A NEW BIOMECHANICAL APPROACH TO SIDE-FOOT SOCCER SHOTS' CHARACTERISTICS DETERMINATION

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This study considers the biomechanical factors that are relevant to succeed in the kicking of a ball into three points; A, B, and C pre-selected in the area of gate. Sixteen amateur of top university players participated in this study. Two cameras at 30 Hz were used in sagital and frontal planes. The recorded data were processed through computer with Ulead Video Studio and AutoCad softwares. The time of flight, time of ball contact with kicking foot, the angle of volley, ball velocity, and the angle of knee flexion were achieved. Then by biomechanical formulae, ball speed, launch angle, range, force exerted to ball, and finally the torques applied to leg joints; ankle, knee, and hip were obtained. The ball speed, launch angle, and the ball range were theoretically estimated and then verified with the mentioned method.

KEY WORDS: side-foot kicks, soccer.

INTRODUCTION: Although there are many types of kick, the variant most widely reported in the literature is the maximum velocity instep kick of a stationary ball. The players normally use the most appropriate one depending on the nature and intent. Success in scoring goals depends on several factors; the ability of shooting powerfully and accurately (Joseph, 1999). Most applications of biomechanical modeling techniques have helped in the understanding of the underlying mechanisms of performances, although their use has been limited. In this study the process of ball being static placed on the ground, kicked by side-foot has been considered as more purposefully and accurately than other kicks. This type of kick showed having more chance to be shot to the goal. It is no doubt that player's experience plays a vital role in a successful and purposeful kick. Yet, proposed kick as individual basic skills of players showed that they could successfully perform the kick with less impact force and torques to the leg joints.
Knowing the characteristics of an optimized style might help coaches to launch an aim-oriented training and speed-up the learning process. One way for achieving such a goal was to quantitatively determine the characteristics of the kick through biomechanical approach, so that coaches can design their training program based on such a quantitative depiction. The main goal of the present study was to quantitatively describe soccer side-foot kick by filming and using the biomechanical formulae to disclose the characteristics of the kick such as; ball velocity, launch angle, the impact force, torques to the joints, and successful and purposeful shots.

METHODS: Thirteen highly skilled university soccer players (age: 21.3 ± 1.4 yr; weight: 72 ± 3.8 kg) volunteered in this study. All subjects preferred to kick the ball with the right leg as dominant leg. After an adequate period of warming up, the players were instructed to perform a purposeful side-step kick to three targets located at three points in the goal gate; A, B, and C (A: near the right corner, B: at the center, and C: near the left corner). The ball was located at initial stationary position and 2m from the right corner and 18m ahead, Fig. 1. All subjects performed at least five shots from which three were selected as good and acceptable kicks. Two video cameras at 25 Hz were used to capture the motion from sagital and frontal views. A digitizing method was used to manually digitize body land marks including; hip, knee, ankle, heel and toe. The frames were analyzed through Ulead Video Studio and AutoCad software in order to achieve the time of flight of ball, the time of contact of ball with foot, and the different angles such as; release angle and the knee and foot angles. Simple biomechanical relationships (Shahbazi et al., 1996, 2002, Shahbazi, 2002) were used in order to achieve ball velocity, mean impact force and torques to the knee and hip during kicking.

Formalism: The ball velocity was achieved by

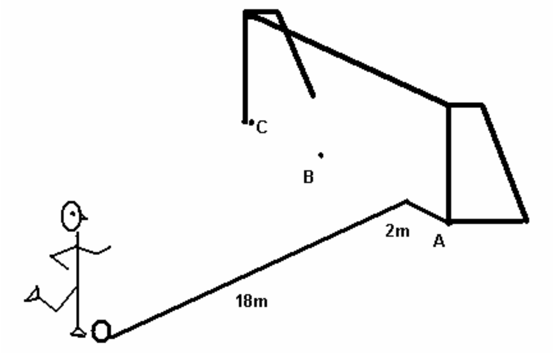


Fig. 1 The selected points and ball coordinates for purposeful kicking.

