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KINEMATIC DIFFERENCES BETWEEN 'ONE-FOOTED' AND 'TWO-FOOTED' YOUNG SOCCER PLAYERS KICKING WITH THE NON-PREFERRED LEG

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The purpose of this study was to examine kinematic differences between 'one-footed' and 'two-footed' players when kicking with the non-preferred leg at a target and with maximal effort. Eighteen highly-trained young soccer players were categorised as one-footed (n=9) and two-footed (n=9) based on results of a kicking test. Motion analysis data showed that two-footed players run-up straighter and have less pelvic rotation at ball-foot impact than one-footed players and the differences are likely to be meaningful (ES differences of 0.89 and 0.99 respectively). Run-up angle and pelvic rotation angle are significantly correlated ($P < 0.1$). The study found that two-footed players are significantly smaller in stature than one-footed players ($P < 0.1$). Practical implications for soccer coaches arose from the study
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KEY WORDS: Soccer, kicking, kinematics, footedness.

INTRODUCTION: During the course of a soccer match, players may be called upon to kick the ball with either foot as the conditions dictate. Thus, many players and coaches agree on the advantage of two-footedness in soccer.
Elite soccer academies place immense importance on developing bilateral kicking proficiency from a young age. The kinematic differences between instep kicks with the preferred and non-preferred leg are well reported in adult players (e.g. Dorge et al., 2002; Nunome et al., 2006b). In contrast, minimal information is available regarding asymmetry of soccer kicking motions of young players or how kicking technique varies between skilled players or those less proficient when kicking with the non-preferred leg. Thus, the design of appropriate instructional methods in youth soccer is confounded by the lack of research in this area. Should a coach possess a good knowledge of the kinematics (technique) of high-level youth players then this would potentially assist them in applying training drills to develop effective kicking technique.
The purpose of this study was to examine kinematic differences between 'one-footed' and 'two-footed' young players when kicking with the non-preferred leg at a target and with maximal effort.

METHODS:
Test procedure: Eighteen highly-trained young soccer players from a National Academy (Table 1) performed three maximal effort instep soccer kicks (IK's) with their non-preferred leg of a stationary ball (FIFA approved size 5, 900 hPa) placed 10.97 m from the centre of a soccer goal (7.32 m in width; 2.44 m in height). An accurate kick was one which passed through the middle vertical third of the plane of the goal area whilst inaccurate kicks passed between the posts or their vertical projection but were outside the middle third. Players were classified as 'one-footed' or 'two-footed' post testing. 'Two-footed' players were those who achieved at least two accurate IK's with a mean loss in maximum ball speed of less than 10% compared to an accurate preferred leg IK. Highly qualified and experienced technical coaches of the players agreed with the player footedness categorization upon review of the results which strengthened the validity of the assessment process. The accurate non-preferred leg IK (or inaccurate if no accurate IK's) with the greatest peak ball speed was chosen for each player for further analysis.

Motion analysis: Reflective markers were fixed firmly by double-sided tape onto body landmarks, including the toe, fifth metatarsal head, posterior side of the calcaneus, the lateral and medial malleolus, middle point of the shank, the lateral and medial epicondyle of femur, middle point of the thigh, greater trochanter, both sides of the anterior superior iliac spine (ASIS) and the anterior superior iliac spine (PSIS).
Kicking motions were captured using a 10-camera motion capture system (Vicon MX; Vicon Motion Systems, Oxford, UK) at 500Hz. Before the experiment, a stationary posture was captured to record relative position between each marker. The markers on the toe and medial side (the medial malleolus and the medial epicondyle of femur) were then removed as they could not be tracked throughout the full kicking action. An additional eight markers were attached on the forward half of the lateral hemisphere of the ball (Figure 1) to which the kicking foot would not have contact. From those surface makers the geometric centre of the ball was estimated, as well as the flight trajectory of the centre of the ball after impact, which was obtained in available airborne frames (typically 20 frames). The initial ball velocity and the velocity of the foot centre of gravity (defined from body segment model by Ae, Tang, & Yokoi, 1992) were computed from the non-smoothed data using the same procedure applied by Nunome et al. (2002).

