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Association between preseason training and performance in elite Australian football

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

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10 Original Investigation

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19 **RUNNING HEAD:** Pre-season training and performance

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41 **ABSTRACT**

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43 **Purpose:** To examine the association between pre-season training variables and
44 subsequent in-season performance in an elite Australian football team. **Methods:** Data
45 from forty-one elite male Australian footballers (mean±SD: age=23.4±3.1y;
46 height=188.4±7.1cm; mass=86.7±7.9kg) was collected from one Australian Football
47 League (AFL) club. Pre-season training data (external load, internal load, fitness
48 testing and session participation) were collected across the 17-week pre-season phase
49 (6-weeks pre-Christmas, 11-weeks post-Christmas). Champion Data© Player Rank
50 (CDPR), coaches' ratings (CR) and round one selection were used as in-season
51 performance measures. CDPR and CR were examined over the entire season, first half
52 of the season and the first four games. Both Pearson and partial (controlling for AFL
53 age) correlations were calculated to assess if any associations existed between pre-
54 season training variables and in-season performance measures. A median-split was
55 also employed to differentiate between higher and lower performing players for each
56 performance measure. **Results:** Pre-season training activities appeared to have almost
57 no association with performance measured across the entire season and the first half
58 of the season. However, many pre-season training variables were significantly linked
59 with performance measured across the first four games. Pre-season training variables
60 that were measured post-Christmas were the most strongly associated with in-season
61 performance measures. Specifically, Total on-field session rating of perceived
62 exertion (sRPE) post-Xmas, a measurement of internal load, displayed the greatest
63 association with performance. **Conclusions:** Late pre-season training (especially on-
64 field match specific training) is associated with better performance in the early season.
65 **Key words:** Workload, Preparation, Competition, Team Sport, AFL

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90 **Introduction**

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92 Australian football (AF) is a field-based team sport requiring various elements of
93 physical fitness¹⁻³. A typical match lasts around 120 minutes, played over four
94 quarters⁴ where players cover around 11-14km⁵. To compete at this level, professional
95 AF players undertake rigorous pre-season training from November, up until the
96 commencement of the competitive season at the end of March.

97

98 In elite AF, most clubs will undertake three main on-field and four main off-field
99 sessions per week during the pre-season phase⁶. To optimise physiological adaptation,
100 they are usually accompanied by recovery and injury prevention sessions such as
101 massage, yoga and hydrotherapy⁷. On-field sessions are commonly monitored using
102 Global Positioning System (GPS) technology, providing measures of external load
103 such as total distance and distances covered in various speed zones⁸. Especially in
104 early pre-season, players may cover up to 35km a week during on-field sessions,
105 undertaking a combination of skill, development and conditioning sessions⁷. However,
106 off-field session load is commonly calculated by multiplying a subjective measure of
107 session intensity, the rating of perceived exertion (RPE), by the duration of the session
108 in minutes to form a session-load score^{3,9}. Fitness staff then combine both these
109 methods to calculate a universal loading figure^{3,6}.

110

111 Avoiding injury during the pre-season phase can maximise players' opportunity to
112 build a solid fitness base, that is likely beneficial when dealing with the demands of
113 the competitive season¹⁰. Recently, Murray, Gabbett, Townshend¹ explored the
114 association between pre-season training and match availability in elite AF. It was
115 discovered that players who completed a greater proportion of pre-season training
116 were more likely to avoid injury. Consequently, these players were available for a
117 greater number of in-season competitive matches, compared to players who completed
118 less pre-season training. Similarly, Colby and colleagues¹⁰ reported elite AF players
119 who had accumulated a low total distance across the pre-season phase were
120 significantly more susceptible at succumbing to injury during the competitive season.
121 This suggests that inadequate pre-season training load may be a risk factor for
122 subsequent injury, while highlighting the importance of achieving appropriate pre-
123 season training load. Furthermore, a positive correlation has also been observed
124 between fitness levels and physiological match performance in team sport athletes^{11,12}.
125 What is unclear however, is whether greater pre-season training loads are conducive
126 to an increase in subsequent match performance.

