Original Research

La Postura del Ejecutante y las Probabilidades de Atajar un Tiro Penal en Fútbol Masculino

The Shooter´s Posture and the Goalkeeper´s Chances Of saving Penalty Kicks in Men's Football

Manuel Aquino[1] y Richard A. Fariña[2]

[1]*Curso de Educación Física, Universidade Luterana de Santarém, Pará (Brasil)*
[2]*Departamento de Paleontología, Facultad de Ciencias, Universidad de la República (Uruguay)*

RESUMEN

Esta investigación tiene como objetivo evaluar la influencia entre el uso de un programa de entrenamiento específico para goleros y el aumento de la probabilidad de atajar penales en el fútbol masculino. El programa se basa en entrenar por medios virtuales y físicos la capacidad del golero de elegir correctamente el lado (izquierdo o derecho) al que irá dirigida la pelota. Fueron ejecutados 800 penales antes del programa y 800 penales después de su aplicación, con cuatro diferentes goleros de las categorías sub 21 de un equipo de primera división del futbol brasileño en la ciudad de Santarém, estado de Pará, Brasil. El resultado fue comprobado estadísticamente a través del test de Student, que corroboró la hipótesis de que existe una relación de causa y efecto entre las dos variables mencionadas. Se observa que las probabilidades de atajar el tiro penal o, al menos, elegir el lado correcto para tirarse, aumentan drásticamente cuando se aplica el referido programa de entrenamiento.

Palabras Clave: penalti, portero, entrenamiento

ABSTRACT

This research aimed to evaluate the influence of the use of a specific training programme for goalkeepers on the probability of defending penalties in men's soccer. The programme is based on training by virtual and physical means in order to develop the goalkeeper´s ability to correctly choose the side (left or right) to which the ball will be directed. Eight hundred penalties were executed before the training programme and another 800 penalties after its application. The experiment was conducted with four different goalkeepers from the sub 21 category of a team of the first division of the Brazilian state of Pará in the city of Santarém in the Amazonia region. The data were statistically tested through the Student test. The results corroborated the hypothesis that, after training, the chances of saving penalty kicks or, at least, choosing the correct side, increase dramatically.

Keywords: penalty, goalkeeper, training

INTRODUCTION

With an audience that amounts to nearly half the total world population in the recent World Cup in Russia, association football (also known as soccer in some countries) is a sport of great popularity and an activity of paramount importance in the global economy (FIFA, 2014), due to its engraining, in the popular culture of many countries. Also, it has recently received attention as a subject of scientific research (Kuhn, 1988; Oudejans et al., 2000; Harvey, 2005), even from the point of view of biomechanics and the science of movement (Belda Maruenda, 2009) and despite the fact that many aspects of the game (its collective nature, the need of the usage of the feet to play the ball, and the size of the pitches, to mention some) makes skills less important than the player´s decisions and good judgement (Leite y Guerra, 2004). Nonetheless, a situation with more controlled variables exists in football: the penalty kick. This play is performed by only one player of each opposing team (the shooter and the goalkeeper) in an individual duel with very strict rules (Arruda, 2013): the goalkeeper must remain on the goal line, while the shooter must kick the ball in a forward direction and cannot touch it again until another player does.

This dramatic event is very frequently decisive, since it ends in a goal in 82% of the cases (FIFA, 2017). Moreover, in many championships, including 4 out of 16 matches in the knockout stage of the last World Cup (FIFA, 2018), the winner of a game that ended in a draw is decided through the shooting of penalty kicks in a certain order (FIFA, 2018). There is a strong belief among players, coaches, and other people related to the sport that scoring a penalty kick is a matter of luck (see statements in the documentary Ciencia Celeste, 2011). It is also considered that the goalkeeper is always a victim and that scoring a goal in a penalty kick is always the shooter´s responsibility.

In this research, it is proposed that a cause-effect relationship exists between the shooter and the goalkeeper (Carvalhal et al., 2013), a clear example of game theory applied to this sport. This relationship depends on the capability of the goalkeeper to interpret the posture and gestures of the shooter from a biomechanical point of view and, performing the saving action in time, dive to the side (right or left) that the ball is kicked at. Here we intend to demonstrate that this set of skills can be learned (Carvalhal et al., 2013) through a software specifically created to train goalkeepers (Morya et al., 2005).

As in other examples of visual perception training (McGuckian et al., 2018), the software is based on the assumptions that: a) the goalkeeper can interpret the body movements (essentially, that at the time of stepping with the support foot the trunk is inclined to the side at which the ball will be aimed) of the shooter just before the ball is kicked and b) once that is learnt, the goalkeeper will dive to the side that the ball is kicked at. In that case, the goalkeeper has 0.5 seconds to make the decision of diving left or right, improving the chances of stopping the ball.

MATERIAL AND METHODS

The first experiment took place in the city of Santarém, Pará State in the Brazilian Amazonia. Three goalkeepers and two field players from the reserve team of the São Francisco Esporte Clube, a professional club that participates in the under-20 local championship, were chosen. The pitch (with official dimensions) of the ASSIBAMA (Asociação de Funcionários do Instituto Brasileiro do Meio Ambiente), located on the Tapajós Avenue in Santarém, was used for the experiment.

