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**Article Title:** Quantifying the Gap Between Under 18 and Senior AFL Football: 2003–2009

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Title: Quantifying the Gap between Under 18 and Senior AFL Football: 2003-2009

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ABSTRACT

Purpose
The understanding of the gap between Under 18 years and senior level competition and the evolution of this gap in Australian Football, lack a strong evidence base. Despite the multimillion dollars invested in recruitment, scientific research on successful transition is limited. No studies have compared individual players’ movement rate, game statistics and ball speed in U18 and senior competition of the Australian Football League across time. This project compared differences in player movement and ball speed between matches from senior AFL competitive matches and U18 players in the 2003 and 2009 seasons.

Methods
TrakPerformance Software and Global Positioning System (GPS) technology were used to analyse the movement of players, ball speed and game statistics. Analysis of variance (ANOVA) compared the two levels of competition over time.

Results
Observed interactions for distance travelled per minute of play (p = 0.009), number of sprints per minute of play (p < 0.001), time spent at sprint speed in the game (p < 0.001), time on field (p < 0.001), and ball speed (p < 0.001) were found. Subsequent analysis identified increases in movement patterns in senior AFL competition in 2009 compared with the same level of competition in 2003 and U18 players in 2003 and 2009.

Conclusions
Senior AFL players in 2009 were moving further, sprinting relatively more frequently, playing less time and playing at game speeds significantly greater than the same senior competition in 2003 as well as compared with both cohorts of U18 players.

INTRODUCTION

Talented footballers are recruited in the National Australian Rules Football League (AFL) draft from the age of 18 years. However, it is an exception rather than a rule that drafted players advance directly into the senior team playing in the national competition. Typically, a transition period of one to four years occurs, during which less experienced recruits play second tier games in state-based competitions and are irregularly exposed to the highest professional competition. Eventually, players with the necessary attributes to succeed in the senior competition will be more consistently included in first-grade. The transition period represents an apprenticeship during which players refine their skills and develop physically to manage the rigours of AFL.
Financial investment in player development programs in professional AFL environments has increased considerably as teams look to fast-track players’ capabilities. However, finding the balance between appropriate physical overload and overtraining remains challenging. Therefore, modified strength and conditioning programs are common for players in both the feeder competitions such as the under 18’s leagues (U18), and once they are in professional AFL clubs. Most of these programs appear founded on experience and subjective opinion rather than scientific evidence. However, the level of confidentiality within professional clubs means the specific program details are rarely published.

Quantifying differences between game movement patterns (distances, speeds and overall work rates) of talented U18 players and elite senior AFL players may advance physical preparation for induction programs to senior competition. A smoother transition from U18 to professional AFL may serve multiple goals. Targeted objectives include increased motivation, player longevity, decreasing injuries and developmentally suitable progressive loading.

Motion analysis in Australian football games is frequently reported in public and scientific domains. However, the vast majority of scientific reports and media telecasts focus on elite level competition. The first standardised benchmark of the physiological capability for aspiring elite players occurs at the National Australian Football Draft Camp (www.afl.com.au/draft/tabid/282/default.aspx). Results from camp testing comprise mostly of objective physical, psychological and medical assessments. Traditionally, talent identification combines objective test outcomes and subjective match performance assessments conducted by AFL club talent scouts and coaches.

Limitations of existing AFL talent identification processes include; the relevance of selected draft tests to on-field performance, an inadequate number of assessment opportunities, pressure associated with the assessment environment, and subjective scout-dependent game performance ratings. Objective measures of match performance from movement analysis technology can compliment subjective player ratings and may also be useful in quantifying the progression required between U18 and senior level match performance.

A better understanding of differences in the game structure between U18 and senior games could assist training loads for induction programs. The understanding refers to variables such as the duration of play and stop periods, number of stoppages in a game, total time played, player density and game speed assessed using ball speed analysis. For example, within the last decade of AFL, game speed during senior matches has generally increased, while total play time has increased and stoppage time decreased and player density in the 2010 season was at the highest level measured. Changes to speed and stoppages have significant implications for player work-to-rest opportunities and overall game demands. Availability of similar, objective data at U18 level and the trends over time remain unknown. Accurate player movement data, combined with knowledge of
game structure and speed experienced by both U18 and senior AFL players over time should provide quantifiable benchmarks for training and playing expectations and may also influence draft selection.