127

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

138

139 **Methods**

140

141 **Subjects**

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

150

151 **Design**

152 This retrospective cohort study involved the use of existing data from the participating
153 club's database. Pre-season training data (6 weeks pre-Christmas, 11 weeks post-
154 Christmas) were gathered from the first session on November 13, 2015 until the
155 commencement of the 2016 AFL premiership season on March 24. The players had a
156 16-day Christmas break (19th December – 3rd January) where they were provided with
157 a home-based training program to ensure fitness levels were maintained, but no
158 training data was collected. The team also participated in three pre-season friendly
159 games against other AFL teams between mid-February and early-March in the lead-
160 up to the competitive season. These were incorporated into overall on-field training
161 load. Pre-season training variables were grouped under one of four categories; external
162 load variables, internal load variables, fitness testing or session participation and were
163 measured over the entire pre-season and post-Christmas alone (Table 1). This was
164 performed due to the increased training load and intensity in the post-Christmas
165 training sessions. Individual performance data were collected after each game, over
166 the 22-game season which included Champion Data© Player Rank (CDPR) and
167 coaches' ratings (CR) split into three phases (first four games, first half of season and
168 entire season) as it was believed that the influence of pre-season training on in-season
169 performance would diminish as the season progressed. Round one selection was also
170 used as a performance indicator.

171

172 **Methodology**

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

180 As a subjective measure of training load, an intensity measure of training was provided
181 by each player using a modified Rating of Perceived Exertion (RPE) scale⁹ similar to
182 previous work³. RPE was then multiplied by the session duration to form session load
183 (session-RPE [sRPE]). A total sRPE value was then calculated across the pre-season
184 for on-field, off-field and both forms inclusively (Table 1).

185

186

Insert Table 1 about here

187

188 CDPR was used as a performance measure and is based on official AFL statistics that
189 players accumulate during a game (Champion Data©, Melbourne, Australia). The
190 CDPR algorithm, which has been developed to rate player performance during
191 matches, is widely accepted within the Australian football industry. The statistics that
192 make up CDPR are collected in real-time by trained professionals with a final
193 correction of statistics conducted post-game by reviewing the match footage in
194 depth¹⁴. The formula is weighted towards efficient ball use and gaining possession of
195 the ball in a contested situation, so a separate analysis was conducted on
196 midfielders/nomadic players to reduce bias in the analysis¹⁴⁻¹⁶.

197

198 CR are a subjective measure of performance, assessing the ability of each player to
199 fulfil their role during the match, based on team game-plan requirements. With the aid
200 of video footage, the head coach, two assistant coaches and three line coaches would
201 meet post-game and assign a rating to each player based on a scale of 1-5
202 (1=significantly underperformed to AFL standard; 2= underperformed to AFL
203 standard; 3= performed to AFL standard; 4= performed above AFL standard and; 5=
204 significantly performed above AFL standard)¹⁷. Players who sustained an injury
205 during a specific game were exempt from a rating.

206

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

213

214

Insert Table 2 about here

215

216 **Statistical Analysis**

217 Pearson correlations were initially performed between all pre-season training
218 measures and in-season performance indicators. Correlation coefficients were
219 classified as 0-0.09=Trivial; 0.1-0.29=Small; 0.3-0.49=Moderate; 0.5-0.69=Large and
220 0.7-0.89=Very large; 0.9-0.99=Near perfect²¹. A meaningful relationship was defined
221 as having both statistical significance ($p \leq 0.05$) and a magnitude that was considered
222 at least moderate ($r \geq 0.30$)²¹.

223

224 Following the Pearson correlations, pre-season training variables that produced a
225 meaningful relationship ($p \leq 0.05$ and $r \geq 0.30$) with performance indicators were added
226 into a multiple linear regression (using the Enter method). A rule of two participants
227 per variable was followed which has been used in previous research²² allowing the use
228 of a maximum of 20 pre-season training variables to be added into the regression for
229 each performance indicator. Consequently, a regression was conducted for
230 performance across the first four games (CDPR all players and midfielders/nomadic
231 players and CR) as this was the only time multiple significant pre-season training
232 variables were observed.

233

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

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

241

242 Finally, a median-split was implemented to separate players into a higher and lower
243 performing group according to CDPR and CR accumulated across each of the three
244 phases (first four games, first half of season, entire season). Two-sample independent
245 t-tests were adopted to examine whether any differences existed for pre-season
246 training variables between the two groups for each performance measure. The
247 magnitude of the difference between the groups was assessed using Cohen's *d* effect
248 sizes (ES)²¹. Effect sizes were used as follows; 0.00-0.19-Trivial, 0.20-0.59-Small,
249 0.60-1.19-Moderate, 1.20-1.99-Large, 2.00-3.99-Very large, >4.00-Nearly perfect.
250 The difference between higher and lower performing groups was considered
251 meaningful if there was statistical significance ($p \leq 0.05$) and the effect size was at least
252 moderate (≥ 0.60). Statistical analysis was undertaken using the IBM software
253 Statistical Package for the Social Sciences (SPSS, version. 23.0, IBM Corporations,
254 Somers, New York, USA).

