

1 RUNNING HEAD: Pre-season load and in-season availability

2

3 **Relationship between pre-season training load and in-season availability in elite**  
4 **Australian Football players**

5

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19 *Submission Type:* Original Investigation

20 *Abstract Word Count:* 234 Words

21 *Text-Only Word Count:* 3138 Words

22 *Number of Figures and Tables:* 2 figures; 1 table

23 *Number of References:* 29

24

25 **KEY WORDS:** GPS; Training; Competition; Load; Injury

26 **ABSTRACT**

27

28 **Objectives:** Investigate the relationship between the proportion of pre-season training sessions  
29 completed, and load and injury during the ensuing Australian Football League season.

30 **Design:** Single cohort, observational study.

31 **Methods:** Forty-six elite male Australian football players from one club participated in this  
32 study. Players were divided into three equal groups based on the amount of pre-season  
33 training completed (high, HTL, >85% sessions completed; medium, MTL, 50-85% sessions  
34 completed, and low, LTL, <50% sessions completed). Global Positioning System (GPS)  
35 technology was used to record training and game loads, with all injuries recorded and  
36 classified by club medical staff. Differences between groups were analysed using a two-way  
37 (group x training/competition phase) repeated measures ANOVA, along with magnitude-  
38 based inferences. Injury incidence was expressed as injuries per 1,000 hours.

39 **Results:** The HTL and MTL group completed a greater proportion of in-season training  
40 sessions (81.1% and 74.2%) and matches (76.7% and 76.1%) than the LTL (56.9% and  
41 52.7%) group. Total distance and Player load were significantly greater during the first half of  
42 the in-season period for the HTL ( $p=0.03$ ,  $ES=0.88$ ) and MTL ( $p=0.02$ ,  $ES=0.93$ ) groups than  
43 the LTL group. The relative risk of injury for the LTL group (26.8/1,000 hours) was 1.9 times  
44 greater than the HTL group (14.2/1,000 hours) ( $\chi^2=3.48$ ,  $df=2$ ,  $p=0.17$ ).

45 **Conclusions:** Completing a greater proportion of pre-season training resulted in higher  
46 training loads and greater participation in training and competition during the competitive  
47 phase of the season.

## 48 **Introduction**

49

50 During Australian football (AF) match-play, players are required to perform repeated high-  
51 speed (i.e. sprinting, running) efforts and physical contacts, interspersed with low-speed (i.e.  
52 jogging, walking) movements.<sup>1,2</sup> In order to reach and maintain the required level of physical  
53 activity throughout a match, strength and conditioning staff are required to prescribe adequate  
54 training loads to enhance physical qualities, while also minimizing the negative responses to  
55 training (e.g. fatigue, illness, and injury).<sup>3,4</sup> As previously suggested,<sup>5</sup> an inadequate training  
56 stimulus will fail to elicit the required physiological adaptation, while an excessive training  
57 stimulus, with inadequate recovery periods may increase the risk of injury or illness.

58

59 During the competitive season, it is difficult to prescribe a training stimulus sufficient to  
60 enhance fitness, as time to allow recovery between matches is required.<sup>6</sup> Accordingly, the pre-  
61 season period is seen as a crucial period to develop physical qualities to meet the required  
62 level of physical demands during match-play.<sup>4</sup> Previously, training loads during the pre-  
63 season period have been reported as 2–4 times greater than during the in-season period,<sup>7,8</sup> and  
64 consequently the accurate control of training loads during this period is essential to both  
65 maximize positive training adaptations, and minimize the negative training response.<sup>7-9</sup> The  
66 relationship between training load and incidence of injury and illness over a pre-season period  
67 has been analyzed, with Piggott et al.<sup>10</sup> reporting no significant relationships between injuries  
68 or illness and training load across this period. However these findings should be interpreted  
69 with some caution due to the small number of injuries (n = 5) and study duration (a 15-week  
70 pre-season). Further research and larger studies are required to provide a more comprehensive  
71 understanding of the relationship between load and injury during the pre-season period, and  
72 the ensuing in-season period, including early season and late season.

