©Journal of Sports Science and Medicine (2007) **6,** 254-260
http://www.jssm.org

Research article
Young investigator

Player movement patterns in an elite junior Australian Rules Football Team: An exploratory study

James P. Veale [1], Alan J. Pearce [1,2]✉ and John S. Carlson [2]
[1] School of Human Movement, Recreation and Performance, Victoria University Melbourne, Australia
[2] Centre for Ageing, Rehabilitation, Exercise and Sport, Victoria University, Melbourne, Australia

Abstract
This study explored the physical movement patterns associated with an elite Under 18 Australian Football (AF) team. Five field positions were selected with observations recording the number and relative per cent of "working" efforts (jogging, running, and sprinting), "resting" efforts (walking) and the total distances associated with "working" or "resting" efforts. Intra-observer reliability, using test-retest method, showed correlations were r = 0.98 or greater. The Wing position covered 11,877 m, the greatest total distance during an entire game, whilst the HBF and Centre positions both recorded 11,545 m and 11,537 m respectively and the Ruck position covered 9,203 m. The HBF recorded the greatest frequency of 'working' and 'resting' efforts (180 and 182 respectively), whilst the Wing (166 and 158), Centre (162 and 149) and Ruck (161 and 166) showed similarities in their results. The Wing position recorded the longest average distance per 'working' effort (58 m) whilst the Centre position recorded the longest average distance per 'resting' effort (17 m). Results also show the completion of less total efforts and smaller total distances, in Under 18 players, recorded compared to professional senior AF data. The results from this study suggest that further in-depth research is required into movement patterns and game activity demands in this AF playing group.

Key words: Australian football, time-motion analysis, game demands.

Introduction

Australian football (AF) is, arguably, Australia's major football code with high participation at numerous levels ranging from young children and junior levels, through to amateur senior leagues and at the top level, the professional Australian Football League. Similar to other sports, the opportunities to reach the professional level diminish considerably with many dropping out due to injuries and de-selection, as well as motivation, study and time conflicts with other activities.

Over the past decade, it is commonly accepted that AF has progressed into a fast paced sport characterised by high intensity play periods and longer rest intervals (Norton et al., 1999). As a result, coaches and sports scientists have increased their attention and focus on determining the game-related physical demands with a view to maximising the training and physical preparation of each athlete. Consequently, time-motion analysis (a component of notational or performance analysis) has developed into an important tool for use when investigating movement patterns and the occurrence of specific game-related skills with a view to increasing the understanding and knowledge of the demands of this sport. Time-motion analysis has been widely used across a variety of major football codes (Kay and Gill, 2003; Reilly and Thomas, 1976) as a tool for analysis of specific players and/or their positions. However, its use in AF to assess game demands is sparse.

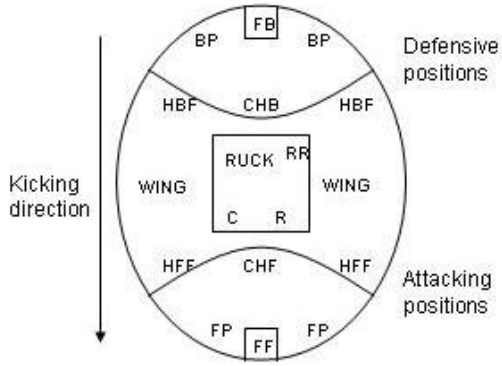
Early analyses in AF conducted by Jacques and Pavia (1974), Hahn et al. (1979) and McKenna et al. (1988) are now considered outdated, as a direct result of the sports progression in both rules and standards of play. However, more recent analyses by Dawson et al. (2004a; 2004b) have presented contemporary data on the physical and movement patterns in professional AF players.

Presently, the research available on game demands in AF has focused exclusively on the elite senior competition. Subsequently, there is an absence of analysis conducted at the elite junior Under 18 (U/18) competition level. Coaching staff at the elite junior level must attempt to make decisions regarding training regimes and performance expectations from non-age specific data, taking into account the development and maturational differences in their players when adapting the data collected on the professional population. As this level of competition is a precursor to professional AF, it is essential to study the differences in game demands and movement patterns between the two elite playing levels so the data obtained can be used to appropriately develop athletes to improve their performance. Therefore, as no study has been presented on the movement patterns at this level of AF performance, the aim of this exploratory study was to investigate any observable differences in the movement patterns and game demands between elite junior and senior athletes participating in AF.

