COORDINATION AND VARIABILITY IN AUSTRALIAN RULES FOOTBALL KICKING: IMPLICATIONS FOR PERFORMANCE

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The purpose of this study was to quantify coordination and coordination variability (CV) of drop-punt kicking in professional Australian Football players and investigate the association between CV and in-game kicking performance and professional playing experience. Intra-limb couplings described to be associated with kicking accuracy were investigated during 30m successful drop-punt kicking efforts in 14 players. Coordination and CV were quantified using a modified vector coding technique. Higher CV of frontal plane trunk/pelvis, frontal and transverse plane thigh/leg and frontal plane leg/foot coupled motion were associated with higher in-game kicking performance. In-game kicking performance and CV did not change following two years of professional experience. These results highlight the significance of junior level skill development and kicking performance in talent identification.

KEYWORDS: vector coding, sport, skill, training.

INTRODUCTION: Australian Rules Football (ARF) has the nation's largest sport participation with over 1.5 million registrants (2017 AFL Annual Report). Integral to the game is drop-punt kicking which is the most frequently used kick in ARF due to its accuracy for the kicker and ease of catching the ball by the receiver (Ball, 2008). Considerable coaching resources are devoted to coaching players to improve kicking accuracy, as games may be won or lost from the outcome of a single kick. New approaches to movement variability have been described in the literature (Preatoni, E., Hamill, J., Harrison, A. J., Hayes, K., Van Emmerik, R. E., Wilson, C., & Rodano, R, 2013). Outcome variability (i.e. ball trajectory) is undesirable, however variability in the system (i.e. segment/joint kinematics) describes the flexibility and adaptability of the system and it is therefore desirable to achieve the same outcome in multiple ways by mastering the degrees of freedom (Bernstein, 1967). Research has described kicking among multiple codes of football and has identified that knee flexion of the support limb and knee extension, hip flexion and foot plantar flexion of the kicking limb are important factors for performance (Ball, 2008; Lees, Asai, Andersen, Nunome, & Sterzing, 2010). While the upper body contributes up to 70% of the body's mass, little research in ARF kicking performance has examined the influence of the trunk. Additionally, the majority of research assessing lower limb biomechanics during kicking have reported on lower extremity kinematics in isolation, rather than addressing the interaction between them. Therefore, the aim of this study was to quantify coordination and coordination variability (CV) of drop-punt kicking in ARF players and understand how this relates to in-game kicking performance. We hypothesized that; 1) higher CV would be positively associated with in-game kicking performance, 2) CV would increase following two years of experience playing among a professional sporting environment.

METHODS: Fourteen male professional ARF players (age: 19.4 ± 1.6 yrs, height: 1.8 ± 0.1m, mass: 81.8 ± 9.7 kg) attended the Sports Biomechanics Laboratory at the University of Western Australia on one occasion in the pre-season of the year they were drafted to the team (i.e. professional playing age = 0yrs). Five of these players (age: 20.8 ± 1.8 yrs, height: 1.8 ± 0.1m, mass: 84.4 ± 7.5 kg) attended the laboratory on a second occasion in the pre-season of their third year at the team (i.e. professional playing age = 2yrs). Ethics approval was received by the university's Human Research Ethics Board. Participants were fitted with retroreflective makers as per a customised kinematic marker set and model (Besier, Sturnieks, Alderson, & Lloyd, 2003; Donnelly et al., 2012). Marker trajectories were recorded using a 22 camera Vicon® motion analysis system (12 Vicon® MX and 10 Vicon® T40 cameras) (Oxford Metrics, Oxford, UK) operating at 250 Hz. These data, with a reliable full body customised model fully compliant with International Society of Biomechanics (ISB) standards for the reporting of data (Wu et al., 2002), were used to calculate full body kinematics.