$$V=\frac{t_f g}{2Sin\theta} \quad (1)$$

Where t_f and θ are ball time of flight and release angle which are obtained by video filming. The impacts mean force can be obtained by

$$F=\frac{M_B V}{t_C} \quad (2)$$

The torques applied to the knee and hip Are estimated as followings

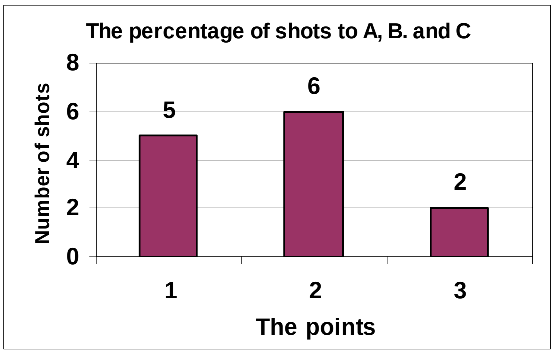
$$\tau_S = F l_S \sin(\pi/2-\theta) \quad (3)$$

$$\tau_H = F l_{(shank+thigh)} \sin(\pi/2-\theta)$$

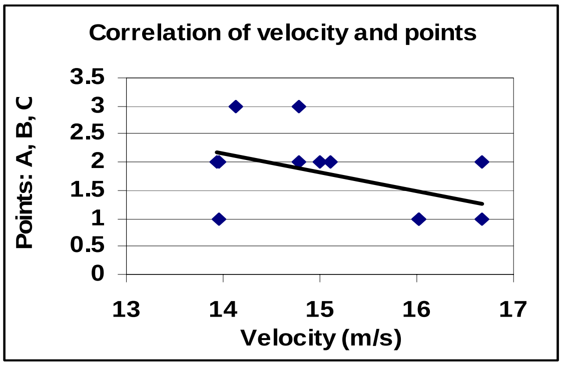
RESULTS AND DISCUSSION: As there are normally three opponent players for defending the shot, the kicker should kick in such a way that the ball has proper height and gets enough spin in order to have adequate curvature to pass by these defenders and reach the right corner; A. The goal keeper normally moves towards the other corner to catch the ball giving way to the ball to enter the goal. This is what happened most of the time and therefore was considered as the best and most purposeful and successful shot in our study.
In Table 1, the first four columns yield the range, time of flight, ball contact time, and release angle, which apart the range, were achieved by video filming. The release angle; θ, could also be achieved through biomechanical relationships with reasonable approximation. The columns 5 and 6 yield ball velocity and height when launched towards the goal and the columns 7, 8, and 9 yield the impact force and the torques applied to the knee and hip which were calculated through the biomechanical relationships.

Table 1- Maximal, Minimal, Average, and $\pm$ SD of different parameters

Parameters	**R(m)**	**t ^{f} (s)**	**t ^{C} (s)**	θ **(Deg)**	**V(m/s)**	**h(m)**	**F(N)**	τ_K	τ_H
Maximal	20	1.89	0.084	41.20	16.68	4.30	171.75	78.81	164.33
Minimal	18.5	1.26	0.042	21.80	13.94	1.36	74.67	24.96	53.47
Average	18.65	1.46	0.058	28.80	15.16	2.53	132.24	54.92	110.45
$\pm$ **SD**	0.52	0.21	0.021	6.43	1.02	1.02	44.31	26.45	33.85



(a)



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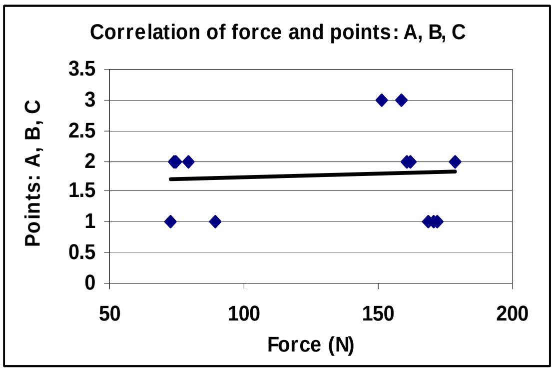

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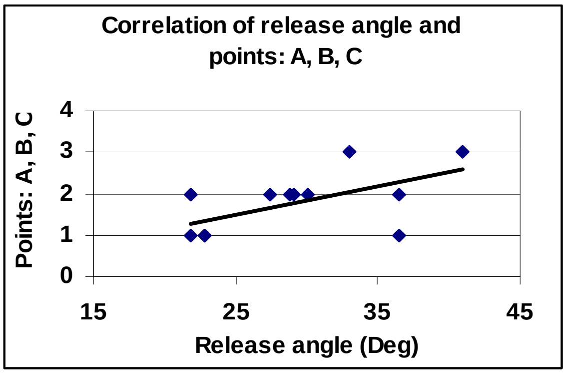

