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Research article

Profile of position movement demands in elite junior Australian rules footballers

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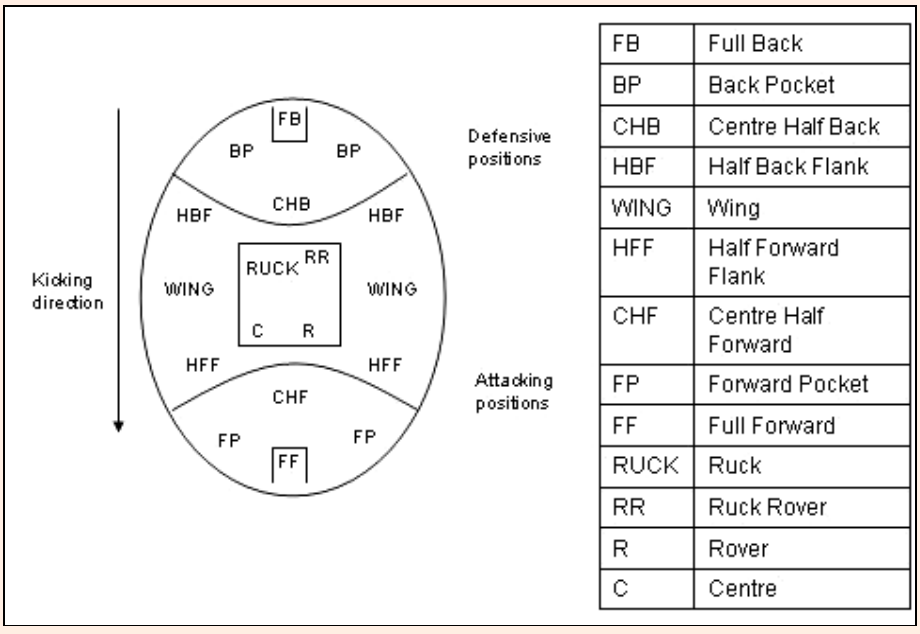
Abstract
This study investigated the positional movement patterns in elite junior Australian Football (AF). Thirty players (17.1 ± 0.9 years) participating in this study were tracked over seven home games of the regular 2006 Victorian junior (Under 18) league season. Using lapsed-time video analysis, each position for an entire match was videotaped on three separate occasions over the course of the season. Data analysed included the number of individual efforts, duration and frequency of efforts; distance and percentage time for the classifications of standing, walking jogging, running and sprinting. Results showed that the midfield position travelled the greatest distance (4173 ± 238 m per quarter; $p < 0.05$; ES = .94) whilst the full forward/full back travelled the least (2605 ± 348 m per quarter, $p < 0.05$, ES = 1.21). For all positions, walking or jogging accounted for the greatest number of efforts (45-55%), conversely running and sprinting accounted for 5-13% of match efforts. The majority of efforts across all classifications were between 0-3.99 s. The data from this study provides further evidence that AF is an intermittent sport characterised by high intensity movements separated by low intensity movements at a ratio of one high intensity effort every 12-40 s. However, careful interpretation of the data is required when training junior AF players for specific positions, given the specific group studied.

Key words: Australian football, movement patterns, time-motion analysis.

Introduction

Australian Football (AF) is played on an oval pitch, ranging between 130 – 150 m by 150 – 190 m, by two teams of 22 players, with each match lasting between 100 and 120 minutes (See Figure 1and Table 1 for position placement and descriptions). Presenting many similarities with soccer and Gaelic football, AF is a relatively continuous tempo sport, played over four quarters, with short breaks (6 min) after the first and third quarters and an extended half time break (20 min) after the second quarter. At any one time there are 18 players from each team on the field and four interchange players. An unlimited number of player interchanges are allowed. Although specific field positions exist, there is no limitation on where players can move. Typically, players are characterised as forwards, backs and midfielders.