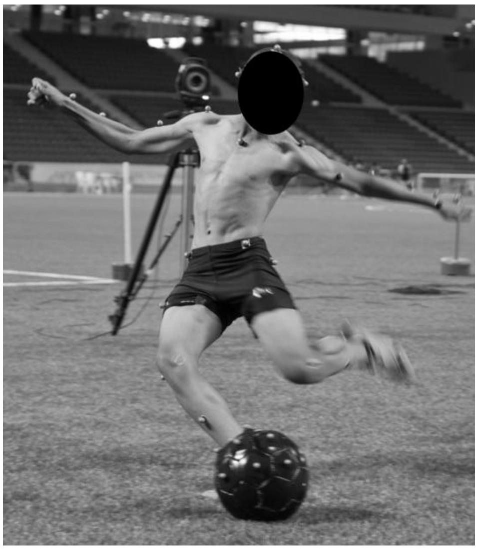

Figure 1: Player performing IK with the non-preferred leg - location of reflective markers on the ball and player shown.

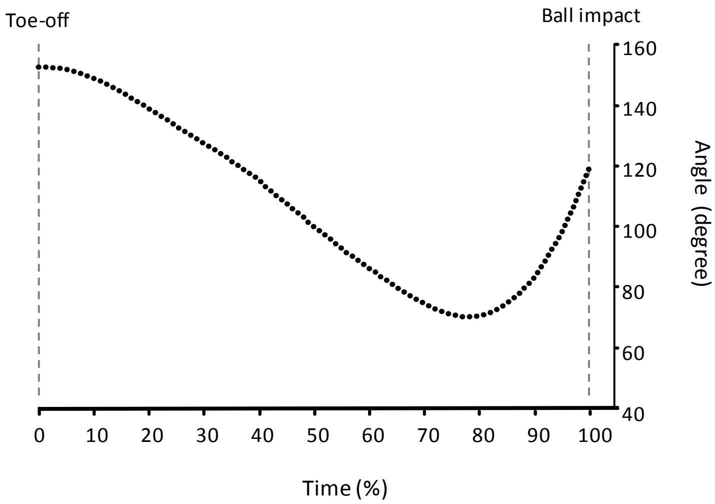

Figure 2: Typical non-smoothed time-series change of knee joint angle from toe-off the kicking leg to ball impact.

Selected kinematic parameters are summarized in Table 2. In general, noise on time-series angular changes is of high frequency nature and it can be observed as oscillations on the baseline. After plotting the time-series angular change of all the signals available, the non-smoothed data apparently had negligible noisy oscillations (Figure 2). For this reason, we judged it is not necessary to smooth those angular changes. Thus, all kinematic parameters were represented as raw data. That computational procedure also avoided data distortion due to smoothing procedure including ball impact artifact (Nunome et al., 2006a). Besides lower leg angular kinematics, the pelvic rotation angle within the horizontal plane was computed using the same procedure. The run-up angle within the horizontal plane was computed as the angle between a vector from the midpoint of ASISs (at the moment of kicking leg 'toe-off') to the static position of the ball centre and the global Y axis pointed in the direction towards the goal. A program was written within a software package (Matlab; MathWorks, Massachusetts, USA) to compute the aforementioned parameters.
Statistical analysis: Effect size (ES) differences were computed (Hopkins et al., 2009) to observe meaningful difference. The differences were assessed qualitatively (e.g., unclear,

likely, very likely) using the estimated smallest worthwhile change and the 90% Confidence Interval associated with each ES. Pearson (2-tailed) correlation coefficients were calculated in SPSS 19 (SPSS Inc, Chicago, USA) based on 90% Confidence Intervals to establish relationships between kinematic parameters. Also using SPSS 19 a 2-tailed independent t-test based on 90% Confidence Intervals was done to establish if there was a significant difference between the ages, heights and body masses of the one- and two-footed groups of players.

RESULTS: The age, height and body mass of the players is reported (Table 1) along with a comparison of selected kinematic parameters between one-footed and two-footed young players performing IK's with the non-preferred leg (Table 2).