73

74 The physical demands of AF have increased over the last decade,<sup>11</sup> and soft tissue injuries  
75 remain the most common injury in the game.<sup>12</sup> Previously, it has been shown that high  
76 training loads, or inadequate recovery periods can increase the risk of soft tissue injury in elite  
77 team sport athletes.<sup>13,14</sup> As such, an increased emphasis has been placed on quantifying loads  
78 during training and competition, to determine the relationship between load and injury.<sup>13,15,16</sup>  
79 Specifically, in sub-elite rugby league players, increases in session-RPE training load have  
80 been associated with increases in the likelihood of injury.<sup>5</sup> In addition, recent work by  
81 Rogalski et al.<sup>15</sup> in AF showed that larger 1-weekly (>1750 arbitrary units, OR = 2.44 – 3.38),  
82 2-weekly (>4000 arbitrary units, OR = 4.74), and previous-to-current week changes in load  
83 (>1250 arbitrary units, OR = 2.58) were significantly related to an increased injury risk during  
84 the in-season period. Similarly, during a pre-season training block, greater 3-weekly distance  
85 covered (OR = 5.49, p = 0.008) and 3-weekly sprint distance (OR = 3.67, p = 0.074) were  
86 associated with a higher non-contact soft tissue injury risk during the pre-season period.<sup>16</sup>

87

88 Recent investigations into the relationship between load and injury, and load and performance  
89 have investigated the acute:chronic load ratio, i.e. the load performed in 1 week (acute load)  
90 relative to the average of the previous four weeks (chronic load).<sup>17-19</sup> Specifically, in elite  
91 cricket fast bowlers, it has been shown that high loads over a chronic period (i.e. 4-weeks)  
92 results in positive physiological adaptations that potentially minimize the fatigue response,  
93 and in turn reduce the likelihood of injury.<sup>17</sup> Similarly, Hulin et al.<sup>18</sup> reported that elite rugby  
94 league players with a high chronic load, compared to those with a low chronic load, were  
95 more resistant to injury when acute load was similar to chronic load (i.e. acute:chronic load  
96 ratio ~0.8-1.3).<sup>18</sup> Collectively, these findings suggest that high chronic loads, coupled with  
97 moderate acute:chronic load ratios may provide a protective effect against injury.<sup>17-19</sup>

98

99 Recent work from elite rugby league has shown that players who completed a greater  
100 proportion of the planned pre-season experienced a lower incidence and severity of injuries  
101 during the competitive phase of the season.<sup>20</sup> While studies have explored the relationship  
102 between load and injury in elite AF players, there is limited research that has investigated the  
103 relationship between the proportion of pre-season training sessions completed, and  
104 subsequent training and match loads and injury risk in the ensuing season. Therefore, it was  
105 the aim of the present study to investigate the relationship between the proportion of pre-  
106 season training completed and subsequent in-season load, match availability, and injury risk  
107 in the ensuing season in elite Australian football players.

108

## 109 **Methods**

110

### 111 *Subjects*

112 Forty-six elite Australian football players from one professional Australian Football League  
113 (AFL) club (mean  $\pm$  SD age, 23.1  $\pm$  3.7 years; height, 189.2  $\pm$  7.1 cm; mass, 87.0  $\pm$  8.2 kg)  
114 participated in this study. All participants received a clear explanation of the study, including  
115 information on the risks and benefits of participation. The Australian Catholic University  
116 Human Research Ethics Committee approved all experimental procedures (Approval Number  
117 182E).

118

### 119 *Training and Competition Loads*

120 Participants were fitted with a 10 Hz GPS (Global Positioning System) unit (Optimeye S5,  
121 Catapult Innovations, Melbourne, Victoria, Australia) during data collection. The GPS unit  
122 also housed a tri-axial accelerometer, gyroscope, and magnetometer sampling at 100 Hz to  
123 provide information on the movement demands during training and competition. Participants  
124 were equally divided into thirds and assigned to a high (HTL, completed > 85% of pre-season  
125 sessions, n = 15), medium (MTL, completed 50-84.9% of pre-season sessions, n = 16), or low  
126 (LTL, completed <50% of pre-season sessions, n = 15) training load group at the beginning of  
127 the competitive season based on the percentage of main pre-season sessions completed. The  
128 characteristics of players in each group were as follows; HTL group (mean  $\pm$  SD age, 22.8  $\pm$   
129 2.9 years; playing experience, 3.9  $\pm$  2.6 years; percentage of pre-season spent in rehabilitation  
130 group, 4.6  $\pm$  4.3 %), MTL group (mean  $\pm$  SD age, 23.3  $\pm$  3.8 years; playing experience, 5.0  $\pm$   
131 3.5 years; percentage of pre-season spent in rehabilitation group, 21.8  $\pm$  11.5 %), LTL group  
132 (mean  $\pm$  SD age, 22.8  $\pm$  4.2 years; playing experience, 4.7  $\pm$  4.3 years; percentage of pre-  
133 season spent in rehabilitation group, 46.0  $\pm$  33.5 %). While it would have been ideal for all  
134 players to complete all training sessions, on occasions, players were required to undertake  
135 modified training activities in order to minimize excessive fatigue and injury risk. The types  
136 of training sessions were main training sessions, modified training sessions, and rehabilitation  
137 training sessions. Main training sessions reflected completion of the total prescribed sessions  
138 comprised of running and speed along with skills; modified training sessions reflected partial  
139 completion of prescribed sessions; and rehabilitation sessions reflected completion of an  
140 individualized injury-specific return-to-play program.

