COUPLING ANGLE MAPPING TO ASSESS PELVIS-THORAX COORDINATION AND COORDINATION VARIABILITY DURING THE MAXIMAL INSTEP KICK IN ASSOCIATION FOOTBALL

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The traditional approach of reporting time-series data on outcome measures from a modified vector coding technique can be problematic when overlaying multiple trials on the same illustration. The purpose of this study was to provides researchers the prospect to inspect an entire dataset and to compare data across multiple participants and experimental conditions via the use of colour. This study showcases the application of coupling angle mapping, coordination variability mapping, and segmental dominancy profiling during the maximal instep kick in association football. These new data visualisation approaches can assist current data analysis techniques such as coordination profiling and mulitple single-single research design studies.

KEYWORDS: vector coding, coordination, coupling angle mapping, single-subject, coordination profiling, maximal instep kick

INTRODUCTION: Vector coding (VC) is non-linear data analysis technique used to quantify movement coordination and coordination variability (CAV). A modified vector coding technique 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 (Hamill, Haddad, & McDermott, 2000) (Figure 1). The coupling angle can then be assigned to a coordination pattern classification (Figure 3c) (Needham, Naemi, & Chockalingam, 2015). Converting the coupling angle to gradian provides a technique to quantify segmental dominancy across time (Needham et al., 2015). Since the CA is a circular variable, direction statistics are necessary for averaging and coupling angle deviation calculations (Needham et al., 2014).

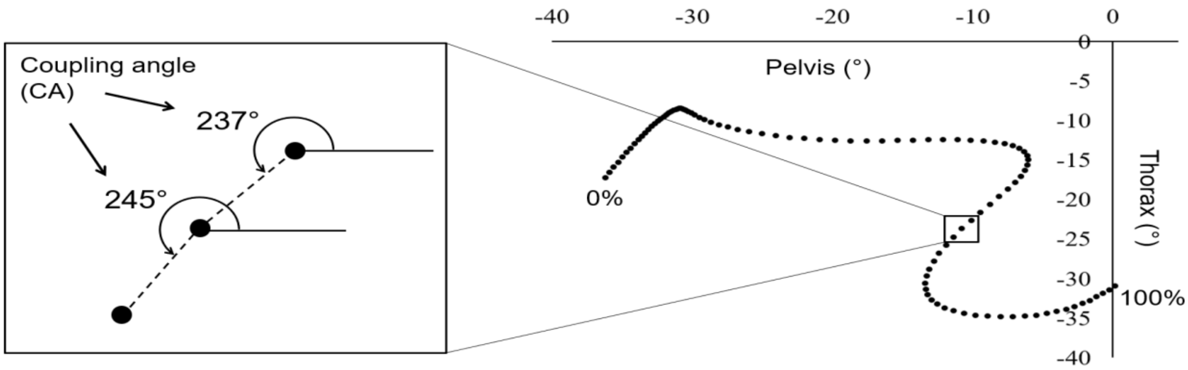

Figure 1: An angle–angle plot representing axial rotation of the pelvis and thorax segment during a maximal instep kick. The inset provides an expanded view of two coupling angles.

VC was used to assess coordination and CAV between the pelvis and thorax during a maximal instep kick. While high CAV for the group was noted on both dominant (D) and non-dominant limbs (ND), higher pelvis-thorax CAV on the ND limb in comparison to the D limb was attributed to lower kicking ability (Gosling, Needham, Naemi, & Chockalingam, 2017). However, the traditional approach to report VC data (i.e. mean coupling angle and mean CAV) did not permit an interpretation of movement coordination and CAV between participants. Traditional time-series reporting of VC data can be difficult to interpret when multiple trials are overlapped (Figure 2). Therefore, this study showcased the use of coupling angle mapping, which is a reporting technique that will illustrate movement coordination and CAV during the maximal instep kick across multiple participants, experimental conditions (D versus ND), and trials via use of colour (Needham, Naemi, Hamill, & Chockalingam, 2017).