Elite junior (Under 18) AF competitions serve as the platform to develop young players in their physical abilities and sport-specific skills required for a future senior AF playing career. Preparation of these junior players should rely on evidence based research using methods such as notational analysis, the umbrella term for a range of methods to quantify movement and game patterns. These include time-motion analysis (TMA), computer based tracking (CBT), and global positioning



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

Figure 1. Terminology, position descriptions (modified from Dawson et al., 2004) and placement of positions in an AF team.

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Table 1. Field position descriptions (Dawson et al., 2004).

Position	Description
Full Forward/ Back (FF/ FB)	More 'static' key position players,
Centre Half Forward/ Back (CHF/ CHB)	More mobile tall forward or back players,
Forward/ Back Pocket (FP/BP)	Small forward/ defender responsible for kicking goals and for defending their direct opponent,
Half Forward/ Half Back Flank (HFF/ HBF)	Mobile forward/ defender responsible for linking the backline to the forwards,
Ruck	Involved in the passage of play immediately after a stoppage (i.e. the resumption of play after a goal is kicked, ball-ups, boundary throw-ins)
Midfield (Rover [R]/ Ruck Rover [RR]/ Centre [C]	Responsible for participating in contests around the ground, following the flight of the ball
Wing (W)	Responsible for covering one side of the playing field, constantly running between the offence and defence.

system (GPS), all of which have associated advantages and disadvantages. However, generally speaking, notational analysis is an important tool when investigating movement patterns and specific game-related skills with a view to increasing the understanding and knowledge of the demands of the sport. Notational analysis has been widely used across a variety of major football codes (for reviews please refer to Roberts et al., 2006; Dobson et al., 2007; and Carling et al, 2008) as a tool for analysis of specific players and/or their positions. Moreover, notational analysis assists coaching staff to measure activity profiles of players or positions, including distances covered, intensities, volumes (number of repetitions or efforts at various intensities) and match characteristics which assist coaching staff to develop sport-specific training protocols.

However, its use in AF to assess game demands has been sparse, particularly at the junior level. Published notational analysis research within AF has predominately focused on the elite senior level of competition. Early studies completed by Nettleton and Sandstrom (1963), Jaques and Pavia (1974), Hahn et al, (1979) and McKenna et al. (1988) are now considered outdated since all aspects of the game of AF, such as rule changes, and a nationalised competition allowing for full-time professional athletes, have evolved significantly (Norton et al., 1999). For example, although the predominance of high intensity efforts lasting less than 3 s has not changed from the study by McKenna et al. (1988) to Dawson et al. (2004), the number of high intensity efforts in a match has notably increased from 110-115 reported by Hahn et al. (1979) and McKenna et al. (1988) to over 150 by Dawson et al. (2004).

Recent published notational analysis studies in AF have been limited to one senior and one junior study. Dawson et al. (2004) investigated position related demands in senior AF by videoing and notating the movement characteristics for each position, twice, over one season of the Australian Football League (AFL). Results revealed differences in movement patterns between various field positions; full forward/full back positions (see Table 1 and Figure 1) spent more time in stationary (standing) and jogging motion categories, and less time in high intensity running categories; whereas Ruckmen and midfielders were involved in more game skill activities than the other positions. A recent pilot study in elite junior AF players (Veale et al, 2007) suggested that despite overall match volumes being less than elite adult AFs, the data showed position specific differences in distances travelled and number work efforts, encouraging further research in junior AF.

Therefore, the aim of this study was to extend on the preliminary elite junior AF research (Veale et al., 2007) and the study by Dawson et al. (2004) by measuring the movement patterns of each playing position throughout an entire season, from one elite junior Under 18 AF team, providing age-appropriate data that can be used by coaching staff for the design of specific training programs for junior AF players.

Methods

Participants and position descriptions

Thirty players (17.1 ± 0.9 years) participating in the study were tracked over seven home games during the 2006 Victorian elite junior under 18 (U18) league season. All matches were recorded under dry conditions. The study, sanctioned by the Australian Football League (AFL) Victoria, was approved by a university ethics committee and in accordance with the Declaration of Helsinki, each volunteer and parent provided written informed consent. The positions to be recorded by the investigators (see Table 1 for positions, abbreviations and description) were not revealed to participating players, ensuring that data collection was "single blind".

