

USING COMPUTER SIMULATORS TO IMPROVE SHOTS ON GOAL EFFICIENCY IN FOOTBALL

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Annotation. The paper presents the results of a computer simulation of powerful shots on goal and curved free kicks. It shows how the accuracy of the kick depends on the initial speed of the ball, the initial angle, the rotational moment and the distance of the kick. The paper aims to help young athletes master and refine the execution of shots on goal to improve their efficiency.

Keywords: *football, goal shooting simulator, goal shot, curved kick*

Introduction. The motion of a ball in the air is one of the most difficult problems in sports and has not yet been fully studied. One of the reasons why this problem is difficult is the large number of forces acting on the ball (Egoyan, Khipashvili, & Moistsrapishvili, 2017; Egoyan, Khipashvili, Moistsrapishvili, & Gobirakhashvili, 2018; Goff, & Carré, 2009; Dupeux, Le Goff, Quéré, & Christophe, 2010).

In this article, we use our goal shooting simulator to model the ball's trajectory, taking into account air resistance, wind, altitude, temperature, initial ball velocity and direction, and ball spin (Egoyan, et al., 2017; Egoyan, et al., 2018).

This study aims to model the trajectory of powerful shots on goal and curved free kicks and determine the optimal values of key parameters, such as the initial velocity, initial angle, and torque of the kick.

The study also has educational goals to make the process of modelling the motion of a soccer ball easier and more understandable.

Research methods. Using our simulator, we model the trajectory of the ball in the coordinate system shown in Figure 1. In this coordinate system, the

initial position of the ball, as well as the distance to the goal, are determined by the coordinates of the ball at point $A(0,d,0)$. The final position of the ball on the goal line is determined by the coordinates of point $B(X, 0, Z)$.

We can simulate real shots from video recordings and from there determine individual player characteristics such as maximum shot speed, shot accuracy and spin ability. Or, knowing the values of these parameters for a particular player, we can select the optimal positions for him to perform a shot.

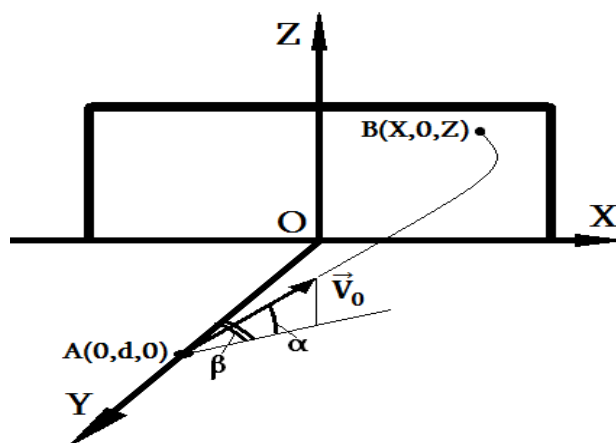


Fig. 1. The trajectory of a curled ball in the coordinate system.

Discussion of the results of the study. First, we looked at long shots on goal without curl. Using our simulator, we have calculated the allowed ranges of the angle α for different values of the distance to the goal d and the initial velocity of the ball V_0 (See Table 1). Knowing his maximal value of V_0 and knowing his ability to direct a shot within the allowed angle range, we can choose for him the best position to deliver the shot.

Table 1 – Ranges of α angle in degrees for given d and V_0

$V_0(m/s)$ $d(m)$	22	26	30	34	38
18	11.9-18.7	8.4-15	6.2-12.8	4.9-11.3	3.9-10.3
22	15.1-20.8	10.5-15.9	7.8-13.1	6.1-11.3	4.9-10
26	18.7-23.8	12.9-17.5	9.5-14	7.3-11.7	5.8-10.2
30	23-27.9	15.4-19.5	11.3-15.2	8.7-12.5	6.9-10.7
34	28.5-33.9	18.3-22.1	13.2-16.7	10.1-13.5	8-11.3

As for the curved free kicks, we are investigating two types of free kicks: the initial velocity of the first kick is directed toward the goal, while the initial velocity of the second kick is directed away from the goal. In the first case, the goalkeeper initially follows the ball's starting trajectory, but the ball then changes direction, and the goalkeeper fails to catch it in time. Such a kick was brilliantly executed by David Beckham in the 2001 World Cup qualifying match against Greece (see Fig. 2 a) (Goff, et al., 2009). In the second case, the goalkeeper initially believes the ball is missing the goal and is therefore unprepared to catch the ball as it curves back. Roberto Carlos of Brazil scored such a goal against the French national team in 1997 (see Fig. 2 b) (Dupeux, et al., 2010).