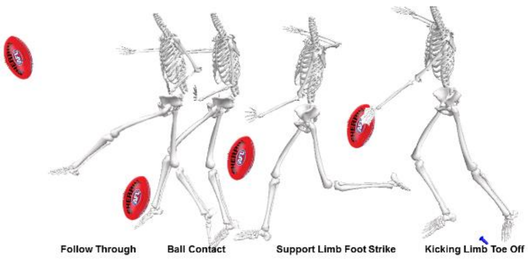

Figure 1. Drop-punt kicking technique in Australian Rules Football.

Players were asked to kick using a drop-punt technique to a 30m target (Figure 1). Five successful kicking trials (i.e. ball reached 30m target within 2m deviation) were analysed for each participant. Data were normalised for time from kicking limb toe off to maximal hip flexion of the kicking limb (i.e. follow-through). Segment coordination and coordination variability were calculated using a modified vector coding technique (Needham, Naemi, & Chockalingam, 2015) for each participant. Angle-angle plots were created for motion between adjacent segments (trunk, pelvis, thigh, leg, foot) over the kicking phase. Coordination was calculated as the mean and coordination variability as the standard deviation of the vector connecting corresponding consecutive time points of the angle-angle plots across trials using circular statistics (Chang, Van Emmerik, & Hamill, 2008). Based on previous kicking literature (Ball, 2008; Lees et al., 2010), intra-limb couplings in the sagittal, frontal and transverse planes were examined for the trunk/pelvis, thigh/tibia and tibia/foot couplings.

In-game kicking performance were determined from Champion Data Statistics (Champion Data, Victoria, Australia). Kicking efficiency was defined as the percentage of kicks performed during a game which were successful in reaching a target (i.e. player). Kicking efficiency was averaged over all Australian Football League matches each season. To determine the association between coordination variability with in-game kicking efficiency, Spearman's rank-order correlations were used. To determine the effect of professional playing experience, paired samples t-tests were utilised. All statistical analyses were conducted in SPSS (IBM SPSS Statistics 22, SPSS Inc., Chicago, IL) with an $\alpha = 0.05$.

RESULTS: Coordination of the trunk-pelvis during drop-punt kicking was characterized by predominantly pelvis dominant motion in the sagittal (76%) and frontal (71%) planes (Figure 2A & B). Where the majority of frontal plane motion (47%) was trunk lateral flexion toward the support limb coupled with kicking limb ASIS up. Trunk rotation/pelvis rotation was primarily anti-phase (Figure 2C). Thigh/leg coupled motion in the sagittal plane was characterized by leg dominant (68%) motion (Figure 2D). Eighteen percent of the kicking phase the thigh was adducting while the leg was abducting (Figure 2E). The thigh dominated the thigh/leg coupling in the transverse plane (58%) (Figure 2F).