Methods

Approval of the study, conforming to the Code of Ethics of the World Medical Association (Declaration of Helsinki), was granted by the Board of Management and Coaching Panel, Western Jets Football Club, which participates in the Victorian U/18 year competition. Ethics approval was granted by the Human Ethics Committee of Victoria University, Melbourne, Australia.

Received: 14 August 2006 / Accepted: 09 February 2007 / Published (online): 01 June 2007



FB	Full Back
BP	**Back Pocket**
CHB	Centre Half Back
HBF	**Half Back Flank**
WING	**Wing**
HFF	Half Forward Flank
CHF	Centre Half Forward
FP	Forward Pocket
FF	Full Forward
RUCK	**Ruck**
RR	Ruck Rover
R	Rover
C	**Centre**

a) Ruck	Usually the tallest player on the field, the ruckman does not normally play in a 'set' position on the ground and is involved in the passage of play immediately after a stoppage (i.e. the resumption of play after a goal is kicked, the ball goes out of bounds or the umpire calls for a re-start).
b) Wing	Classified as a part of the 'midfield', the wing is responsible for covering one side of the playing field, constantly running between offence and defence.
c) Centre	Classified as a part of the 'midfield', the centre in most games will cover the greatest total distance and is therefore often filled by the fittest player in the team.
d) Half Back Flank (HBF)	Positioned on the second last line of defence, the HBF is a set position required to minimise the influence of their direct opponent, whilst also providing a rebound role when moving the ball out of defence. As it is a set position it often does not cover as great a distance as other positions.
e) Back Pocket (BP)	As it is a set position on the last line of defence, not only is the Back Pocket directly responsible for minimising the effect of their direct opponent, but it is also often used to rest 'midfield' players rather than sitting them on the substitute bench.

Figure 1. Terminology, position descriptions (modified from Dawson et al., 2004) and placement of positions in an AF team. Those positions in bold are the positions used in the current study.

Players and, match selection

Nine U/18 AF athletes (17.3 ± 0.7 years) participated in the study and were tracked over five randomly chosen games throughout the 18 games of the regular 2005 season period (March to September). Prior intention to record a position was not indicated to any athlete and randomly chosen by the head coach certifying that data collection was "single blind".

Position, field placement descriptions

Figure 1 illustrates the nomenclature, placement of positions on the field and position descriptions adapted from those used in the study by Dawson et al. (2004a).

Sprinting, running and jogging in any direction were collectively categorised under 'working'; and walking in any direction was categorised under 'resting'.

Data collection

The following procedures were completed throughout the study:

i. Before the game, length and width of the oval being used was determined through the use of a recently calibrated measuring wheel. The ground length and width was then used to calculate the length and width of each grid (4m x 3.32m) superimposed over the oval outline used when tracing the positional movement patterns throughout the game.

ii. Data was collected with one investigator seated in an elevated position during each game when recording a player's movement patterns.

iii. During each quarter, the athlete's movements in the position of focus were tracked on an A3 size paper grid oval based on the pre-game measurements (Asami et al. 1988). Adopting the methods used by Dawson et al. (2004a), when a player was interchanged or moved into another position during this study, the new player in the position of focus was followed and tracked, subsequently focusing on the position and not the individual athlete. Over the five games viewed, the following number of athletes were tracked in each position; Ruck (n = 2), Wing (n = 3), Centre (n = 1), Half Back Flank (HBF; n = 2) and Back Pocket (BP; n = 1).

iv. During each quarter two time clocks were used. One was started at the first siren of the quarter and left running until the final siren, recording the length of each quarter. The second clock was started when the individual was determined to be 'resting' and stopped when he was determined to start 'working' again, subsequently recording the total time spent 'resting' and 'working' during each quarter.

Table 1. Distance analysis during an entire elite junior U/18 AFL game.

