QUANTIFYING SEGMENTAL COORDINATION DURING A SPORT SPECIFIC MOVEMENT USING A MODIFIED VECTOR CODING TECHNIQUE: A COMPARISON BETWEEN TWO COORDINATION PATTERN CLASSIFICATIONS

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The purpose of this study was to compare two coordination pattern classifications associated with a modified vector coding technique, with a view to examine how differences between these classification systems affect the interpretation of movement patterns during the maximal instep kick in association football. This study strongly recommends the use of a coordination pattern classification that details the phase relationship between two segments (i.e. in-phase or anti-phase), provides an understanding of the direction of segmental rotations, and is able to quantify segmental dominancy at each point in time.

KEY WORDS: vector coding, coordination, variability, movement, sport

INTRODUCTION: The application of a dynamical systems theoretical framework in biomechanics and motor control research has provided non-linear data analysis techniques that offer a quantitative measure of movement coordination and coordination variability over time. For example, an angle-angle diagram illustrates the continuous interaction between two segments and provides a qualitative means for analysing coordination dynamics (Fig. 1a). A modified vector coding technique (VC) is an approach used by dynamical system theorists to calculate the vector orientation between adjacent data points on an angle-angle diagram relative to the right horizontal (Needham, Chockalingam, & Naemi, 2014). The vector orientation can range between 0-360° and refers to as the coupling angle (CA) (Hamill, Haddad, & McDermott, 2000) (Fig. 1b). Since the CA is a circular variable, direction statistics are necessary for averaging and CA deviation calculations (Batschelet, 1981; Needham et al., 2014).

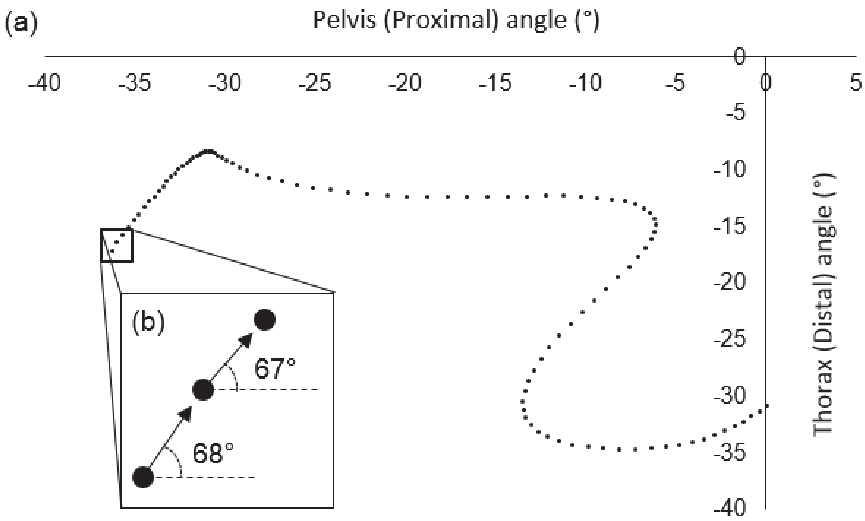

Figure 1: An angle–angle plot representing pelvis and thorax axial rotation in the transverse plane during a maximal instep kick from kicking leg toe off to maximal hip flexion of the kicking leg (a). The inset provides an expanded view of two CA's (b).

At each instance in time across a normalised movement cycle, the CA is classified to a coordination pattern. Chang, Van Emmerik, and Hamill (2008) introduced the terms 'in-phase', 'anti-phase', 'proximal phase' or 'distal phase' (Fig. 2a). While this study provided a new perspective on foot function, the CA can only be classified to one of the four coordination patterns. Recently, Needham, Chockalingam, and Naemi (2015a) offered a new coordination pattern classification that details the phase relationship between two segments (i.e. in-phase or anti-phase), and based on the polar position of the CA, segmental dominancy is quantified (Fig. 2b).

