2019

Association between preseason training and performance in elite Australian football

Callum J. McCaskie

Warren B. Young

Brendan B. Fahrner

Marc Sim
Edith Cowan University, marc.sim@ecu.edu.au

10.1123/ijspp.2018-0076
Accepted author manuscript version reprinted, by permission, from: McCaskie, C. J., Young, W. B., Fahrner, B. B., & Sim, M. (2019). Association between preseason training and performance in elite Australian football. *International journal of sports physiology and performance, 14*(1), 68-75. Available here © Human Kinetics, Inc.

Association between pre-season training and performance in elite Australian football

Callum J. McCaskie[1], Warren B. Young[1], Brendan B. Fahrner[2], Marc Sim[1,3]

[1]*School of Health Sciences and Psychology, Federation University, Victoria, Australia*

[2]*Richmond Football Club, Victoria, Australia*

[3]*School of Medical and Health Sciences, Edith Cowan University, Western Australia, Australia*

Original Investigation

Corresponding author: Callum J. McCaskie

Institution: School of Health Sciences and Psychology, Federation University, Victoria, Australia

Mailing address: University Dr, Mount Helen, VIC 3350, Australia

Telephone: +61431877405

Email: callum.mccaskie@hotmail.com

RUNNING HEAD: Pre-season training and performance

ABSTRACT

Purpose: To examine the association between pre-season training variables and subsequent in-season performance in an elite Australian football team. ***Methods:*** Data from forty-one elite male Australian footballers (mean±SD: age=23.4±3.1y; height=188.4±7.1cm; mass=86.7±7.9kg) was collected from one Australian Football League (AFL) club. Pre-season training data (external load, internal load, fitness testing and session participation) were collected across the 17-week pre-season phase (6-weeks pre-Christmas, 11-weeks post-Christmas). Champion Data© Player Rank (CDPR), coaches' ratings (CR) and round one selection were used as in-season performance measures. CDPR and CR were examined over the entire season, first half of the season and the first four games. Both Pearson and partial (controlling for AFL age) correlations were calculated to assess if any associations existed between pre-season training variables and in-season performance measures. A median-split was also employed to differentiate between higher and lower performing players for each performance measure. ***Results:*** Pre-season training activities appeared to have almost no association with performance measured across the entire season and the first half of the season. However, many pre-season training variables were significantly linked with performance measured across the first four games. Pre-season training variables that were measured post-Christmas were the most strongly associated with in-season performance measures. Specifically, Total on-field session rating of perceived exertion (sRPE) post-Xmas, a measurement of internal load, displayed the greatest association with performance. ***Conclusions:*** Late pre-season training (especially on-field match specific training) is associated with better performance in the early season.

Key words: Workload, Preparation, Competition, Team Sport, AFL

Introduction

Australian football (AF) is a field-based team sport requiring various elements of physical fitness[1-3]. A typical match lasts around 120 minutes, played over four quarters[4] where players cover around 11-14km[5]. To compete at this level, professional AF players undertake rigorous pre-season training from November, up until the commencement of the competitive season at the end of March.

In elite AF, most clubs will undertake three main on-field and four main off-field sessions per week during the pre-season phase[6]. To optimise physiological adaptation, they are usually accompanied by recovery and injury prevention sessions such as massage, yoga and hydrotherapy[7]. On-field sessions are commonly monitored using Global Positioning System (GPS) technology, providing measures of external load such as total distance and distances covered in various speed zones[8]. Especially in early pre-season, players may cover up to 35km a week during on-field sessions, undertaking a combination of skill, development and conditioning sessions[7]. However, off-field session load is commonly calculated by multiplying a subjective measure of session intensity, the rating of perceived exertion (RPE), by the duration of the session in minutes to form a session-load score[3,9]. Fitness staff then combine both these methods to calculate a universal loading figure[3,6].

Avoiding injury during the pre-season phase can maximise players' opportunity to build a solid fitness base, that is likely beneficial when dealing with the demands of the competitive season[10]. Recently, Murray, Gabbett, Townshend [1] explored the association between pre-season training and match availability in elite AF. It was discovered that players who completed a greater proportion of pre-season training were more likely to avoid injury. Consequently, these players were available for a greater number of in-season competitive matches, compared to players who completed less pre-season training. Similarly, Colby and colleagues[10] reported elite AF players who had accumulated a low total distance across the pre-season phase were significantly more susceptible at succumbing to injury during the competitive season. This suggests that inadequate pre-season training load may be a risk factor for subsequent injury, while highlighting the importance of achieving appropriate pre-season training load. Furthermore, a positive correlation has also been observed between fitness levels and physiological match performance in team sport athletes[11,12]. What is unclear however, is whether greater pre-season training loads are conducive to an increase in subsequent match performance.