		Working		Resting	
	Total Distance (m)	Distance (m)	% of Total Distance	Distance (m)	% of Total Distance
Ruck	9,203	6,631	72%	2,573	28%
Centre	11,537	8,924	77%	2,613	23%
Wing	11,877	9,424	79%	2,452	21%
HBF	11,545	8,903	77%	2,642	23%
BP*	5,319	3,152	59%	2,167	41%

* Note three quarters only recorded in Back Pocket (BP) position.

Observer reliability

To ensure reliability of measurements, three of the five games were chosen at random for retrospective re-analysis, with movement patterns re-measured to determine intra-observer reliability. As suggested by Hughes et al. (2004) reliability testing was conducted on the raw data sets obtained from the three games. Test-retest reliability was assessed by applying Wilcoxon-Mann-Whitney U Test, and Kendall Tau correlation analysis as the data was not normally distributed. Analysis revealed values for all movement patterns were non-significant and correlations were r = 0.98 or greater which were found to be similar to those reported by Dawson et al. (2004a).

Data analysis

Following game observations, data was logged into an Excel spreadsheet producing a report documenting the movement patterns for the different positions each quarter and across the entire game. Limitations in the collection of data, measuring only time spent resting and walking, did not allow for the delineation between movement intensities such as walking, jogging, running and sprinting within the 'working' and 'resting' categories. With small numbers of athletes observed (n = 9) for the five positions analysed, no inferential statistics were calculated. Descriptive data were produced with values expressed as mean (± SD) and ranges, and rounded to the nearest whole number.

Results

The results presented are totals of five different playing positions from the one team, each being recorded once during separate junior elite U/18 AFL games. Due to the unexpected requirement of the observer to complete another game-related task, the BP position was tracked during the first three quarters, resulting in an incomplete game data for the BP and will be presented "as is". Three of the five games were completed on the team's home ground, whilst two were played at different away venues. Each game was played in dry conditions, and only one game was won by the team involved in this study.

Movement patterns

The total distance analysis of each position, including the total game distance and the break down of distances spent 'working' (sprinting, running and jogging) and 'resting' (walking) are shown in Table 1. The Wing position was recorded to have covered the greatest total distance during a full game. Centre and HBF positions recorded slightly shorter total distance than the Wing but greater than the Ruck position.

Analysis of 'working' and 'resting' efforts showed the Wing position recorded the greatest total distance covered whilst 'working'. The Ruck position covered 30% less distance than the Wing position whilst working. Both the HBF and Centre positions covered a greater distance 'resting' (7.2% and 6.2% respectively) when compared to the Wing position. Although total distance 'resting' was less than the Centre or HBF positions, the Ruck showed a greater percentage of total field position distance covered whilst 'resting' than either the Wing, HBF or Centre positions.

Table 2. Positional analysis of the number of working efforts completed each quarter.

	EFFORTS - WORKING			
Position	**Period**	**No. of Efforts**	**Distance of Efforts (m)#**	**Range of Efforts (m)**
Ruck	Q1	40	44 (29)	7 - 122
	Q2	42	38 (25)	6 - 112
	Q3	44	42 (25)	6 - 121
	Q4	35	43 (27)	4 - 112
Centre	Q1	45	57 (42)	6 - 179
	Q2	38	60 (46)	4 - 185
	Q3	40	55 (50)	3 - 202
	Q4	39	49 (34)	4 – 141
Wing	Q1	42	63 (47)	4 - 172
	Q2	37	60 (46)	4 - 187
	Q3	49	51 (42)	5 - 174
	Q4	38	58 (34)	8 - 176
HBF	Q1	45	49 (41)	7 - 167
	Q2	46	47 (38)	3 - 152
	Q3	51	52 (45)	5 - 183
	Q4	38	66 (55)	3 - 182
BP*	Q1	33	30 (19)	4 - 74
	Q2	23	53 (48)	5 - 200
	Q3	22	43 (28)	10 - 114

* Note three quarters only recorded in Back Pocket (BP) position.
# Means (±SD).

Tables 2 and 3 report the number of 'working' and 'resting' efforts performed during each quarter, showing the average distance, the longest effort and also the distance range per effort. The HBF position completed the greatest number of 'working' efforts throughout the entire game, completing 180 efforts. The HBF position also completed the greatest number of efforts whilst 'resting', recording 182 efforts. The HBF and Ruck positions recorded more 'resting' efforts than 'working' efforts, two and five respectively. In accordance with recording the greatest total distance covered whilst 'working', the Wing position also recorded the greatest mean distance per effort, covering 58 m per effort (Figure 2).