141

142 Training and match loads were categorized cumulatively into the following variables; (1) total  
143 distance (TD, m), (2) low-speed distance (LSD, 0.00–6.00 km.hr<sup>-1</sup>), (3) moderate-speed  
144 distance (MSD, 6.01–18.00 km.hr<sup>-1</sup>), (4) high-speed distance (HSD, 18.01–24.00 km.hr<sup>-1</sup>), (5)  
145 very high-speed distance (VHSD, >24.00 km.hr<sup>-1</sup>), and (6) player load (PL, au). This  
146 technology has demonstrated adequate validity and reliability for accurate measurement of  
147 velocity, distance, acceleration, and player load.<sup>21,22</sup> Player load was measured as a modified

148 vector magnitude using accelerometer data from the microtechnology unit. It is expressed as  
149 the square root of the sum of the squared instantaneous rate of change in acceleration in each  
150 of the three vectors (X, Y, and Z axis) and divided by 100.<sup>21</sup> In addition, all injuries were  
151 classified by medical staff at the football club with injury reports maintained and updated  
152 daily throughout the season. An injury was recorded if it occurred during training or  
153 competition and resulted in a missed match.<sup>15</sup> Injuries were categorized according to injury  
154 type (description) and body site (location).

### 155 156 **Statistical Analysis**

157 Data were analyzed using SPSS 22.0 (SPSS Inc., Chicago, IL, USA), where load variables in;  
158 1) the pre- and in-season period, and 2) the first and second half of the in-season period were  
159 compared using a two-way (load group x training/competition phase) repeated measures  
160 ANOVA. If significant main effects were found, Bonferroni post hoc analyses were used to  
161 determine the source/s of the differences. Data were checked for normality using a Shapiro-  
162 Wilk test, and a Pearson's product moment correlation coefficient was used to assess the  
163 relationships among: percentage of pre-season completed, match availability, pre-season  
164 training load, and in-season training load. Descriptors were used to describe the size of the  
165 correlation between variables, and were as follows: trivial; <0.1, small; 0.1–0.3, moderate; 0-  
166 3–0.5, large; 0.5–0.7, very large; 0.7–0.9, and nearly perfect; >0.9.<sup>24</sup> Given the practical  
167 nature of the study, magnitude-based statistics were used to determine any practically  
168 meaningful differences between groups.<sup>23,24</sup> The magnitude of the change in the dependent  
169 variables were also assessed using Cohen's effect size (ES) statistic,<sup>25</sup> and 90% confidence  
170 intervals (CI). Effect sizes of <0.2, 0.2–0.6, 0.61–1.2, 1.21–2.0, and >2.0 were considered  
171 trivial, small, moderate, large, and very large, respectively.<sup>24</sup> Likelihoods were subsequently  
172 generated and thresholds used for assigning qualitative terms to chances were as follows:  
173 <1%, almost certainly not; <5%, very unlikely; <25%, unlikely; <50%, possibly not; ≥50%,  
174 possibly; ≥75%, likely; ≥95%, very likely; ≥99%, almost certainly.<sup>23,24</sup> The magnitude of  
175 differences between groups was considered practically meaningful when the likelihood was  
176 ≥75%.<sup>23,24</sup> In addition, injury rates were also calculated for each load group (i.e. high,  
177 medium, and low). Injury incidence was calculated by dividing the total number of injuries by  
178 the overall exposure hours for each load group and expressed as rates per 1,000 hours of  
179 exposure and 95% confidence intervals (CIs). The chi squared test ( $\chi^2$ ) was used to determine  
180 significant differences between load groups. All data were reported as means  $\pm$  SD and  
181 significance was set at  $p < 0.05$ .

### 182 183 **Results**

184  
185 Across the season, a total of 3,710 individual sessions were recorded. Of these, 1,765  
186 individual training sessions were observed during the pre-season period, and 1,945 individual  
187 sessions (i.e. training and competition) were recorded during the in-season period.  
188 Collectively, training loads were ~1.3 times greater during the pre-season period than the in-  
189 season period ( $p = 0.02$ ). Figure 1 shows the total training duration and the proportion of  
190 session distribution across the pre- (A, B) and in-season (C, D) periods. During the pre-season  
191 period, the HTL group collectively completed 87.2% of the prescribed sessions, while the  
192 MTL and LTL groups completed 61.3% and 35.4%, respectively. Similarly, during the in-  
193 season period, the proportion of time in main training was slightly higher for the HTL group  
194 with 57.3%, compared with the MTL groups with 57.1% ( $p > 0.05$ , ES=0.16 [-0.51-0.66], 52%  
195 Possibly). Further, the proportion of time in main training for both the HTL ( $p > 0.05$ , ES=1.20  
196 [0.71-1.70], 100% Almost Certainly) and the MTL ( $p > 0.05$ , ES=1.01 [0.47-1.56], 99%  
197 Almost Certainly) groups were higher than the LTL (49.8%) group. Similarly, the HTL and