While numerous studies have explored the influence of pre-season training on both subsequent injury and physiological performance, no study has examined the relationship between pre-season training and in-season match performance. Therefore, this investigation aims to examine the association between pre-season training and ensuing in-season match performance in an elite AF team. Additionally, this study seeks to examine which pre-season training variables are most related to in-season performance, and whether accumulating training load in different parts of pre-season alters the association with in-season performance. The results of which may help inform fitness staff and coaches about the pre-season training variables most related to in-season match performance.

Methods

Subjects

Forty-one [28 midfielders (nomadic role whereby players follow the ball), 13 key-position (role spent predominantly at one end of the ground)] elite male AF players (mean±SD: age=23±3 years; height=188.4±7.1cm; mass=86.7±7.9kg) from one Australian Football League (AFL) club participated in this study. All participants held full-time playing contracts with the club and had an AFL age (length of time spent on an AFL list) of 4.5±3.4 years. Written consent was provided by the participating AFL club for use of their data, collected as part of players' contractual arrangements. Research was approved by the University's Human Research Ethics Committee.

Design

This retrospective cohort study involved the use of existing data from the participating club's database. Pre-season training data (6 weeks pre-Christmas, 11 weeks post-Christmas) were gathered from the first session on November 13, 2015 until the commencement of the 2016 AFL premiership season on March 24. The players had a 16-day Christmas break (19th December – 3rd January) where they were provided with a home-based training program to ensure fitness levels were maintained, but no training data was collected. The team also participated in three pre-season friendly games against other AFL teams between mid-February and early-March in the lead-up to the competitive season. These were incorporated into overall on-field training load. Pre-season training variables were grouped under one of four categories; external load variables, internal load variables, fitness testing or session participation and were measured over the entire pre-season and post-Christmas alone (Table 1). This was performed due to the increased training load and intensity in the post-Christmas training sessions. Individual performance data were collected after each game, over the 22-game season which included Champion Data© Player Rank (CDPR) and coaches' ratings (CR) split into three phases (first four games, first half of season and entire season) as it was believed that the influence of pre-season training on in-season performance would diminish as the season progressed. Round one selection was also used as a performance indicator.

Methodology

All on-field training sessions included football-related training, physical conditioning and practice games. Sessions were monitored by GPS technology to record player movements (OptimEye S5 units, Catapult Innovations, Melbourne, Australia)[8,13]. Data was downloaded off the GPS units after every session using specific computer software (OpenField, version 1.12.0). The variables derived from these units were selected based on their ability to quantify training load and player wellness, and have been used previously (Table 1, External Load Monitoring Variables)[1,3,4].

As a subjective measure of training load, an intensity measure of training was provided by each player using a modified Rating of Perceived Exertion (RPE) scale[9] similar to previous work[3]. RPE was then multiplied by the session duration to form session load (session-RPE [sRPE]). A total sRPE value was then calculated across the pre-season for on-field, off-field and both forms inclusively (Table 1).

Insert Table 1 about here

CDPR was used as a performance measure and is based on official AFL statistics that players accumulate during a game (Champion Data©, Melbourne, Australia). The CDPR algorithm, which has been developed to rate player performance during matches, is widely accepted within the Australian football industry. The statistics that make up CDPR are collected in real-time by trained professionals with a final correction of statistics conducted post-game by reviewing the match footage in depth[14]. The formula is weighted towards efficient ball use and gaining possession of the ball in a contested situation, so a separate analysis was conducted on midfielders/nomadic players to reduce bias in the analysis[14-16].

CR are a subjective measure of performance, assessing the ability of each player to fulfil their role during the match, based on team game-plan requirements. With the aid of video footage, the head coach, two assistant coaches and three line coaches would meet post-game and assign a rating to each player based on a scale of 1-5 (1=significantly underperformed to AFL standard; 2= underperformed to AFL standard; 3= performed to AFL standard; 4= performed above AFL standard and; 5= significantly performed above AFL standard)[17]. Players who sustained an injury during a specific game were exempt from a rating.

Round 1 selection was also used as a performance measure. Criteria included if the player was selected to play in the first game of the 2016 AFL premiership season[2,18-20]. Five players were unable to be considered for selection due to injury/illness, resulting in 22 and 14 players who were selected and not selected for round 1, respectively. A high level of consistency in player selection was recorded in the first four games (~77%) compared to round 1.

Insert Table 2 about here

Statistical Analysis

Pearson correlations were initially performed between all pre-season training measures and in-season performance indicators. Correlation coefficients were classified as 0-0.09=Trivial; 0.1-0.29=Small; 0.3-0.49=Moderate; 0.5-0.69=Large and 0.7-0.89=Very large; 0.9-0.99=Near perfect[21]. A meaningful relationship was defined as having both statistical significance ($p \leq 0.05$) and a magnitude that was considered at least moderate ($r \geq 0.30$)[21].

Following the Pearson correlations, pre-season training variables that produced a meaningful relationship ($p \leq 0.05$ and $r \geq 0.30$) with performance indicators were added into a multiple linear regression (using the Enter method). A rule of two participants per variable was followed which has been used in previous research[22] allowing the use of a maximum of 20 pre-season training variables to be added into the regression for each performance indicator. Consequently, a regression was conducted for performance across the first four games (CDPR all players and midfielders/nomadic players and CR) as this was the only time multiple significant pre-season training variables were observed.