255

256 **Results**

257

258 ***Champion Data Player Rank***

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

266

267 *Insert Table 3 about here*

268

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

274

275 Partial correlations produced two pre-season training variables that were significantly
276 associated with CDPR accrued across the first half of the season (Total on-field sRPE
277 post-Xmas; $r = 0.337$ [moderate], $p = 0.033$; Total on-field sRPE; $r = 0.312$ [moderate],
278 $p = 0.050$). No significant variables were associated with CDPR (all players) accrued
279 over the entire season. Additionally, eight significant pre-season training variables
280 were discovered for performance across the first four games (Table 4). Additionally,
281 pre-season training variables were only significantly related to CDPR for
282 midfielders/nomadic players over the first four games (Table 4).

283

284 *Insert Table 4 about here*

285

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

288 entire season (Higher=1441±427; Lower=299±211), the first half of the season
289 (Higher=749±206; Lower=121±148) and the first four games (Higher=294±93;
290 Lower=24±41). For midfielders/nomadic players, large differences ($p \leq 0.001$,
291 $ES \geq$ very large) were also observed for CDPR over the entire season
292 (Higher=1453±439; Lower=356±204), first half of the season (Higher=766±218;
293 Lower=232±142) and the first four games (Higher=302±89; Lower=82±47).

294

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

301

302

Insert Table 5 about here

303

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

311

312 **Round 1 selection**

313 Significant differences between the selected ($n=22$) and not-selected ($n=14$) groups
314 were only observed for Total on-field sRPE post-Xmas (Selected=17236±1674au;
315 Not-selected=15712±1975au; $p=0.018$, $ES=0.85$ [moderate]) and Total running
316 duration post-Xmas (Selected=2300±177min; Not-selected=2157±232min; $p=0.044$,
317 $ES=0.72$ [moderate]).

318

319 **Discussion**

320

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

332

333 **Champion Data Player Rank**

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

338 cross-training) contribute to overall training load, completing a higher proportion of
339 training load in off-field activities may limit the potential to accumulate on-field
340 training load, which is likely to be more specific to match performance. Across the
341 first four games, Total on-field sRPE post-Xmas was the most highly associated with
342 CDPR and was also the only pre-season training variable to display a large correlation
343 (Table 3). This emphasises the importance of accumulating on-field load in the latter
344 parts of pre-season to give players the greatest opportunity of performing well in the
345 early parts of competition. The later stages of pre-season usually incorporates match
346 simulation sessions in conjunction with competitive pre-season games which may
347 significantly aid in improving match fitness before the official season commencement.
348 Colby and colleagues¹⁰ reported that injury incidence is the highest in the very late
349 stages (pre-competition) of pre-season due to the introduction of competitive matches.
350 However, restricting running loads in late pre-season may also increase players' injury
351 vulnerability, as they may be underprepared for maximal exertion during
352 competition²³. Several external load monitoring variables also registered moderate
353 correlations with CDPR (Total distance post-Xmas, Total run distance post-Xmas,
354 Total high-speed running distance post-Xmas) further accentuating the importance of
355 achieving on-field load in the latter parts of pre-season to increase performance in the
356 initial stages of competition.

357

358 For analyses conducted on midfielders/nomadic players, it appeared that the only pre-
359 season training variables significantly associated with CDPR were from across the
360 first four games (Table 3). Of these four pre-season training variables, two were related
361 to session participation (% of on-field sessions completed, % of sessions missed).
362 Similarly, in elite AF, Murray, Gabbett, Townshend¹ discovered that players who
363 completed $\geq 85\%$ and 50-84.9% of on-field sessions were subsequently available for
364 76.7% and 76.1% of in-season competitive matches. However, players who completed
365 $< 50\%$ of on-field sessions in pre-season, were only available for 52% of in-season
366 competitive matches. The authors suggested that players who completed a higher
367 percentage of on-field training sessions across pre-season, may have been able to reach
368 and maintain a high training load, allowing them to avoid injury and be more available
369 to play.

370

371 For all players, the 11-combined significant pre-season training variables were able to
372 account for 28.4% of the variability (i.e. adjusted R^2) in CDPR accrued across the first
373 four games. However, Gastin and colleagues²⁴ found that total variability in match
374 performance was significantly impacted by individual player characteristics (adjusted
375 $R^2=0.453$). Although it was not within the scope of the study, combining pre-season
376 training variables in the current study with individual player characteristics (eg. age,
377 height, weight, playing experience) may have produced an even stronger relationship.
378 A greater number of pre-season training variables were found to be significantly
379 associated with CDPR when correlations were controlling for AFL age. Many of the
380 significant variables found for the correlation were also existent in the partial
381 correlations, but the magnitude of the association had increased. This depicts that the
382 time players spend on an AFL list may have an influence on the association between
383 pre-season training activities and in-season match performance, which has been
384 reported previously²⁴.