The quarter by quarter analysis of 'working' efforts (Table 2) for each position showed that the Centre, Wing and BP positions recorded the greater number of efforts

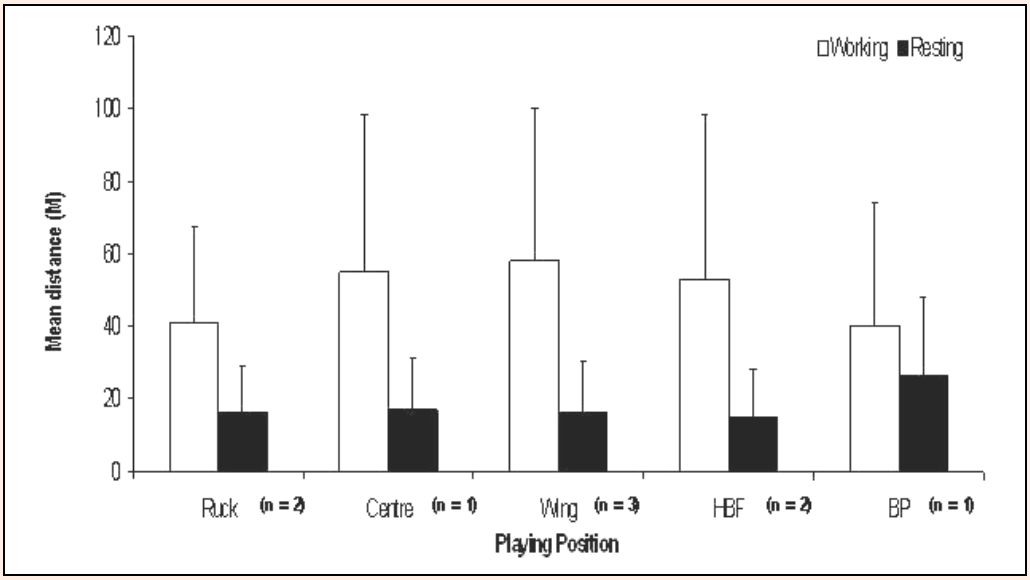


Figure 2. Mean (± SD) distance per work vs. rest effort completed by each playing position.

during the first quarter compared to the second and all positions tracked for the entire four quarters recorded the greater number of 'working' efforts in the third quarter compared to the fourth. Mean distance per effort (Table 2) showed increased values in the Ruck, Wing and HBF positions between first and second quarters. After the half-time break the Ruck, Wing and HBF showed decreased mean distance per effort in the third quarter compared to the final quarter.

Table 3. Positional analysis of the number of resting efforts completed each quarter.

		EFFORTS - WORKING		
Position	**Period**	**No. of Efforts**	**Distance of Efforts (m) #**	**Range of Efforts (m)**
Ruck	Q1	46	16 (14)	3 - 64
	Q2	38	16 (11)	3 - 40
	Q3	45	13 (10)	3 - 50
	Q4	37	18 (15)	3 – 69
Centre	Q1	43	17 (13)	3 - 65
	Q2	36	17 (12)	4 - 50
	Q3	33	20 (19)	4 - 77
	Q4	37	14 (15)	3 - 68
Wing	Q1	40	17 (14)	3 - 60
	Q2	40	15 (13)	1 - 60
	Q3	43	16 (14)	3 - 58
	Q4	35	17 (15)	4 -77
HBF	Q1	44	14 (11)	2 - 48
	Q2	47	17 (14)	4 - 68
	Q3	51	12 (10)	3 - 45
	Q4	40	16 (16)	3 - 75
BP*	Q1	35	26 (26)	3 - 111
	Q2	25	23 (18)	4 - 71
	Q3	22	30 (21)	8 - 65

* Note three quarters only recorded in Back Pocket (BP) position. # Means (±SD).