Partial correlations controlling for AFL age were performed. As per club guidelines, players who had been in the AFL system for less than five seasons were required to begin pre-season training earlier than their more experienced counterparts. This is based on beliefs that more experienced players have built up a tolerance to the

increased training load, and may not require the same volume of training to prepare for the demands of competition. All correlations were again interpreted using the aforementioned criteria.

Finally, a median-split was implemented to separate players into a higher and lower performing group according to CDPR and CR accumulated across each of the three phases (first four games, first half of season, entire season). Two-sample independent t-tests were adopted to examine whether any differences existed for pre-season training variables between the two groups for each performance measure. The magnitude of the difference between the groups was assessed using Cohen's *d* effect sizes (ES)[21]. Effect sizes were used as follows; 0.00-0.19-Trivial, 0.20-0.59-Small, 0.60-1.19-Moderate, 1.20-1.99-Large, 2.00-3.99-Very large, >4.00-Nearly perfect. The difference between higher and lower performing groups was considered meaningful if there was statistical significance ($p \leq 0.05$) and the effect size was at least moderate (≥ 0.60). Statistical analysis was undertaken using the IBM software Statistical Package for the Social Sciences (SPSS, version. 23.0, IBM Corporations, Somers, New York, USA).

Results

Champion Data Player Rank

Pearson correlations revealed that no pre-season training variables were significantly associated with CDPR (all players) over the entire season. However, a significant moderate inverse association was observed for Total off-field sRPE over the first half of the season (r=-0.33, p=0.033). Several variables were also discovered to be significant for CDPR measured across the first four games (Table 3). Similarly, pre-season training variables were only significantly related to CDPR for midfielders/nomadic players across the first four games (Table 3).

Insert Table 3 about here

Eleven specific pre-season training variables (that displayed a meaningful relationship with CDPR) (Table 3) accounted for 28.4% (adjusted R^2=0.284, p=0.027) of the total variability in CDPR (all players) across the first four games. Despite four significant training variables, no such results were uncovered for midfielders/nomadic players on CDPR.

Partial correlations produced two pre-season training variables that were significantly associated with CDPR accrued across the first half of the season (Total on-field sRPE post-Xmas; r=0.337 [moderate], p=0.033; Total on-field sRPE; r=0.312 [moderate], p=0.050). No significant variables were associated with CDPR (all players) accrued over the entire season. Additionally, eight significant pre-season training variables were discovered for performance across the first four games (Table 4). Additionally, pre-season training variables were only significantly related to CDPR for midfielders/nomadic players over the first four games (Table 4).

Insert Table 4 about here

The median-split procedure created higher and lower performing groups that had very large significant differences ($p \leq 0.001$, ES≥very large) in CDPR (all players) for the

entire season (Higher=1441±427; Lower=299±211), the first half of the season (Higher=749±206; Lower=121±148) and the first four games (Higher=294±93; Lower=24±41). For midfielders/nomadic players, large differences ($p \leq 0.001$, ES≥very large) were also observed for CDPR over the entire season (Higher=1453±439; Lower=356±204), first half of the season (Higher=766±218; Lower=232±142) and the first four games (Higher=302±89; Lower=82±47).

No significant differences existed between higher and lower performing groups for any pre-season training variables for CDPR (all players and midfielders/nomadic players only) measured across the entire season or the first half of the season. However, three pre-season training variables differentiated between the higher and lower groups for CDPR (all players) and four pre-season training variables for CDPR (midfielders/nomadic players only) across the first four games (Table 5).

Insert Table 5 about here

Pearson correlations were also conducted between the objective (CDPR all players) and subjective (coaches' ratings) performance indicators for the same corresponding period of the competitive season. Entire season ($r=0.983$, $p<0.001$), first half of the season ($r=0.970$, $p<0.001$) and first four games ($r=0.970$, $p<0.001$) all produced near perfect correlations. High collinearity suggests both methods are assessing the same characteristics of playing performance, and consequently, CR have not been presented.

Round 1 selection

Significant differences between the selected (n=22) and not-selected (n=14) groups were only observed for Total on-field sRPE post-Xmas (Selected=17236±1674au; Not-selected=15712±1975au; $p=0.018$, ES=0.85 [moderate]) and Total running duration post-Xmas (Selected=2300±177min; Not-selected=2157±232min; $p=0.044$, ES=0.72[moderate]).

Discussion

This is the first study investigating the association between pre-season training and in-season performance in elite AF. No pre-season training variables were significantly correlated with performance measured across the entire season and very few pre-season training variables significantly associated with performance across the first half of the season. However, numerous pre-season training variables were significantly associated with in-season performance across the first four games. This suggests that the relationship between pre-season training and in-season performance diminishes as the season progresses. Furthermore, pre-season training variables measured post-Christmas were more highly associated with performance than pre-season training variables which were quantified across the entire pre-season. This may allude that later pre-season load has a greater influence on early season performance.