Therefore, the aims of this study were to compare: (1) player movement and game speed between current U18 and senior AFL players, and (2) player movement and game speed changes between 2003 and 2009.

**METHODS**

**Player Movement Analysis**

Ethics approval was provided by the Australian Catholic University. A total of 64 players were analysed during competitive games at the 2003 National U18 AFL Championships and 64 players during matches of the premier U18 AFL competition (Teal Cup) in 2009. Data from senior AFL were collected on 64 players throughout the 2003 and 2009 AFL seasons. This time period was selected as it reflects the onset of popular use of motion analysis within the AFL. A 5 year period is deemed an appropriate length of time to determine whether a player will be, or has been successful in AFL. Match performance data were included if players completed at least 50% of playing time. Any period less than 50% may result in artificially high player speeds as greater rest for players would allow them to produce greater physical output.

Player movement was analysed for 2003 matches using computer-based tracking software (CBT; TrakPerformance, SportsTec, Australia) for senior and U18 competition. This software system relies on tracking skills and is most effectively applied using a drawing tablet connected to a computer. A scaled image of the playing field was placed on the drawing tablet. The player to be ‘tracked’ was followed around the miniaturised field by the tracker with the aid of a drawing pen. Custom video footage of individual players was viewed after each game and retrospectively analysed. Variables of interest were; total distance covered per minute of game time (player speed in m/min), sprints per minute (where the sprint velocity was > 20 km/hr for a duration of >2 s), the percentage of total playing time at sprint speed (>20 km/hr), and the player’s game time. Results expressed relative to time were used because absolute variables would be influenced by player time on field. Fundamental game statistics (kicks, handballs, marks and tackles) were also entered using keystrokes on the laptop. For trend analysis, these values were combined to represent total ball engagement by the player during the game. In 2009, data collection involved global positioning systems (GPS) and game statistics available through the public domain (Champion data -www.championdata.com.au).

The same GPS devices (‘SpiElite’, GPS Sports, Canberra, Australia) were worn by both U18 and senior AFL players during matches. The CBT and GPS tracking devices have acceptable reliability when compared with an odometer for precision of distances covered (TEM = 4.7 and 5.5%, respectively). While GPS accuracy is essentially independent of
the user, CBT relies on smooth and accurate movements by the tracker. In this study the trackers used repeated video analysis to track the player and had to demonstrate an intratester technical error of measurement (TEM) of less than 5% prior to data collection. The intertester reliability estimate for CBT has been shown to result in a TEM of about 5% \(^5\). Intertester TEMs in the present study were less than 7% using the same procedures.

Additional research suggests similar GPS technology elicits an average error 4.7% for total distance and a coefficient of variation of 5.8% for maximum speed\(^6\). Previous CBT analysis of senior AFL matches also demonstrates tracking distances were within 2% of values using video analysis of players\(^5,7\). Furthermore, comparisons of CBT and GPS during a Rugby Union circuit demonstrated acceptable agreement over varying running intensities\(^8\).

**Game Speed**

An additional feature of CBT is the capacity to apply tracking technologies to ball movements during game play. For the U18s, 36 quarters were measured during each of the 2003 and 2009 seasons. For senior competition, 19 quarters were measured during the 2003 season and 50 quarters during the 2009 season. The ball tracking analysis allowed the following variables to be determined; game (ball) speed (m/s), distance the ball travelled during play periods (m), average number and duration of play and stop periods, and total play and stop time per quarter (s). Repeated measures using the same quarters of football found the TEM to be no different to those reported for tracking player movements (<5%).