The quarter by quarter analysis of 'resting' efforts (Table 3) revealed the Ruck, Centre and BP positions completed more efforts in the first quarter compared to the second. The Wing and BP recorded the greater mean distance in the first compared to the second quarter and the Ruck and Centre positions the same mean distance during the first two quarters. Of the four positions tracked for the entire four quarters, the Centre was the only position to record more 'resting' efforts in the fourth quarter compared to the third and the only position to record a greater mean distance per effort in the third quarter compared to the fourth.

Figure 3 shows the number of 'working' efforts completed over various distances throughout each game. All positions show a tendency to complete the greatest number of 'working' efforts between 0-39.99 m, with four of the five positions recorded most 'working' efforts in the 20-39.99 m category (HBF completed more efforts between 0-19.99 m). Each position showed a decrease in the number of 'working' efforts completed over distances greater than 40m. The Ruck position showed the greatest drop in number of working efforts as the distance increased, showing a tendency to complete only 6% of total efforts greater than 80 m.

Figure 4 shows the number of 'resting' efforts completed over all distances throughout each game. Similar to the working efforts, all positions showed a tendency to complete the greatest number of efforts over shorter distances (0-20 m), reporting a decrease in the number of efforts over increasing distances.

Discussion

The purpose of this exploratory study was to observe the movement patterns of five different playing positions involved during a junior elite U/18 game in the 2005 season and compare this initial data to previous research (Dawson et al., 2004a). The underlying aim of the analysis was to assist the appropriate design of specific training programs for this specific U/18 team however; the data may also have general implications to the wider population within this age group. This study is the first to

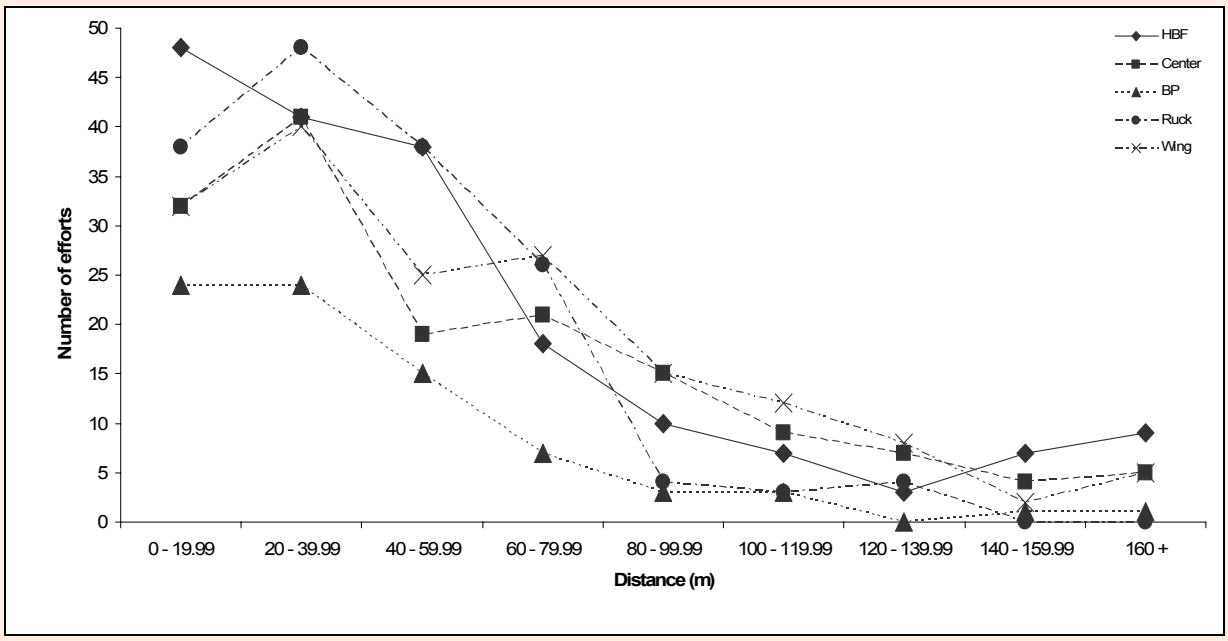


Figure 3. Positional analysis of "working" efforts throughout an entire junior elite U18 AFL game. Connecting lines are for position identification across each distance category.

accompany the current limited research available documenting the match-play movement patterns and physical requirements of this AF population group.

