BIOMECHANICAL ANALYSIS OF THE HANDBALL IN AUSTRALIAN FOOTBALL

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The handball pass in Australian Football has become increasingly important in recent years. However, important technical elements of handballing have not been identified in the scientific literature. The purposes of this study were to provide a descriptive analysis of the handball through the evaluation of a player considered to have good technique, to compare handballs for maximal speed and accuracy, and to compare preferred and non-preferred hands. Three-dimensional data were collected from one elite level Australian Football player using Optotrak Certus. The player performed three handballs for maximal speed and three handballs for accuracy with both the preferred and non-preferred hand. Linear hand speed, linear shoulder speed, shoulder angular velocity and elbow angular velocity were larger in the maximal speed condition. Differences in the development of hand speed were found for preferred and non-preferred hands.

KEY WORDS: handball, Australian football, three-dimensional analysis.

INTRODUCTION: Within Australian football (AF), the two methods of passing the ball are kicking and handballing. Handballing permits quick movement to assist in catching the opposition off guard (McLeod and Jaques, 2006) and is becoming an increasingly important skill in AF. The handball involves gripping the ovoid shaped ball (similar to American football/ rugby ball) with a stationary platform hand; punching the ball from the platform hand using the area between the thumb and forefinger of the punching hand; connecting with the ball near the back point where the laces meet; stepping toward the target to gain power and distance; and to follow-through with the punching hand in a motion upwards and towards the target (McLeod and Jaques, 2006). Figure 1 displays a pictorial sequence of the handball.

Figure 1: Handball sequence

Game trends over the past ten years indicate increasing use and importance of the handball in the game of AF. Since 1998, the total number of handballs per Australian Football League season has increased by 45%, from 224 to 325 per game. Additionally, the ratio of kicks to handballs has changed, with handballs contributing 44% of disposals (i.e. kick or handball) in 2008 compared to only 35% in 1999 (Champion data, 2008).

Handballs are performed for both accuracy and speed of pass, and with both hands. Game-based handball analysis (Parrington et al., 2008) demonstrated both left and right hands were used for handballing (41% and 59% for the left and right hands respectively). Further, handballs were produced over short (less than 2 m) and long distances (greater than 10 m); and were performed under different time constraints with some passes predominantly requiring accuracy only while others additionally required greater speed of ball flight to reach the intended target before an opponent could intercept the pass. As such, the ability to dispose the ball effectively with either the left or right hand is an important skill (B. Gotch, AFL Development Coach, personal communication). Additionally, there are increased options when the ball can be passed over both short and long distances.

In spite of its increased importance, there have been no scientific studies performed on handballing with biomechanical research largely focused on kicking (e.g. accuracy kicking, Dichiera et al., 2006; distance kicking, Ball, 2008). This study aimed to evaluate handball technique, and identify technical differences that exist between distance and accuracy passes and between preferred and non-preferred hands.

METHODS: Data Collection: One male elite AF player (19 years, 192cm, 80kg) considered by the coaches at his club to have good handball technique participated in this study. Handpasses were performed using a Sherrin football (used in competition) for maximal speed/ distance and accuracy. Six trials were captured for maximal speed (three on each hand) and six trials were captured for accuracy (three on each hand). For maximal trials, the participant was instructed to perform a handball with the aim of passing the ball to another player 10 m away as fast as possible by propelling the ball with maximal speed. For accuracy trials, the participant was instructed to attempt to hit a 0.5 m x 0.3 m rectangle (6.5 m from the test area with the bottom edge positioned at a height of 1.5 m).

Prior to testing, rigid body markers composed of clusters of light emitting diodes [Optotrak Certus (Northern Digital Inc., Ontario, Canada)] were placed on the upper extremity (upper arm, forearm and hand), lower extremity (shank, thigh and foot) and torso (upper trunk and pelvis). Elastic neoprene wrap assisted the attachment of rigid bodies to each segment and sports strapping tape was used in addition to tightly secure each placement.
Joint centres were digitised at the shoulder, elbow, wrist, metacarpophalangeal joints two and five, hip, knee, ankle, and metatarsophalangeal joints two and five. For each trial, a three tower Optotrak motion analysis system, sampling at 100Hz captured 3D coordinates of these markers during handball execution from the initial forward step until after the end of follow through. The player landed his front foot on an AMTI OR6-5-1 force plate (Advanced Mechanical Technologies, Inc, Massachusetts, USA). Two dimensional video was used to determine the time between front foot heel strike and ball contact. One researcher recorded target accuracy, with a score of zero allocated to a direct hit, and scores of one, two and three as the ball moved in sections 0.3 m, 0.6 m and 0.9 m away from the central square.

