CORRELATION BETWEEN SUPPORT FOOT PLACEMENT AND GOAL ACCURACY FOR INSTEP KICKS IN THE SOCCER FIELD

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The aim of the present work was to evaluate the correlation between the placement of the support foot on the ground and the precision of the shot: the placement of the support foot relative to the ball was supposed to have an effect on the shot precision for a given target. The goal was divided with a visual grid enabling to identify six possible targets of the shot, high/low for vertical placement and left/center/right for horizontal placement. Skilled players were asked to perform repetitive penalty instep kicking in the soccer field with a defined target such as high/left or low/right: ground reaction loads were recorded by means of a force platform installed in a suitable board and the movement was video recorded. The position of COP at the kick instant with respect to the ball and the average trajectory of COP on the platform resulted to be correlated with successful target in such a way that training procedures can be defined to improve the player coordination for precision shooting. Finally, differences between free kicking and kicking with a goalkeeper were recorded, enabling to analyze a realistic player behaviour in the study.

KEY WORDS: soccer, instep kick, accuracy, GRF.

INTRODUCTION: Soccer is one of the most popular sports in Europe and the world: the application of motion analysis, EMG recording and force acquisition techniques, showed great advances in the last few years.

The ball speed is correlated with the Ground Reaction Forces (GRFs) values that skilled players exhibit vertically, anteriorly-posteriorly and laterally are greater than those of unskilled players (Barfield, 1998). The direction of approach to the ball has an influence on the ground force components (Kellis, Katis, Gissis, 2004); also the ball speed in different ways of kicking (instep and side-foot) has been investigated (Nunome, Asai, Ikegami, Sakurai, 2002).
Aim of the present work was not only to study the force magnitude in relation with the ball speed, as known from previous works, but also to evaluate the correlation between the foot/ball relative placement and the precision of the kick in a soccer field in order to create a situation very close to what happens during the kick of a penalty in an official football match. The x-y distance of the support foot from the ball at the kick instant was supposed to have an optimum range to maximize the target precision.
The goal was divided with a visual grid enabling to identify six possible targets of the shot, high/low for vertical placement and left/center/right for horizontal placement.

METHOD:

Data Collection: The Ground Reaction Forces (GRFs) at the support foot and the trajectory of the Centre of Pressure (COP) were measured by means of a Bertec force platform (600x400 mm, Model 4060, Bertec Corporation, U.S.A.). Signals were recorded on a National Instruments NI-PXI-1042 at 1000 Hz per channel.
The force platform was placed inside a wooden module, dimensions 1m x 1m, height 120mm, and placed on the football ground together with a set of 6 equal modules to create for the player a suitable and safe runway at a constant height from the ground.
The goal was divided in six equal rectangular sectors (2,44 m x 1,22 m) and a wooden rectangular panel was hanged in correspondence of the target sector.
The instant of ball kicking and the average horizontal ball speed were detected by means of a suitable electric circuit including a support trigger under the ball, a trigger at the target panel, a LED at the force platform and a 3.6 V battery. The two trigger, normally open, were connected in parallel to the NI-PXI-1042 and recorded synchronously with the force signals.

The support trigger was applied on a hollow grid placed laterally to the force platform, to let the tester adjust the ball position. The placement of the ball onto the support trigger will close the circuit and switch the LED on; at the kick instant, the circuit will open and the LED will switch off until the ball will hit the target, close the circuit again and switch the LED on again. The trigger signal enables to individuate the kick instant and to estimate the ball average speed from the ball flight time. Each test was filmed via two digital video cameras JVC GR-DVL357, one from the back and the other from the left side of the tester, both viewing the LED for image/force synchronization. Tests were performed on a regular football field: the ball was placed centrally with respect to the goal, at a distance of 16m from the goal line. The balls were nr. 5 FIFA approved. Four non professional players with experience in the junior leagues were involved in the study: data of the testers are presented in Table 1. All players were wearing standardized shoes for indoor soccer and were requested to read and sign an informed consensus about the tests.

(a) **(b)**

Figure 1: **(a)** Force platform embedded in the wooden runway. **(b)** Detail of the ball trigger.

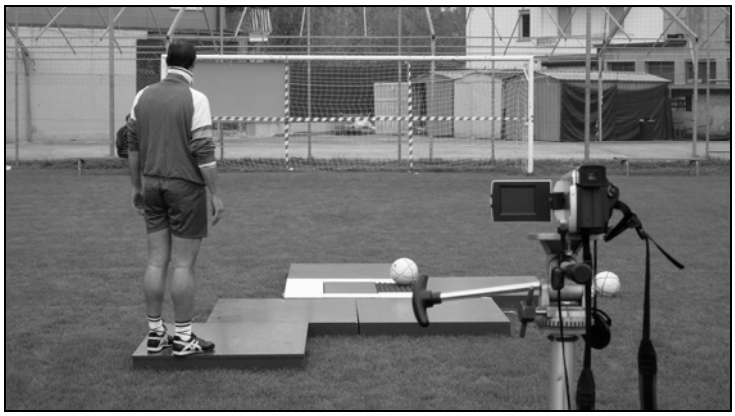

Figure 2: Rear view of the experimental setup for a right foot player.