Following Bar-Eli y Azar (2009), the goal (with official dimensions; 8 feet or 2,44 metres high and 8 yards or 7,32 metres long) was divided (Fig. 1) into six zones to the right (10 to 15), three to the centre (1, 2, and 3) and six to the left (4 to 9) of a football goal.
The design was printed in a fabric with the necessary hooks to adjust it to the goal. Six uniforms with visible marks on the area of the relevant joints (shoulders, elbows, wrists, hips, knees, and ankles) were made in order to facilitate the measurements to be used in the analyses.

The observations were made in two 30-minutes weekly sessions after the regular training of the team for three months from February to April 2014. Forty penalties were kicked during each session (20 for each goalkeeper in series of 10), amounting to a total of 960 penalty kicks. The experiments were filmed with three cameras, all of which had been previously calibrated and prepared.

The free software Kinovea was used to decompose the movements and analyse the biomechanical performance of both the shooter and the goalkeeper. Four official footballs (PenaltyTM) calibrated according to the specifications of professional competition were used.

The software Kinovea was used to analyse frame by frame the movements of the shooters as they kicked the ball and the goalkeepers as they intended to save the shots. The measured variables included angle, distance, time, direction of the ball, and the instants in which the goalkeeper's reaction starts and the shooter contacts the ball. According to those measurements, it was determined that the reaction time for the goalkeeper to correctly decide which side to dive at and have the chance to intercept the ball was 0.5 sec. This is also the moment in which the shooter lands the support foot beside the ball before kicking, as previously predicted and observed (Bar-Eli y Azar, 2009).

The second phase of the experiment included professional first division goalkeepers and shooters in official stadiums. In this phase, apart from the observations, it was intended to gather the opinions of those experienced goalkeepers about the strategy they used for saving penalties and the consequent development of the specific training programme for improving their performances.

The locations for this second phase were two official stadiums: the Barbalhão, which belongs to the municipality of Santarém, and the Panterão, property of the Pará State first division club São Raimundo. The observed goalkeepers and shooters belonged to São Raimundo and its traditional rival in the Pará first division championship, São Francisco.
There were two sessions with five series of ten penalties for each goalkeeper. Apart from filming the shooting, the opinion about the software of two of the players was recorded (see the interviews in Manolo, Ricardinho y Labilá, 2016).

The third phase of the experiment consisted of training the goalkeepers through the mentioned software to measure, compare, and assess the efficacy and efficiency of that training programme (Tubino, 1984; Marcellus, 2004; Weineck, 2004; Orloff et al., 2008; Fariña et al., 2013; Bompa y Buzzichelli, 2015). Once the four goalkeepers were trained, a new series of 800 penalties was kicked following the same order described for the first one.

The data were analysed with the Student *t*-test. The null hypothesis (*Ho*) implied that differences regarding the number of times goalkeepers chose the correct side before and after the training were explained by random variations not related to training.

Then:

$$t = d/\sigma/\sqrt{n}$$

where σ is the standard deviation, *d* is the average of the differences between pairs of related observations, and *n* is the number of paired observations.

$$\sigma = \sqrt{\frac{\sum d^2 - \sum d/n}{n-1}}$$

n-1 = degrees of freedom

RESULTS

Table 1. *Penalties shot before training.*

Goalkeeper	Number of penalties kicked	Ball to the right	Ball to the centre	Ball to the left	Goalkeeper to the right	Goalkeeper to the centre	Goalkeeper to the left	Right-Right coincidence	Left-Left coincidence
Samuel	200	85	44	71	92	22	86	38	24
Da Mota	200	83	34	83	92	16	92	26	27
Henrique	200	83	46	71	85	32	83	23	19
Sandrinho	200	82	47	71	92	38	70	41	29
TOTAL	**800**	**333**	**171**	**296**	**361**	**108**	**331**	**128**	**99**

***Table 2**. Coincidences between the side at which the ball was shot and the side to which the goalkeeper dived before training.*

Total coincidences	Right-Right	Left-Left
227	128	99

Tables 1 and 3provide the raw data from the two sessions (i.e., before and after training), while tables 2 and 4 show the coincidences between the side to which the ball was shot and the side to which the goalkeeper dived to. Overall, goalkeepers chose the appropriate side much more frequently after training (63%) than before it (28%), which implies an increase of more than two-fold. In both cases, i.e., left (t = -6.57, p = 0.05) and right (t = -10.39, p = 0.05), the differences were significant when the coincidences before and after the training were compared.