Data Analysis: Three-dimensional trajectory values were reconstructed using Visual3D (C-Motion, Inc., Maryland, USA). Raw data were interpolated and smoothed using a lowpass Butterworth filter (10Hz cutoff frequency), then were transferred to Microsoft Excel. Data were normalised from the onset of downswing (defined as the first downward motion of the hand after backswing) to ball contact (100%). Mean, standard deviation and effect sizes (Cohen's *d*) were calculated to provide additional information. However, effect size values should be viewed with caution due to the small number of trials analysed.

RESULTS: Parameter definitions and mean values are presented in Table 1. Differences existed between the maximal pass (MP) condition and the accuracy pass (AP) condition. All linear and angular velocities, step length and 3D shoulder angle were larger for the MP condition, while larger values were recorded for the AP for hand height and trunk angle. Differences also existed between the preferred hand (P) trials and non-preferred hand (NP) trials. Step length, 3D shoulder angle, linear velocities, trunk angle and forearm angular velocity were all larger for the P, while 3D elbow angle, shoulder angular velocity and upper arm angular velocity were larger for the NP. Greater shoulder range of motion (ROM) was matched with smaller elbow ROM for the NP trials. Accuracy was better in the P than NP.

DISCUSSION: Speed of the distal segment at ball contact is a major determinant of ball speed in kicking (Ball, 2008), required for maximal based passes. Hand speed was thus used as an indicator of performance, along with accuracy scores in this study. Based on the magnitude of the values, shoulder angular velocity appears to be a major contributor to hand speed. Elbow angular velocity contributes comparatively less, and although values were small (between 0.5 and 1.2m/s) shoulder speed appears to play a role.

Table 1 Kinematic Variables (Parameters refer to punching hand at ball contact unless stated).

Parameter	Definition	Condition	Preferred		Non-preferred	
			mean	SD	mean	SD
Step length (m)	Distance between the left and right foot. Measured from the fifth metatarsal head.	Speed	1.07	0.04	0.96	0.02
		Accuracy	0.94	-	0.89	0.05
Hand height (m)	The vertical distance from the hand to the ground	Speed	0.77	0.02	0.76	0.01
		Accuracy	0.82	0.01	0.83	0.02
Hand speed (m/s)	Speed of the hand segment	Speed	10.4	0.2	10.1	0.3
		Accuracy	9.8	0.6	9.4	0.4
Shoulder speed (m/s)	Linear speed of the shoulder	Speed	1.2	0.1	0.7	0.1
		Accuracy	1.0	0.01	0.5	0.2
3D Shoulder angle (°)	Angle measured between the trunk and upper arm segment	Speed	36	1	31	5
		Accuracy	32	2	30	3
3D Elbow angle (°)	Angle between the upper arm and the forearm segment	Speed	96	1	99	3
		Accuracy	95	0.3	100	6
Trunk angle (°)	Angle of the trunk in the 2D sagittal plane	Speed	55	2	48	4
		Accuracy	57	1	53	5
Shoulder angular velocity (°/s)	Angular velocity of the shoulder	Speed	268	71	565	103
		Accuracy	230	-	503	123
Elbow angular velocity (°/s)	Angular velocity of the elbow	Speed	-39	4	-35	13
		Accuracy	-32	-	-33	3
Shoulder ROM (°)	Difference between minimum and maximum shoulder angle measured between the onset of down swing and ball contact	Speed	31	12	37	9
		Accuracy	20	-	42	18
Elbow ROM (°)	Difference between minimum and maximum elbow angle measured between the onset of down swing and ball contact	Speed	12	-	5	-
		Accuracy	17	-	2	-
Accuracy	Lower values represent hits closer to the target	Accuracy	2		4	

*Some standard deviations are not reported. Due to marker occlusion, values could not be calculated for some parameters for all trials (i.e. N < 3).