Video recording procedures

Three playing positions were videotaped at each home game using digital video cameras (SONY DV Handycam 4 mega-pixel, 12x optical zoom). Each position category was videotaped on three separate occasions throughout the season. Three video cameras where placed in an elevated position, situated in an enclosed room located in the grandstand situated on the side of the oval (half way from either end), free from any obstructions, approximately 20 m from the playing field. The player who started in the position of interest each quarter was videotaped until a rotation (swap in playing position of two players already on the ground) or interchange (one player on the ground is removed and replaced by a player from the bench) occurred, whereby the change was noted and the position recording was continued with the new player, thus ensuring the *position* (rather than player) was recorded for the game duration.

Each videotape was reviewed by the same researcher using a commercially available video analysis

system (Prowess Systems, Australia.) customised to record the following movement classifications as assessed by the reviewer, modified from Dawson et al. (2004), completed by each playing position:

Standing: No movement in any direction.

Walking: In any direction.

Jogging: Slow, easy, unhurried running in any direction.

Running: Purposeful running, but not near maximal speed.

Sprinting: Running at top speed (>95% max).

This data was then exported to an Excel spreadsheet (Microsoft Corporation, USA), from which the following movement categories were calculated:

Calculated Total Game Time and Number of Efforts Spent Moving at Each Movement Classification;

Calculated Total Time and Number of Efforts per Quarter Spent Moving at Each Movement Classification;

The Calculated Duration and Frequency of Each Movement Classification.

To estimate the total distance covered at each movement pattern classification, all participating players were videoed over a 20 m distance moving at each of the above specified movement classifications (Dawson et al. 2004). Two trials were conducted at each movement pattern classification, and the two attempts were then averaged to provide values for steps per second and metres per step. These were then multiplied by the time spent walking, jogging, running and sprinting throughout the game and the following measurements recorded:

Approximate Total Game Distance Coverage at Each Movement Classification;

Approximate Total Quarter Distance Coverage at Each Movement Classification.

Data and statistical analysis

One researcher was used to analyse all of the match videotapes for each position, to minimise any inter-tester effects on the data. However, reliability and consistency checks of data collected were made, using a similar process to those implemented by Dawson et al. (2004), where one quarter of one game per playing position (seven quarters in total) were reviewed, separately by all investigators, on two separate occasions. Test-retest reliability was assessed by applying paired t-Test, Pearson Correlation analysis and Technical Error of Measurement Calculations (TEM) to the data obtained from the first and second trials of the quarters viewed. Friedman's ANOVA was used to compare differences between movement patterns of the positions recorded. Where appropriate, post hoc comparisons of the seven playing positions were performed, with Bonferroni correction (Rampinini et al, 2007), using Wilcoxon Signed Ranks Test. An alpha level of $p < 0.05$ was accepted as significant. All descriptive results presented are means (± SD).

Results

Observer reliability

Intra-observer reliability showed high IOR between first and second trials of the quarters viewed with t-Test values for all movement patterns non-significant $p > 0.05$), high correlations ($r = 0.98$), and a % TEM value (mean 4.2%) which was found to be similar and a level accepted as reliable by Dawson et al. (2004). Similarly, inter-tester reliability, between investigators, showed a high correlation between testers ($r = 0.97$ or greater for each position analysed) and % TEM value of between 5-8%, which were similar and accepted as reliable by Dawson et al. (2004).

Movement patterns

Mean distance covered by each position per quarter is illustrated in Figure 2 with total distance covered by each position in Table 2. Friedman's ANOVA revealed a significant difference in mean distance covered per quarter ($p < 0.01$). Post-hoc analyses showed that the midfield position travelled a significantly greater mean distance per quarter than all other positions ($p < 0.01$; ES = 0.94).