385

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

388 highlights the importance of on-field training load across the entire pre-season.
389 However, many pre-season training variables were also associated with CDPR across
390 the first four games with a large proportion being external load measures (GPS-
391 derived). Numerous studies have investigated the association between measures of
392 external load and subsequent injury^{4,25,26}. Colby and colleagues¹⁰ reported that a low
393 total distance during pre-season was associated with greater in-season injury risk in
394 elite AF. While no direct extrapolations can be made from those results, this study
395 found both Total distance and Total distance post-Xmas to be significantly, positively
396 associated with CDPR over the first four games. Collectively, these results suggest
397 that accumulating on-field distance during pre-season is important to both injury risk
398 reduction and better match performance. Furthermore, Total sprint distance across the
399 pre-season was found to have no association with any performance measures; building
400 on previous findings suggesting that cumulative sprint distance has no influence on
401 injury risk over a competitive season²⁷.

402

403 For midfielders/nomadic players (compared to all players), fewer pre-season training
404 variables were found to have significant associations with CDPR (Table 4), and is
405 likely influenced by the smaller sample size. Of these significant variables, only one
406 incorporated load that was accrued solely after the Christmas break (Total on-field
407 sRPE post-Xmas), suggesting that training load accrued over the entire pre-season
408 may be a better predictor of performance for this group. Three pre-season training
409 variables relating to session participation were also significantly associated with
410 CDPR for this group (% of on-field sessions completed, Number of sessions missed,
411 % of total sessions missed). Considering the high percentage of running associated
412 with midfielders as compared to key-position players²⁸, missing on-field sessions in
413 pre-season may have a greater detrimental performance effect.

414

415 The only fitness testing variable examined in this study was aerobic fitness (e.g. 3km
416 time-trial), which was not significantly associated with CDPR over any period of the
417 season. Due to the high-intensity intermittent nature of AF, the 3km time-trial may not
418 reflect the demands of AF match-play. Furthermore, performing the 3km time-trial 7.5
419 weeks out from the start of the season may not be a true indication of fitness levels
420 immediately prior to round 1. This possibly explains the lack of association to
421 performance here. Perhaps our results may have been different if fitness tests that
422 better replicate the demands of AF (i.e. 30:15 Intermittent Fitness Test²⁹ or Yo-Yo
423 test¹⁴) were adopted just prior to round 1. Of importance, other fitness measures such
424 as strength, speed and agility (not measured in the current investigation) cannot be
425 understated and could have an influence on performance.

426

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

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

443

444 ***Rd 1 Selection***

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

459

460 **Practical Applications**

461

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

473

474 **Conclusion**

475

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

485

486 **Acknowledgments**

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489 and for supporting this study.

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

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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 $>1.7\text{m}\cdot\text{s}^{-1}$
Total off-field duration (min)	Total time spent in off-field activities
Total distance (m)	Total distance covered $\geq 0.0\text{ m}\cdot\text{s}^{-1}$
Total run distance (m)	Total distance covered $\geq 1.7\text{ m}\cdot\text{s}^{-1}$
Total high-speed running distance (m)	Total distance covered $\geq 5.5\text{ m}\cdot\text{s}^{-1}$
Total sprint distance (m)	Total distance covered $\geq 7.0\text{ m}\cdot\text{s}^{-1}$
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 $\geq 1.7\text{m}\cdot\text{s}^{-1}$ 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 $\geq 0.0\text{m}\cdot\text{s}^{-1}$ after Christmas break
Total run distance post-Xmas (m)	Total distance covered $\geq 1.7\text{m}\cdot\text{s}^{-1}$ after Christmas break
Total high-speed running distance post-Xmas (m)	Total distance covered $\geq 5.5\text{m}\cdot\text{s}^{-1}$ after Christmas break
Total sprint distance post-Xmas (m)	Total distance covered $\geq 7.0\text{m}\cdot\text{s}^{-1}$ 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

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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

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

First four games	All players (n=41)			Midfielders/nomadic players (n=28)		
	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

667 *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.

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

First four games	All players (n=41)			Midfielders/nomadic players (n=28)		
	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

673 *pre-season training variables that fitted the criteria of $p \leq 0.05$ and $r \geq 0.30$.

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

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

676 *pre-season training variables that fitted the criteria of $p \leq 0.05$ and $ES \geq 0.60$.

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