It is important to note that methodological limitations in this exploratory study were the type of observation (only recording distances covered) and type recording technique, and the relatively low number of players observed in the study which makes normative profiling difficult (Hughes et al, 2004).. However, the mean results of all players presented from the five matches highlight both similarities and differences in the movement patters observed from the five playing positions chosen during games in this study which suggest further research must continue.

Previous research (Norton et al., 1999; Dawson et al., 2004a) has presented data reporting the movement patterns of elite senior level athletes competing at the national level of competition (Table 4). The data obtained within this study has used an elite junior population group at the relatively early stage of their development within

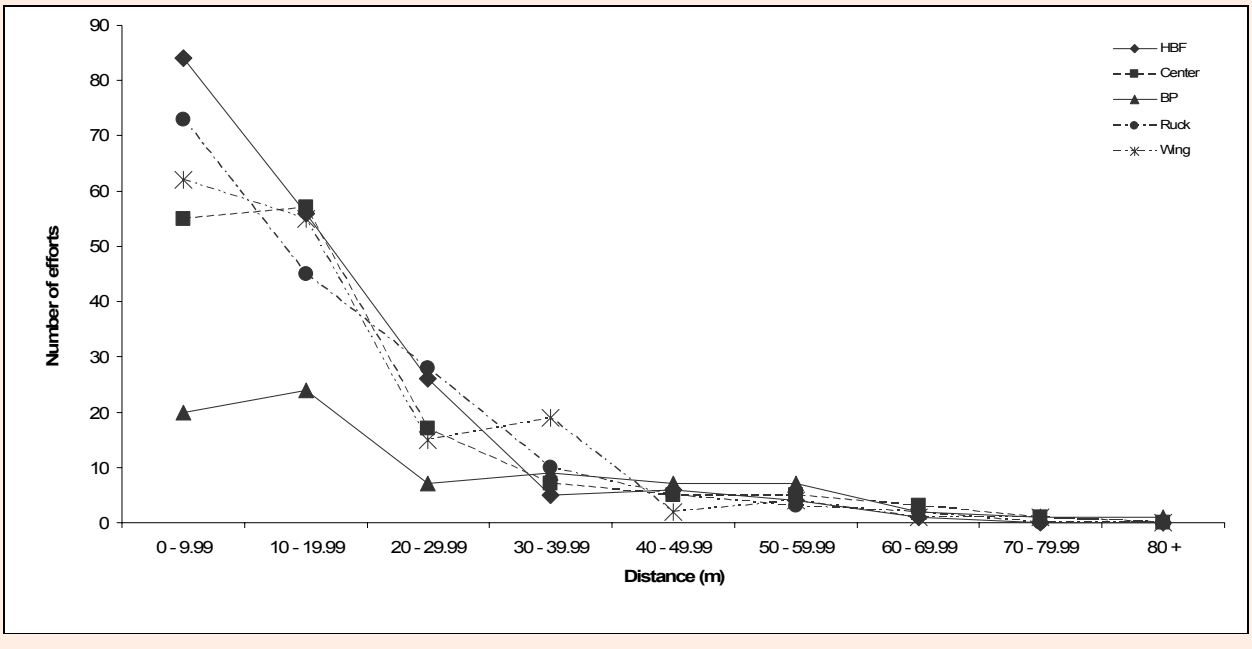


Figure 4. Positional analysis of "resting" efforts throughout an entire junior elite U18 AFL game. Connecting lines are for position identification across each distance category.

Table 4. Comparison of work and resting efforts and distances between elite senior (statistics directly recorded from Dawson et al. 2004a) and junior AFL competitions. The split results for the junior data refers to the specific position under the general classification (e.g. Under "midfield", the left result refers to the "centre" position whereas the right result refers to the "wing" position).