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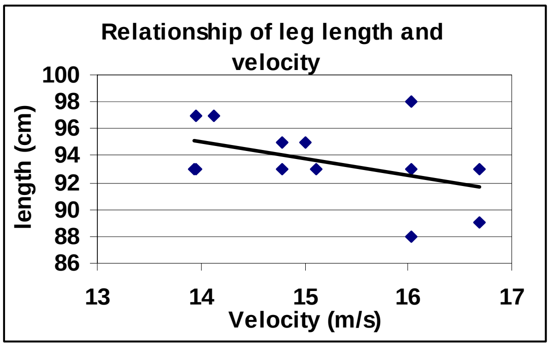

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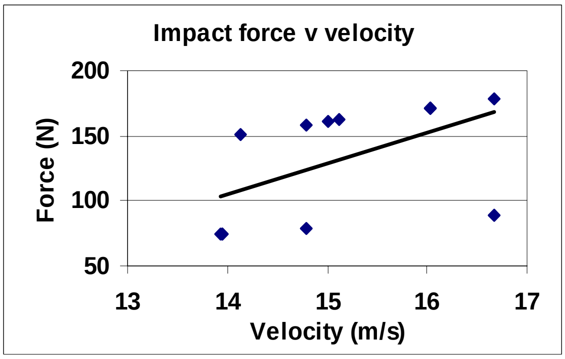

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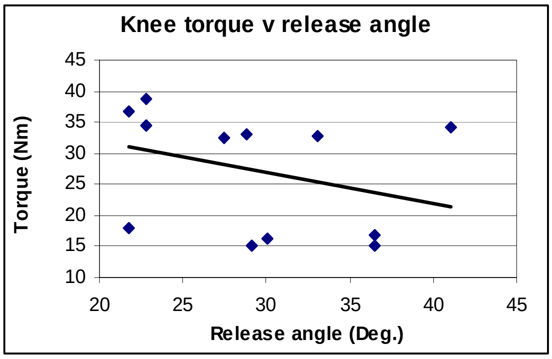
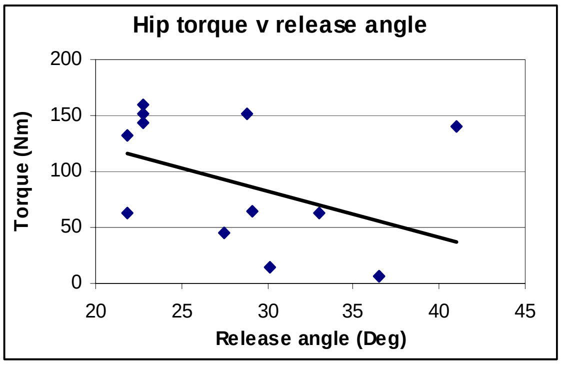


(g)



(h)

Figures; a, b, c, d, e, f, g, and h- The correlations of release angle, velocity and impact force with selected points; A, B, and C and relationship of impact force with velocity and torques with release angles are depicted.

Figure (a) shows that 38.5% of players were able to shoot the ball to the corner A, where we considered as the most purposeful shots. 46% of players could not aim corner A and therefore shot near point B, where the goal keeper probably could arrive to catch the ball. As

it is seen, 15.4% of players could not manage to shoot either the corner A or the point B, therefore at point C the goal keeper is probably able to catch the ball.
Figure (b) depicts that the points A and B could be targeted with any velocities. Figure (c) shows the correlation of impact force and selected points and supports the idea that the corners A and B could be targeted with any forces, while to target the point C the impact force should be more than 150N. Figure (d) depicts that points A and B could be targeted with any release angle, while the point C should be targeted with higher release angle. Figure (e) shows an inverse relationship of leg length and ball velocity. This is because shorter leg had shorter time of impact and therefore producing higher impact force. Figure (f) supports well the idea of the greater the velocity, the higher the impact force. Figures (g) and (h) depict the relationships of the amount of torques applied to the knee and hip and the release angles. As can be seen, the torques applied to hip are more than three times the torques applied to knees but still the risk of injury to knee is three times more than hip injury. This is because hip is covered with passive muscle tendons, while it is not the case for the knee.

CONCLUSION: In the present study, a new approach to determine the side-foot shots characteristics has been presented. Three points were selected where point A was the one to which the shots were considered as most purposeful. This approach also enabled us to determine the impact force and torques applied to knee and hip resulted from the side-foot kick.

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