THE EFFECT OF ALTERING DISTANCE ON GOAL-KICKING TECHNIQUE IN AUSTRALIAN FOOTBALL

Stephanie Blair[1], Sam Robertson[12], Grant Duthie[3], & Kevin Ball[1]

Institute for Health and Sport (IHES), Victoria University, Melbourne, Australia[1]
Western Bulldogs Football Club, Melbourne, Australia[2]
School of Exercise Science, Australian Catholic University, Sydney, Australia[3]

Goal-kicks are taken from different positions during a game in Australian Football (AF), which can influence the difficulty of scoring a goal. This study examined the effect of altering kicking distance on goal-kicking technique in 18 AF players. Players performed 10 goal-kicks from 30 m and 40 m directly in-front of goals and kicking kinematics were measured using the Xsens MVN inertial measurement system (240 Hz). Increasing distance resulted in substantially more support-leg knee extension (> 3.8°, large effect) during the stance phase, with moderately higher foot speeds (1.9 m.s^{-1}), shank (93 deg/s) and knee (186 deg/s) angular velocities at ball contact. These findings have important implications for the conditioning and coaching of the skill; when kicking further for goals, increasing knee extension (support-leg), foot speed, shank and knee angular velocities are recommended.

KEYWORDS: Goal-kicking, distance, accuracy, kinematics, Australian Football.

INTRODUCTION: Goal-kicking is an important component of winning games in Australian Football (AF), with accurate goal-kicks identified the most influential performance indicator in match outcome (Robertson et al., 2016). During a game, goal-kicks are taken from different distances from goals, which can increase the difficult of scoring a goal (Galbraith & Lockwood, 2010). As a result, players are often required to simultaneously perform under both distance and accuracy constraints, to achieve a successful outcome.

Conflicting findings exist between accuracy and distance kicking literature in AF. When kicking for accuracy, players demonstrated increased support-leg knee flexion (> 10˚, $p < 0.05$), with increased kick-leg knee flexion (> 3˚, $p < 0.05$) during the kick phase (Blair et al., 2017; Dicheria et al., 2006). Dicheria et al. (2006) suggested this was a strategy used by players to lower their centre of mass to increase stability during the kick, which was postulated to be beneficial for kicking accuracy. Whereas, when kicking for distance, Ball (2003) found a more extended support-leg knee during the stance phase was correlated to larger foot speeds (r = 0.73, $p = 0.004$) at ball contact. The author suggested this could be related to players maintaining a higher kick-leg hip position, enabling a more extended leg during the swing phase to achieve larger foot speeds. Ball (2003) suggested this may be indicative of different strategies adopted by players when kicking for accuracy or distance. As players are often required to simultaneously perform goal-kicks under both distance and accuracy constraints, research is warranted to address these inconsistencies in the literature.

Understanding how distance influences goal-kicking performance will help establish an evidence base to better define the key technical factors that are associated with goal-kicking in AF, to assist with the conditioning and coaching of the skill. This information can also be used to objectively guide development programmes designed to improve goal-kicking performance across all skill levels. Therefore, the aim of this study to was to examine if technical differences exist between successful goal-kicks taken at 30 m and 40 m.

METHODS: Eighteen male AF players (Mean ± SD: 17.0 ± 0.8 yrs; 183.2 ± 4.6 cm; 70.1 ± 6.8 kg) volunteered to participate in this research. Participants provided written informed consent and ethical approval was granted from the University's Human Ethics Committee. Players ranged in skill level from elite (Australian Football League Academy squad), to school and club first grade teams representing an elite and sub-elite cohort. All players reported taking set shots in games in the previous season.

Following a standardised warm-up and familiarisation, players were instructed to perform ten goal-kicks from two different distances, 30 m and 40 m, directly in-front of goals. Five kicks were performed at each position and the order of kicks was randomised. Positions were selected based on champion data statistics of typical goal-kicking positions used during the Australian Football League (AFL) 2017 season (official match statistics). Players were instructed to perform kicks under match-like conditions using their preferred foot and new Sherrin AF footballs (size 5, Sherrin, Australia) inflated within the AFL specified pressure range were used. Accuracy was assessed using a performance criterion: hit vs miss (Blair et al., 2017; Peacock et al., 2017); which corresponds to how kicks are assessed as accurate or inaccurate in competition. The testing venue was the regular training ground for each player and testing was performed during low wind and dry.

