSS 20.0 (SPSS Inc., Chicago, IL, USA).

RESULTS AND DISCUSSION: Female soccer players have higher peak linear velocities of the ball and toe while kicking with the dominant limb (Table 1), a finding concurrent with previous literature (van den Tillaar & Ulvik, 2014). On the other hand, male professional soccer players appear to be adept at kicking the ball with either limb owing to the demands of the environment (Starosta, 1988) as limb dominance did not seem to have a marked effect on the linear velocities (Table 1). The values of velocities for males were higher than those for females with both the non-dominant and dominant limbs (Table 1). A greater skill level (Katis et al., 2015) among male professionals could account for the discrepancy with previously published research carried out on amateur and youth players (Nunome et al., 2006; Sinclair et al., 2014).

Table 1
Comparison of peak linear velocities

		Ball velocity (m/s)	Toe Velocity (m/s)	Ankle Velocity (m/s)
Total Female	ND	22.36 ± 2.68*	17.76 ± 2.17*	14.88 ± 1.33
	D	25.00 ± 2.47*	19.58 ± 1.86*	16.12 ± 1.37
Total Male	ND	26.11 ± 2.71	20.95 ± 1.43	17.16 ± 1.26
	D	28.53 ± 1.61	22.68 ± 1.11	18.32 ± 0.95

Table 2
Comparison of normalized phases of kicking

		Backswing%	Leg Cocking%	Leg Acceleration %	Follow through %
Total Female	ND	25.44 ± 5.58*	18.20 ± 4.89	14.44 ± 1.94	41.88 ± 6.44
	D	27.23 ± 4.75*	17.73 ± 4.48	15.04 ± 1.87	40.04 ± 5.60
Total Male	ND	24.47 ± 3.47*	17.26 ± 2.40	15.37 ± 2.22	42.63 ± 4.25*
	D	29.47 ± 4.81*	16.89 ± 1.85	15.00 ± 1.76	38.63 ± 5.48*

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

In both males and females the total time of the kick was the same between the dominant (females: 0.39 ± 0.04 s, males 0.39 ± 0.05 s): and the non-dominant limb (females: 0.40 ± 0.07 s, males 0.39 ± 0.04 s). However, the backswing phase was longer in the dominant limb as compared to the non-dominant limb (Table 2), with the difference being compensated specifically in the follow through phase for males only (Table 2). Although the backswing was longer in the dominant limbs, it is interesting to note, that the maximum hip extension angles (Table 3) are similar between the dominant and non-dominant limb for either gender. Similarly, the peak knee flexion was also similar across the two limbs (Table 4). However, in female soccer players, the non-dominant limb was more flexed than the dominant limb at ball impact (Table 4). This modification on the limb positioning at ball impact increase the surface area of contact with the ball which assists the higher transfer of velocity from the foot to the ball when kicking with the dominant limb (Barfield et al., 2002), resulting in a greater ball and toe velocities while kicking with the dominant limb (Table 1). This difference was not seen in male soccer players, who had a similar knee flexion at ball impact which probably accounts for the lack of difference in ball and toe velocities across limb dominance. At the same instance the knee extension angular velocity (Table 4) was similar across the two limbs for either gender. There was no difference in hip flexion angle at ball impact (Table 3) nor in peak flexion velocities for the hip (Table 3) and knee (Table 4).

Table 3
Hip angular parameters

		Peak Hip Extension (°)	Ball Impact(°)	Peak AV (rad/s)	Ball Impact AV (rad/s)
Total F	ND	-11.96 ± 9.30	29.64 ± 9.38	12.80 ± 2.35	-1.88 ± 1.98
	D	-14.73 ± 9.37	27.35 ± 10.08	14.27 ± 2.31	-2.31 ± 3.03
Total M	ND	-9.05 ± 8.99	30.58 ± 9.52	12.53 ± 2.25	0.37 ± 2.89
	D	-12.42 ± 7.76	27.16 ± 8.53	14.32 ± 2.26	-1.05 ± 3.01

Table 4
Knee Angular parameters

		Peak Knee Flexion (°)	Ball Impact(°)	Peak AV (rad/s)	Ball Impact AV (rad/s)
Total F	ND	113.68 ± 11.27	56.68 ± 12.55*	15.72 ± 2.09	-25.96 ± 3.84
	D	111.96 ± 11.55	45.12 ± 8.95*	15.85 ± 2.59	-27.69 ± 4.47
Total M	ND	115.95 ± 8.58	47.47 ± 14.49	17.37 ± 3.39	-28.26 ± 4.98
	D	118.11 ± 8.31	42.95 ± 9.84	17.84 ± 4.15	-32.00 ± 4.08

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

Elite female soccer players have different kicking techniques with the dominant and non-dominant limbs, and this must be taken into account by coaches and biomechanists. Although the range of motion and peak values seem to be similar across either limb for both genders, female soccer players must work to reduce knee flexion at ball impact with the non-dominant limb. Both males and females have a shorter backswing in the non-dominant limbs, and must try not to cut it short. Working on bilateral symmetry and coordination in the non-dominant limb would help too.

Conclusions: Unlike the female soccer players, male professional soccer players were adept at kicking the ball with the dominant and non-dominant limb. Female soccer players had a lesser flexed knee at ball impact in the non-dominant limb which contributed to lower ball velocities in the toe and subsequently in the ball. Coaches and biomechanists could use the results of this study to improve kicking in the non-dominant limb.

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