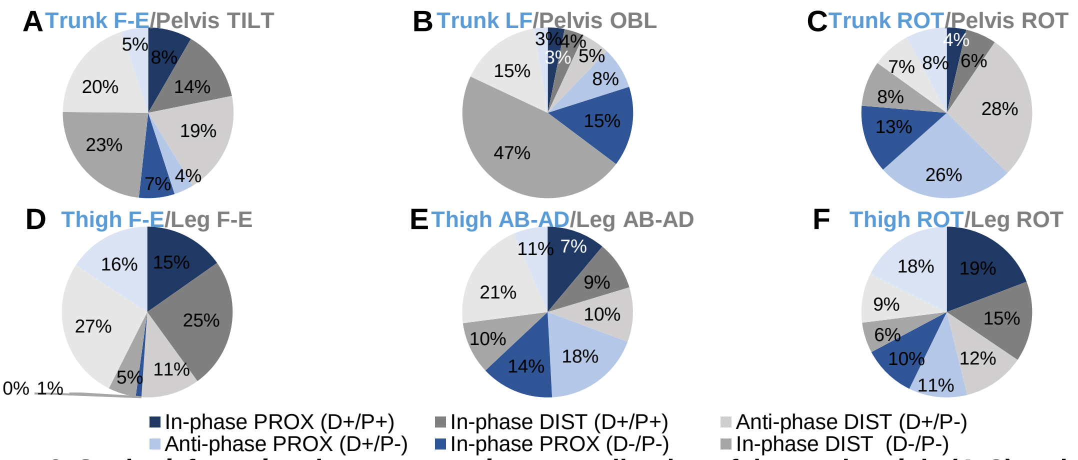

Figure 2. Sagittal, frontal and transverse plane coordination of the trunk-pelvis (A-C) and thigh-leg (D-F) couplings during 30m drop-punt kicking efforts for 1st year players (n=14). Blue shading indicates proximally dominated motion, grey indicates distally dominated motion and lighter shades indicate anti-phase coupled motion.

Relationship between coordination variability and in-game kicking performance: There was no association between sagittal (r_s=0.49) and transverse (r_s=0.17) plane trunk/pelvis CV and in-game kicking performance (P>0.05). Higher frontal plane trunk/pelvis coordination was associated with higher in-game kicking performance (r_s=0.74, P=0.006). Higher CV in the frontal (r_s=0.64, P=0.018) and transverse (r_s=0.71, P=0.007) plane thigh/tibia couplings were associated with higher in-game kicking performance. Higher CV of the frontal plane tibia/foot coupling was associated with higher in-game kicking performance (r_s=0.57, P=0.039) (Figure 3).

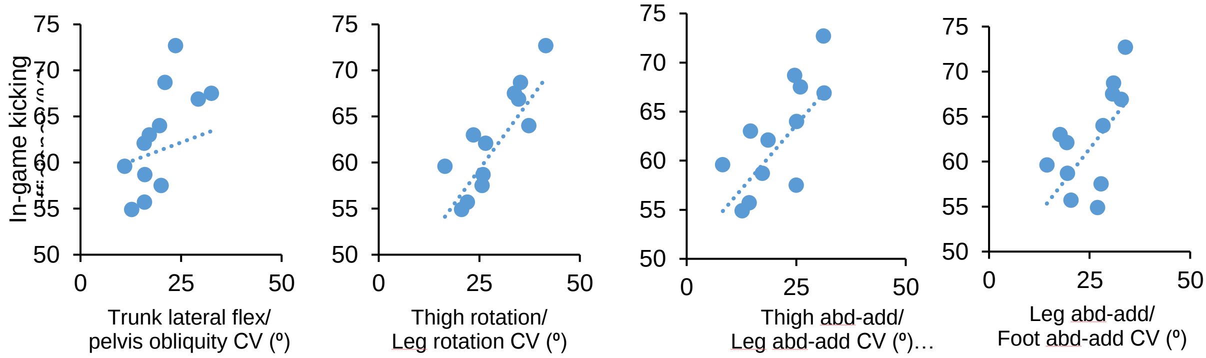

Figure 3. Associations between in-game kicking efficiency (i.e. successful efforts/all efforts) and average coordination variability (º) from kicking limb toe off to maximal hip flexion for significant inter-limb couplings for first year players (n=14).

Effect of professional playing experience on in-game kicking performance and coordination variability: As a group there were no differences in in-game kicking performance from 1st year (67 ± 2%) to 3rd year (66 ± 10%) (P=0.66) (Figure 4A). Additionally, there were no differences in CV following two years of professional playing experience. Individual analysis revealed players 2 and 4 increased their kicking efficiency by 6%, players 1 and 5 had no change and player 3 reduced efficiency by 25%. Looking individually at CV, player 3 who reduced kicking efficiency also reduced CV in 4 of the seven couplings by over 40%. There were mixed changes in CV for the other 4 players (Figure 4B).