Champion Data Player Rank

For all players, a moderate negative association was observed between Total off-field sRPE and CDPR across the first half of the season. This negative correlation may indicate that increased amounts of training load accumulated in off-field activities are associated with poorer match performance. While off-field activities (strength and

cross-training) contribute to overall training load, completing a higher proportion of training load in off-field activities may limit the potential to accumulate on-field training load, which is likely to be more specific to match performance. Across the first four games, Total on-field sRPE post-Xmas was the most highly associated with CDPR and was also the only pre-season training variable to display a large correlation (Table 3). This emphasises the importance of accumulating on-field load in the latter parts of pre-season to give players the greatest opportunity of performing well in the early parts of competition. The later stages of pre-season usually incorporates match simulation sessions in conjunction with competitive pre-season games which may significantly aid in improving match fitness before the official season commencement. Colby and colleagues[10] reported that injury incidence is the highest in the very late stages (pre-competition) of pre-season due to the introduction of competitive matches. However, restricting running loads in late pre-season may also increase players' injury vulnerability, as they may be underprepared for maximal exertion during competition[23]. Several external load monitoring variables also registered moderate correlations with CDPR (Total distance post-Xmas, Total run distance post-Xmas, Total high-speed running distance post-Xmas) further accentuating the importance of achieving on-field load in the latter parts of pre-season to increase performance in the initial stages of competition.

For analyses conducted on midfielders/nomadic players, it appeared that the only pre-season training variables significantly associated with CDPR were from across the first four games (Table 3). Of these four pre-season training variables, two were related to session participation (% of on-field sessions completed, % of sessions missed). Similarly, in elite AF, Murray, Gabbett, Townshend [1] discovered that players who completed ≥85% and 50-84.9% of on-field sessions were subsequently available for 76.7% and 76.1% of in-season competitive matches. However, players who completed <50% of on-field sessions in pre-season, were only available for 52% of in-season competitive matches. The authors suggested that players who completed a higher percentage of on-field training sessions across pre-season, may have been able to reach and maintain a high training load, allowing them to avoid injury and be more available to play.

For all players, the 11-combined significant pre-season training variables were able to account for 28.4% of the variability (i.e. adjusted R^2) in CDPR accrued across the first four games. However, Gastin and colleagues[24] found that total variability in match performance was significantly impacted by individual player characteristics (adjusted R^2=0.453). Although it was not within the scope of the study, combining pre-season training variables in the current study with individual player characteristics (eg. age, height, weight, playing experience) may have produced an even stronger relationship. A greater number of pre-season training variables were found to be significantly associated with CDPR when correlations were controlling for AFL age. Many of the significant variables found for the correlation were also existent in the partial correlations, but the magnitude of the association had increased. This depicts that the time players spend on an AFL list may have an influence on the association between pre-season training activities and in-season match performance, which has been reported previously[24].

For all players, both Total on-field sRPE and Total on-field sRPE post-Xmas were significantly associated with CDPR accrued across the first half of the season which

highlights the importance of on-field training load across the entire pre-season. However, many pre-season training variables were also associated with CDPR across the first four games with a large proportion being external load measures (GPS-derived). Numerous studies have investigated the association between measures of external load and subsequent injury[4,25,26]. Colby and colleagues[10] reported that a low total distance during pre-season was associated with greater in-season injury risk in elite AF. While no direct extrapolations can be made from those results, this study found both Total distance and Total distance post-Xmas to be significantly, positively associated with CDPR over the first four games. Collectively, these results suggest that accumulating on-field distance during pre-season is important to both injury risk reduction and better match performance. Furthermore, Total sprint distance across the pre-season was found to have no association with any performance measures; building on previous findings suggesting that cumulative sprint distance has no influence on injury risk over a competitive season[27].

For midfielders/nomadic players (compared to all players), fewer pre-season training variables were found to have significant associations with CDPR (Table 4), and is likely influenced by the smaller sample size. Of these significant variables, only one incorporated load that was accrued solely after the Christmas break (Total on-field sRPE post-Xmas), suggesting that training load accrued over the entire pre-season may be a better predictor of performance for this group. Three pre-season training variables relating to session participation were also significantly associated with CDPR for this group (% of on-field sessions completed, Number of sessions missed, % of total sessions missed). Considering the high percentage of running associated with midfielders as compared to key-position players[28], missing on-field sessions in pre-season may have a greater detrimental performance effect.

The only fitness testing variable examined in this study was aerobic fitness (e.g. 3km time-trial), which was not significantly associated with CDPR over any period of the season. Due to the high-intensity intermittent nature of AF, the 3km time-trial may not reflect the demands of AF match-play. Furthermore, performing the 3km time-trial 7.5 weeks out from the start of the season may not be a true indication of fitness levels immediately prior to round 1. This possibly explains the lack of association to performance here. Perhaps our results may have been different if fitness tests that better replicate the demands of AF (i.e. 30:15 Intermittent Fitness Test[29] or Yo-Yo test[14]) were adopted just prior to round 1. Of importance, other fitness measures such as strength, speed and agility (not measured in the current investigation) cannot be understated and could have an influence on performance.