Kicking kinematics were measured using the Xsens MVN link system (Xsens Technologies B.V., Enschede, the Netherlands) (240Hz) which is composed of 17 inertial measurement sensors. Each sensor integrates a tri-axial accelerometer (± 160 $m.s^2$), gyroscope (± 2000 deg.s) and magnetometer (± 1.9 Gauss), internally sampling at 1000 Hz. Sensors were placed following the manufacturers recommendations, however the foot sensor was moved to the lateral side of each player's boot (Blair et al., 2018). Prior to data collection, anthropometric measures were collected from participants and a static and dynamic calibration was performed to determine the sensor to segment orientation in MVN Analyze (Xsens software, MVN 2018). Sensor data was fused using the Xsens proprietary algorithms (Xsens Kalman Filter) in MVN Analyze and processed Visual 3D (c-motion, Inc. Germantown, USA). All kicks were analysed from kick foot toe-off until the instance before ball contact (BC) (Ball, 2008). The Xsens 3D model was assigned to motion files and joint angle trajectories where calculated following a YXZ cardan sequence (c-motion, 2016). Ten discrete parameters we chosen based on technical parameters identified important in accuracy and distance kicking literature (Ball, 2008; Ball, 2011; Blair et al., 2017; Dicheria et al., 2006; Peacock et al., 2017). Linear foot and pelvis velocity and angular velocities of the knee, thigh and shank were calculated. Joint angles were calculated as anatomical angles, with the pelvis used as the coordinate system for the hip.

Mean ± standard deviations were calculated for each parameter for 30 m and 40 m goal-kicks. Only successful (hit) kicks were included in the analysis to control for accuracy (N= 48 and 42 for 30 m and 40 m kicks, respectively). Mean differences (40 m - 30 m) were analysed using non-clinical magnitude-based inferences and evaluated via standardisation (Batterham & Hopkins, 2006; Hopkins et al., 2009). The thresholds for assessing the magnitude of mean differences were: 0.20, small; 0.60, moderate; 1.2, large; and 2.0, very large (Hopkins et al., 2009). Uncertainty in each effect was expressed as 90% confidence limits and as probabilities that the true effect was substantially positive and negative. These probabilities were used to make a qualitative probabilistic non-clinical magnitude-based inferences about the true effect (Hopkins et al., 2009): if the probabilities were >5% the effect was reported unclear; the effect was otherwise clear and reported as the magnitude of the observed value, with the qualitative probability that the true effect was a substantial increase, a substantial decrease, or trivial. The scale for interpreting the probabilities was: 25–75%, possible; 75–95%, likely; 95–99.5%, very likely; and >99.5%, most likely.

RESULTS & DISCUSSION: The aim of this study was to investigate if technical differences exist between successful goal-kicks taken at 30 m and 40 m. Substantial technical differences were reported between 30 m and 40 m kicks, indicating distance influences goal-kicking technique in AF (Table 1). Foot speeds reported in this study (19.9 $m.s^{-1}$) lay within the ranges reported for Elite AF players when kicking for distance and accuracy (15.5 - 26.6 m/s^{-1} : Baker & Ball, 1996; Ball, 2008; Ball, 2013; Peacock et al., 2017). Knee, hip, shank, thigh and pelvis kinematics also lay within the ranges reported for punt kicking reported in

AF literature (Baker & Ball, 1996; Ball, 2008; Ball, 2013; Blair et al., 2018; Dicheria et al. 2006; Peacock et al., 2017).

Table 1: Kinematic means (SD) for each distance, mean difference between distance (40 m – 30 m) with 90% confidence limits (CL) and the magnitude of the inference for each parameter indicated. All parameters refer to the kick-leg unless stated otherwise.

