

1 **The influence of changes in acute training load on daily sensitivity of morning-**  
2 **measured fatigue variables in elite soccer players.**

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23 **The influence of changes in acute training load on daily sensitivity of morning-**  
24 **measured fatigue variables in elite soccer players**

25 **Abstract**

26 **Purpose** To determine the sensitivity of a range of potential fatigue measures to daily  
27 training load accumulated over the previous two, three and four days during a short in-season  
28 competitive period in elite senior soccer players (n=10).

29 **Methods** Total high-speed running distance, perceived ratings of wellness (fatigue, muscle  
30 soreness, sleep quality), counter-movement jump height (CMJ), submaximal heart rate  
31 (HRex), post-exercise heart rate recovery (HRR) and heart rate variability (HRV: Ln rMSSD)  
32 were analysed during an in-season competitive period (17 days). General linear models were  
33 used to evaluate the influence of two, three and four day total high-speed running distance  
34 accumulation on fatigue measures.

35 **Results** Fluctuations in perceived ratings of fatigue were correlated with fluctuations in total  
36 high-speed running distance accumulation covered on the previous 2-days ( $r=-0.31$ ; small), 3  
37 -days ( $r=-0.42$ ; moderate) and 4-days ( $r=-0.28$ ; small) ( $p<0.05$ ). Changes in HRex ( $r=0.28$ ;  
38 small;  $p= 0.02$ ) were correlated with changes in 4-day total high-speed running distance  
39 accumulation only. Correlations between variability in muscle soreness, sleep quality, CMJ,  
40 HRR% and HRV and total high-speed running distance were negligible and not statistically  
41 significant for all accumulation training loads.

42 **Conclusions** Perceived ratings of fatigue and HRex were sensitive to fluctuations in acute  
43 total high-speed running distance accumulation, although, sensitivity was not systematically  
44 influenced by the number of previous days over which the training load was accumulated.  
45 The present findings indicate that the sensitivity of morning-measured fatigue variables to  
46 changes in training load is generally not improved when compared with training loads  
47 beyond the previous days training.

48

## 49 Introduction

50

51 The locomotor demands of elite soccer have progressively increased in recent years.<sup>1,2</sup> Since  
52 leading teams are also required to compete in a high number of matches over the course of  
53 season,<sup>3</sup> implementation of effective recovery strategies are paramount in order to avoid the  
54 debilitating effects associated with overtraining and injury.<sup>4</sup> Increasing attention in the  
55 literature has therefore focused upon evaluating the effectiveness of a range of monitoring  
56 tools which may serve as valid indicators of fatigue status of athletes.<sup>5</sup> For the purpose of  
57 this manuscript, fatigue will be defined as an inability to complete a task that was once  
58 achievable within a recent time frame.<sup>6</sup>

59 Recent research has examined the sensitivity of potential measures of fatigue to daily  
60 fluctuations in training load in Australian Rules Football (AFL).<sup>7,8</sup> In AFL players, perceived  
61 ratings of wellness,<sup>7,8</sup> sub-maximal heart rate (HR<sub>ex</sub>)<sup>7</sup> and an index (LnSD1) of vagal-  
62 related heart rate variability (HRV)<sup>7</sup> were sensitive to the fluctuations in daily training load  
63 during a pre-season training period. Similarly, in elite soccer players competing in the  
64 English Premier League (EPL),<sup>9</sup> both rating of perceived fatigue and vagal related HRV  
65 measure Ln rMSSD were most sensitive to the previous days fluctuations in training load  
66 experienced during the in-season competition period. Furthermore, in the same population,  
67 only perceived ratings of wellness were sensitive to within-week fluctuations in match and  
68 training load during typical in-season competition weeks.<sup>10</sup> Collectively, these findings  
69 demonstrate that these measures, particular perceived ratings of wellness, show promise as  
70 acute, simple, non-invasive assessments for tracking the fatigue status of elite team sport  
71 athletes.

72 Physiological adaptation to training is the culmination of repeated daily applications of  
73 training load.<sup>11</sup> The level of fatigue experienced by an athlete at any one point in time is  
74 therefore unlikely to purely reflect the load incurred from the previous day's activity,<sup>9</sup> but  
75 rather the load accumulated from a number of training days. Indeed high-intensity exercise  
76 and eccentric type activity leads to increases in muscle soreness that may be present for up to  
77 72-hours following the exercise stress.<sup>12,13</sup> In line with such observations, Buchheit (2014)  
78 recently suggested that HRV indices, used as an indicator of the athletes training status, may  
79 be more sensitive to changes in training loads when averaged across 7-days compared to a  
80 single daily measurement.<sup>14</sup> Similarly, reductions and increases in heart rate recovery (HRR)  
81 have been seen in response to weekly increases in training load and performance in  
82 physically active subjects and elite cyclists respectively.<sup>15,16</sup>