Pre-season training variables could only differentiate between higher and lower performing groups for CDPR accrued across the first four games (Table 5). Significant moderate differences were observed for both Total on-field sRPE post-Xmas and Total off-field sRPE post-Xmas. These findings coincide with Murray, Gabbett, Townshend [1] who found that players not able to complete a specific on-field load, had to achieve their weekly load through off-legs conditioning and individually modified rehabilitation programs. Total running duration post-Xmas also appeared to be significantly greater in the higher performing group compared to the lower group. While no previous study has investigated the association between pre-season training and in-season performance, these results suggest that higher performing AF players are undertaking a greater on-field pre-season workload than their lower performing

counterparts, which may lead to improved fitness and consequently, a greater performance output. While our results suggest that post-Christmas training load is important for match performance, pre-Christmas training load is likely crucial in building resilience and a fitness base to be able to withstand the increasing training loads post-Christmas.

Rd 1 Selection

Selected players registered significantly greater Total on-field sRPE post-Xmas and Total running duration than not-selected players, further reiterating that on-field load post-Christmas is vital in preparing players for the start of competition. Numerous studies have examined physiological and anthropometric differences between starters and non-starters[2,18-20]. However, no study has examined the association between pre-season training loads and team selection. Interestingly, previous research in elite AF indicates that aerobic fitness was not significantly different between starters and non-starters in the first match of the competitive season[2,20]. Similarly, no significant differences in the 3km time-trial performance between selected and not-selected players were observed. Previous work suggests that starters versus non-starters in elite team sports tend to be quicker, older and have more playing experience[2,18,20]. Future research could examine the influence of pre-season training variables on different physiological qualities (strength, speed, agility, etc.) and examine their influence on performance.

Practical Applications

Fitness and coaching staff should consider prescribing programs for players to undertake greater post-Christmas pre-season training load. Additionally, sRPE can be a practical tool for measuring training load that is linked to performance (e.g. CDPR and/or CR). Despite higher on-field training loads being linked to improved early-season performance, careful attention to training load spikes should still be observed to limit injury risk. Additionally, pre-season training programs catering to specific player demands should be considered (e.g. playing position). Limitations of the current study include its observational nature, as such causal links cannot be established. Furthermore, as only one AF club was considered in the analysis, results might not be generalised to all AF teams and/or sporting codes. Future work should include multiple teams analysed over numerous competitive seasons to confirm our findings.

Conclusion

This is the first study to examine the association between pre-season training activities and subsequent in-season performance in elite Australian football players. While a relationship does exist between pre-season training activities and in-season performance, these findings suggest pre-season training may only have an influence on performance across the first four games. Pre-season training load measured post-Christmas is also a better predictor of in-season performance. These findings highlight the importance of accumulating on-field training load in pre-season, that is more specific to competitive match play. Finally, it appears that sRPE measured during on-field sessions is a good predictor of early in-season performance.

Acknowledgments

The authors would like to thank the Richmond Football Club for the use of their data and for supporting this study.

The authors declare there are no conflicts of interest to disclose.

References

1. Murray NB, Gabbett TJ, Townshend AD. Relationship between pre-season training load and in-season availability in elite Australian football players. *Int J Sports Physiol Perform.* 2016:1-21.
2. Young W, Newton RU, Doyle TL, et al. Physiological and anthropometric characteristics of starters and non-starters and playing positions in elite Australian rules football: a case study. *J Sci Med Sport.* 2005;8(3):333-345.
3. Veugelers KR, Young W, Fahrner B, Harvey JT. Different methods of training load quantification and their relationship to injury and illness in elite Australian football. *J Sci Med Sport.* 2016;19(1):24-28.
4. Piggott B, Newton MJ, McGuigan MR. The relationship between training load and incidence of injury and illness over a pre-season at an Australian Football League club. *J Aus Strength Cond.* 2008;17(3):4-17.
5. Garrett JM, McKeown I, Rogers DK. The improvement of strength performance during an Australian football pre-season. *J Aus Strength Cond.* 2016;24(7):6-11.
6. Rogalski B, Dawson B, Heasman J, Gabbett TJ. Training and game loads and injury risk in elite Australian footballers. *J Sci Med Sport.* 2013;16(6):499-503.
7. Newton B. Planning a mesocycle for an Australian rules football (AFL) pre-season program. *J Aus Strength Cond.* 2015;23(2):54-68.
8. Wundersitz DWT, Josman C, Gupta R, Netto KJ, Gastin PB, Robertson S. Classification of team sport activities using a single wearable tracking device. *J Biomech.* 2015;48(15):3975-3981.
9. Foster C, Florhaug JA, Franklin J, et al. A New Approach to Monitoring Exercise Training. *J Strength Cond Res.* 2001;15(1).
10. Colby M, Dawson B, Heasman J, et al. Preseason Workload Volume and High-Risk Periods for Noncontact Injury Across Multiple Australian Football League Seasons. *J Strength Cond Res.* 2017;31(7):1821-1829.
11. Helgerud J, Engen LC, Wisloff U, Hoff J. Aerobic endurance training improves soccer performance. *Med Sci Sports Exerc.* 2001;33(11):1925-1931.
12. Castagna C, Impellizzeri F, Cecchini E, Rampinini E, Alvarez JC. Effects of intermittent-endurance fitness on match performance in young male soccer players. *J Strength Cond Res.* 2009;23(7):1954-1959.
13. Varley MC, Fairweather IH, Aughey RJ. Validity and reliability of GPS for measuring instantaneous velocity during acceleration, deceleration, and constant motion. *J Sports Sci.* 2012;30(2):121-127.
14. Mooney M, O'Brien B, Cormack S, Coutts A, Berry J, Young W. The relationship between physical capacity and match performance in elite Australian football: A mediation approach. *J Sci Med Sport.* 2011;14(5):447-452.
15. Johnston RJ, Watsford ML, Pine MJ, Spurrs RW, Murphy A, Pruyn EC. Movement demands and match performance in professional Australian football. *Int J Sports Med.* 2012;33(2):89-93.
16. Heasman J, Dawson B, Berry J, Stewart G. Development and validation of a player impact ranking system in Australian football. *Int J Perform Anal Sport.* 2008;8(3):156-171.