Parameter	30 m Mean (SD)	40 m Mean (SD)	Mean difference, ± 90%CL
At ball contact			
Foot speed (m.s^{-1})	18.0 (1.8)	19.9 (1.8)	1.9, ± 0.4; mod↑****
Ankle plantarflexion (deg)	37.8 (15.9)	41.7 (16.9)	3.9, ± 2.3; small↑****
Shank angular velocity (deg/s)	1643 (126)	1736 (191)	107, ± 3; mod↑****
Knee angular velocity (deg/s)	1446 (225)	1632 (251)	183, ± 34; mod ↑****
Thigh angular velocity (deg/s)	177 (140)	186 (107)	86, ± 25; trivial***
Pelvis linear velocity (m.s^{-1})	2.5 (0.4)	2.7 (0.5)	0.2, ± 0.1; small ↑*
Maxima			
Max support leg knee flexion (deg)	44.8 (7.5)	39.5 (10.2)	-6.2, ± 1.3; large↓***
Max knee flexion (deg)	117 (12)	122 (14)	4.6, ± 2.0; small↑***
Max hip extension (deg)	30.1 (6.0)	32.2 (6.8)	2.1, ± 1.1; small↑****
At support-leg heel-strike			
Support leg knee flexion (deg)	19.6 (7.0)	15.7 (6.1)	-3.8 ± 0.9; large↓****

Direction of effect: ↑ positive, ↓ negative; **mod**: moderate
Symbols denote: * possibly, ** likely, *** very likely and **** most likely chance of the true effect was substantial.

Support-leg knee motion was found to be largely associated with altering kicking distance on successful goal-kicking technique. Players demonstrated a more extended knee at support-leg heel strike that remained more extended (lower maximum knee flexion) during the stance phase during 40 m kicks compared to 30 m kicks (> 3.8°; large effect), supporting previous findings in distance kicking (Ball, 2013). Lifting the whole-body upward through the motion of the support-leg has been suggested to be an effective action that assists with maintaining a higher hip position, to generate faster foot speeds through achieving a more extended leg during the swing phase. Post-hoc analysis supported this idea by identifying a strong relationship (r= -0.71) between maximum support-leg knee flexion and foot speed. Faster foot speeds have been highlighted in the literature as a major contribution to kicking distance (Ball, 2008; Ball, 2013; Peacock et al., 2017). Similar findings have been reported in soccer kicking (Inoue et al., 2014). However, these findings are in contrast to Blair et al. (2017) & Dicheria et al. (2013), who found a more flexed support-leg knee during stance phase may be more beneficial for accuracy in AF. A plausible reason for the conflicting findings may be directly related to the shorter distances used between the accuracy tasks (15 m: Dicheria et al., 2006; 20 m: Blair et al., 2017) compared to when kicking for maximal distance (Ball, 2013). When kicking over shorter distances players may have altered their ball flight trajectory to adopt a flatter trajectory to effectively increase the size of the target area to improve accuracy, and hence their technique (more flexed position), which has previously been discussed by Peacock et al., 2017. Whereas, when kicking at further distances from goals, achieving a higher ball flight trajectory may be more beneficial to achieve the distance, as well as ensuring accuracy. Finding suggest conditioning the support-leg to maintain a more extended support position during stance phase is important when goal-kicking at further distances from goals. However, it is acknowledged that this recommendation may be different if players are awarded a goal-kick closer to goal (< 20 m out). Future work is required to substantiate these findings by examining accurate goal-kicking technique over a range of distances.

A moderate increase in foot speed (1.9 m.s^{-1}), shank angular velocity (93 deg/s) and knee (186 deg/s) angular velocity at BC was reported when kicking at 40 m compared to 30 m. Faster foot speeds and shank/ knee angular velocities has been highlighted in the literature as a major contribution to kicking distance (Ball, 2008; Ball, 2013; Peacock et al., 2017). Findings in this research indicate that when increasing distance from goals, players are required to generate higher speeds to achieve the distance. Future work should examine the differences between successful and unsuccessful kicks at each distance to determine if faster speeds are maintained in accurate kicks compared to inaccurate kicks.