198 MTL groups were available to play for 76.7% and 76.1% of in-season competitive matches,  
199 respectively ( $p>0.05$ ,  $ES=0.02$  [-0.64-0.60], 41% Possibly). In comparison to the HTL  
200 ( $p>0.05$ ,  $ES=0.84$  [0.27-1.41], 97% Very Likely) and MTL ( $p>0.05$ ,  $ES=0.82$  [0.25-1.39],  
201 96% Very Likely) groups, the LTL group was only available to play for 52.7% of in-season  
202 competitive matches.

203  
204 *Insert Figure 1 About Here*

205  
206 During the pre-season period, the HTL group completed greater training load for all variables  
207 than both the MTL ( $p<0.05$ ,  $ES=1.32-1.58$ , 100% Almost Certainly) and LTL ( $p<0.05$ ,  
208  $ES=1.47-1.78$ , 100% Almost Certainly) groups (Table 1). Similarly, the MTL group  
209 completed greater training load for each measured variable ( $p<0.05$ ,  $ES=1.09-1.43$ , 100%  
210 Almost Certainly) than the LTL group. During the competitive season, there were no  
211 statistically significant differences in TD covered between the groups, however practically  
212 meaningful differences were observed where the HTL ( $p=0.12$ ,  $ES=0.72$  [0.13-1.31], 93%  
213 Likely) and MTL ( $p=0.12$ ,  $ES=0.73$  [0.16-1.31], 94% Likely) groups covered practically  
214 greater TD than the LTL group. Moreover, the HTL group completed moderately greater  
215 VHSD ( $p=0.01$ ,  $ES=0.80$  [0.22-1.38], 96% Very Likely) and PL ( $p=0.12$ ,  $ES=0.73$  [0.14-  
216 1.31], 93% Likely) than the LTL group. The MTL group had moderately greater VHSD  
217 ( $p=0.01$ ,  $ES=0.54$  [0.05-1.14], 83% Likely), and PL ( $p=0.15$ ,  $ES=0.70$  [0.12-1.28], 92%  
218 Likely) than the LTL group. There were no differences between the HTL and MTL groups  
219 during the season.

220  
221 *Insert Table 1 About Here*

222  
223 Percentage of pre-season training completed, match availability, pre-season training load, and  
224 in-season training load are shown in Table 2. A near perfect correlation was observed  
225 between the percentage of pre-season training completed and pre-season TD ( $r = 0.96$ ,  $p =$   
226  $0.001$ ). Further, a very large correlation was observed between the percentage of pre-season  
227 training completed and pre-season HSD ( $r = 0.86$ ,  $p = 0.001$ ). Similarly, a near perfect  
228 correlation was observed between in-season TD and match availability ( $r = 0.95$ ,  $p = 0.01$ ).  
229 There were moderate correlations observed between percentage of pre-season training  
230 completed and match availability ( $r = 0.31$ ,  $p = 0.04$ ), and pre-season TD ( $r = 0.36$ ,  $p = 0.02$ ),  
231 HSD ( $r = 0.34$ ,  $p = 0.02$ ), and match availability.

232  
233 *Insert Table 2 About Here*

234  
235 During the first half of the season, the HTL ( $p=0.03$ ,  $ES=0.88$  [0.31-1.44], 97% Very Likely)  
236 and MTL ( $p=0.02$ ,  $ES=0.93$  [0.38-1.47], 98% Very Likely) groups covered significantly  
237 greater weekly TD than the LTL group. Similarly, PL values were significantly higher for  
238 both the HTL ( $p=0.03$ ,  $ES=0.89$  [0.33-1.45], 98% Very Likely) and MTL ( $p=0.02$ ,  $ES=0.93$   
239 [0.38-1.48], 98% Very Likely) groups compared to the LTL group. The HTL group  
240 completed moderately greater (albeit not significantly) MSD ( $p=0.32$ ,  $ES=0.60$  [0.00-1.19],  
241 87% Likely) and VHSD ( $p=0.18$ ,  $ES=0.75$  [0.17-1.34], 94% Likely) than the LTL group  
242 (Figure 2). Further, there were no significant or practical differences in any load category for  
243 the LTL group from the first to the second half of the season.

