6. BIOMECHANICS (1)

O-033 Ball-foot interaction in impact phase of instep soccer kick

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OBJECTIVE Ball impact technique is essential for successful in instep soccer kicking. However, to date, only a few studies focused on ball impact phase, in which plantar flexion motion of the foot was solely reported (Asai et al., 1995; Nunome et al., 2006). Furthermore, no study has examined the behavior of the ball during ball impact that would be related to motion of the foot during ball impact. The aims of this study were to illustrate the three-dimensional motion of the foot (plantar / dorsal flexion, abduction / adduction, inversion / eversion) and the motion of center of gravity of the ball during ball impact, and to examine the interaction between the motion of the foot and the ball behavior during ball impact.

METHODS Eleven experienced male soccer players participated in this study. To analyze the interaction between foot and ball in detail, two ultra high-speed video cameras (NAC Inc., Tokyo, Japan) were used to capture the motion of kicking limb and ball at 5000 Hz. Ball deformation and position of center of gravity of the ball were calculated from the lateral side image.

RESULTS The foot was plantarflexed, abducted and everted during contact with the ball. In particular, the foot was dorsalyflexed slightly at the beginning of the impact, and begins to plantarflexed after middle of the impact. The peak force acing on the foot almost coincides with the peak ball deformation, and magnitude of peak force reached approximately 2700N.

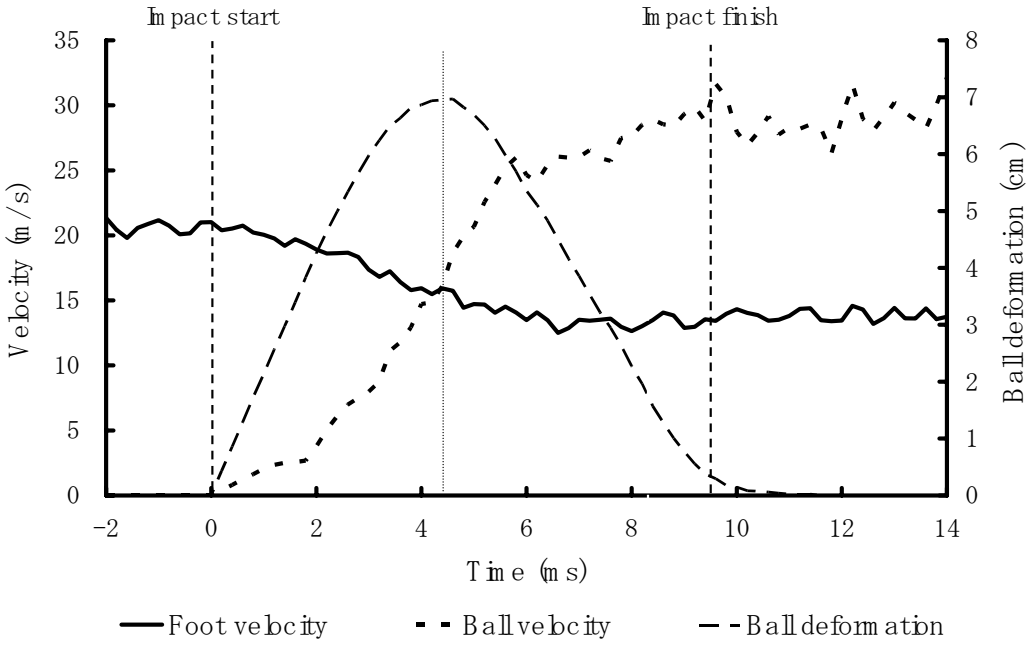

Figure 1. Foot velocity, ball velocity and ball deformation during ball impact.

DISCUSSION In this study it was seen that the foot was forced into plantar flexion by the force of the ball. The ball velocity exceeded foot velocity when the ball was maximally deformed (see Figure 1). It can be suggested that the foot can't directly increase the ball velocity after this moment, nevertheless the foot contact with the ball.

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KEY WORDS Three-dimensional foot kinematics, ball deformation, ball reaction force.