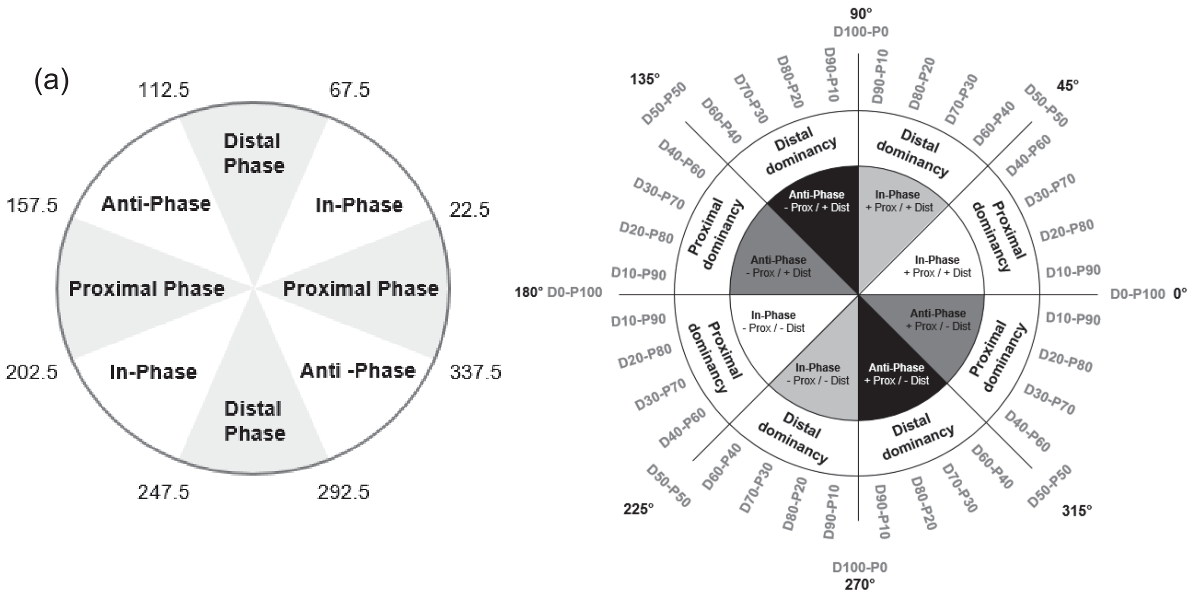

Figure 2: A polar plot showing the coordination pattern classification adapted from Chang et al. (2008) (a). The new coordination pattern classification adapted from Needham et al. (2015) (b). Segmental dominancy is shown around the circumference of the polar plot as a percentage contribution to relative movement (grey text).

The biomechanics of the maximal instep kick in association football has been an area of investigation for several years. However, there is still a paucity of information on segmental coordination during the maximal instep kick. Such information could support and expand on current theories on kicking technique and provide further information on coaching interpretation. Therefore, the purpose of this study is to compare two coordination pattern classifications, with a view to examine how differences between these classification systems affect the interpretation of movement patterns during the maximal instep kick.

METHODS: Nine male university football players participated in this study (21.5 ± 5 years, height: 181.38 ± 23.2 cm, mass: 74.54 ± 19.01 kg). Ethical approval was sought and granted by the University Research Ethics Committee. Pelvis and thorax kinematic data was collected at 200 frames per second using an 18-camera motion capture system (VICON, Oxford, UK). The marker configuration used was in accordance with Leardini et al. (2011). Ten trials of the maximal instep kick were collected on the dominant side. The data was normalised for time from kicking leg toe off to maximal hip flexion of the kicking leg. Further information on the CA and averaging calculations along with the details on the interpretation of the new coordination pattern classification is reported elsewhere (Needham et al., 2014; Needham et al., 2015a).

RESULTS: In Area A of Fig. 3a, the CA lies on the boundary between an in-phase and distal phase coordination pattern. An examination of Area A in Fig 3b reveals further information, suggesting there is an in-phase coordination pattern with distal dominancy and that both segments are rotating in a positive direction. In Area B of Fig. 3a, there is a transition from anti-phase to a proximal phase and then back to an anti-phase coordination pattern. In Fig. 3b (Area B), an anti-phase coordination pattern with proximal dominancy is reported.