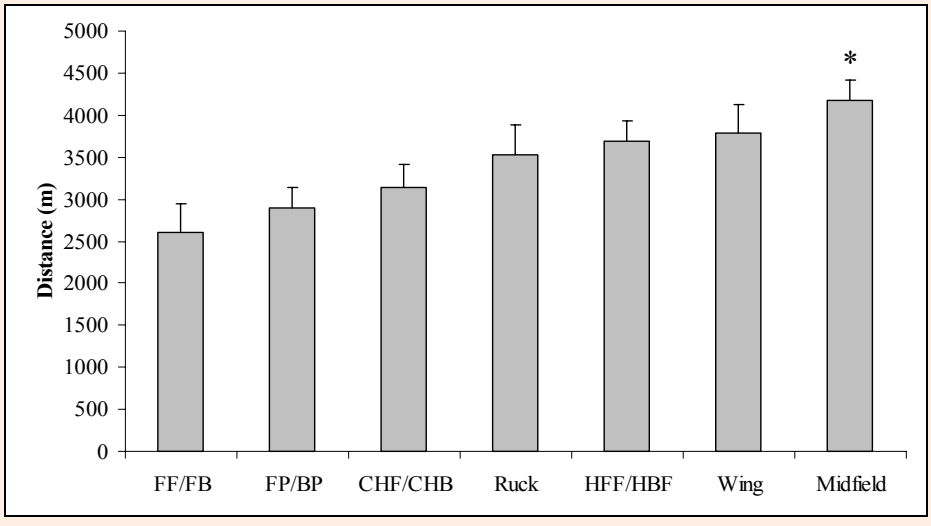

Figure 2. Mean distance travelled per quarter by position. * refers to post-hoc statistical significance. Please refer to Table 1 for abbreviations of positions.

Table 2. Position category movement patterns during an entire elite junior AF match. Data are means (± SD) and [ranges]. N/A refers to "not applicable".

	Movement	No. of Efforts	Time (%)	Distance (m)
FP/BP	standing	118 (17)	19 (1)	N/A
	walking	247 (36) ‡	55 (4)	5500 [5096-6018]
	jogging	205 (16)	20 (4)	3715 [3078-4479]
	running	76 (8) †	5 (0)	1832 [1596-1999]
	sprinting	16 (14)	1 (0)	536 [226-701]
	Total			**11583 [11398-11774]**
HFF/HBF	standing	75 (35)	9 (2)	N/A
	walking	339 (52)	45 (3)	4335 [4041-4891]
	jogging	339 (56)	35 (1)	6892 [6230-7254]
	running	177 (42)	10 (3)	2887 [2136-3765]
	sprinting	23 (19)	2 (1)	629 [272-1207]
	Total			**14743 [14270-15407]**
Midfield	standing	68 (8)	6 (2)	N/A
	walking	338 (13)	46 (2)	4963 [4807-5124]
	jogging	386 (31) *	39 (2)	8532 [8226-8871]
	running	130 (20)	8 (1)	2845 [2287-3210]
	sprinting	20 (5)	1 (0)	351 [258-497]
	Total			**16691 [16167-17012]**
Wing	standing	102 (42)	10 (3)	N/A
	walking	332 (66)	46 (8)	4891 [3872-5866]
	jogging	351 (63)	34 (2)	6833 [6625-6975]
	running	127 (34)	9 (3)	2738 [1739-3755]
	sprinting	26 (13)	2 (1)	657 [349-1228]
	Total			**15119 [14672-15785]**
Ruck	standing	88 (35)	11 (2)	N/A
	walking	312 (10)	47 (5)	5002 [3840-5814]
	jogging	276 (26)	30 (3)	5393 [4797-6573]
	running	145 (23)	12 (5)	3345 [2413-4551]
	sprinting	22 (12)	1 (1)	527 [231-923]
	Total			**14268 [13466-15227]**
CHF/CHB	standing	138±4	22 (2)	N/A
	walking	321±13	52 (3)	5573 [5191-6226]
	jogging	274±29	24 (2)	4545 [4267-4918]
	running	105±11	6 (1)	1947 [1807-2206]
	sprinting	21±6	1 (0)	485 [305-624]
	Total			**12550 [12259-12829]**
FF/FB	standing	159 (18) #	28±7	N/A
	walking	291 (31)	47±9	5757 [4484-6302]
	jogging	205 (38)	20±2	3270 [3039-3694]
	running	76 (17) †	4±1	1308 [1084-1462]
	sprinting	21 (9)	1±1	531 [246-668]
	Total			**10419 [9811-10774]**

* refers to significant increase in midfield position jogging efforts to other positions jogging efforts.
† refers to significant decrease in FF/FB and FP/BP position running efforts to other position running efforts.
# refers to significant increase in FF/FB position standing efforts to other position standing efforts.
‡ refers to significant decrease in FP/BP walking efforts to other position standing efforts.

