Kinematical Characteristics of Accurate Penalty-Kicking for Turkish Football Players in Goalkeeper Confrontation

by Abdelkader Guebli

KINEMATICAL CHARACTERISTICS OF ACCURATE PENALTY-KICKING FOR TURKISH FOOTBALL PLAYERS IN GOALKEEPER CONFRONTATION

Guebli Abdelkader[1,5,*], Abdullah Arguz[2], Moh Nanang Himawan Kusuma [3], Nurtekin Erkmen[4], Ömer Calişkan [4] and Reguieg Madani [5]

[1]Laboratory APSSEH, Faculty of Physical Education and Sports, Hassiba Benbouali University of Chlef, Algeria.
[2] School of Physical Education and Sports, Karamanoğlu Mehmetbey University, Karaman, Turkey.
[3] Department of Physical Education, Faculty of Health Sciences, University of Jenderal Soedirman, Indonesia.
[4] Faculty of Sports Sciences, Selçuk University of Konya, Turkey.
[5] Laboratory SMAH, Faculty of Physical Education and Sports, Abdelhamid Ibn Badiss University of Mostaganem, Algeria.

Abstract

This study aimed to analyze the kinematical characteristics values of accurate penalty-kicking for Turkish football players in goalkeeper confrontation. Fifteen male Turkish Regional Amateur League players (Age: 21.08± 1.56 years old) was scanned, by two video cameras synchronous in two-dimensional (2D), placed at optical axes X&Y. the best three tries of penalty kicking performance were analyzed by video analysis Dartfish 9.0 software. Standard statistical methods were used for the calculation of mean±sd, Pearson test for the correlations between all variables. A value of p-value ≤ 0.05 was considered a threshold of statistical significance. The results were shown in the ball contact phase that the distance pivot foot & ball factor has a statistically significant effect in producing accuracy (p-value=.001), and the interaction between two main factors namely the trunk and inclination body angles has a statistically significant effect with a p-value≤.05 in producing accuracy too. In addition, in the follow-through phase, we can see too the statistically significant effect in p-value≤.005 of the trunk angle, and in p-value≤.05 of the thighs angle in producing accuracy. As a conclusion, it can be conveyed that the distance between the support leg and the ball is very decisive for the kinematic profile formed such as contraction of the abdominal muscles (trunk angle), the amortization process (the pivot leg angle), shot power (angle and length of the shot leg swing trajectory), where these aspects are significantly affected to the shot power, ball velocity and the level of accuracy.

Keywords*: Biomechanics, Football, Kicking, Accurate, Penalty.*

Introduction

Football is one type of sports game (Mohr et al., 2020). Today, football is becoming very popular throughout the world (Barbieri et al., 2010; Sarmento et al., 2018). Where the number of member countries of the International Fédération of Football Association has reached 211 (FIFA.com, 2021). FIFA (Fédération International de Football Association) does not doubt that football will continue to develop so that it becomes important and interesting (Komarudin et al., 2018). Football is a sport that requires physical, technical, and tactical qualities (Dichiera et al., 2006), and involves basics skills like Passing, Receiving, Dribbling, and Shooting (Clarys et al., 2003; Henni et al., 2020). In general, ball kicking is well known as one of the most fundamental and important techniques in association football (Abdelkader et al., 2021; Zerf, 2017). Players commonly use this technique when kicking the ball with power and accuracy, like in penalty (Barfield, 1998; Lees et al., 2010; Manolopoulos et al., 2004; Nunome et al., 2006).

Penalty kicks are a confrontation between the kicker and the goalkeeper to determine the outcome of the game in a special situation where the ball is placed at the point 11m away from the goal (Coloma, 2007; Csató, 2020). semingly, the penalty kick in football is a simplistic play. however, it has increased in complexity since 1997 when the rules changed allowing goalkeepers to move laterally along their goal line before the ball was kicked in which the physical skill during kicks performance and strong pressure should be overcome (Atiyat & Fattah, 2019). especially facing a goalkeeper who might be known to be good, when a penalty miss could mean the immediate loss of the match. Thus, the outcome of these kicks is typical may be attributed to factors such as psychology (e.g., coping with stress), skill kinetic (e.g., kicking technique) (Abdelkader et al., 2021), physiology (e.g., overcoming the fatigue of 120 min play), and chance (e.g., in what direction the goalkeeper moves) (Acuña & Romero, 2018; Arguz et al., 2021; Kellis & Katis, 2007).