Interestingly, knee angular velocities were smaller than the reported shank angular velocities for both distances. This has previously found by Ball (2008), who identified that AF players demonstrate different movement strategies when kicking for distance. Post-hoc evaluation of the data indicated that some players used more thigh angular velocity and relatively less knee angular velocity at BC, whilst others used more knee angular velocity and less thigh angular velocity (e.g. player 1 had a knee angular velocity of 1653 deg/s and a thigh 117 deg/s, whilst player 3 had a knee angular velocity of 1198 deg/s and a thigh 282 deg/s). This supports the possibility that different strategies exist for different individuals in goal-kicking. Future research is warranted to explore if different strategies (thigh vs knee) exist in goal-kicking, as it will directly affect how the skill should be conditioned and coached for different individuals.

This study chose to examine the effect of altering kicking distance on goal-kicking performance from two positions directly in-front of goal. This information identified key technical characteristics, which can be used to better inform coaching practice. However, it is acknowledged that players also perform goal-kicks from various angles in-front of goals (Galbraith & Lockwood, 2010), which may place additional constraints on goal-kicking performance. Future research is warranted to determine the effect of altering kicking angle on goal-kicking technique and performance. This information could be utilised to gain more comprehensive understanding of the key characteristics underpinning the goal-kicking skill.

CONCLUSION: This study identified technical differences between successful goal-kicks taken at 30 m and 40 m. Players demonstrated a substantially more extended support-leg during the stance phase, with moderately higher foot speeds, shank and knee angular velocities at BC when kicking at 40 m compared to at 30 m. Finding from this research have important implications for the conditioning and coaching of the skill; when kicking further from goals, increasing knee extension (support-leg), foot speed, shank and knee angular velocities are recommended.

REFERENCES

Baker, A. & Ball, K. (1996). Biomechanical considerations in the drop punt kick in Australian Football. Technical report.

Ball, K. (2008). Biomechanical considerations of distance kicking in Australian Rules Football. *Sport Biomechanics*, 7, 10-23.

Ball, K. (2013). Loading and performance of the support leg in kicking. *Journal of Science and Medicine in Sport*, 16, 455-459.

Batterham, A. M., & Hopkins, W. G. (2006). Making meaningful inferences about magnitudes. International *Journal of Sports Physiology and Performance*, 1, 50-57.

Blair, S., Duthie, G., Robertson, S., Hopkins, W., & Ball, K. (2018). Concurrent validation of an inertial measurement system to quantify kicking biomechanics in four football codes. *Journal of Biomechanics*, In Press.

Blair, S., Duthie, G., Robertson, S., & Ball, K. (2017). Biomechanics of goal-kicking accuracy in Australian Football using an inertial measurement system. *International Society of Biomechanics in Sports Conference Proceedings*, 35, 208-212.

Dichiera, A., Webster, K.E., Kuilboer, L., Morris, M.E., Bach, T.M., & Feller, J.A. (2006). Kinematic patterns associated with accuracy of the drop punt kick in Australian Football. *Journal of Science and Medicine in Sport*, 9, 292-298.

Galbraith, P. & Lockwood, T. Things may not always be as they seem: the set shot in AFL football. *Australian Senior Mathematics Journal*, 24, 29-42.

Hopkins, W. G. Marshall, S.M., Batterham, A.M., & Hanin, J. (2009). Progressive statistics for studies in sports medicine and exercise. *Medicine & Science in Sports & Exercise*, 41, 3-12.

Inoue, K., Numone, H., Sterzing, T., Shinkai, H., & Ikegami, Y. (2014). Dynamics of the support leg in soccer instep kicking. *Journal of Sport Sciences*, 32, 1023-1032.

Peacock, J. Ball, K., & Taylor, S. (2017). The impact phase of drop punt kicking for maximal distance and accuracy. *Journal of Sport Sciences*, 35- 2289-2296.

Robertson, S., Back, N. & Bartlett, J.D. (2016). Explaining match outcome in elite Australian Rules football using team performance indicators. *Journal of Sport Sciences*, 34, 637-44.