The mean match totals of the number of efforts, the percentage of overall match time and the estimated total distance covered for standing, walking, jogging, running and sprinting are shown in Table 2. In all seven position categories, walking or jogging was the most observed movement, which also accounted for the greatest number of efforts completed in all position categories. Across all positions, sprinting showed the lowest percentage of overall time, the smallest number of efforts and the smallest estimated distance covered. Even when combined, running and sprinting only accounted for a small percentage of total match efforts across all playing position categories. The HFF/HBF and midfield were the only positions to spend less than 10% of the game in a stationary position.

Significant differences in jogging were recorded between the midfield position and all other positional categories ($p < 0.01$, ES = 0.82). Running efforts between

the FF/FB and FP/BP to all other positions were significantly different ($p < 0.01$, ES = 0.61). Standing (stationary) efforts were significantly different between the FF/FB and other positions ($p < 0.05$, ES = 0.37) and in walking efforts between the FP/BP to all other positions ($p < 0.05$, ES = 0.80).

Walking was the predominant activity with players walking 48.3±3.7% of match time, followed by jogging (28.9±7.6%), standing (15.0±8.1%), running (7.7±2.9%) and sprinting (1.3±0.5; Table 2). However, players completed an average of 21.3±3.0 sprints and 119.4±36.8 high-intensity running efforts per match (Table 2).

Across position categories and movement pattern classifications (Table 3), the majority of all efforts lasted between 0-3.99 s, decreasing in frequency as the duration of effort increased. Ruck and CHF/CHB positions were the only field positions to report a greater number of walking efforts lasting 4-6.99 s compared to 0-3.99 s (Table 3). Similarly, the FP/BP and FF/FB showed greater number of times stationary longer than 20 s (18 and 30 respectively).

Discussion

The purpose of the present study was to present AF movement pattern data at the elite junior level, furthering a previous, preliminary study by Veale et al. (2007). This is the first time data has been presented at this level and only the second time since the study by Dawson et al. (2004). This is surprising given the availability of methods to collect and analyse this data and suggests continued research is necessary at all levels of the sport.

The distances recorded in this study suggests that the positions, indeed, show a large endurance component,

Table 3. The total match number of efforts completed by each playing position category within different time (s) categories across each movement pattern classification.