From the proofs, the course of movement of the body is an important factor (Guebli et al., 2020; Guebli Abdelkader et al., 2018) in the successful execution of kick penalties, besides, there are many principles of physics in soccer games (Clarys et al., 2003; Hay, 1978; Shan et al., 2019). So, an analysis of the biomechanics of the specific skills that are performed (Abdelkader et al., 2018; Benelguemar et al., 2020; Hennī et al., 2020; Zerf Mohammed et al., 2015) by soccer athletes permit optimal sports performance (Clarys et al., 2003; Katis & Kellis, 2010). The present study, challenge to inspect the gaps of accurate penalty performance methods of Turkish football players. Based on the kinematical determinants, accurate in kicking, as protocol chosen for this modest study. Thus, it is hypothesized that, during the performance of penalty-kicking in goalkeeper confrontation, the values of variables analyzed would increase, and effective on accurate of kick.

Methods

Subjects

Fifteen (15) male Turkish Regional Amateur League players (eight right-footed and Seven left-footed) participated as the subjects in this study (Age: 21.08± 1.56 years old, Experience: 10.81± 2.09 years old, Body Mass: 68.85± 6.89 kg, Size: 1.76 ± 0.06 m). To represent a higher-skilled cohort of penalty-kickers, all participants were competing regularly in competition and performed penalties-kick during a match (full forwards, half forwards, and centerline players). In addition, all participants were in good health (no injuries which could alter kicking performance in penalties) in the previous six months. The study complied with the Helsinki declaration for human experimentation and the participants provided written consent to participate with the condition of keeping personal data secret like names...etc. Approval to conduct the study was obtained from the Ethics committee institute of Physical Education at the Abdelhamid Ibn Badiss University of Mostaganem, Algeria.

Design

The study was conducted on the football stadium of the Faculty of Sports Sciences at Selçuk University in Konya, Turkey. at 13h45. The weather was; -2°Temperature, 64% Humidity, 81% cloud cover, 11.3km visibility, 3.4km/h wind, 1012.0mb pressure, -8° dew point. In the penalty kick scenario, the goalkeeper is the threatening primary source in the environment (Martin, 2015). In the case of thisstudy, we recruited the players who framed their penalty shots well. For analysis, we have analyzed the biomechanical variables of penalty-kick performance in two-dimensional (2D). The players kicked a penalty with their dominant foot. Five attempts of players were recorded and only the bestthree were included in the final analysis. All kicks were in the legal position defined by FIFA's laws. During data collection, the recordings of penalty-kickperformance were made by two video cameras in a rectangular frame and capture area 5*4 m, these cameras were placed at optical axes x and y. Wherethe angle between the optical axes of the two cameras was 90°. Camera 1: Canon EOS 700D, video resolution: 4 megapixels (2304x1728 pixels), recording speed: 25 fps/50fps, 6.5 m perpendicular to the front plane of the ball, in height 0.77m for rightlateral view. Camera 2: Fujifilm NINEPIX HS35 EXR, video resolution: 1808p, recording speed: 25 fps/50 fps, 5m perpendicular to the front plane of the ball, in height 0.9m for posterior view (Figure 1. a). For syncing the cameras, all start buttons were linked together electrically by a LANC (CONTROL-L) device to a computer (100 Hz). Since the device requires LANC inputs on camcorders or ACC inputs on still cameras, it can be used on some camcorders. then,the kicks were manually synced. to measure the realdistance, a series of markers were placed in carefullymeasured locations along the inside with axes x, y, zwithin the reference scaling frame, and the calibration was based on eight reference points for the two cameras (side view, rear view). These markers served as reference measurements. Theplayers wore reflective markers on eight landmarks to track their motions. Markers were applied on jointsof the hips, the knees, and the ankles, and down theneck with the least possible number of occlusions, toanalyze the length and angle of movement.