Greater hand speed was found in the MP condition (P, *d*=1.2, NP, *d*=1.8). Similarly, the MP condition revealed greater values for shoulder speed (P, *d*=3.4, NP, *d*=1.6), angular shoulder velocity (P, *d*=0.8, NP, *d*=0.5) and elbow angular velocity (P, *d*=0.7, NP, *d*=0.2) than the AP condition. The data presents similar achievement of hand speed across hands. However, there was a difference in the contribution of the shoulder speed and shoulder angular velocity in the development of this speed. Shoulder speed values for P (1.2m/s and 1.0m/s) were approximately double that found for NP (0.7m/s and 0.5m/s respectively). In comparison, shoulder angular velocity in the P (268°/s and 230°/s) was just under half of the NP value (565°/s and 503°/s respectively). This demonstrates a similar outcome of hand speeds were achieved through different movements for the P and NP for this player.

The larger step length for the MP (NP, *d*=1.7) supported the coaching literature that states stepping toward the target is important in order to gain power and distance (McLeod and Jaques, 2006). For this player, a larger step length was evident in the MP condition for both P and NP. The increase in step length may assist in developing speed of the body towards the target, demonstrated by larger shoulder speed for the MP task. In turn the greater shoulder speed might contribute to the larger hand speed also displayed in the MP condition.

Competency to perform handballs with either hand is important in elite competition. In comparing performance, accuracy was greater for the P, and while hand speed between hands was quite similar, it was greater in the P (MP, *d*=1.1, AP, *d*=0.7). As discussed above, differing contributions of shoulder speed and shoulder angular velocity provide similar performance of hand speed. Although hand speed performance was similar across hands, results suggest a less developed motor skill for the NP. Greater shoulder speed (MP, *d*=7.4, AP, *d*=3.8) and elbow angular velocity (for MP; *d*=0.5), and lower shoulder angular velocity (MP, *d*=3.4) in the P trials suggests the development of hand speed occurs through the contribution of a number of parameters in the preferred arm. In comparison, it appears that the development of hand speed in the NP occurs mainly through greater shoulder angular velocity. The higher contribution to the movement from a number of parameters in the P trials indicates a releasing of the degrees of freedom in the preferred arm (Vereijken et al., 1992). In comparison, the arm of the NP locks the elbow (only 2 and 5 degrees of movement) during down swing, prior to ball contact. Moreover, the less skilled arm appears to compensate for a lack of range of the elbow joint, by increasing ROM at the shoulder. Releasing degrees of freedom has been shown to occur in the later stages of learning (Vereijken et al., 1992). Greater accuracy in the P trials also indicates a more refined skill in the preferred arm.

Differences between MP and AP relate to the player developing greater hand speed at ball contact in the MP condition. Larger values were found for shoulder speed, angular shoulder velocity and elbow angular velocity. These differences may be attributed to the attempt to swing faster in the MP to attain maximum speed/ distance; and/or a slower controlled swing in the AP in order to establish control and stabilise the hand at ball contact for accuracy. Nonetheless, similarities in the pattern of values between the MP and AP indicate a similar, but scaled movement pattern for this player.

The main limitations of this study relate to the positioning of the motion capture towers and the target in the AP condition. First, positioning of the cameras made tracking of the non-punching arm difficult. Modifications to tower locations may allow greater capture of both arms during data collection. Second, the positioning of the body in relation to the target is needed to gain an understanding of segment orientations. Future directions for study could involve looking at segment orientations in reference to the target, and parameters in the non-punching arm and the lower extremities. Further study with more participants would be beneficial to establish whether any values reported show significant differences or trends.

CONCLUSION: This study explored the kinematics of handballing in Australian football through the comparison of maximal and accuracy passing, and preferred and non-preferred hands. All linear speed and angular velocity values were greater for the MP. Different contributions of shoulder speed and shoulder angular velocity were used to develop similar hand speed values across hands, while accuracy was greater for the P. Findings require further investigation with more participants to establish any significant differences or trends.

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