Shot success and kinematic differences with altering kicking position on goal shooting technique in Australian football

Kevin Ball[1] & Stephanie Blair[1]

Institute for Health and Sport (IHES), Victoria University, Melbourne, Australia[1]

In Australian Football, goal shots are taken from a range of distances and angles to the goal. The aim of this study was to evaluate if performance and technique differed for goal shots from different sides of the posts. Seventeen players performed 10 goal shots from two different positions (45° to the left (L45) and 45° to the right (R45) of goals) on an Australian Football ground. Kicking kinematics were measured using the Xsens MVN link inertial measurement system (240Hz). Shot success was slightly better for kicks from the left (62 v 59%). Technical differences were limited with small effects evident for knee and shank angular velocity. Individual differences were evident that indicate that individual-based analysis is necessary for future goal shooting work.

KEY WORDS: Goal-kicking, angle, kinematics, Australian Football.

INTRODUCTION: Goal shooting is an important component of all the football codes. In Australian Football (AF), accurate goal shots have been identified as the most influential performance indicator in match outcome (Robertson et al., 2016). Further, of the past 25 grand finals in the Australian Football League (AFL) 18 have been won by the more accurate team, and in the case of six games, the winning team had fewer shots at goal. Improving a player's accuracy is clearly of advantage to a team's performance.

However, while goal kicking accuracy is crucial to success there has been only limited technical examination of the skill. The challenge for goal shooting assessment is that shots are performed from different distances from, and angles to, goals, which alters the difficult of scoring (Galbraith & Lockwood, 2010). This makes it difficult to assess using motion capture devices such as VICON or video-based analyses as they are lab-based or can only be used at one spot on the ground at a time (Blair et al., in press). Statistics provided by the AFL (AFL.com.au) highlight that goal shooting success reduces the further away from goal the shot is taken and when kicking at a greater angle so evaluation of different distances and angles is needed to develop a full biomechanical picture of goal kicking in AFL.

The validation of wearable technology is allowing for goal kicking to be assessed in the field from different distances and angles. Blair et al. (2017), using the Xsens system to evaluate two juniors kicking for goal, found that technical factors were associated with success for two junior players but there was an individual-specific nature to this. Further, performance and technique varied between shots from the left and the right, indicating a potential 'side' bias. This has implications for coaching and performance as, if performance and technique differences exist for kicks from different distances and angles, this provides useful information to players and coaches to potentially improve performance.

The aim of this study was to expand this analysis to include more players and a wider range of skill levels to determine if differences exist in performance and technical features between set shots from the right and left side of goals. This represents part of a broader study examining technical aspects associated with successful goal shooting in AF examining different distances and angles.

METHODS: Seventeen male AF players (age: 17.0 ± 0.8 yrs; 183.2 ± 4.6 cm; 70.1 ± 6.8 kg) volunteered and provided written informed consent to participate in this study. 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 and performed kicks with their right (preferred) foot. All players reported taking set shots in games in the previous season.

Following a standardised warm-up, players were instructed to perform 15 x 30 m (5 each at 45 degrees left and right of the posts as well as directly in front) and 5 x 45 m goal-kicks (directly in front) with the kicks at 45 degrees being the focus of this study. The order of kicks were randomised. Goal shots positions were selected based on typical set-shot positions reported in games (official Australian Football League match statistics from the 2017 season). Players were instructed to perform kicks under match-like conditions and new Sherrin AF Footballs (size 5, Spalding, Australia) were used. Accuracy was assessed using a performance criterion: hit vs miss.

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).

Parameters chosen for measurement were based on those used in previous literature for AF kicking (Ball, 2008; Ball, 2013). At the instant before foot to ball contact, foot speed, knee (3D), shank (sagittal plane) and thigh (sagittal plane) angular velocity were calculated for each kick. Maximum kick leg hip extension and knee flexion as well as support leg flexion were calculated during the kick leg swing phase. Approach speed was indicated by the centre of mass velocity in the direction of the target just after kick foot toe off. In addition, two coaching cues were calculated at the end of follow through: ankle angle and leg line (line between the hip and ankle joint to indicate the 'straightness of follow through).

Mean ± standard deviations were calculated for each parameter for left and right side goal-kicks. Mean differences were analysed using magnitude-based inferences and evaluated by standardisation (Batterham & Hopkins, 2006; Hopkins et al., 2009). Thresholds for assessing magnitudes 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, negative or trivial. These probabilities were used to make a qualitative probabilistic non-clinical magnitude-based inference about the true effect (Hopkins et al., 2009). The scale for interpreting the probabilities was: 25–75% (possible); 75–95% (likely); (95–99.5%), (very likely); >99.5% (most likely).