Based on similar studies (Abdelkader et al., 2020; Banja, 2007; Banja, T & Tashiro T., 2004; R. M. Bartlett, 1992; Frossard et al., 2013a; Yu et al., 2002), several biomechanical variables in each phase of the soccer penalty kick performance phases were analyzed and calculated; approaching, the backswing, ball contact, follow-through. The variables were the angles of the trunk (α1), the knee of support leg "Knee Pi" (α2), shank (α3), thighs (α4), the knee of shoot leg "Knee Sh" (α5) and inclination body (α6). Distance (m) between pivot foot &ball. Time (s) of the beginning, backswing, footcontact, follow-through. Refer to figure.2 for shows the variables analyzed. We used dartfish 9 software for the biomechanical analysis, it's a video player for sports analysis. It provides a set of tools to capture, slow down, study, compare, annotate and measure technical performances. The films obtained for each trial were phase analyses for each variable and try. To measure the accuracy of the penalty kick, the players were asked to kick a ball with their dominant leg towards a football goal (FIFA regulations; 2.44 m high and 7.32 m wide) placed 11 meters away (penalty). Where the player chooses a space in goal for kicking penalty (Figure 1. b), then he tries to kick the ball in space chosen. We have a drip ladder for that: a/ three (03) points if kick's the ball into the chosen space and score a goal. b/ two (02) points if kick's the ball into the chosen space and didn't score a goal. c/one point (01) if kick's the ball into the side spaces of the chosen space and score a goal. Without that, we give him zero points (00).

Figure 1. a) The method chosen to calculate the variables analyzed in two-dimensional. **b)** Spaces chose for Accuracy penalty-kicking test.

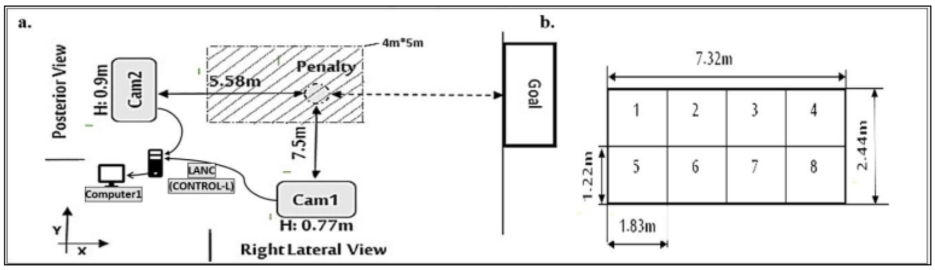
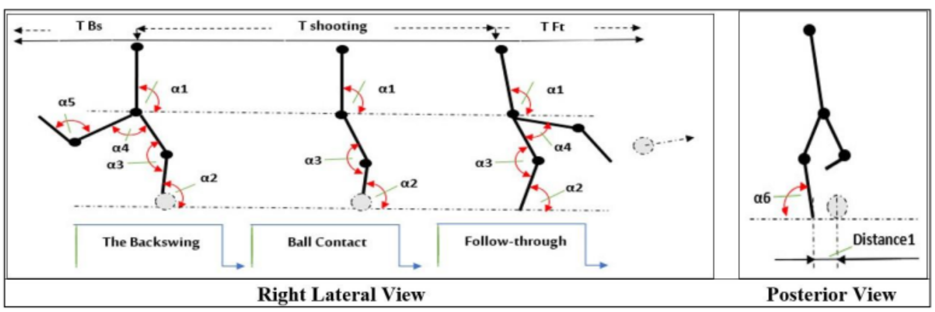


Figure 2. The variables analyzed.



Statistical Analysis

The data analysis procedures used in this study consisted of the computation of the means, standard deviations (SD), minimum and maximum value as descriptive statistics, and the Pearson Test for the correlations between all variables. We used SPSS (SPSS for Windows, version 22.0, SPSS Inc. Chicago, Illinois, USA) statistical program for that statistical analysis of the data obtained. Significance was accepted at $p<.05$.