**Statistics**

Results from continuous variables of player movements included player speed, number of sprints and game events per minute, and percentage of time spent sprinting. Game speed was calculated by dividing the total distance the ball travelled by the total time of each quarter. Comparisons between U18 and senior AFL variables across time were assessed using ANOVA with two levels of play (U18 and AFL) and two fixed time periods (2003 and 2009). T-tests assessed mean changes within each competition across time. Effect sizes (ES, Hedges' \(g\)) were calculated and 95% confidence intervals estimated (95%CI). Effect Sizes between 0 and 0.3 were considered small, 0.31 to 0.6 moderate and scores above 0.6 were considered large. Statistical analyses were performed using SPSS version 17.
RESULTS

Player Speed

Table 1 shows the variables measured in the two competitions across time. The average distance per minute players travelled increased in both levels of competition from 2003 to 2009. This was about 5 m/min in U18 and 13 m/min in AFL, resulting in a year by competition interaction \( F(1,252) = 6.899, p <0.009 \). Within group comparisons between years showed the magnitude of change over time for AFL players (large \( ES = 0.95 \)) was greater than U18 (moderate \( ES = 0.37 \)).

A statistic often used is the number of sprints performed per minute of play (sprints/min). No changes in sprints per minute were observed across the seven-season time span at U18 level (moderate \( ES = 0.34 \)), but a 12% increase occurred at the AFL level (moderate \( ES = 0.56 \)). However, no interaction between year and competition was found \( F(1,252) = 0.648, p = 0.421 \).

Despite minimal changes in the number of sprints per min, the percentage of time spent sprinting showed a large year by competition interaction \( F(1,252) = 27.252, p <0.001 \). The increase in time at sprint speed within-group was equal to 14% at the U18 level (moderate \( ES = 0.35 \)) and 60% for the AFL players (large \( ES = 1.56 \)).

Statistics per minute (stats/min) is a way to represent game involvement by players and includes a count of the number of tackles, kicks, marks and handballs players encounter during the game. In contrast to changes in the movement variables investigated, stats/min remained unchanged between 2003 and 2009 in both the U18 (moderate \( ES = 0.546 \)) and AFL (small \( ES = 0.063 \)) competitions \( F(1,252) = 3.581, p = 0.06 \).

Differences were observed for players’ average game time in both competitions across time. Year by competition interaction \( F(1,251) = 32.941, p <0.001 \) can be attributed to the relatively unchanged time on field for U18 (small \( ES = 0.08 \)) players across the study but a 9% decrease over the same time for AFL (moderate \( ES = 0.57 \)) players.

At the U18 level, between 2003 and 2009 game speed remained similar (small \( ES = 0.29 \)). In contrast, a 25% increase was evident in game speed across the same time period in AFL (large \( ES = 3.17 \)). The differences between the two levels of competition over time again supported a significant year by competition interaction \( F(1,251) = 51.26, p <0.0001 \).
DISCUSSION

The present study demonstrated differences for a number of player movement and match speed profiles in both U18 and senior AFL competitions between 2003 and 2009. Within-group changes at U18 level were significant only for player speed (dist/min). At the AFL level, increases were found in player speed, percentage of time spent sprinting, number of sprint efforts per minute and overall game speed, along with a decrease in overall time on the field. The only variable failing to show changes over time for AFL players was the number of match statistics per minute. Interaction effects were found in player speed, the percentage of time spent sprinting, time on field and overall game speed. These patterns of change show the gap between the two levels of competition has widened markedly in a short period of time.

Rapid evolution of game intensity and player demands are characteristic of early development in professional sport\(^9\text{-}\,12\). A significant gap between U18 and professional ranks can lead to a longer period of transition or urgent strategies are required to fast-track physical and skill development of early recruits at the elite level.

Player Speed and Movement

The physical demands of senior players in the AFL have previously been objectively estimated by separate groups using video analysis\(^7\), and tracking software\(^3\text{-}\,4\). Since these two studies were completed in the same season they represent relative validity in analytical methods. In the present study, physical demands were estimated from a combination of CBT and GPS tracking technologies. Despite acknowledged limitations, acceptable intraterster and intertester reliability has been established with the CBT system and reasonable agreement with GPS tracking devices has been shown\(^5\text{-}\,8\). The same systems and trackers were used across the duration of the present study which also help to reduce measurement error.