Position / Playing Standard		Total Game Distance (m)	Total Game 'Working' Distance (m)	Total Game 'Resting' Distance (m)	Total Game no. of 'Working' Efforts	Total Game no. of 'Resting' Efforts
Midfield (Centre/Wing)	Elite Senior	16,979 m	11,537 m	5,442m	644	381
	Elite Junior (U/18)	11,537/11, 877m	8,924/9,424m	2,613/2,452m	162/166	149/158
Ruck	Elite Senior	15,393 m	10,618 m	4,775 m	641	407
	Elite Junior (U/18)	9,203 m	6,631 m	2,573 m	161	166
Small F/B (HBP / BP)	Elite Senior	16,278 m	9,249m	7,029 m	574	397
	Elite Junior (U/18)	11,545 /5,319m*	8,903/3,152m*	2,642/2,167m*	180/78*	182/82*

* Note three quarters only recorded in Back Pocket (BP) position

the sport. Consequently, discretion is required, in terms of fitness levels and skill abilities, when comparing the observed differences within the two population groups.

Of the five positions tracked during this study, two positions (Centre and Wing) are classified as a part of a team's midfield, whilst a third position (HBF) is important in returning the ball out of defence and starting a counter-attack. Coaches may fill these positions with players of similar athletic capabilities involving speed, agility and endurance, highlighted by similar total movement distances recorded. However, there were a number of differences observed between these three positions that could be important and should be considered carefully when determining who might be capable of playing each position and how each position should be adequately prepared.

The HBF position has two roles during a game: (1) limiting the impact of their direct opponent; and (2) providing a key role in linking up the defensive and offensive positions when returning the ball out of defence. During this study, the participants' team lost the game, indicating a greater workload placed upon the defensive positions, possibly resulting in a greater distance of coverage when compared to a game in which the participant's team won. This concurs with Reilly and Thomas (1976) who reported the large variation in distance covered by the defensive positions according to the attacking style and line-up of the opposing team. Subsequently, the HBF position recorded the greatest number of 'working' efforts during an entire game. As the HBF is often constrained to the defensive half of the ground, it covered less total 'working' distance than the midfield positions due to a smaller average distance per effort, being more 'stop-start' in nature.

The midfield positions (Wing and Centre) on the other hand, as reported by Dawson et al. (2004a), complete a greater number of game skills and are involved in a greater number of contests than any other position on the ground. Hence, they are required to cover a greater distance per effort and in total to be present at as many contests as possible. The Wing and Centre positions completed more 'working' than 'resting' efforts throughout the game, suggesting a larger number of 'working' efforts were broken by the completion of a skill compared to a true 'resting' effort. Skill execution requires the expenditure of energy, therefore decreasing recovery time further as they continued to work to the next contest. Based on this study, planning for training activities involving the midfield players should involve a large number of working efforts with minimal recovery intervals. This could include some working efforts followed by minimal rest perhaps broken only by the inclusion of a skill such as kicking.

The Ruck position, usually the tallest player on the team, is a key component of the team's midfield, being the first person to contest the ball upon the restart of play. However, tactical innovations in recent years have resulted in positioning the ruckman predominantly through the midfield and defensive regions with a forward positional player taking on the ruckman's duties in the attacking 50m area. Subsequently, whilst providing his team with a kick to target, the ruckman is often responsible to run to contests through the middle and defensive area of the ground, thus covering a similar number of 'working' efforts, although lesser distance compared to the midfield positions. In comparison to the other positions in this study, the Ruck spent a greater percentage of total distance whilst 'resting' and a smaller percentage of distance whilst 'working'. This suggests that training drills for the ruckman involving greater resting intervals between working efforts should be prescribed compared to the midfield positions.

In general, the number of efforts performed was similar across the playing positions, but there were larger differences in the distances covered. These results confirm that fitness sessions should be designed and implemented throughout each training session that focus on repeat efforts over these specific distances required by the playing positions. Whilst some efforts recorded over 150 m and fewer over 200 m, the mean distances recorded during this study were between 30-70 m. Therefore, running sessions should be designed around efforts covering distances of 30-70 m with recovery intervals covering 10-30m, specifically replicating those recorded during this study.