Results and discussion

Table 1 shows the descriptive Analysis of variables analyzed during penalty kicking performance, by the mean, standard deviation, minimum and Maximum values. that in each phase of Soccer penalty kick performance phases (The Backswing, Ball Contact, Follow-through). Table 2 shows the significant correlations coefficients between variables analyzed in all phases of penalty-kicking performance (the backswing, ball contact, follow-through) and point achievements of accuracy test. From the results of data processing, it can be seen in the ball contact phase that the distance pivot foot & ball factor has a statistically significant effect in p-value=.001 in producing accuracy, and for the interaction between the two main factors namely the trunk and inclination body angles has a statistically significant effect with p-value≤.05 in producing accuracy too. In addition, in the follow-through phase, we can see too the statistically significant effect with p-value≤.005 of the trunk angle, and with p-value≤.05 of the thighs angle in producing accuracy. Also, accuracy kicking test results show that there are obvious significant correlations between variables in/between all phases of penalty-kicking performance. In The Backswing phase, A positive interactive correlation between shank angle with knee Pi angle in p-value≤.001, and with knee Sh angle in p-value≤.005, and knee Pi angle with thighs angle in p-value≤.05. Also, negative correlation between trunk angle with thighs angle in p-value≤.05. In the backswing with ball contact phases, a positive interactive correlation of trunk and shank angles in p-value=.005, and between trunk angle with shank angle in p-value≤.005, and with knee Pi angle p-value≤.05. knee Pi angle with trunk angle, and knee Pi angle in p-value≤.05, and with Shank angle in p-value=.005. Also, negative correlation between the time of beginning with knee Pi angle, knee Sh angle with inclination body angle, thighs angle with knee Pi angle in p-value≤.05. and between inclination body angle with thighs angle in p-value≤.005. In the backswing with follow-through phases, a positive interactive correlation of trunk angle in p-value=.05, and of shank angle in p-value=.005, and between trunk angle with shank angle in p-value≤.05, and knee Pi angle with shank angle in p-value≤.05. In the ball contact phase, a positive interactive correlation between trunk angle and shank angle in p-value≤.05, and between shank angle with knee Pi angle in p-value≤.005. In the ball contact with follow-through phases, a positive interactive correlation of trunk angle in p-value≤.01, shank angle in p-value≤.005, and knee Pi angle in p-value≤.05, and between knee Pi angle with thighs angle, time of follow-through in p-value≤.05, and with shank angle in p-value=.001, and between shank angle with thighs angle in p-value≤.01, and between the time of foot contact with the time of follow-through in p-value≤.05. In the follow-through phase, a positive interactive correlation between shank angle with knee Pi angle, thighs angle in p-value≤.005, and with the time of follow-through in p-value≤.05, and between knee Pi angle with thighs°, time of follow-through in p-value≤.005, and between the time of follow-through and thighs angle in p-value=.005.

Table 1. Descriptive Statistics of tests & kinematic variables analyzed.

Variables	Mean ± Std.D	Min	Max
Points	1.333±1.171	0.000	3.000
The Backswing			
T Beginning	2.088±0.963	0.960	5.240
Trunk°	94.361±4.428	80.000	103.000
Shank°	92.611±7.897	79.000	109.000
Knee° Pi	143.972±7.937	129.000	171.000
Knee° Sh	91.861±19.142	62.000	127.000
Thighs°	78.639±14.281	53.000	120.000
T Back Swing	1.123±0.448	0.520	2.840
Ball Contact			
Trunk°	99.278±5.338	82.000	110.000
Shank°	74.972±8.076	53.000	96.000
Knee° Pi	130.639±8.676	103.000	147.000
Inclination Body°	65.444±8.161	36.000	77.000
Distance Pivot Foot &Ball	0.293±0.047	0.220	0.410
T Foot Contact	0.209±0.235	0.120	1.160
Follow-through			
Trunk°	103.444±9.584	70.000	118.000
Shank°	59.806±11.902	41.000	92.000
Knee° Pi	131.389±13.139	103.000	166.000
Thighs°	57.167±31.761	8.000	124.000
T Follow Through	0.404±0.257	0.120	1.200

*Correlation is significant at the P<0.05 level.

**Correlation is significant at the P<0.01 level.

Table 2. The statistical analysis of the significant correlation between variables in test with Goalkeeper.