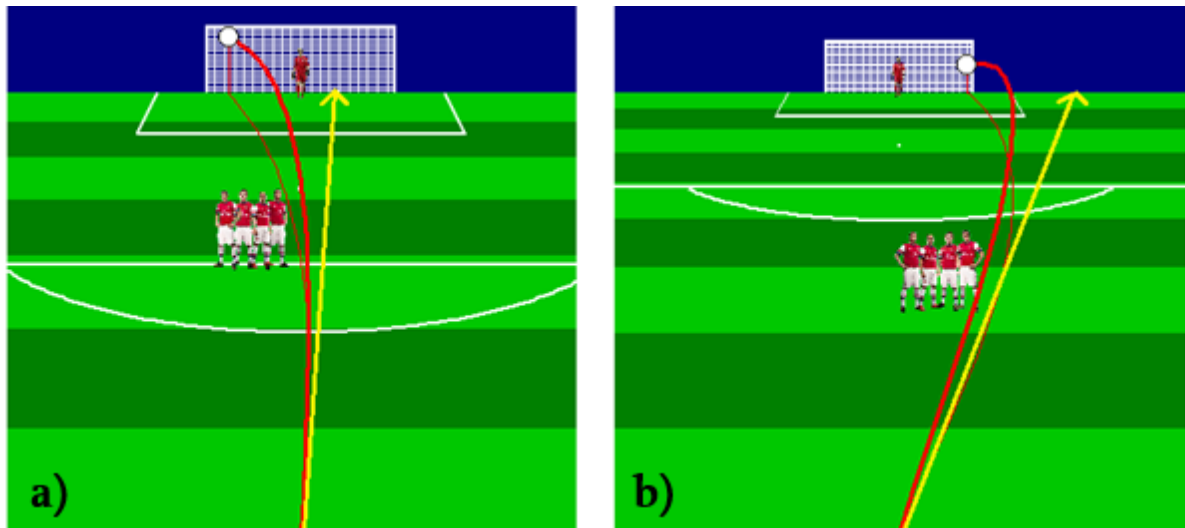


Fig. 2 – a) - Computer simulation of David Beckham's free kick, b) - Computer simulation of Roberto Carlos' free kick.

Tables 2, 3 show the characteristic parameters of these free kicks for different values of V_0 and d , where β is the azimuthal angle, and s is the spin.

Table 2 – Parameters of free kicks of the first type (α is measured in degrees, s - in revolutions per second, X , Z - in meters).

-	$V_0=26$ m/s	$V_0=28$ m/s	$V_0=30$ m/s
$d=18$ m $\beta=2^\circ$	$\alpha=16$, $s=9$ $X=-2.08$, $Z=2.22$	$\alpha=14$, $s=9$ $X=-1.82$, $Z=2.04$	$\alpha=13$, $s=9$ $X=-1.59$, $Z=2.07$
$d=24$ m $\beta=3^\circ$	$\alpha=18$, $s=7$ $X=-3.28$, $Z=2.09$	$\alpha=16$, $s=8$ $X=-3.09$, $Z=2.07$	$\alpha=14$, $s=9$ $X=-2.87$, $Z=1.88$

Table 3. Parameters of free kicks of the second type (α is measured in degrees, s - in revolutions per second, X, Z - in meters).

-	$V_0=26$ m/s	$V_0=28$ m/s	$V_0=30$ m/s
$d=18$ m $\beta=15^\circ$	$\alpha=15, s=3$ X=3.32, Z=2.05	$\alpha=14, s=4$ X=3.18, Z=2.13	$\alpha=13, s=4$ X=3.36, Z=2.14
$d=24$ m $\beta=15^\circ$	$\alpha=18, s=4$ X=3.03, Z=2.32	$\alpha=16, s=5$ X=2.95, Z=2.25	$\alpha=14, s=5$ X=3.32, Z=2.05

Generating such tables helps to see the relationship between the parameters of a free kick and, based on the player's abilities, recommend a more advantageous position for the kick, or helps the coach make changes to the training program to eliminate weaknesses in the player's preparation.

Conclusions. The results of computer modelling can be useful for both the ordinary player and the goalkeeper. A player must know his abilities: initial speed, initial angle and spin of the kick, and based on these parameters, he must decide from which distance and what type of kick is more acceptable for him. The goalkeeper must always be ready to repel a curved free kick.

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