O-034 An alternative feature of impact phase kinematics of instep kicking in football

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OBJECTIVE Biomechanical data associated with impact situations involving large accelerations can be prone to error due to inadequate data processing (Knudson et al. 2001) and sampling rate. For football kicking, the movement data at or just before initial ball contact could suffer from such problems, which would affect true kinematics of lower limb motion during ball impact phase. The purpose of this study was to describe the more representative kinematics of kicking motion through ball impact phase by exploring the influence of both sampling rate and smoothing procedures.

METHODS Nine male footballers performed maximal instep kicking. The lower limb motion was three-dimensionally captured at 1000 Hz. The displacements were smoothed by a new time-frequency filtering (TFF). Also the co-ordinates were re-sampled (250 Hz) and smoothed by Butterworth digital filter using a 10 Hz cut-off (RSF) to resemble typical sampling and processing conditions used in the literature.

RESULTS The shank angular velocity was found to be increased during the final phase of kicking (TFF). Meanwhile, a totally different curve (apparent decrease in the shank angular velocity before ball impact) was created when the conventional filtering at 10 Hz cut-off was applied on the re-sampled co-ordinates (RSF). This nature has been consistently observed in the most of previous studies.

CONCLUSION Practically, coaches often recommended players to kick as if kicking through the ball. However, in literature no evidence was shown to support this type of instruction from a biomechanical point of view. The present study was the first to strongly support the above practical advice of kicking by clearly illustrating the true kinematics of the shank during kicking.

REFERENCES
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KEY WORDS True kinematics of shank, time-frequency filtering, soccer**.**

O-035 How to evaluate full instep kick in soccer?

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OBJECTIVE Soccer performance such as kicking performance is dependent on a myriad of factors such as technical/biomechanical, tactical and physiological aspects. One of the reasons for soccer being so popular and common worldwide is that players do not necessarily need to have extraordinary level of endurance, strength, power and flexibility but need to possess some level of the ability to be efficient during a soccer game. The purpose of this article was to present a way on how to evaluate the full instep kick in soccer. The instep kick test is comprised of three parallel tests; the ball speed test (km/h measured by stalker radar gun, Texas), the full instep kick accuracy test (goal divided into six fields) and the full instep kick technique test (seven aspects of the full instep kick).

METHODS The sample was comprised of elite male soccer players, members of first league clubs in the Croatian League (n=21), age 22.13±0.85. Reliability of kicking performance test was determined by reliability analysis (alpha) and test-retest. ($p < 0.05$). Ball Velocity was measured using the radar gun (Stalker-Pro, Texas).

RESULTS All tests had normally distributed data. Mean ball velocity measured by radar was 104,4 (4,38) km/h. Reliability coefficient alpha and test-retest analysis for all three tests was 0,96.

Table 1. Results of elite Croatian male and female soccer players in full instep kick test

ID	Unite of measurement	U-19 (f)	Seniors (f)	U-19 (m)	Seniors	Cadets (m)
MESBL	Km/h	78.07	80.08	101.3	112.2	100.4

CONCLUSION The soccer full instep kick test with parallel evaluation of technique, ball accuracy and speed was a very good diagnostic procedure. A similar test could be used for the evaluation of other soccer kick types

KEY WORDS Soccer, evaluation, full instep kick

O-036 Consistency of the lower limb acceleration patterns during inside and instep soccer kicks

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OBJECTIVE The inside kick is the most frequently used technique when a shorter and precise pass or shot is required, whereas the instep kick is used when a faster ball speed must be generated. The difference in accuracy of the inside and instep kick might be explained by repeatability of acceleration patterns. The repeatability of the kicks might be evaluated by acceleration waveforms. Therefore, the aim of this study was to examine the consistency of the lower limb acceleration patterns of these two soccer kicks.

METHODS 13 male soccer players (between 15-16 years old) performed 4 trials for each type of kick. Acceleration data were collected by tri-axial accelerometers fixed on subjects' knee and ankle. The RMS SD (precision error) of the 4 trials was calculated for 3 axes. Were there no difference among acceleration curves among trials, the RMS SD would yield a value of 0, corresponds highest repeatability.

RESULTS Comparisons were made between the two kicks using Student t-tests. Differences in the RMS SD values of acceleration waveforms measured at knee were statistically significant for all axes between inside and instep kicks, whereas it was only significant for x- and y-axis at ankle ($p<0.05$). Correlation coefficient between RMS SD values at knee and ankle in the relevant limb was higher for instep kick.