Points							
Ball Contact	Trunk°			.034*			
	Inclination Body°			.033*			
	Distance Pivot Foot &Ball			.001**			
Follow-through	Trunk°			.004**			
	Thighs°			.032*			
The Backswing							
	Variables	T Beginning	Trunk°	Shank°	Knee°Pi	Knee°Sh	Thighs°
The Backswing	Knee°Pi			.000**			
	Knee°Sh			.001**			
	Thighs°		-.033*		.035*		
Ball Contact	Trunk°		.005**		.033*		
	Shank°		.000**	.004**	.005**		
	Knee°Pi	-.036*	.034*		.039*		-.038*
	Inclination Body°					-.033*	-.004**
Follow-through	Trunk°		.035*				
	Shank°		.033*	.004**	.033*		
Ball Contact							
	Variables	Trunk°	Shank°	Knee°Pi		T Foot Contact	
Ball Contact	Shank°	.032*					
	Knee°Pi		.004**				
Follow-through	Trunk°	.007**					
	Shank°		.001**	.001**			
	Knee°Pi			.035*			
	Thighs°		.007**	.033*			
	T Follow-through			.038*		.030*	
Follow-through							
	Variables	Shank°		Knee°Pi		Thighs°	
Follow-through	Knee°Pi	.002**					
	Thighs°	.000**		.002**			
	T Follow-through	.039*		.001**		.005**	

***Correlation is significant at the P<0.05 level.**
****Correlation is significant at the P<0.01 level.**

Motion capture is repeatedly applied to soccer including a penalty kick to define the characteristics of skill, provide an understanding of mechanical effectiveness in correlation with physical ability, identify and record crucial factors for optimal performance quantitatively (Ángel-López et al., 2017). Relatively restricted scientific study has been undertaken on the kinematic aspects of soccer in the phases of kicking including the distance of pivot foot to the ball (Nakamura et al., 2018), despite the result has the debatable opinion regarding its relationship with kicking accuracy (Izovska et al., 2016). Nevertheless, the recent study showed that the kinematics profile of lower limbs is closely related to success in penalty performance primarily since they are significantly affected in imparting kicking the ball (Pereira Santiago et al., 2016). This conclusion will discuss the relationship between the kinematic profile such as angle of the trunk (α1), the shank of support leg (α3), and knee angle of the swing leg (α5) and the pivot leg distance with the ball against the kicking accuracy in the phases of the backswing, contact ball, follow-through. Based on the above result, it can be seen that the angle of the trunk (α1) appears to be +/- 90º in the backswing phase, however, progressively decreases (<90º) in the contact ball phase. This angle change indicates muscle shortening through concentric contractions in the adnominal and obliges (core muscles) areas which are assumed to be an energy storage process in the core area by involving the glutes, hamstrings, lumbar, pelvis, and hip muscles which will then be used to kick the ball (El-Kerdi, 2016). This is following the principle of force in biomechanics, where it is explained that to move a ball as an objecttakes a greater force than the ball as a mover (Ma &Gao, 2018). The change of angle in the trunk (α1) inthe contact ball phase is smaller than the backswingphase, it is believed to be an attempt by the sampleto produce power through concentric contractions inthe abdominal area, thus causing the trunk to lean forward (adduction), and decrease the angle of trunkangle (<90º) in the phase of contact ball (Prieske etal., 2016). On the other hand, the finding of a trunk angle (α1) that has not shortened in the contact ballphase, assumed that the sample kicked the ball with minimal concentric contraction of the core muscles, resulting in less power and reduce ball velocity, consequently decrease the kicking accuracy to the target (El-Kerdi, 2016). This opinion stated in the discussion of kinematic studies where the shortening of the trunk angle (α1) in the core muscles when kicking the ball, has a significant correlation to the amount of power of abdominal muscles used to kick the ball and level of accuracy (Hides et al., 2016). Other studies also confirmed the relationship of the trunk angle with the body inclination and kick point on the ball to the trajectory pattern of the ball, which explained that kicking on the bottom side of the ball, creates a greater lateral angle of body inclination (α6) and greater adduction angle of the trunk (α1), resulted in a wider parabolic trajectory, thus made the ball bounce farther (Moura et al., 2018). It can be concluded that the trunk angle (α1) has a significant relationship to the kicking power, distance, velocity, trajectory profile of the ball, and accuracy.