17. Bauer AM, Young W, Fahrner B, Harvey J. GPS variables most related to match performance in an elite Australian football team. *Int J Perform Anal Sport.* 2015;15(1):187-202.
18. Gabbett TJ, Jenkins DG, Abernethy B. Relative importance of physiological, anthropometric, and skill qualities to team selection in professional rugby league. *J Sports Sci.* 2011;29(13):1453-1461.
19. Risso FG, Jalilvand F, Orjalo AJ, et al. Physiological characteristics of projected starters and non-starters in the field positions from a division 1 women's soccer team. *Int J Exerc Sci.* 2017;10(4):568-579.
20. Le Rossignol P, Gabbett TJ, Comerford D, Stanton WR. Repeated-sprint ability and team selection in Australian football league players. *Int J Sports Physiol Perform.* 2014;9(1):161-165.
21. Hopkins WG, Marshall SW, Batterham AM, Hanin J. Progressive statistics for studies in sports medicine and exercise science. *Med Sci Sports Exerc.* 2009;41(1):3-13.
22. Austin PC, Steyerberg EW. The number of subjects per variable required in linear regression analyses. *J Clin Epidemiol.* 2015;68(6):627-636.
23. Gabbett TJ. The training-injury prevention paradox: should athletes be training smarter & harder? *Br J Sports Med.* 2016:1-9.
24. Gastin PB, Fahrner B, Meyer D, Robinson D, Cook JL. Influence of physical fitness, age, experience, and weekly training load on match performance in elite Australian football. *J Strength Cond Res.* 2013;27(5):1272-1279.
25. Gabbett TJ, Ullah S. Relationship between running loads and soft-tissue injury in elite team sport athletes. *J Strength Cond Res.* 2012;26(4):953-960.
26. Varley MC, Gabbett TJ, Aughey RJ. Activity profiles of professional soccer, rugby league and Australian football match play. *J Sports Sci.* 2014;32(20):1858-1866.
27. Colby M, Dawson B, Heasman J, Rogalski B, Gabbett TJ. Accelerometer and GPS-derived running loads and injury risk in elite Australian footballers. *J Strength Cond Res.* 2014;28(8).
28. Wisbey B, Montgomery PG, Pyne DB, Rattray B. Quantifying movement demands of AFL football using GPS tracking. *J Sci Med Sport.* 2010;13(5):531-536.
29. Čović N, Jelešković E, Alić H, et al. Reliability, Validity and Usefulness of 30–15 Intermittent Fitness Test in Female Soccer Players. *Front Physiol.* 2016;7:510.