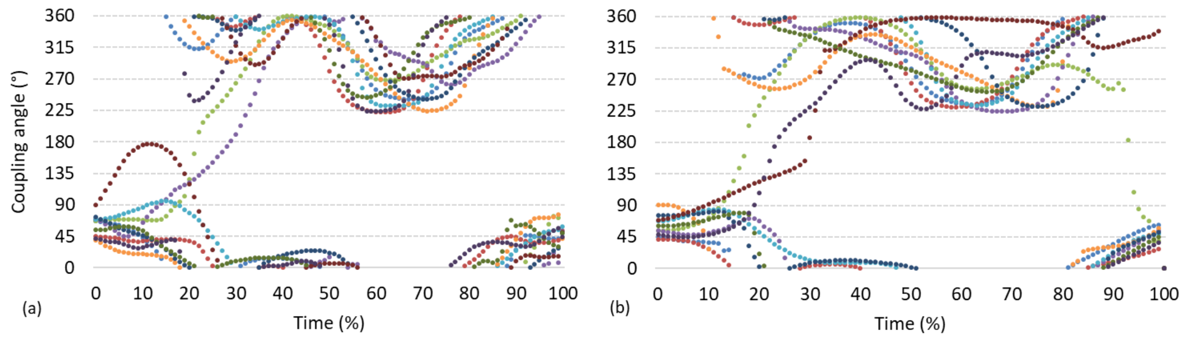

Figure 2: Mean coupling angle data on pelvis–thorax coordination during the MIK in the transverse plane (10 participants) on the dominant (a) and non-dominant limb (b).

METHODS: Ten male university football players participated in this study (mean ±SD: 22.1 ±5 years, 183.5 ±24.1 cm, 75.9 ±18.1 kg). Ethical approval was received from the University Research Ethics Committee. An 18-camera motion capture system (VICON, Oxford, UK) collected pelvis and thorax segment angle data at 200 Hz. Five trials were collected on the D and ND sides. Data were normalised for time (0-100%) from kicking leg toe off (KLTO) to maximum hip flexion (MHF) of the kicking leg. Additional events during the maximal instep kick included maximum hip extension (MHE), maximum knee flexion (MKF) and ball contact (BC). VC calculations and interpretation of coordination pattern classification are reported elsewhere (Needham et al., 2014; Needham et al., 2015). “Coupling angle mapping” signifies a colour-scale approach to display changes in coordination pattern classifications across a movement cycle. For example, coupling angles of 237° and 245° (Figure 1) were assigned a dark green colour which is classified as an in-phase with distal dominancy coordination pattern (Figure 3c). A combined visualisation technique of using colour and data bars mapped and profiled CAV data, respectively (Figure 3e). Coordination variability mapping displays the degree of CAV across three-colour scales, with green representing low CAV and red indicating high CAV (Figure 3f). Since the length of a vector (r) is quantified between a value of 1 and 0, coordination variability is bound between 0° and 80°. Data bars profile segmental dominancy across a movement cycle to signify segment percentage contributions to relative movement (Figure 3d).

RESULTS: In Figure 3, subtle differences in the coordination pattern were noted between the D and ND limbs for several participants (a), while the coordination pattern for some participants did not coincide with the coordination pattern reported for the group (b). CAV was higher and extended for the group across experimental conditions (Figure 3b) in comparison with individual participant data. On group data, segmental dominancy profiles were similar between D and ND limbs (Figure 3b), although distal segmental dominancy was extended for time between kicking leg toe off and maximum hip extension for the ND limb compared with the D limb.