The dynamic changes of angle of the shank (α3) are also seen from the phase of the backswing, contact ball to the follow-through phase, which is found that the angle of the shank (α3) in the backswing phase is around (>90º), then decreases (<90º) in thephase of contact ball, however, increase again by reaching (+/- 90º) in the phase of follow-through. Several studies describe the dynamic contraction process which constantly occurs to the pivot leg immediately when has contact with the ground for supporting the body weight and causing elongation of the muscle (eccentrically), followed by an isometric contraction while bending the knee joint tomaintain the body's balance along with produce the force (amortization) in the contact ball phase, then ends with shortening the muscle (eccentric) return tothe original shape at the end of kicking the ball in thefollow-through phase (L. Barker et al., 2021). This process is also explained on the principle of stretch- shortening cycles, that rapid muscle changes throughreactive movements on bending of the knee onkicking that involve rapid eccentric and concentric contractions, have been shown to produce better power than other strength exercises (Kusuma, 2018). Several studies concluded that the shot powerformed through the amortization of the support leg isinfluenced by the angle of the knee pivot, ground reaction time, and muscle elasticity in performing kicking movements on the pivot leg (L. A. Barker et al., 2018). It can be concluded that the longer time the stretching-shortening cycle (>150ms) and smaller shank angel (<135º) occurs when the pivot knee bent in kicking position, causes the over- stretching movement, excessive lengthening of the muscle, decreased the shot power, consequentlydecreases the speed and travel time of the ball, increases the gravity force of the ball, thus decreasethe shot accuracy.

Another discussion can be seen in the profile of the distance between the foot and the ball in the kicking position. The kinematic study explains that the distance between the foot and the ball has a significant correlation with the angle of body segmentation formed, which is needed in producing an external force and is represented from the profile of the length of the kicking foot, the profile of the ball's trajectory and the level of accuracy of the ball (Jones et al., 2016). It is explained on the principle of impulse direction that an object will only be able to move under the influence of an external force in the same direction acting on the object ball (Kusuma, 2021). The study explains that the short distance between the foot and the ball causes the core to lean forward with the trunk angle (<90º), the shank angle becomes large (>135º) and the thighs angle decreases, resulting in a shorter kicking leg swing, produces a low external force to kick the ball, thus the ball velocity is decreased and the level of accuracy rate is less (Jones et al., 2016). It can be concluded that the short distance of the foot to the ball produces the body to be not in a power position, thus the impulse transfer process from the swing leg, core, and support leg becomes less than optimal

This contradicts the principle of summing joint forces which explains that to produce a large force, it is necessary to optimally engage (interrelation) of each body segment (Duncan & Bellar, 2015). In terms of producing force when kicking the ball, it is necessary to have an optimal swing leg length at the angle of the thighs, to be forwarded to the tip of the foot like a ball kicker, and an optimal distance is needed between the pedestal and the ball. This is influenced by the trajectory of the kicking foot which functions as an external force that must not be hampered, where any pause is evident as a jerkiness or hesitation in the motion disrupts the smooth proximal to distal flow and causes a reduced impulse so that the ball speed becomes low (Inoue et al., 2013). The correlation between ball speed and accuracy is also described in some literature where the higher the ball speed, the smaller the gravitational force, so that the ball trajectory is easier to direct, and ultimately has a higher accuracy rate (Torreblanca-Martinez et al., 2020). Therefore, some data showing differences in the profile of the distance between the foot and the ball are interesting for further calculations on the profile of foot swing, power, ball speed, and accuracy. Accordingly, we can answer our hypothesiswith yes, during the performance of penalty-kicking in goalkeeper confrontation, the values of variables analyzed would increase, and effective on accurate of kick.

Conclusion

As a conclusion, it can be conveyed that the distance between the support leg and the ball is very decisive for the kinematic profile formed such as contraction of the abdominal muscles (trunk angle), the amortization process (the pivot leg angle), shot power (angle and length of the shot leg swing trajectory), where these aspects are significantly affected to the shot power, ball velocity and the level of accuracy.

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