635 **Table 1.** Pre-season training variables analysed

Pre-season training variable	Description
External load monitoring variables	
Total duration (min)	Total time spent in on-field and off-field activities
Total on-field duration (min)	Total time spent in on-field activities
Total running duration (min)	Total time spent in on-field activities >1.7m·s^{-1}
Total off-field duration (min)	Total time spent in off-field activities
Total distance (m)	Total distance covered ≥0.0 m·s^{-1}
Total run distance (m)	Total distance covered ≥1.7 m·s^{-1}
Total high-speed running distance (m)	Total distance covered ≥5.5 m·s^{-1}
Total sprint distance (m)	Total distance covered ≥7.0 m·s^{-1}
Total Player Load (au)	Total Player Load accumulated
Total duration post-Xmas (min)	Total time spent in on-field and off-field activities after Christmas break
Total on-field duration post-Xmas (min)	Total time spent in on-field activities after Christmas break
Total running duration post-Xmas (min)	Total time spent in on-field activities ≥1.7m·s^{-1} after Christmas break
Total off-field duration post-Xmas (min)	Total time spent in off-field activities after Christmas break
Total distance post-Xmas (m)	Total distance covered ≥0.0m·s^{-1} after Christmas break
Total run distance post-Xmas (m)	Total distance covered ≥1.7m·s^{-1} after Christmas break
Total high-speed running distance post-Xmas (m)	Total distance covered ≥5.5m·s^{-1} after Christmas break
Total sprint distance post-Xmas (m)	Total distance covered ≥7.0m·s^{-1} after Christmas break
Total Player Load post-Xmas (au)	Total Player Load accumulated after Christmas break
Internal load monitoring variables	
Total on-field sRPE (au)	Accumulated session-RPE from on-field sessions only
Total off-field sRPE (au)	Accumulated session-RPE from off-field sessions only
Total on & off-field sRPE (au)	Accumulated session-RPE from all sessions
Total on-field sRPE post-Xmas (au)	Accumulated session-RPE from on-field sessions only after Christmas break
Total off-field sRPE post-Xmas (au)	Accumulated session-RPE from off-field sessions only after Christmas break
Total on & off-field sRPE post-Xmas (au)	Accumulated session-RPE from all sessions after Christmas break
Fitness testing	
Late pre-season time trial-time (TT) (s)	The last time-trial result that was measured in pre-season
Early TT – Late TT (s)	The difference in seconds between the first time-trial score and the last one that was conducted
Difference between Early and Late TT (%)	The percentage difference between the first time-trial score and the last one that was conducted
Training session participation	
% of sessions completed in full	% of on-field sessions prescribed that were fully completed
Number of sessions completed in full	# of on-field sessions prescribed that were fully completed
% of sessions completed partially	% of on-field sessions prescribed that were partially completed
Number of sessions completed partially	# of on-field sessions prescribed that were partially completed
% of sessions missed	% of on-field sessions prescribed that were missed with injury/illness
Number of sessions missed	# of on-field sessions prescribed that were missed with injury/illness
% of on-field sessions completed	% of total time in on-field sessions that were completed

636 au = arbitrary units; Player Load = exertion metric based on rate of change of acceleration across the three planes
637 of movement; sRPE = session Rating of Perceived Exertion; TT = time-trial; Xmas = Christmas
638

Table 2. Performance variables analysed

Performance measure	Season period	Description
Champion Data Player Rank (All Players)	Entire season	Champion Data ranking points accrued throughout the entire season for all players
	First half of season	Champion Data ranking points accrued throughout the first 11 games for all players
	First four games	Champion Data ranking points accrued throughout the first four games for all players
Champion Data Player Rank (Midfielders/nomadic players only)	Entire season	Champion Data ranking points accrued throughout the entire season for midfielders/nomadic players only
	First half of season	Champion Data ranking points accrued throughout the first 11 games for midfielders/nomadic players only
	First four games	Champion Data ranking points accrued throughout the first four games for midfielders/nomadic players only
Coaches' ratings	Entire season	Coaches ratings points accrued throughout the entire season
	First half of season	Coaches ratings points accrued throughout the first 11 games
	First four games	Coaches ratings points accrued throughout the first four games
Round 1 selection	Round 1	Whether or not a player was selected to play in the first game of the 2016 AFL premiership season

Table 3. Pre-season training variables with a Pearsons correlation coefficient of ≥0.30 with CDPR (all players and midfielders/nomadic players) across the first four games.

	All players (n=41)			Midfielders/nomadic players (n=28)		
First four games	**r-value**	**p-value**	**Correlation classification**	**r-value**	**p-value**	**Correlation classification**
Total on-field sRPE post-Xmas (au)	0.536	0.001	Large*	0.495	0.027	Moderate*
Total running duration post-Xmas (min)	0.498	0.001	Moderate*	0.412	0.071	Moderate
Total Player Load post-Xmas (au)	0.379	0.015	Moderate*	0.335	0.148	Moderate
Total off-field sRPE post-Xmas (au)	-0.374	0.016	Moderate*	-0.335	0.149	Moderate
Total on-field sRPE (au)	0.368	0.018	Moderate*	0.489	0.029	Moderate*
Total distance post-Xmas (m)	0.365	0.019	Moderate*			
Total high-speed running distance post-Xmas (m)	0.356	0.022	Moderate*	0.322	0.166	Moderate
Total run distance post-Xmas (m)	0.332	0.034	Moderate*			
Total off-field sRPE (au)	-0.332	0.034	Moderate*	-0.315	0.176	Moderate
Total off-field duration post-Xmas (min)	0.329	0.036	Moderate*	-0.370	0.108	Moderate
Total running duration (m)	0.326	0.038	Moderate*	0.435	0.056	Moderate
% of on-field sessions completed				0.493	0.027	Moderate*
% of sessions missed				-0.443	0.050	Moderate*
Total distance (m)				0.306	0.189	Moderate
Total high-speed running distance (m)				0.362	0.116	Moderate
Total Player Load (au)				0.374	0.105	Moderate
Total off-field duration (min)				-0.308	0.187	Moderate
Number of sessions completed in full				0.376	0.102	Moderate
% of sessions completed in full				0.412	0.071	Moderate
Number of sessions missed				-0.440	0.052	Moderate

*pre-season training variables that fitted the criteria of $p \leq 0.05$ and $r \geq 0.30$ and were included in the regression model.