244  
245 *Insert Figure 2 About Here*

246

247 Across the in-season period, 50 injuries were recorded, with the knee (22%), hamstring  
248 (14%), and ankle (10%) the most common sites of injury. Although there was a trend toward  
249 greater injury rates in the low load group, no significant differences ( $\chi^2=3.48$ ,  $df=2$ ,  $p=0.17$ )  
250 were found between the HTL (14.2 [95% CI, 6.92-25.50] per 1,000 hours), MTL (17.7 [95%  
251 CI, 9.90-27.22] per 1,000 hours), and LTL (26.8 [95% CI, 12.22-30.89] per 1,000 hours)  
252 groups.

253

## 254 **Discussion**

255

256 This study investigated the relationship between training load completed during the pre-  
257 season period and subsequent in-season weekly loads (i.e. training and match loads) and  
258 injury during the ensuing season in elite Australian football players. During the in-season  
259 period, the HTL group completed a greater proportion of main training sessions and matches  
260 than both the MTL and LTL groups. Similarly, there were large differences in the proportion  
261 of main training sessions completed and training load between the HTL, MTL, and LTL  
262 groups during the pre-season period. No differences between the HTL and MTL groups  
263 during the in-season were observed, however both groups were higher than the LTL group for  
264 TD, VHSD, and PL. In addition, there were moderate to large differences for TD, PL, MSD,  
265 and HSD between the HTL and MTL groups, and the LTL group during the first half of the  
266 season. Furthermore, the lowest and highest injury rates were observed for the HTL and LTL  
267 groups, respectively.

268

269 Similar to previous findings,<sup>8,15</sup> we found that training load was higher during the pre-season  
270 phase than the in-season phase. Further, very large to nearly perfect correlations existed  
271 among the percentage of pre-season training completed and pre-season TD and HSD. A  
272 moderate correlation existed between the proportion of pre-season training completed and  
273 match availability suggesting that factors in addition to, or other than pre-season training  
274 determine in-season match availability. However, our findings demonstrate that 1) completing  
275 a greater proportion of pre-season training sessions results in a greater pre-season training  
276 load, 2) greater pre-season training load is positively associated with a greater in-season  
277 training load, and 3) greater in-season training load is positively associated with greater match  
278 availability.

279

280 Unlike previous work, once separated into respective load groups, training load was  
281 significantly higher during the pre-season phase for both the HTL and MTL groups, but not  
282 the LTL group. This is likely due to the fact that during the pre-season period, the LTL group  
283 were unable to complete as much training as both the HTL and MTL group, respectively  
284 (Figure 1A). These findings suggest that players in both the HTL and MTL groups had  
285 greater opportunity to 1) participate in a greater proportion of training and 2) maintain a  
286 higher training load to develop the required physical qualities to compete in matches during  
287 the in-season phase.<sup>4</sup> Of the training the LTL group did perform, they were only able to  
288 complete 35.4% of the prescribed training sessions. In contrast, the HTL group and the MTL  
289 group completed 87.2% and 61.3% of the prescribed training sessions, respectively (Figure  
290 1B). This may be due to a multitude of factors including but not limited to; injury, “off-legs”  
291 conditioning, increased time spent in the rehabilitation program, and individually modified  
292 training load programs. Moreover, during the in-season period, players in the HTL and MTL  
293 groups spent more time completing main training sessions, and less time completing  
294 rehabilitation sessions than players in the LTL group (Figure 1C). Similar to previous  
295 findings,<sup>26</sup> approximately 50% of external load was obtained through competition during the  
296 in-season period (Figure 1D). These findings have important practical applications for

297 strength and conditioning staff involved in the preparation of athletes. Specifically, players  
298 should attempt to complete as much of the planned pre-season training program as possible in  
299 order to; 1) develop the physical qualities required to compete in competition, and 2) develop  
300 resilience to tolerate training and match loads during the season.<sup>20</sup>

301

302 As expected, there were significant differences among load groups for all measured load  
303 variables during the pre-season period. During the in-season there were no notable differences  
304 between the HTL and MTL groups, although both groups were higher than the LTL group for  
305 TD, VHSD, and PL. In addition, during the first half of the season we found that TD and PL  
306 were significantly greater for the HTL and MTL groups compared to the LTL group. A  
307 possible explanation for this finding is that players who were unable to complete a large  
308 amount of pre-season training (<50%) may have been underprepared for the physical  
309 demands of competition,<sup>1,2</sup> and therefore below the load threshold necessary to promote  
310 physiological adaptation.<sup>4</sup> As a consequence, their risk of injury may have increased due to an  
311 inadequate level of fitness.<sup>4,27,28</sup> In contrast, there were only moderate differences between  
312 both the HTL and MTL group and LTL for VHSD, with no significant differences between  
313 any groups during the second half of the season. This most likely reflects decreases in training  
314 load for the HTL and MTL groups due to an increased in-season focus on recovery between  
315 competitive matches,<sup>8,30</sup> as opposed to increases in training load for the LTL group. However,  
316 across the first to second half of the season, the LTL group experienced a minor increase  
317 (albeit not significant) in total load. With competition cited as the main external stimulus  
318 during an in-season weekly cycle,<sup>26</sup> a possible explanation for this finding is that players  
319 within the LTL group were able to use competition to increase their weekly total load during  
320 the in-season period.