CONCLUSION The findings of this study revealed that the inside kick with smaller precision error have higher consistency considering the acceleration patterns of the lower limb. Since the waveform demonstrates different acceleration-deceleration patterns for segments, it might also be used to evaluate consistency in proximo-distal sequence between different types of kick.

KEY WORDS Acceleration, soccer, repeatability, instep kick, inside kick.

O-037 Kicking velocity: Barefoot kicking superior to shod kicking?

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OBJECTIVE Full instep kicking in soccer has received wide attention in biomechanical research (Barfield et al., 1998). There are just a few contributions on the influence of soccer shoes on kicking velocity (Amos et al.,2002)Soccer shoes evoke different ball velocities during full instep kicking. So far, the basic consideration that a shoe is an additional artificial interface between foot and ball during kicking has been neglected. Anecdotally, shod kicking is reported to be inferior compared to barefoot kicking already in 1971 (Plagenhoef, 1971). This study aimed to examine the general influence of a shoe in the kicking procedure, as it is necessary to know whether a soccer shoe acts as an enhancing, reducing or neutral piece of equipment in fast kicking. Features like mechanical support and protection of the foot had to be addressed.

METHODS Five shoe/kicking conditions were tested: Adidas (AAA), Nike (NNN), subject's own (OSC), sock (SOC), barefoot (BAR). Peak ball velocity was measured by a Stalker Pro radar gun. GRFs and HSV were taken. 19 subjects performed six full instep kicks in each condition. A pain rating (1 - low, 9 - high) and a velocity ranking of perceived ball velocity (1 - highest speed, 5 - lowest speed) was required.

RESULTS The ANOVA showed higher ball velocity for barefoot compared to shod kicking (Figure 1). Perception data showed that barefoot and sock conditions were perceived most painfully. Although perceiving highest pain in the bare

foot condition, subjects kicked faster compared to the shod conditions. The more painful a kicking condition was perceived the lower the condition was ranked for ball velocity.

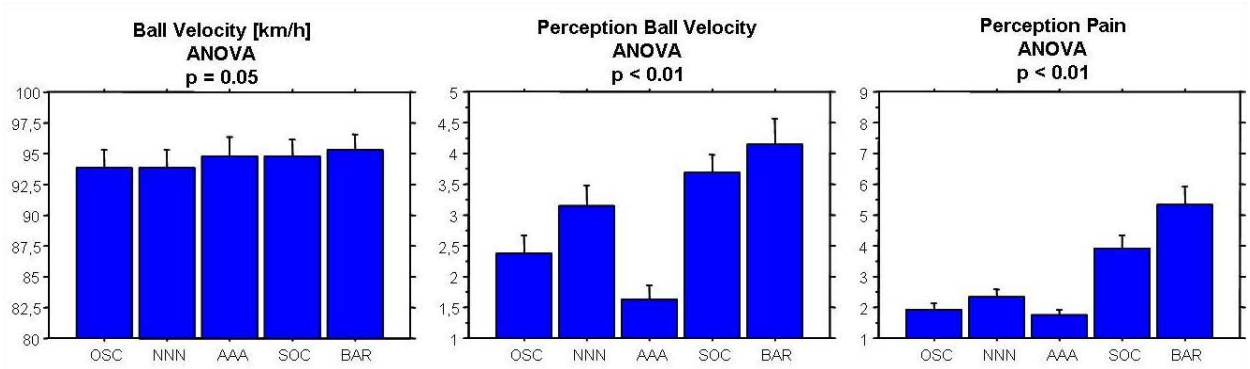

Figure 1. Means and standard errors for ball velocity and perception parameters

CONCLUSION Soccer shoes do not generally provide support for fast kicking. Pure anatomical structures perform better in a full instep kicking situation than the functional unit of foot and shoe does. At initial ball contact, a bigger plantar flexion angle at the talus joint results in higher foot rigidity and less give during the collision in barefoot kicking, as high speed video pictures suggest.

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KEY WORDS Kicking velocity, full instep kick, soccer shoe, barefoot.