The comparison between AFL and U18 players over time confirmed predicted increases in player ‘movement loads’ during senior AFL games. As expected, in 2003 the physical requirements of elite U18 competition were less than AFL game demands in all variables measured. In 2009 this trend continued, but importantly the gap between the competitions in these movement loads increased significantly. Similar trends have been seen in football\(^9\text{-}\,10\) and Rugby League\(^11\). In general, as sports evolve, the level of professionalism and competition for selection and game success increase, and the overall demands are also elevated\(^12\). Consequently, as the AFL has rapidly developed into a full-time professional sport, the game intensity and physical demands have increased substantially. Concomitantly, the part-time U18 competition has improved, but to a lesser degree.

At U18 level, only player speed increased across the seven years of the study. Within the senior AFL cohort, all movement variables increased over time. Interestingly, decreases in average playing time occurred in both competitions, reaching significance for the AFL players only. However, when the playing time was combined with player speed, total distances players travel per game remained relatively stable over time. The important change was the rapid increase in time spent sprinting at the AFL level (Large \(ES = 1.56\)). While
players are spending less time on the ground, the intensity at which they work has risen dramatically. Despite the required increases in physical output, game involvement by players remained stable across time. Therefore, modern day AFL players are required to work harder in games in order to achieve the same level of game involvement they had previously.

A lower absolute level of distances covered in all speed categories at the U18 compared with senior AFL level has been described previously. This trend presents the AFL coaches with enormous challenges when preparing U18 players for AFL match play. Presumably, the U18 players are prepared physically for their match intensities. However, these intensities can be as much as 50% (in the case of time spent sprinting) below AFL intensities (2 min 55 s vs 5 min 49 s sprinting between competition levels in 2009). Moreover, in 2009 the differences in total distance (3080 m) as well as distance covered in sprinting (386 m) between the competitions were substantial. Practically, this means training of recently drafted U18 players in AFL squads needs to be strategically progressed from U18 to AFL workloads and intensities. One common method of introducing recently drafted U18 players to AFL match intensities is to expose these players to sub-elite games (WAFL, SAFL, VFL). These competitions have also been found to be below AFL player speeds, but may represent an ‘mid-point’ in match intensity between U18 and AFL competitions.

Caution must be applied when selecting U18 players for senior matches in their first year of AFL. Regular player monitoring and assessment dictates when a player is physically able to cope with AFL matches and recover appropriately. Specifically, repeated sprint capacity and overall body strength should be developed and regularly assessed in order to mitigate the potential for injuries occurring in talented young players. These capacities can be monitored using a number of indices. Appropriate indices include individualised player feedback, football history, training load experience, and physical maturation.

**Game Speed**

Game speed (measured as ball speed) is an index of game intensity and may reflect the speed required for decision-making and physical movement. It can also represent increases in skill execution and the ability to rapidly carry the ball, or to accurately pass to other players without touching the ground. Furthermore, game speed may be a useful measure of the impact of rule changes such as those encouraging quicker re-starts after a stoppage or even game tactics such as the use of slow plays or strategies to ‘waste time’. Tracking the movement of the ball is useful for monitoring the evolution of the game and quantifying the impact of rule changes and tactics on game structure. Between-competition game speeds in the 2003 season did not differ but increases were apparent by 2009. The differences were identified by increases in the senior AFL game speed (large ES = 3.17), but not U18 competition.