Conclusion

This study examined the physical positional requirements of an elite junior U/18 AF club. The results showed that when compared to recent data at the elite level (Dawson et al., 2004a; Table 4), this preliminary study shows clear delineation in work and rest loads between elite senior and junior U/18 AFL level games. Consequently, this

highlights the need for further research into the movement patterns at the U/18 level, including analysis of all positions and more games for normative profiling, the subdivision of 'working' and 'resting' into more specific categories (for example, walking, jogging, running and sprinting) using time criteria, and game activity demands (for example, specific skills) using technologies such as video analysis, global positioning systems and computer based tracking to provide greater in-depth information.

References

Asami, T., Togari, H. and Ohashi, J. (1988) Analysis of movement patterns of referees during soccer matches. In: *Science and Football: The proceedings of the First World Congress of Science and Football*. Eds: Reilly, T., Lees, A., Davids, K. and Murphy, W. Liverpool, E. & FN Spon. 341-345.

Dawson, B., Hopkinson, R., Appleby, B., Stewart, G. and Roberts, C. (2004a) Player movement patterns and game activities in the Australian Football League. *Journal of Science and Medicine in Sport* **7,** 278-291.

Dawson, B., Hopkinson, R., Appleby, B., Stewart, G. and Roberts, C. (2004b) Comparison of training activities and game demands in the Australian Football League. *Journal of Science and Medicine in Sport* **7,** 292-301.

Hahn, A., Taylor, N., Hunt, B., Woodhouse, T. and Schultz, G. (1979) Physiological relationships between training activities and match play in Australian Football rovers. *Sports Coach* **3,** 3-8.

Hughes, M., Evans, S., and Wells, J. (2004) Establishing normative profiles in performance analysis. In: *Notational analysis of sport.* 2nd Edition. Eds: Hughes, M. and Franks, I. M. London-New York: Routledge.

Hughes, M., Cooper, S.M. and Neville, A. (2004) Analysis of notation data: Reliability In: *Notational analysis of sport.* 2nd Edition. Eds: Hughes, M. and Franks, I. M. London-New York: Routledge.

Jacques, T.D. and Pavia, G.R. (1974) An analysis of the movement patterns of players in an Australian Rules league football match. *Australian Journal of Sports Medicine* **5,** 10-21.

Kay, B., and Gill, N.D. (2003) Physical Demands of elite Rugby League referees: Part one – time and motion analysis. *Journal of Science and Medicine in Sport* **6,** 339-342.

McKenna, M.J., Patrick, J.D., Sandstrom, E.R. and Chennells, M.H.D. (1988) Computer-Video analysis of activity patterns in Australian football. In: *Science and Football: The proceedings of the First World Congress of Science and Football*. Eds: Reilly, T., Lees, A., Davids, K., and Murphy, W. Liverpool, E. & FN Spon. 274-281

Norton, K.I., Craig, N.P. and Olds, T.S. (1999) The Evolution of Australian Football. *Journal of Science and Medicine in Sport* **2,** 389-404.

Reilly, T. and Thomas, V. (1976) A Motion Analysis of work-rate in different positional roles in Professional Football Match-Play. *Australian Journal of Science and Medicine in Sport* **2,** 87-97.

Key points

- Little information currently exists in the movement patterns and physical activity levels in Australian football at both senior and junior levels.
- The results from this preliminary study found differences in the number of physical efforts and the total volume of work completed in junior Australian football players when compared to previous research in senior players.
- Further in-depth research is required in movement analysis, particularly at the junior level, in order to assist junior coaching staff in developing specific programs for this population group.

AUTHORS BIOGRAPHY

James P. VEALE
Employment
Honours student, Victoria University
Degree
BAppSci (Hum Mvt)
Research interests
Applied physiology of elite junior football.
E-mail: james.veale@students.vu.edu.au

Alan J. PEARCE
Employment
Lecturer, Victoria University
Degrees
BSc (Spt Sc) Hons, Grad Dip (Elite Spt Coach), PhD
Research interests
Applied physiology and physical performance of sport. Physiology of movement and motor control.
E-mail: alan.pearce@vu.edu.au

John S. CARLSON
Employment
Professor, Victoria University
Degrees
Dip PE, TSTC, BPE, MSc, PhD
Research interests
Physical performance of sport. Exercise and children.Exercise and aging.
E-mail: john.carlson@vu.edu.au

✉ **Alan J. Pearce**
School of Human Movement, Recreation and Performance, Victoria University Melbourne, Australia.