321

322 Recent investigations in cricket,<sup>17</sup> and rugby league,<sup>18</sup> have demonstrated that sustained high  
323 chronic loads may offer a protective effect against injury.<sup>19</sup> There were no significant  
324 differences between groups for injury rates, although injury rates were nearly two-fold greater  
325 in the LTL group compared with the HTL group. While these are preliminary findings from  
326 one club in an elite Australian football competition, further research is required to understand  
327 the protective effect of sustained high chronic load in Australian football.

328

329 While this study provides some novel findings surrounding training load, there are some  
330 limitations that warrant discussion. First, it should be acknowledged that the present data is  
331 from one club and may be solely related to this particular cohort of players in this particular  
332 season. It is also possible that the results are a reflection of the training philosophies of the  
333 coaches and strength and conditioning staff of the studied club, and may not reflect the  
334 training practices of other AFL clubs. Second, it should be noted that the ability to draw  
335 strong conclusions on the relationship between load and injury may be limited due to an  
336 overall low number of injuries (n = 50). Further investigations across a larger number of  
337 players and Australian Football teams would clearly strengthen the present findings. Finally,  
338 no measures of internal load were included in this study. While GPS technology provides  
339 detailed information on the external load of players, other measures of internal training load  
340 (i.e. session-RPE, heart rate, etc.) should also be monitored to provide detailed insight into the  
341 training loads, and subsequent load-injury relationship of athletes. Including internal loads,  
342 larger injury numbers, and more players would provide a greater understanding of the  
343 relationship between load and injury.

344

## 345 **Practical Applications**

346



347 The results of the present study demonstrate that high training loads during the pre-season  
348 period allow players to develop the required physical qualities for competition, while also  
349 resulting in greater training and competition participation in-season. Further, greater pre-  
350 season participation may reduce the risk of injury in the ensuing in-season competition  
351 period. Similarly, players who complete less pre-season training, also complete less training  
352 and compete in fewer matches during the following season. These findings hold important  
353 ramifications for practitioners involved in the physical development and preparation of  
354 players. Particularly, there is a need to develop strategies to maximize participation in pre-  
355 season training as this may result in a greater proportion of the squad available for training  
356 and selection during the competitive phase of the season.

357

### 358 **Conclusions**

359

360 This is the first study to examine the relationship between the amount of pre-season training  
361 completed and subsequent training load and injury during the ensuing competitive season in  
362 elite Australian football players. Our findings demonstrate that players who are able to  
363 complete a greater amount of pre-season training are able to maintain higher training loads  
364 during the ensuing season, and similarly, players who complete less pre-season training also  
365 complete less training and fewer competitive matches during the in-season phase.

366

### 367 **Acknowledgements**

368

369 The authors would like to thank the players of the Brisbane Lions Australian Football Club  
370 for participating in and supporting this study.