WALKING								
Time (s)	**HFF/HBF**	**FP/BP**	**Wing**	**Midfield**	**Ruck**	**CHF/CHB**	**FF/FB**	**Mean (±SD)**
0-3.99	77	49	87	90	70	75	74	74.6 (13.4)
4-6.99	75	38	70	71	77	79	53	66.1 (15.1)
7-9.99	48	29	53	46	48	47	39	44.3 (7.9)
10-12.99	28	23	35	38	31	36	34	32.1 (5.2)
13-15.99	20	17	28	26	27	23	25	23.7 (4.0)
16-19.99	23	28	21	25	17	27	25	23.7 (3.8)
20+	38	70	37	42	43	53	52	47.9 (11.6)
JOGGING								
Time (s)	**HFF/HBF**	**FP/BP**	**Wing**	**Midfield**	**Ruck**	**CHF/CHB**	**FF/FB**	**Mean (±SD)**
0-3.99	95	64	108	106	77	93	79	88.9 (16.2)
4-6.99	84	49	98	83	72	86	58	75.7 (17.2)
7-9.99	53	30	53	54	45	46	32	44.7 (10.0)
10-12.99	32	20	26	40	26	31	20	27.9 (7.1)
13-15.99	20	13	21	27	23	13	18	19.3 (5.1)
16-19.99	16	19	16	23	13	14	18	17.0 (3.4)
20+	33	39	27	35	32	25	27	31.1 (5.0)
RUNNING								
Time (s)	**HFF/HBF**	**FP/BP**	**Wing**	**Midfield**	**Ruck**	**CHF/CHB**	**FF/FB**	**Mean (±SD)**
0-3.99	59	31	65	67	61	61	46	55.7 (12.8)
4-6.99	37	27	37	40	55	26	21	34.7 (11.4)
7-9.99	16	9	14	14	19	12	4	12.6 (4.9)
10-12.99	6	5	5	6	9	2	2	5.0 (2.4)
13-15.99	3	3	2	1	6	2	0	2.4 (1.9)
16-19.99	2	0	1	1	3	1	1	1.3 (1.0)
20+	2	1	2	0	3	1	0	1.3 (1.1)
SPRINTING								
Time (s)	**HFF/HBF**	**FP/BP**	**Wing**	**Midfield**	**Ruck**	**CHF/CHB**	**FF/FB**	**Mean (±SD)**
0-3.99	17	10	15	15	12	14	10	13.3 (2.7)
4-6.99	5	7	8	3	5	4	4	5.1 (1.8)
7-9.99	1	1	2	0	2	0	0	.9 (.9)
10-12.99	1	0	1	0	1	0	0	.4 (.5)
13-15.99	0	0	0	0	0	0	0	.0
16-19.99	0	0	0	0	0	0	0	.0
20+	0	0	0	0	0	0	0	.0
STATIONARY								
Time (s)	**HFF/HBF**	**FP/BP**	**Wing**	**Midfield**	**Ruck**	**CHF/CHB**	**FF/FB**	**Mean (± SD)**
0-3.99	29	28	38	33	26	40	40	33.4 (5.9)
4-6.99	23	29	29	17	23	37	46	29.1 (9.7)
7-9.99	11	18	14	7	13	18	24	15.0 (5.5)
10-12.99	6	14	8	4	13	16	16	11.0 (4.9)
13-15.99	6	8	5	3	7	9	11	7.0 (2.6)
16-19.99	3	8	3	2	3	8	13	5.7 (4.1)
20+	5	18	6	2	9	9	30	11.3 (9.7)

and much greater than previously published in the junior area (Veale et al, 2007). However, although not measured in this study, player rotations suggest that players themselves would not be covering these total distances individually. Moreover, the breakdown of efforts performed by the players in these positions suggest that despite over three-quarters of the time (77.2%) spent in low-intensity activity (walking and jogging), players (across all positions) were required to produce an average of 140 high intensity (running and sprinting) efforts in the 0-3.99 s and 4-6.99 s time brackets. Although recovery time between high intensity efforts, as reported by Dawson et al. (2004), were not recorded in this study, the calculated average ratio between the high intensity movements of running and sprinting (work) to low intensity walking and jogging efforts (rest), in this study, of 1:4.4 would suggest that one high intensity effort every 12-40 s resemble those reported by Dawson et al. (2004). This supports previous assertions that AF is a sprint-based, intermittent sport (Norton et al., 1999).

Due to the developmental nature of the elite junior competition, the players filmed in this study were not classified as "specialists" in these positional roles, unlike those involved in the study by Dawson et al. (2004). However, differences between positions were observed. Greater match volumes and efforts of work were observed in the HFF/HBF, midfield and wing positions compared to the less mobile field positions of FP/BP. Differences were also observed between midfield and wing positions, combined as one positional category by Dawson et al., (2004), with midfielders covering a greater overall total distance of 1.5 km despite similar number of high-intensity efforts. However, standing efforts and time spent standing were greater in the wing position suggesting a reactionary approach from these players, whilst midfielders who are expected to cover more ground and participate in a larger number of match related contests are proactive (i.e. jogging rather than standing) in moving and positioning themselves more effectively.