RESULTS & DISCUSSION: Accuracy for set shots from 45 degrees right and left combined was 60.5% with a slightly lower percentage for right side kick (58.8%) compared to left side kicks (62.4%). For individuals, nine were more successful on the left side, five on the right and four were the same on both sides. This indicated firstly that differences in performance existed for the cohort tested. It also highlighted the individual nature of the task, with the more successful side differing for different individuals, similar to the findings of Blair et al. (2017).

For technical aspects, on a group-basis, there were only small and trivial differences between left and right side set shots (Table 1). Shank and knee angular velocity were slightly higher for kicks taken from the left hand side of goal. Mean foot speeds were the same for both sides so a slightly different mechanism might have existed for this group. Given the centre of mass velocity at kick foot toe off, used to indicate approach speed, was also similar o for both groups, the only way for this to occur would be for players to brake slightly more, slowing hip linear speed more on the left side kicks compared to the right side

kicks. Post hoc analysis indicated a 0.8 m/s lower hip linear velocity at ball contact for left side kicks supporting this possibility.

Table 1: Kinematic means (SD) for each position, mean difference between positions (R45 – L45) with 90% confidence limits (CL) and the magnitude of the inference for each parameter. All parameters relate to the kick- leg unless stated.

Parameter	R45 Mean (SD)	L45 Mean (SD)	Mean difference, ± 90% CL
At ball contact			
Footspeed (m/s)	18.4 (1.8)	18.4 (1.9)	0.0, ± 0.2; trivial****
Shank angular velocity (deg/s)	1623 (163)	1684 (142)	61, ± 25; small↑****
Knee angular velocity (deg/s)	1435 (205)	1486 (205)	51, ± 30; small↑****
Thigh angular velocity (deg/s)	122 (95)	141 (99)	8.6, ± 25; trivial***
Maxima			
Hip extension (deg)	30 (6)	30 (7)	0, ± 1; trivial
Knee flexion (deg)	119 (14)	119 (14)	0, ± 1; trivial
Support-leg knee flexion (deg)	45 (12)	44 (9)	-2, ± 2; trivial
Kick foot toe-off			
COM velocity (m/s)	4.6 (0.7)	4.6 (0.7)	0.0, ± 0.1; trivial****
End of follow through			
Ankle angle (deg)	-24.7 (15.3)	-24.9 (15.2)	-0.2, ± 2.5; trivial
Leg position (deg)	2.1(12.4)	4.2 (13.4)	2.0, ± 2.2; small↑**

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

While there were only minor differences based on the group analysis for the cohort tested, examination of individual data held some interesting findings. Performance differed between sides for different players, a pattern evident in AFL also with players showing better percentages on one side compared to the other (AFL.com.au). Further, some relatively large differences in mean values were evident for some players, indicating that differences existed in technique. For example, one player had a 2 m/s slower foot speed for kicks on the right compared to on the left (17 v 19 /s) and achieved greater accuracy on the right side in contrast to the group mean data.

The use of hit and miss as the criterion measure for performance was the most appropriate first step to take. This is the true performance measure in the game and so is extremely important that this is the first avenue of examination as this is what players and coaches will expect to see and most easily understand. The weaknesses of this method are its limited resolution of performance and kicks that pass near either post where only a slightly different ball flight is the difference between a hit and a miss. To increase the resolution of the analysis, the radial distance approach can provide finer detail on kicking accuracy and can follow this initial analysis. Using the centre of the goal as the 'bulls-eye', measuring the lateral distance from this point can provide a continuous performance measure that can increase statistical power and allow for regression-based statistics to be employed. The weakness of this method is it is not directly related to the game-based performance measure. A combination of both approaches is recommended.

Future directions for this work suggest examining goal-shooting with an individual-based approach. Given the different patterns evident for different players, this analysis is clearly necessary. Examining more factors around impact and ball flight might also provide useful information as impact factors have been found to be important in accuracy kicking (Peacock et al., 2017). Finally, increasing the number of kicks per player would provide a greater statistical power. This is a challenge for this type of testing as a limited number of kicks can be performed in a single session (due to mental and physical fatigue affecting performance) so a choice between more kicks at the same location versus more distances and angles needs to be made. Testing over multiple days is a possible solution although as the football codes are outdoor games, changes in weather, particularly wind which will affect ball flight, is a factor that might affect findings and needs to be considered.

CONCLUSION: Small performance and small to trivial technical differences existed between right and left side goal-shots for AFL. Left side kicks were 3% more successful and these kicks exhibited slightly higher knee and shank angular velocities. However, the remaining technical parameters were similar in their mean values. Individual differences were evident that should be explored in future. The different accuracies for different individuals indicate individual patterns need to be explored to better understand technical factors important to goal shooting in AF. This is also an important direction as it directly links into coaching individuals. It would also be of interest to explore contralateral and ipsilateral side patterns.

REFERENCES:

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., & 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.

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.

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.

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.

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.