Table 1 Testers involved in the study

TESTER	AGE	HEIGHT [cm]	MASS [Kg]	FOOT	ROLE
1 (M.C.)	29	183	84	RIGHT	Midfielder
2 (M.S.)	29	186	80	RIGHT	Midfielder
3 (E.Z.)	32	168	67	RIGHT	Midfielder
4 (G.M.)	27	184	77	LEFT	Forward

The test protocol was subdivided in 3 stages:
Stage 1. After 10 minutes of standard warm up, each tester was asked 5 pilot shots to define the most suitable placement of the ball with respect to the platform and of the runway modules, to feel comfortable and focus on the kicking action.

Stage 2. Two series of 18 shots without goalkeeper with given target: for right footer players, first target was High-Left (HL), second target was Low Right (LR) (left footed target were High Right and Low Left).
Stage 3. One series of 16 shots with goalkeeper, with the ask of scoring at a given target sector of the goal. Four possible targets, Low Right, Low Left, High Right, High Left were randomly mixed and communicated to the player only before each shot, with the request of shooting with the maximum power aiming to the given target.

Data Analysis: For each shot, the three components of Ground Reaction Forces Fx (anterior-posterior), Fy (medio-lateral) and Fz (vertical) were plotted synchronously with the trigger as in Figure 4. Peak values of Fz were normalized to the body weight and evaluated; the average horizontal speed of the ball was also calculated as the ratio between the goal distance and the flight time. The COP of each shot was plotted in the platform system of reference inside the interval between the instant of contact and 50 ms after the ball kick. The first part of the contact, from the Heel-Strike to the Foot Flat, corresponds to force Fz raising from zero to a peak and involves the settling of the ankle. The following part, from the Fz peak to the kick, corresponds to the swing phase before the ball kicking. For this reason, the COP trajectory included between the Fz peak and 50 ms after the kick was linearly approximated: the slope coefficient *m* was evaluated as shown in Figure 4, together with the coordinates of the Impact Point (*IP*), that is the position of the COP at the ball impact. For each series with a given target, the different values of *m* and of *IP* coordinates were averaged: the IP scatter was expressed as an ellipse with semi axes equal to the x and y standard deviations. The slope *m* scatter was expressed as three lines pointing to the ellipse centre and defining the upper and lower standard deviation bands around the mean value of slope *m*, as reported in Figure 5. The coordinates of the impact point *IP* measured in the platform reference system 0xyz as described in Figure 1(a), were transformed in the ball coordinate system OXY after the knowledge of placement of the ball trigger relative to the platform in the suitable grid shown in Figure 1(b).