The results may be explained by differences in both game structure and physiological demands. The duration of the quarters was shorter for U18 than AFL. For example, in both 2003 and 2009, the average duration of each U18 quarter was approximately 80% of the
senior time. A typical 2003 quarter also had more total play time (where the ball is ‘in-play’) for senior AFL than U18. In 2009, the quarter length was unchanged for both levels but the fraction of play time within the quarter had risen significantly in senior AFL. Since it is a well-known phenomenon that average human power drops over time (or across quarters) this suggests there should be less of a speed decrease in the U18 compared to that in AFL level. Intuitively, the effect of these changes could decrease the game speed of the senior competition and not alter the U18 speed. Negligible increases in game speed were observed in the U18’s but a very large increase occurred in senior AFL games. In other words, despite AFL games having longer play time within the quarters, game speed was elevated. This is almost certainly related to the reduced individual game time for AFL players who regularly rest on the sidelines. When they return to the field after recovering they exhibit greater running intensities. This further demonstrates the impact of the relatively greater change in demands required of AFL players.

One of the major strategic changes in the AFL competition during the study period was the accelerated use of interchange players. The interchange rules in the AFL allow unlimited players to be rotated on and off the bench during the game. This resulted in a three-fold increase in the interchange rate from an average of 27 per team per game in 2003, to 91 in 2009 (and 117 in 2010) and helped to advance the game speed because fresh players were rotated for fatigued players. Additionally, in 2006 some minor rule changes were introduced in order to reduce the time the ball is out of play. For example, reduced time has been allowed for goal shots, kick ins, free kicks, boundary throw ins and ball-ups. Subsequently, the sum of all the stop periods decreased in the senior games by 28% while it increased in the U18 games by 17%. Despite structural changes that would tend to reduce game speed in the senior games and increase it in the U18s, the reverse was found. The explanation lies in the escalated use of interchange players and probably greater training levels, fitness and game demands within the professional ranks.

The implications for the ‘step-up’ required for U18 players is substantial. Results for the time period analysed support greater selectivity of U18 players who can tolerate these increasing physical demands. Just as importantly, talented junior players unable to adapt would be ‘de-selected’ either via performance ratings or repeated injury. The ability to minimise the gap by increasing the physical capabilities of U18 players is difficult as training sessions are necessarily less frequent here than in professional ranks. To minimise injury and increase physical resilience, training strategies such as those designed to increase maximal aerobic speed, repeated sprint training and the use of small sided games have been suggested. At this stage however, no one form of training has proven superior to others in preventing injury or maintaining career longevity, particular in the early transition phases of competitive development.
**PRACTICAL APPLICATIONS**

Overall, the gap between U18 and senior AFL movement and game demands is increasing thus making the transition from elite junior to elite senior match play more challenging today than ever before. This trend has implications for preparing talented aspiring AFL players for elite senior competition. It is apparent that successful U18 players may need to be supplemented with modified conditioning and access to professional sports medicine services across the transition period from junior to elite level in order to prepare fully for the demands of AFL match play.

**ACKNOWLEDGMENTS**

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**REFERENCES**


Table 1. Comparison of player and game profiles of senior and AFL matches between 2003 and 2009.

<table>
<thead>
<tr>
<th></th>
<th>U18</th>
<th>Senior AFL</th>
<th>Between Groups Comparison</th>
<th>Year * Competition Interaction</th>
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<tr>
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<td>2003 (mean ± SD)</td>
<td>2009 (mean ± SD)</td>
<td>p value</td>
<td>ES (95% CI)</td>
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<tr>
<td>Dist/ min</td>
<td>113.07 ± 17.1</td>
<td>118.94 ± 14.13</td>
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<td>121.19 ± 14.74</td>
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<td>Sprints/ min</td>
<td>0.44 ± 0.25</td>
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<td>0.51 ± 0.28</td>
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<td>0.002</td>
<td>0.56 (0.21 – 0.91)</td>
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<td>% Sprint</td>
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<td>3.89 ± 1.11</td>
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<td>1.56 (1.21 – 1.91)</td>
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<td>Stats/min</td>
<td>0.33 ± 0.16</td>
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<td>0.0562</td>
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<td>Game time (min)</td>
<td>81.13 ± 16.5</td>
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<td>93.55 ± 10.3</td>
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<td>Game Speed (m/s)</td>
<td>3.186 ± 0.39</td>
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