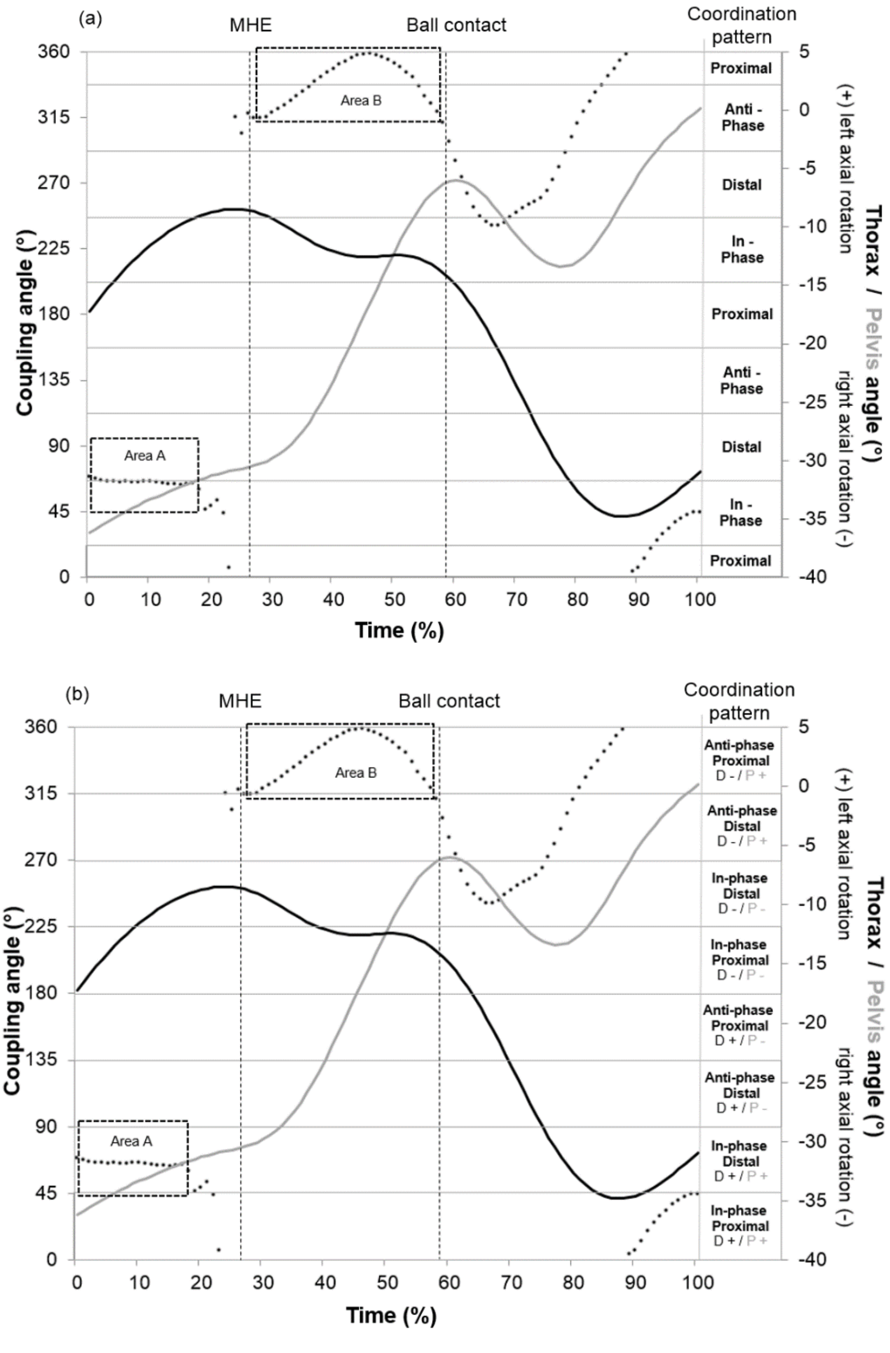

Figure 3: Mean coupling angle for pelvis-thorax coordination in the transverse plane (black dots corresponding to left vertical axis) during a maximal instep kick, presented using the coordination pattern classification by Chang et al. (2008) (a) and Needham et al. (2015) (b). The grey and black lines represent pelvis and thorax segment angle, respectively (corresponding to right vertical axis). Two working examples were provided to assist in this interpretation (Area A/Area B). MHE – maximal hip extension.

DISCUSSION: Results of this study clearly highlights that the new classification provides more information on the interaction between segments. In Figure 3a (Area A) the CA lies on the boundary between coordination patterns which makes it difficult to distinguish between an in-phase and distal phase coordination. The inclusion of segmental angle data clearly outlines an in-phase coordination (rotation in the same direction) with distal dominancy (slope of the black line is greater in comparison to the grey line), which is presented in the new coordination pattern classification (Fig. 3b Area A). The new classification system also allows for the CA to be assigned to an appropriate coordination pattern if the CA lies on the boundaries. For example, a CA of 45° and 225° suggests an in-phase coordination pattern with both segments contributing equally to relative movement. A CA of 0-360° and 180° or 90° and 270° represents complete dominancy from either the proximal to distal segment, respectively. Having said that, one needs to appreciate that during a highly dynamic physical activity or a sports specific movement, it is rare for one segment to be in a fixed position for an extended period of time.

The power of a maximal instep kick has been attributed to the formation and release of a tension arc (TA) (Shan & Westerhoff, 2005). The release phase of the TA follows maximal hip extension (MHE) through to ball contact and involves thorax rotation towards the kicking side and rotation of the pelvis towards the non-kicking side (Shan & Westerhoff, 2005) (Area B). Segment angle rotation in the opposite direction reveals this anti-phase coordination pattern. In Figure 3a (Area B), there is a transition from anti-phase to proximal phase then back to an anti-phase coordination. However, in Figure 3b an anti-phase coordination between the pelvis and thorax segments is still noted during this proximal dominancy phase, which is not reported in Figure 3a. Therefore, the coordination pattern classification proposed by Needham et al. (2015a) offers a more detailed and accurate account of the coordination between the pelvis and thorax segment.

The added advantage of the new classification system is the possibility to quantify the segmental dominancy using gradians as a measurement unit, in addition to the qualitative insight into proximal and distal dominancy by examining the slope of the segmental angle. For example; based on the polar position of the CA, which in this instant ranged between 63-68° (Area A), there was 70 to 75% contribution from the distal segment towards relative movement. Although this paper looks at maximal instep kick, this approach can be extended to other set of segments and other movements to gain an in depth understanding of the segmental coordination patterns.

CONCLUSION:

Reported approach using vector coding to quantify changes in segmental dominancy and phase relationship between segments not only provides further detail into the inter segmental movement which is very valuable to a sports scientist or a coach to plan any rehabilitation intervention, but also to inform any performance related coaching interventions . Therefore, we strongly recommend adopting such data analysis techniques to inform practice.

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