***Table 3.** Penalties shot after training.*

Goalkeeper	Number of penalties kicked	Ball to the right	Ball to the centre	Ball to the left	Goalkeeper to the right	Goalkeeper to the centre	Goalkeeper to the left	Right-Right coincidence	Left-Left coincidence
Samuel	200	89	35	76	96	14	90	67	60
Da Mota	200	90	30	80	112	7	81	60	50
Henrique	200	92	40	68	104	15	81	78	52
Sandrinho	200	93	39	68	104	12	84	75	65
TOTAL	**800**	**347**	**174**	**279**	**417**	**54**	**329**	**280**	**227**

***Table 4.** Coincidences between the side at which the ball is shot and the side to which the goalkeeper dives after training.*

Total coincidences	Right-Right	Left-Left
507	280	227

DISCUSSION AND CONCLUSIONS

Penalty kicks are mostly non-rotational shots (Nakamura et al., 2017), in which the foot performs a straight-line trajectory to impact the ball. The inclination of the body towards the side at which the ball will be aimed and at the time when the supporting foot is on the ground ,is a biomechanically necessary posture, related to the conservation of the angular moment (Bar-Eli et al., 2007; Navarro et al., 2012; Nakamura et al., 2017; Biswas, 2018; Blair et al., 2018). For example, in the case of a left footed kicker directing the ball to the left of the goalkeeper, the force must be applied at the impact on the ball in a line that requires the kicking foot to be rather close to the support foot. This forces the trunk, as it pivots on the right hip joint, to swing to the right side (which corresponds to the left if seen from the goalkeeper's point of view). On the contrary, when the same left-footed kicker intends to aim the shot at his left side (the right side in the goalkeeper's view), he must impact the ball on a point that is closer to his body, usually by rotating the foot in abduction. To allow that, the support foot must lie farther away from the ball and consequently the trunk will be inclined to the left (or to the right, as seen by the goalkeeper).

If the goalkeeper can develop the ability of properly identify the posture of the shooter at the non-return moment, when the support foot is on the ground and the kicking foot starts its swing towards the ball, he will have about 0.5 sec to activate the muscles to dive towards the appropriate side (Kuhn, 1988)and increase his chances of preventing the penalty kick to be scored (Lees et al., 2010).

As clearly shown in our results, in which the chances of choosing the appropriate side more than doubled after training, competitive advantage can be obtained by the goalkeeper (or improved, in cases of individuals that develop it out of intuition) by changing his motor reaction through the training procedure, including the self-training software presented here (Biswas, 2018). In this way, his chances of saving penalty kicks will increase in this essentially endlessly dynamic game (Campos, 2009), at least until shooters develop a proper strategy to overcome the approach shown here.
We hypothesize that our conclusions could also be useful for women's football, although careful considerations should be given regarding the possible modification in the inclination angle of the trunk due to the anatomical differences in the female pelvis.

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Figure 1. *The shooter starts running to kick the ball. Note the goal area divided into regions following Bar-Eli y Azar (2009).*

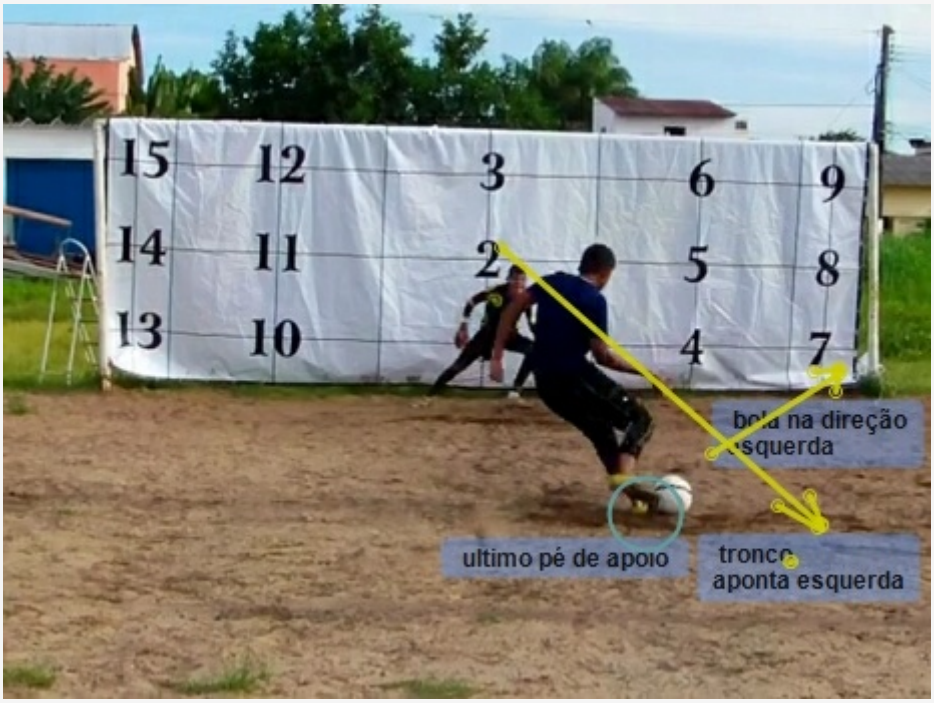

Figure 2. *Moment of contact with the ball, with the shooter´s body inclined to the left side (as seen from the goalkeeper's point of view) and the ball aimed at the same side.*

Figure 3. *Same shot: the goalkeeper dives correctly towards his left side.*

Figure 4. *Same moment shown in Fig. 2. This time the ball will be aimed at the right side of the goalkeeper, which can be observed in the inclination of the shooter´s body towards that side.*

Figure 5. *Same shot: the goalkeeper dives wrongly towards his left side.*

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