Table 1
Player information (mean ± SD with 2-tailed t-test for significant difference †)

Footedness	Age (yrs)	Height (m) †	Body mass (kg) †
one-footed (n=9)	14.8 ± 0.2	1.60 ± 0.06	50.33 ± 6.38
two-footed (n=9)	14.6 ± 1.0	1.55 ± 0.11	44.27 ± 9.11

† significant difference between one- and two-footed players (P < 0.1)

Table 2
Comparison of selected kinematic parameters between one-footed and two-footed young players performing IK's with the non-preferred leg (mean ± SD and effect size difference with Pearson 2-tailed test for significant correlation †)

	one-footed	two-footed	ES*
Maximum ball velocity ($m.s^{-1}$)	20.24 ± 3.13	21.30 ± 1.93	-0.38
Run-up angle (deg)	37.8 ± 8.6	31.2 ± 4.7	0.89†
Ball-foot velocity ratio	1.29 ± 0.11	1.33 ± 0.08	-0.33
Ankle dorsiflexion angle (deg)*	111.7 ± 7.6	114.7 ± 10.7	-0.30
Knee flexion angle (deg)*	118.6 ± 15.4	114.4 ± 11.4	0.28
Hip flexion angle (deg)*	112.0 ± 11.6	123.9 ± 10.2	-0.33
Hip rotation angle (deg)*	-22.0 ± 7.8	-21.9 ± 4.8	-0.01
Hip abduction angle (deg)*	15.3 ± 6.7	17.2 ± 5.4	-0.29
Support foot displacement from ball (m)*	0.34 ± 0.07	0.31 ± 0.08	0.29
Support leg knee flexion angle (deg)*	120.2 ± 8.0	117.9 ± 10.3	0.22
Pelvic rotation angle (deg)*	18.4 ± 9.2	11.0 ± 4.3	0.99†

*ES: < 0.2 no difference, > 0.2 unclear, > 0.6 likely, > 1.2 very likely
† significant correlation between kinematic parameters marked (P < 0.1)
* indicates at instant of ball-foot impact

DISCUSSION: Table 1 indicates that two-footed young players are significantly smaller in stature than one-footed players (P < 0.1). Physically smaller players may have been selected into the Academy initially based on superior technically ability. They may have then received greater opportunity to practice kicking with both feet if playing in a creative midfield position as opposed to a central defender position typically occupied by larger boys.

The most important part of a kick is the ball-foot impact phase since this determines the subsequent ball motion. At the instant of ball-foot impact there are no clear differences in ankle dorsiflexion, knee flexion, hip flexion, hip rotation, hip abduction and support leg knee flexion angles between one-footed and two-footed young players performing IK's with the non-preferred leg. Despite similar kinematics at ball impact, maximum ball velocity is higher for the two-footed players by 1 $m.s^{-1}$ due to a greater ball-foot velocity ratio which indicates a more efficient strike of the ball.

It is likely that there are meaningful differences in run-up angle and pelvic rotation angle between one- and two-footed players (ES differences of 0.89 and 0.99 respectively). There is also a significant positive correlation between these two parameters ($P < 0.1$). Two-footed players tend to run-up straighter than their one-footed counterparts at an angle of around 30 degrees similar to previously reported data for preferred leg kicks (Scurr et al., 2009). This in turn means that the pelvic rotation angle in the horizontal plane is less and the player is more 'square-on' to the target. Since many other kinematic parameters at ball-foot impact are similar between the two groups we suggest that this is a more advantageous position to kick a ball maximally at a target with the non-preferred leg.

There is a tendency (although not clear) for one-footed players to plant the support foot further from the ball. This aligns with previous studies which found that players tend to plant the support foot further from the ball when kicking with the non-preferred as opposed to the preferred leg (e.g. Harrison and Mclean). McLean and Tumility (1993) suggested that this strategy might be to generate greater ball velocity from a larger kicking arc with the non-preferred leg. However, as illustrated in this study, two-footed players are able to generate greater ball velocity by a more efficient ball-foot impact shown by a higher ball-foot velocity ratio on average.

CONCLUSION: By definition, two-footed players are more proficient at kicking with the non-preferred leg than one-footed players from the same highly-trained cohort. This study suggests that run-up angle and pelvic rotation angle are clear determinants of footedness. The practical implication for a coach of a young soccer player is therefore to teach a good preparation strategy for a soccer kick (e.g. run-up angle not 'too wide' and support foot not 'too far' from the ball) before advancing to other technical components such as kicking leg kinematics.

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