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442 **Figure Legends**

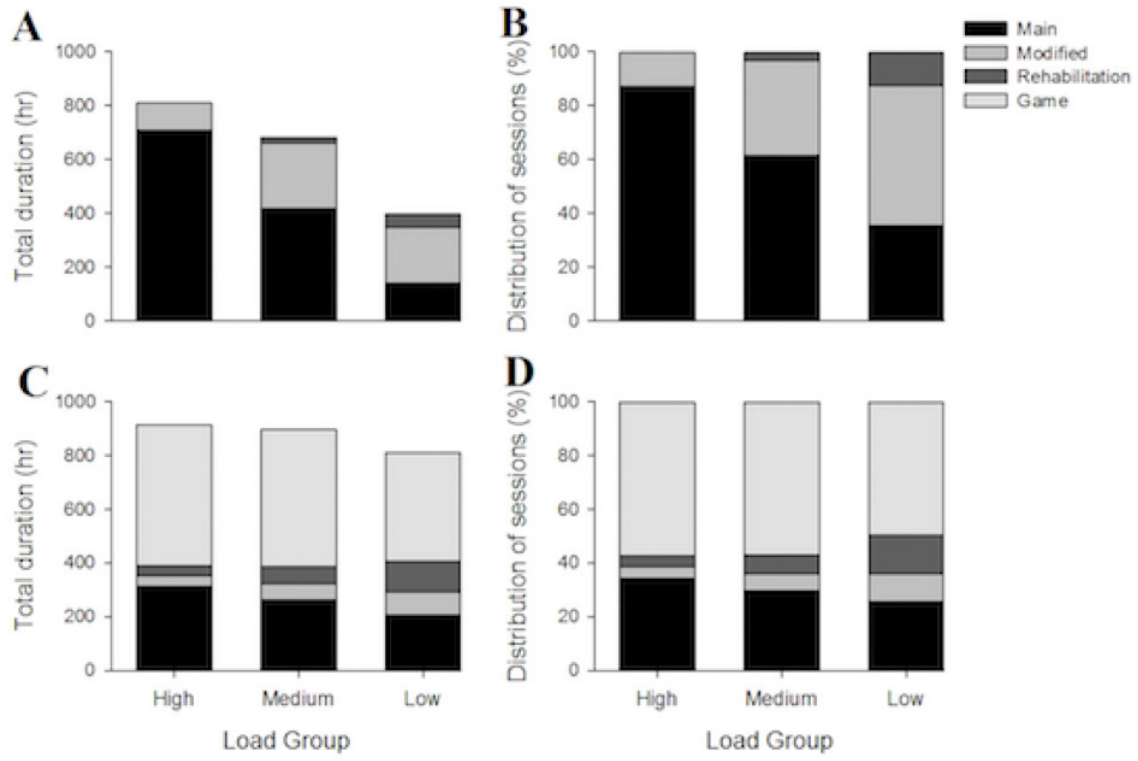
443

444 **Figure 1.** Total duration of training hours during the pre- (A) and in-season (C) periods, with  
445 proportion of sessions completed for each load group (i.e. high, medium, and low) during the  
446 pre- (B), and in-season (D) period.

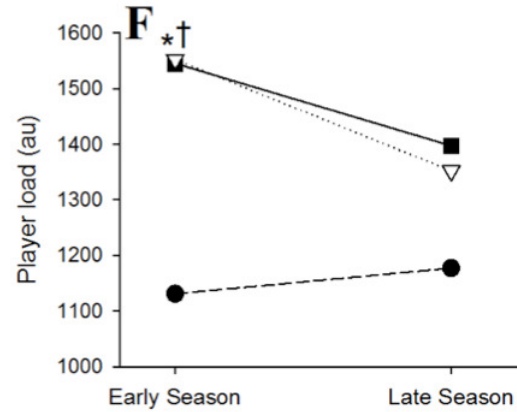
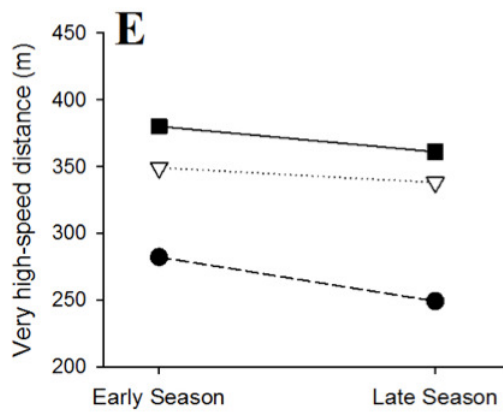
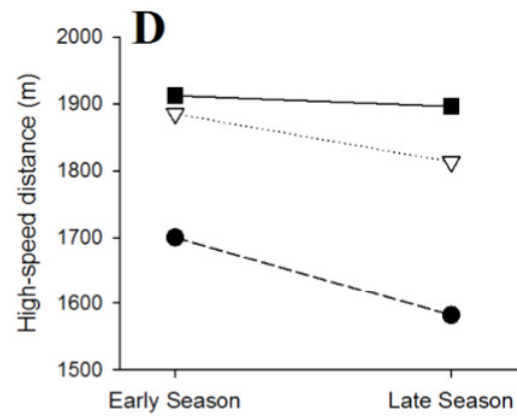
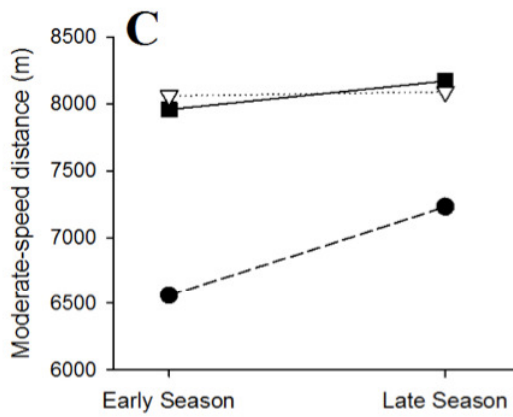
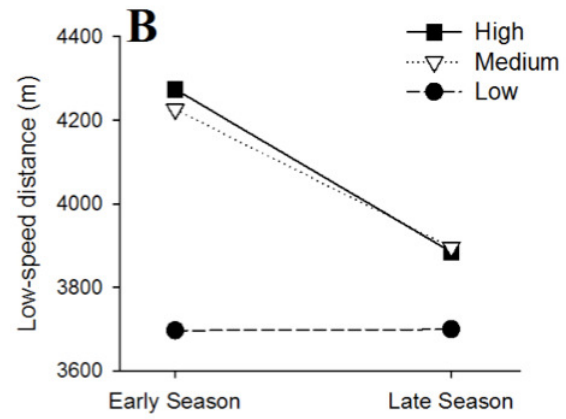
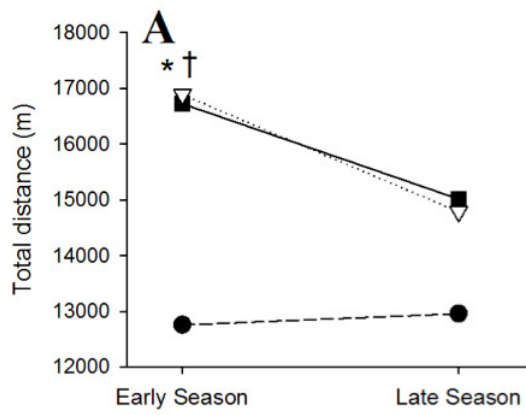
447