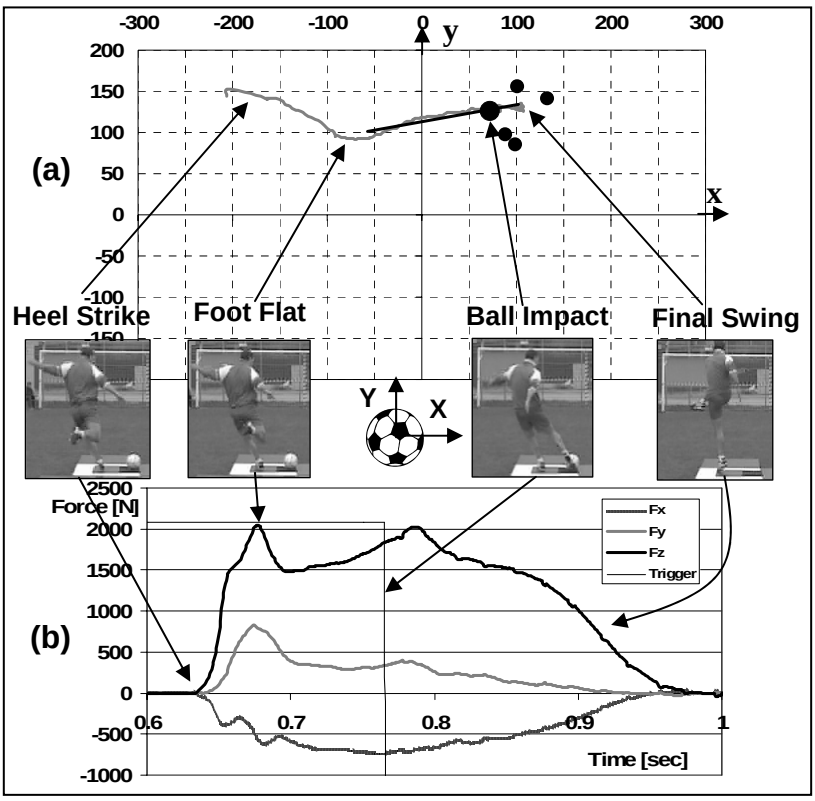

Figure 4: **(a)** COP trajectory for right footed player 1 HL (grey line), linear approximation of the kick phase (black line) and COP at the impact (black points: smaller point for other successful shots) referred to the force platform system. **(b)** Corresponding GRF plots and trigger.

RESULTS: The goal accuracy of the four tester were similar (1-27%, 2-36%, 3-28%, 4-25%), but lower than values that may be expected with professional players. Results of the four analyzed tester are compared in Figure 5, were left footed player 4 has been reported by symmetry. Differences between HL and LR series can be appreciated. For each tester, paired t- test statistical analysis between the two series of free kicks with different targets (e.g. HL-LR) was performed on the following parameters: the anterior-posterior coordinate of IP *(xIP)*, the slope *m* of the COP trajectory trend line, the average ball speed *vm* and the normalized peak vertical force *Fz/BW*.

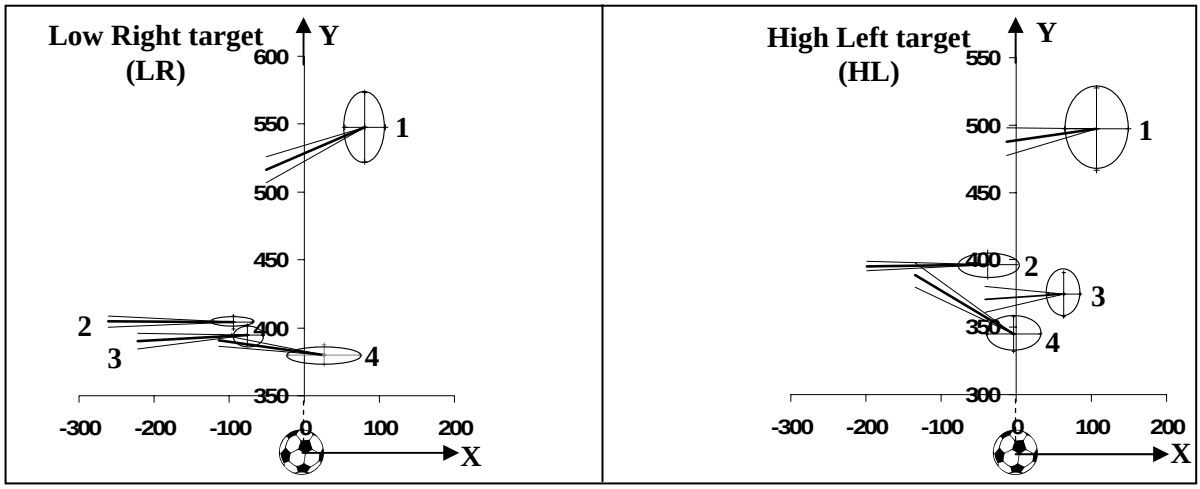

Figure 5: Comparative diagram for the different players in the ball reference system.

DISCUSSION: The values of normalized forces Fz were generally higher than values presented in literature (Kellis et al. 2004): this can be due to the fact that in the present study the tests were performed in a football court and not indoor. The ball speed resulted lower than values reported by Nunome (Nunome et al.2002): differently form that work, in this study the players had been asked to be precise, aiming to the given target. Speed was generally higher in the series with goalkeeper.

The anterior-posterior placement of the foot, coordinate *xIP*, resulted significant for tester 3 and 4 ($p<0.05$); the direction of the foot sole, slope *m*, was significant for tester 1 and 2 ($p<0.05$); the ball speed *vm* was significant only for tester 4 ($p<0.05$); the normalized peak forces *Fz/BW* resulted to differ significantly ($p<0.05$) for testers 2, 3, 4, with a tendency for tester 1 ($p=0.071$). Further tests with professional players will enable to confirm the method and hypothesis of the study.

CONCLUSION: The anterior-posterior position of COP at the kick instant with respect to the ball and the direction of the support foot on the platform resulted to be correlated for two tester out of four with different target in such a way that training procedures can be defined to improve the player coordination for precision shooting.

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