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Full Length Article

Kinematic patterns underlying disguised movements: Spatial and temporal dissimilarity compared to genuine movement patterns

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ABSTRACT

This study examined the kinematic characteristics of disguised movements by applying linear discriminant (LDA) and dissimilarity analyses to the motion data from 788 disguised and 792 non-disguised 7-m penalty throws performed by novice and expert handball field players. Results of the LDA showed that discrimination between type of throws (disguised vs. non-disguised) was more error-prone when throws were performed by experts (spatial: 4.6%; temporal: 29.6%) compared to novices (spatial: 1.0%; temporal: 20.2%). The dissimilarity analysis revealed significantly smaller spatial dissimilarities and variations between type of throws in experts compared to novices ($p < 0.001$), but also showed that these spatial dissimilarities and variations increased significantly in both groups the closer the throws came to the moment of (predicted) ball release. In contrast, temporal dissimilarities did not differ significantly between groups. Thus, our data clearly demonstrate that expertise in disguising one's own action intentions results in an ability to perform disguised penalty throws that are highly similar to genuine throws. We suggest that this expertise depends mainly on keeping spatial dissimilarities small. However, the attempt to disguise becomes a challenge the closer one gets to the action outcome (i.e., ball release) becoming visible.

1. Introduction

Anticipation is an important skill when coping with human interaction in daily life, and it is particularly important for athletes when coping with different challenges in competitive sport. Because athletes generally have to process information under temporal constraints—especially when engaging in complex movement interactions (i.e., one-on-one situations)—anticipatory processes are needed to adapt to the unique constraints of these tasks (Williams, Ford, Eccles, & Ward, 2011). Quite frequently, athletes such as penalty takers deliberately attempt to manipulate their opponents' processes of anticipation. For instance, they may try to convince their opponents that they are performing one action while actually carrying out another. The purpose of such actions is to trigger, first and foremost, an incorrect motor response in the interacting counterpart (e.g., a goalkeeper) in order to gain a competitive advantage. From a more theoretical point of view, such motor actions are performed either (a) to intentionally mislead or (b) to keep the opponent in suspense about one's own real action intention. In the first case, athletes attempt to trigger misperception in the observer by providing deceptive information. This can be an attacking player's deliberate attempt to exaggerate certain kinematic cues (cf. Brault, Bideau, Craig, & Kulpa, 2010) in order to mislead the opponent into anticipating an incorrect kicking or running

Abbreviations: ANOVA, analysis of variance; lArmHand, left arm and hand; LDA, linear discriminant analysis; lLegFoot, left leg and foot; PCA, principal component analysis; rArmHand, right arm and hand; rLegFoot, right leg and foot

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direction. In the second case, however, athletes attempt to keep their opponents in suspense about their own action intentions by disguising their veridical action intent. This type of disguise relies might rely on an attempt to mimic the kinematic patterns of a genuine movement.

Nonetheless, it is widely accepted that movement kinematics convey a rich source of information with which to detect the intentions underlying observed movements and consequently to perceptually distinguish genuine from either deceptive (Brault, Bideau, Kulpa, & Craig, 2012; Cañal-Bruland & Schmidt, 2009; Grèzes, Frith, & Passingham, 2004; Jackson, Warren, & Abernethy, 2006; Runeson & Frykholm, 1983; Sebanz & Shiffrar, 2009; Smeeton & Williams, 2012) or disguised actions (Rowe, Horswill, Kronvall-Parkinson, Poulter, & McKenna, 2009). In this context, research on action recognition has suggested that the information provided by relative motion (dynamic features) is more relevant than structural (Mather & Murdoch, 1994; Troje, 2002) or isolated cues (Johansson, 1973). Up to now, a few studies have tried to characterize the kinematic features of motor actions performed intentionally to manipulate an opponent's anticipatory process. These have focused mainly on discrete or continuous whole body deceptions (Brault et al., 2010; Lopes, Jacobs, Travieso, & Araújo, 2014). Results of these studies have shown consistently that exaggerating specific kinematic features (mainly upper trunk movements) is one major attribute of movement deception. As an example, Brault et al. (2010) analyzed kinematic differences between deceptive and non-deceptive side steps in rugby. The authors reported that the most significant angular changes in the initial running path were found for the upper trunk, whereas players sought to minimize other parameters such as lower trunk movements in order to maintain the postural stability needed to change the final running direction. Further, the largest differences were observed in the final phase of the gait cycle. Similar effects were also reported by Lopes et al. (2014) who observed the largest differences between deceptive and non-deceptive soccer penalty kicks close to the moment of ball contact. These latter findings describe fundamental biomechanical constraints on deceptive movement behavior and are explained by the non-substitutability of genuine action. In this context, assuming that movement patterns are multidimensional, one can argue that effects resulting from changing one kinematic factor cannot be replaced or cancelled out by changing another factor (Richardson & Johnston, 2005; Runeson & Frykholm, 1983, 1986). In other words, when trying to create a deceptive movement pattern, one may be able to produce some of the deceptive kinematics, but not all the necessary details needed to convince the observer that the movement is genuine (Lopes et al., 2014; Richardson & Johnston, 2005). However, when it comes to the different ways of manipulating an opponent's anticipatory processes, the kinematic characteristics of disguised movements are still unknown. In addition, research thus far does not differentiate between the spatial and temporal movement components as potential predictors for either deceptive or disguised actions.

Against this background, the present study aims to investigate the kinematic characteristics of disguised 7-m penalty throws in team handball. More specifically, we ask first, how disguised and non-disguised penalty throws separate kinematically, and second whether these movement kinematics differ in terms of their spatial and temporal components. Third, we add the factor expertise (experienced vs. novice penalty takers) in order to emphasize kinematic attributes linked to practice in performing disguised actions. We address these issues with an analytical approach combining methods from linear statistics with spatial and temporal dissimilarity analysis. A priori, we hypothesized that experienced penalty takers would more probably be able to disguise their action intentions, resulting in a lower linear separation performance between their disguised and non-disguised penalty throws compared to novices. Consequently, we expected that dissimilarities and variations between disguised and non-disguised penalties would be smaller for throws performed by experienced athletes. More specifically, we hypothesized that the effect of disguise would decrease significantly the closer the execution of the throwing phase comes to the moment of (predicted) ball release.

2. Method

2.1. Participants

Ten right-handed male participants volunteered to participate in this study (M_{age} = 22.1 years, SD = 3.5). The study was approved by the local ethics committee of the Justus-Liebig-University Giessen, and all participants gave their informed written consent in accordance with the Declaration of Helsinki. Participants were divided into two different expertise groups: experts (competitive elite team handball field players, according to the criteria by Swann, Moran, & Piggott (2015), n = 5) and novices with no other previous experiences in team handball other than attending a university class for beginners (n = 5). Athletes from the expert group played in one of the four highest national leagues in Germany and were frequent penalty takers for their team. We considered them to be experts in performing disguised movements. They reported training for an average of 13 h per week (SD = 1.9) and had a mean playing experience of 15 years (SD = 2.2).

2.2. Apparatus and design

Four different target locations (1.2 m × 1.2 m) were set up in the upper and lower left- and right-hand corners of a standard handball goal (3 m × 2 m, as specified in the guidelines of the International Handball Federation). Kinematic data were recorded by means of a motion capture system (VICON, Oxford, UK) equipped with 15 CCD high speed cameras and remote-controlled by Presentation software (Neurobehavioral Systems, Albany, NY, USA) running on an additional PC. The system tracked three-