Table 4. Pre-season training variables with a correlation coefficient of ≥0.30 following partial correlations (controlling for AFL age) with CDPR (all players and midfielders/nomadic players) across the first four games.

	All players (n=41)			Midfielders/nomadic players (n=28)		
First four games	**r-value**	**p-value**	**Correlation classification**	**r-value**	**p-value**	**Correlation classification**
Total on-field sRPE post-Xmas (au)	0.592	<0.001	Large*	0.523	0.022	Large*
Total running duration post-Xmas (min)	0.571	<0.001	Large*	0.450	0.053	Moderate
Total Player Load post-Xmas (au)	0.502	0.001	Large*	0.409	0.082	Moderate
Total on-field sRPE (au)	0.482	0.002	Moderate*	0.565	0.012	Large*
Total distance post-Xmas (m)	0.480	0.002	Moderate*	0.337	0.158	Moderate
Total running duration (min)	0.473	0.002	Moderate*	0.537	0.018	Large*
Total run distance post-Xmas (m)	0.464	0.003	Moderate*	0.321	0.181	Moderate
Total high-speed running distance post-Xmas (m)	0.450	0.004	Moderate*	0.376	0.113	Moderate
Total Player Load (au)	0.427	0.006	Moderate*	0.498	0.030	Moderate*
Total high-speed running distance (m)	0.425	0.006	Moderate*	0.459	0.048	Moderate*
Total off-field sRPE post-Xmas (au)	-0.418	0.007	Moderate*	-0.357	0.134	Moderate
Total off-field duration post-Xmas (min)	-0.408	0.009	Moderate*	-0.417	0.075	Moderate
Total on-field duration post-Xmas (min)	0.405	0.009	Moderate*	0.327	0.171	Moderate
Total distance (m)	0.404	0.010	Moderate*	0.423	0.071	Moderate
Total run distance (m)	0.397	0.011	Moderate*	0.402	0.088	Moderate
Total on-field duration (min)	0.363	0.021	Moderate*	0.432	0.065	Moderate
Number of sessions completed in full	0.348	0.028	Moderate*	0.429	0.067	Moderate
% of sessions completed in full	0.335	0.035	Moderate*	0.442	0.058	Moderate
% of on-field sessions completed				0.516	0.024	Large*
% of sessions missed				-0.470	0.042	Moderate*
Number of sessions missed				-0.457	0.048	Moderate*
Early TT - Late TT (s)				0.314	0.236	Moderate
Difference between Early TT and Late TT (%)				0.316	0.233	Moderate

*pre-season training variables that fitted the criteria of p≤0.05 and r≥0.30.

Table 5. Pre-season training variables that met the criteria (p≤0.05 and ES≥0.60) or had a trend to be different (ES≥0.60) between the higher and lower performing groups for CDPR (all players and midfielders/nomadic players) measured across the first four games (mean ± SD).

	All players (n=41)				Midfielders/nomadic players (n=28)			
First four games	**Lower** (n=20)	**Higher** (n=20)	**p-value**	**ES** (descriptor)	**Lower** (n=14)	**Higher** (n=14)	**p-value**	**ES** (descriptor)
Total on-field sRPE post-Xmas (au)	15102 ± 2619	17326 ± 1679	0.003	1.01* (moderate)	14831 ± 2806	17381 ± 1564	0.006	1.12* (moderate)
Total on-field sRPE (au)					21510 ± 5104	25946 ± 3060	0.01	1.05* (moderate)
Total running duration (min)					2947 ± 592	3446 ± 358	0.012	1.02* (moderate)
Total running duration post-Xmas (min)	2097 ± 288	2305 ± 186	0.010	0.85* (moderate)	2073 ± 328	2322 ± 170	0.021	0.95* (moderate)
Total off-field sRPE post-Xmas (au)	16747 ± 3591	14627 ± 1774	0.025	-0.75* (moderate)	16627 ± 4229	14326 ± 1627	0.059	-0.75 (moderate)
Total on-field duration (min)					4775 ± 917	5327 ± 579	0.068	0.72 (moderate)
Total off-field duration post-Xmas (min)					2433 ± 584	2129 ± 174	0.074	-0.71 (moderate)
% of sessions missed					22 ± 30	7 ± 10	0.101	-0.64 (moderate)
% of on-field sessions completed					66 ± 29	80 ± 12	0.113	0.62 (moderate)

*pre-season training variables that fitted the criteria of p≤0.05 and ES≥0.60.