448 **Figure 2.** Quantification of weekly training and game loads (i.e. total loads) throughout the  
449 first and second half of the in-season period for each load group (i.e. high, medium, and low).

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**Table 1.** Quantification of weekly training and game loads throughout the pre- and in-season period for each load group (i.e. high, medium, and low).

Variables	Pre-Season			In-Season		
	High	Medium	Low	High	Medium	Low
<i>Absolute</i>						
Total distance (m)	21580 ± 7255 <sup>*†ab</sup>	17377 ± 7928 <sup>†b</sup>	12356 ± 9472	15833 ± 7898 <sup>b</sup>	15792 ± 7666 <sup>b</sup>	12758 ± 8189
Low-speed distance (m)	5931 ± 1868 <sup>*†ab</sup>	4976 ± 2114 <sup>†b</sup>	3495 ± 2590	4071 ± 2143	4054 ± 2184	3640 ± 2336
Moderate-speed distance (m)	10023 ± 3431 <sup>*†ab</sup>	7879 ± 3656 <sup>†b</sup>	5631 ± 4481	8068 ± 4538 <sup>b</sup>	8075 ± 4723 <sup>b</sup>	6850 ± 4724
High-speed distance (m)	4560 ± 2206 <sup>*†ab</sup>	3709 ± 2181 <sup>†b</sup>	2704 ± 2286	1903 ± 1052 <sup>b</sup>	1847 ± 1053 <sup>b</sup>	1666 ± 1274
Very high-speed distance (m)	1048 ± 744 <sup>*†ab</sup>	822 ± 648 <sup>†b</sup>	498 ± 532	370 ± 258 <sup>†b</sup>	343 ± 263 <sup>†b</sup>	267 ± 289
Player load (au)	1900 ± 670 <sup>*†ab</sup>	1538 ± 733 <sup>†b</sup>	1082 ± 855	1468 ± 745 <sup>b</sup>	1447 ± 731 <sup>b</sup>	1141 ± 763

All data are mean ± SD.

\* Denotes significantly different from medium group.

† Denotes significantly different from low group.

<sup>a</sup> Denotes practically meaningful difference from medium group.

<sup>b</sup> Denotes practically meaningful difference from low group.

**Table 2.** Relationships among the percentage of pre-season completed, match availability, pre-season training load, and in-season training load.

Variables	% Pre-season completed	Pre-season TD	Pre-season HSD	Pre-season VHSD	In-season TD	In-season HSD	In-season VHSD	Match availability
% Pre-season completed	1.00	0.96*	0.86*	0.69*	0.24	0.13	0.21	0.31*
Pre-season TD	0.96*	1.00	0.95*	0.74*	0.30*	0.26	0.29	0.36*
Pre-season HSD	0.86*	0.95*	1.00	0.80*	0.30*	0.36*	0.34*	0.34*
Pre-season VHSD	0.69*	0.74*	0.80*	1.00	0.30*	0.44*	0.53*	0.28
In-season TD	0.24	0.30*	0.30*	0.30*	1.00	0.75*	0.60*	0.95*
In-season HSD	0.13	0.23	0.36*	0.44*	0.75*	1.00	0.80*	0.62*
In-season VHSD	0.21	0.29	0.34*	0.53*	0.60*	0.80*	1.00	0.53*
Match availability	0.31*	0.36*	0.34*	0.28	0.95*	0.62*	0.53*	1.00

\* Denotes a significant correlation ( $p < 0.05$ ). TD = Total distance. HSD = High-speed distance. VHSD = Very high-speed distance.