Whilst the Ruck is a position suited to a limited number of athletes, the completion of similar game related tasks to the other running position categories makes for an interesting comparison. In a similar manner to the midfield, the Ruck position does not fill a particular 'set' position during a game; rather, the Ruck moves around the ground participating in the majority of all stoppages, such as ball-ups and boundary throw-ins (Dawson et al., 2004). This is supported by the low percentage of total match time spent in a stationary position (Table 2). The Ruck also recorded the second-highest number of running efforts (behind the HFF/HBF) and the greatest distance covered running (Table 2), both notably further than CHF/CHB and FF/FB.

Similar to the midfield/wing position, Dawson et al., (2004) classified the FP/BP and HFF/HBF positions as one position category (termed 'small F/B') at the elite senior level. However when these two field positions were analysed separately in our study, differences were evident. The HFF/HBF position covered a greater distance per quarter (Figure 1) and total distance compared to the FP/BP (Table 2), as well as performing a greater number of high intensity efforts (Table 2). Conversely, the HFF/HBF position recorded a greater amount of game time whilst jogging and running and less amount of time in a stationary position to the FP/BP (Table 2).

This study has further demonstrated that AF is primarily a sprint-based, interval sport as suggested by Norton et al. (1999). With the majority of efforts lasting between 1-6s, these results are consistent with those reported at the elite senior level by Dawson et al. (2004), further highlighting the intermittent nature of AF (Norton et al., 1999). Therefore, conditioning drills should be designed to suit the match specific movement demands of each playing position. This study suggests repeated high intensity efforts of running and sprinting lasting six seconds or less, interspersed with active recovery periods of walking and jogging should be completed, with athletes suited to the high movement load position categories completing more total efforts than those in key position forward and defensive roles.

It is well accepted that superior overall fitness, the style at which the game is played, training age and competition experience, biomechanics and full physical development of the senior athletes are all reasons for differences seen between elite junior and senior athletes (Billows et al., 2005). However, it is important to briefly highlight the overall similarities and differences to allow for careful interpretation by coaching staff when planning training programs for junior players.

Despite recording higher total distances covered by the elite senior athletes in all positions, between a mean of 1071 to 3455 m (Dawson et al., 2004), both competition levels reported the midfield position (which included the wing) covered the greatest total distance whilst the FF/FB covered the least (Dawson et al., 2004). However across all playing position categories, the elite junior players covered less total distance jogging (ranging from 885 to 3721 m) and a greater total distance running per game (ranging from 18 to 1717 m), with the Ruck varying the greatest between the two competition levels (19% more running and 12% less jogging than senior players). Furthermore, the junior players recorded a smaller number of efforts (ranging from 226 to 387 less) than their elite senior counterparts.

Conclusion

In conclusion, with the data presented in this study, training practices for different positions are achievable, allowing players to learn and train for the game *through* the game. However, although position movement patterns at the junior level reflect senior AF, this study has also provided evidence that elite junior AF competitions are not identical in physical load to the elite senior AF competition. Coaching staff involved in programming of training junior AF athletes should interpret these findings with care and in relation to the data presented by Dawson et al. (2004). Continued notational analysis research, at both junior and senior levels, is also required in order to maintain a 'moving picture' of the constantly evolving sport of AF.

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Key points

- Training for Australian Football should incorporate repeated sprint bouts rather than long continuous running that reflect the characteristics of the sport.
- Specialised positional training (involving distances and repetitions) can be prescribed to prepare junior athletes for specialist roles in senior level Australian Football.
- Differences between elite junior and senior Australian football provides further evidence to coaches that junior athletes should not be trained as adults.

AUTHORS BIOGRAPHY

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Employment

PhD Student, School of Sport and Exercise Science, Victoria University, Melbourne Australia

Degree

BExSci (Hons)

Research interests

Physiological development in elite junior athletes

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Alan J. PEARCE

Employment

Senior Lecturer, School of Sport and Exercise Science, Victoria University, Melbourne Australia

Degree

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Research interests

Applied physiology of sport; Neuromuscular control of human movement

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✉ **Dr. Alan J. Pearce**

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