Human Movement Science 36 (2014) 199–216

Contents lists available at ScienceDirect

Human Movement Science

journal homepage: www.elsevier.com/locate/humov

Predicting the lateral direction of deceptive and non-deceptive penalty kicks in football from the kinematics of the kicker

José E. Lopes [a,*], David M. Jacobs [b], David Travieso [b], Duarte Araújo [a]

[a] SpertLab, Ciper, Faculdade de Motricidade Humana, Universidade de Lisboa, Cruz Quebrada, Portugal
[b] Departamento de Psicología Básica, Facultad de Psicología, Universidad Autónoma de Madrid, Spain

ARTICLE INFO

Article history:
Available online 17 May 2014

PsycINFO classification:
2300
2323

Keywords:
Anticipation
Deception
Movement
Visual perception
Representative design

ABSTRACT

This study addresses the utility of the kinematics of penalty takers for goalkeepers in association football. Twelve professional and semi-professional players shot to one side of the goal with (deceptive condition) or without (non-deceptive condition) simulating a shot to the opposite side. The body kinematics of the penalty takers were registered with motion-capture apparatus. Correlation and regression techniques were used to determine the relation between the shot direction and aspects of the penalty taker's kinematics at different moments. Several kinematic variables were strongly correlated with shot direction, especially those related to the lower part of the body. Some of these variables, including the angle of the non-kicking foot, acquired high correlations at time intervals that are useful to goalkeepers. Compound variables, here defined as linear combinations of variables, were found to be more useful than locally defined variables. Whereas some kinematic variables showed substantial differences in their relation to ball direction depending on deception, other kinematic variables were less affected by deception. Results are interpreted with the hypothesis of non-substitutability of genuine action. The study can also be interpreted as extending the correlation and regression methodology, often used to analyze variables defined at single moments, to the analysis of variables in a time continuous fashion.

* Corresponding author. Address: SpertLab, Faculdade de Motricidade Humana, Universidade de Lisboa, Cruz Quebrada, Estrada da Costa 1499-002, Cruz Quebrada – Dafundo, Portugal. Tel.: +351 969245530.
E-mail addresses: ze9777@gmail.com (J.E. Lopes), david.jacobs@uam.es (D.M. Jacobs), david.travieso@uam.es (D. Travieso), daraujo@fmh.ulisboa.pt (D. Araújo).

http://dx.doi.org/10.1016/j.humov.2014.04.004
0167-9457/

1. Introduction

In sports such as handball, basketball, or football, there are severe time constraints for athletes while perceiving and acting. In addition, players are pressured to achieve high levels of precision. A match event in which these spatial and temporal constraints are particularly evident is the penalty kick in association football (Lopes, Araújo, Peres, Davids, & Barreiros, 2008). One of the aspects of the penalty kick that has received attention concerns the information that goalkeepers use to anticipate the direction of the ball (Diaz, Fajen, & Phillips, 2012; Dicks, Button, & Davids, 2010a). With the current experiment we aim to contribute to the knowledge about this aspect of the penalty kick, focusing on the information available in the kinematics of the penalty taker and on the role of deception.

Before we describe the purpose of the experiment in more detail, we briefly review previous results. A crucial issue is the time at which goalkeepers commit themselves to a side. Dicks, Davids, and Button (2010) reported average ball flight times between 590 and 648 ms and average goalkeeper movement times between 750 and 1085 ms. Hence, goalkeepers who base the direction of their dives on the first part of the ball trajectory are likely to start moving too late, especially if one takes into account that a small perceptual-motor delay must exist. The findings reported by Dicks et al. (2010) therefore support the common claim that goalkeepers should initiate their movements before ball contact, which means that they should not rely exclusively on information from the ball trajectory (Dicks, Uehara, & Lima, 2011; Franks & Harvey, 1997).

As an alternative source of information, goalkeepers may use the kinematics of their opponent before ball contact to anticipate the direction of the shot. This gives rise to two questions. First, which kinematic variables are good predictors of ball direction? And second, which kinematic variables are actually used by goalkeepers? A substantial body of work has addressed the second question, using self-reports (Kuhn, 1988), occlusion paradigms (Dicks, Button, & Davids, 2010b; Smeeton & Williams, 2012), and, most particularly, gaze-registration methods (Button, Dicks, Haines, Barker, & Davids, 2011; Dicks et al., 2010a; Piras & Vickers, 2011; Savelsbergh, van der Kamp, Williams, & Ward, 2005). Areas that goalkeepers have been claimed to focus on include the penalty takers' hips, the non-kicking foot, and the region between the ball and the kicking leg (i.e., 'visual pivot'; Piras & Vickers, 2011).

Less research has addressed the first question, about how useful the candidate kinematic variables actually are. Franks and Harvey (1997) analyzed videos of penalties in FIFA World Cup competitions. They concluded that several kinematic variables have a high reliability at or immediately before ball contact. These variables include the inward or outward knee rotation of the kicking leg and the point of contact on the ball. However, given the time constraints for goalkeepers, Franks and Harvey considered that variables should be detectable and have a high reliability a certain time interval before ball contact. This led them to consider the final placement (i.e., pointing direction) of the non-kicking foot as the most useful variable. They reported that this variable has a reliability of about 80% and that it can be detected from about 150–200 ms before ball contact.

Studies by Lees and Owens (2011) and Diaz et al. (2012) also concerned the information value of candidate kinematic variables. These studies were more sophisticated than the one reported by Franks and Harvey (1997) in the sense that motion-capture equipment was used to register the kinematics of the penalty takers, allowing more advanced methods to analyze the reliability of the candidate variables. The three studies (i.e., the ones by Franks & Harvey, Lees & Owens, and Diaz et al.) agree in pointing toward the orientation of the non-kicking foot as a relatively reliable source of information around 200–250 ms before ball contact. Lees and Owens also reported hip rotation (as projected on the horizontal plane) and hip and ankle flexion as significant indicators of shot type and shot direction. Diaz et al. presented results for several locally defined kinematic variables. In addition, they concluded that global or distributed information might be useful. At 200 ms before ball contact, for instance, one of the sources of distributed information considered by Diaz et al. had a reliability of 77%. An emphasis on distributed information is consistent with research in other sports (e.g., Abernethy, Gill, Parks, & Packer, 2001; Huys, Smeeton, Hodges, Beek, & Williams, 2008; Ward, Williams, & Bennett, 2002).