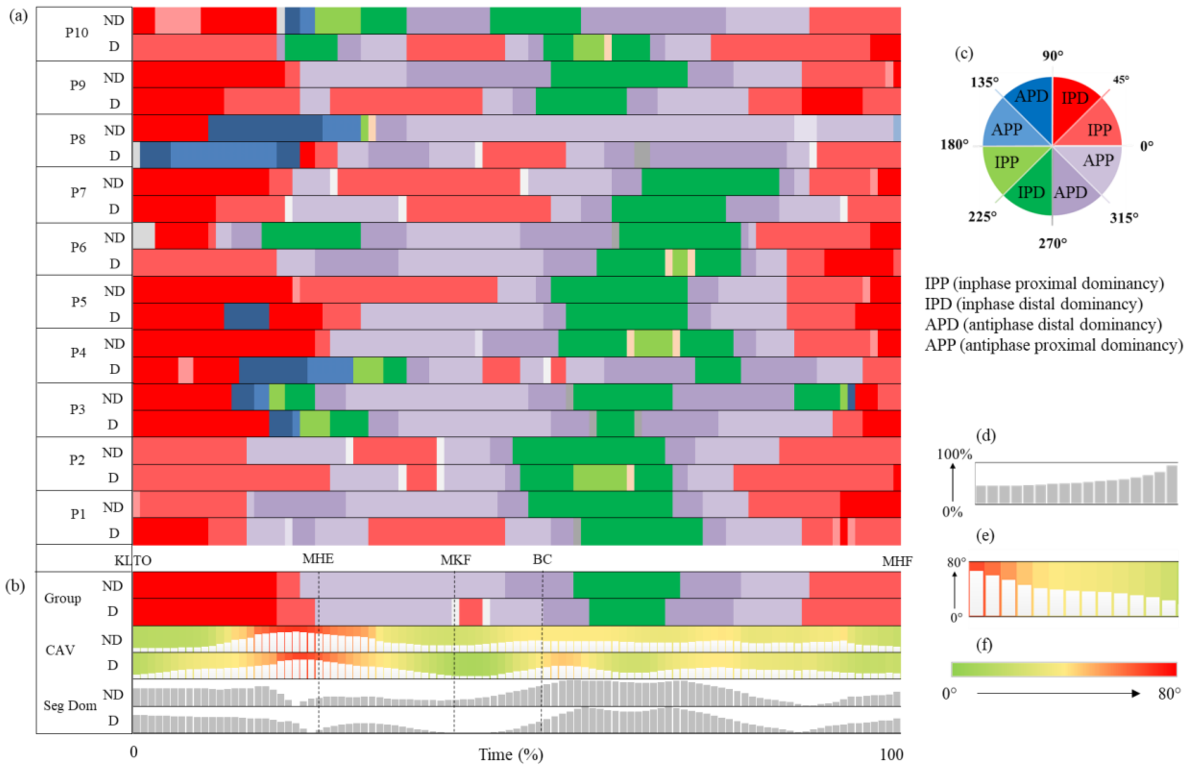

Figure 3: (a) coupling angle mapping during the maximal instep kick from kicking leg toe off to maximal hip flexion for the dominant and non-dominant limb, representing mean CA data across 10 participants (P1-P10); (b) group CA, CAV and segmental dominancy; (c) coordination pattern classification (Needham et al., 2015) illustrating colour-scale for each classification; (d) segmental dominancy profile scale (Seg. Dom. representing distal segment data); (e/f) CAV scale.

DISCUSSION: At present, it is difficult to identify transitions between coordination patterns using traditional couple angle-time series analyses that comprises of overlaying data points on the same figure. This is further confounded if subsequent analyses require comparisons between experimental conditions (i.e. D versus ND limbs). The purpose of this paper was to apply novel graphical techniques for displaying coupling angle, CAV, and segmental dominancy data during the maximal instep kick, that allows for a comparison and contrast of data across multiple participants and experimental conditions.

Coupling angle mapping reported within this study, has provided an opportunity to identify commonalities and differences in coordination patterns across participants while performing the maximal instep kick. In Figure 3a for example, an in-phase coordination pattern between the pelvis and trunk in the transverse plane is noted for several participants between kicking leg toe off and maximum hip extension, which coincides with coordination pattern reported for the group (Figure 3b). However, in comparison to distal dominancy reported for the group (dark red), some participants display proximal dominancy (light red) between kicking leg toe off and maximum hip extension. Furthermore, one participant (P8) displayed a coordination pattern that was not reflective of the mean coupling angle. Based on the observations in Figure 3a, subtle differences in the transitions between coordination patterns across participants explains the high degree of CAV reported for the group (Figure 3b). More importantly, these subtle differences in the coordination patterns between participants potentially raises a relevant issue on the application of group CAV data to inform coaching and clinical interventions. The power of a maximal instep kick has been attributed to the formation and release of a tension arc (Shan & Westerhoff, 2005). The release phase of the tension arc follows maximum hip extension 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). The findings and visualisation reporting techniques of this study have clearly demonstrated that an average performance of a movement task cannot be generalised across a small sample size cohort. It is important to note that single-subject designs can supplement group designs and could be an alternative when the study sample size is low (James & Bates, 1997), which in biomechanics research tends to be the case (Knutson, 2017; Mullineaux, Bartlett, & Bennett, 2001). Coupling angle mapping can support a multiple subject-single research design study and provide a visualisation technique that can assist a current data analysis technique such as ‘coordination profiling’ (Button, Davids, & Schöllhorn, 2006). Coordination profiling establishes commonalities and differences both within and between individuals over repeated trials, providing an in-depth analysis of how an individual uniquely performs specifically to a movement task (Glazier & Wheat, 2014).

CONCLUSION: This study implemented new data reporting techniques that illustrated coordination pattern and coordination variability derived from a modified vector coding technique. Use of colour and data bars to map and profile information on segment coupling, coordination variability and segment dominancy, offers an opportunity to explore an entire dataset and supports current data analysis techniques such as coordination profiling and multiple-single subject analysis. These techniques eliminate issues around commonly reported group data by providing individual coordination pattern and coordination variability profiles and will have benefits by informing coaching and clinical management strategies.

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