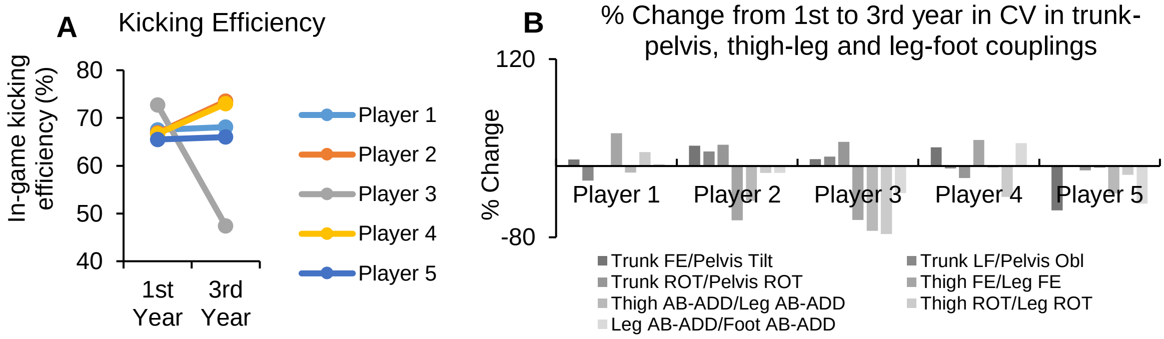

Figure 4. (A) In-game kicking efficiency for players 1-5 in their 1st and 3rd years, and (B) percentage change in coordination variability for 7 couplings from 1st to 3rd year.

DISCUSSION: Coordination patterns between the trunk and pelvis revealed predominantly pelvis dominated motion in all three planes. Additionally, trunk and pelvis rotation coupled motion was mostly anti-phase which describes counter rotation of the pelvis toward the support limb and the trunk toward the kicking limb (Lees et al., 2010). These coordination pattern should be assessed with respect to both performance and injury, as hip/groin related injuries are common among ARF players (10.4 new injuries per club per season – 2016 AFL Injury Report). Coordination of the thigh-leg observed in professional ARF players is similar to isolated kinematic observations of kicking (Ball, 2008; Lees et al., 2010), however this study revealed the role of the thigh in rotation of the lower limb in forward progression of the ball. Additionally, while the leg dominated motion in the sagittal plane, only a small amount of this is active.

In support of our first hypothesis, higher CV was associated with higher in-game kicking performance. These results are supported by dynamical systems theory where it is suggested that coordination variability in a system provides the required flexibility to adapt to external perturbations (Hamill, Palmer, & Van Emmerik, 2012). Coordination variability during kicking was the highest just prior to ball contact though to the end of follow through for all couples. The high CV in the follow through is important from an injury perspective, in order to dissipate the impact forces among the tissues. This is particularly significant as three of the four significantly associated couples were kicking limb variables. High CV in the frontal plane trunk-pelvis coupled motion may describe superior coordination in attempt to manoeuvre the centre of mass dependent upon the approach.
In the attempt to examine the role of coordination variability within the process of skill development (i.e. training among a professional team), we found that there were no group changes in coordination variability. Additionally, these players did not improve their in-game kicking performance from 1st to 3rd year. Wilson et al. (2008) found that in expert triple jumpers, U-shaped changes in coordination variability existed where the least and most skilled participants displayed the highest CV and the intermediate participants had low CV. With respect to this, our mixed results in CV may be the result of players being in differing stages of learning (Newell, 1985). Additionally, players drafted to a professional team may already be at the late stage of learning which highlights the significance of skill development at the junior level and kicking performance in talent identification. Future research should examine CV and learning longitudinally.

CONCLUSION: The results of this study describe coordination patterns during drop-punt kicking of professional ARF players and add to previous literature examining patterns important to target in coaching and strength and conditioning. Coordination variability of trunk-pelvis and thigh-leg coupled motion during drop-punt kicking is associated with higher in-game kicking performance, however it did not increase following two years of training among a professional team. These results highlight the significance of junior level skill development and kicking performance in talent identification.

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