83 Recent observations in elite senior soccer players have demonstrated that potential fatigue  
84 measures, particularly perceived ratings of wellness, were sensitive to within-week  
85 fluctuations in match and training load during typical competition weeks.<sup>9</sup> Changes in these  
86 measures across the training week may, therefore, to some extent reflect the periodised  
87 training load incurred over a number of the preceding days and not solely the previous days  
88 training. It is possible therefore, that the relationship between such potential markers of  
89 fatigue and training load may vary as a function of the number of accumulated training days.  
90 The response to a single training session may not have the same physiological effect or  
91 magnitude compared to multiple training sessions performed over a short period of time.  
92 Therefore, our aim was to determine whether the sensitivity of a range of potential fatigue  
93 measures would vary when compared to the training load accumulated over the previous two,  
94 three or four days during a short in-season competitive phase in elite soccer players. These  
95 data would enable comparison with previous observations in the same population which

96 examined the sensitivity of the same measures to the previous day's fluctuations in training  
97 load.<sup>8</sup>

## 98 **Methods**

### 99 **Subjects**

100 Data were collected from 10 senior outfield soccer players (19.1±0.6 years; 1.84±0.7m;  
101 75.4±7.6 kg) competing in the EPL over a 17-day period (February) during the in-season  
102 competition phase.

103

### 104 **Design**

105

106 Players took part in normal team training throughout the 17-day period as prescribed by the  
107 coaching staff. This included two competitive reserve team home matches (day 1 and 10),  
108 three rest days (day 6, 11 and 16) and twelve training sessions. All players were fully  
109 familiarised with the fatigue assessments in the weeks prior to completion of the main  
110 experimental trials. Fatigue measures were assessed each morning prior to the players  
111 commencing normal training. Perceived ratings of wellness measurements were assessed  
112 every day during the 17-day period. Physiological measurements were assessed every day  
113 with the exception of match and rest days. Each day players arrived at the training ground  
114 laboratory having refrained from caffeine intake at least 12-hours prior to each assessment  
115 point. All assessments were conducted at the same time of the day in order to avoid the  
116 circadian variation in body temperature.<sup>17</sup> Players were not allowed to consume fluid at any  
117 time during the fatigue assessments. The study was approved by the Liverpool John Moores  
118 University Ethics Committee. All players provided written informed consent. Prior to  
119 inclusion into the study, players were examined by the club physician and were deemed to be  
120 free from illness and injury.

121

### 122 **Methodology**

123

124 *Training Load Assessment* Individual player daily training and match load was monitored  
125 throughout the 17-day assessment period. Each player was also monitored during each  
126 training session and match using a portable global positioning system (GPS) technology  
127 (GPSports SPI Pro X 5 Hz, Canberra, Australia). This type of system has previously been  
128 shown to provide valid and reliable estimates of instantaneous velocity during acceleration,  
129 deceleration, and constant velocity movements during linear, multidirectional and soccer-  
130 specific activities<sup>18,19</sup>. All devices were activated 15-min before the data collection to allow  
131 acquisition of satellite signals.<sup>20</sup> The minimum acceptable number of available satellite  
132 signals was 8 (range 8-11).<sup>21</sup> Players wore the same GPS device for each session in order to  
133 avoid inter-unit error<sup>21</sup>. Based on GPS data, locomotive speed above the threshold of 14.8  
134 km/h was classified as high-speed running. Total high-speed running distance was employed  
135 in the present study as an index of training and match load due to its frequent inclusion in  
136 attempts to quantify the load incurred by elite players during training and match-play.<sup>22</sup>  
137 However, high speed running will underestimate the true load incurred by the athlete since it  
138 does not account for the stress associated with the frequent accelerations and decelerations  
139 which occur during soccer.<sup>23</sup> It should be noted, however, that initial analysis in the present

140 study highlighted a large correlation ( $r=0.57$ ) between total high-speed running distance and  
141 session ratings of perceived exertion (sRPE) which has previously been used as a global  
142 indicator of internal load in soccer players.<sup>24</sup>

143

#### 144 *Perceived Ratings of Wellness*

145 A psychometric questionnaire was used daily prior to any training or exercise to assess  
146 general indicators of player wellness.<sup>9,10</sup> The questionnaire comprised three questions  
147 relating to perceived sleep quality (coefficient of variation 13%), muscle soreness (coefficient  
148 of variation 9%) and fatigue (coefficient of variation 12%).<sup>9</sup> Each question scored on a  
149 seven-point Likert scale [scores of 1-7 with 1 and 7 representing very, very poor (negative  
150 state of wellness) and very, very good (positive state of wellness) respectively].

151 *Countermovement Jump* Countermovement jump<sup>9</sup> (coefficient of variation 4%)<sup>9</sup> (CMJ)  
152 performance was evaluated using a jump mat (Fusion Sport, Queensland, Australia).  
153 Participants performed five CMJ efforts in total, two practice and three assessment jumps  
154 ensuring the hands were affixed to the hips throughout the jump. The highest jump was used  
155 as the criterion measure of performance.

156 *Heart rate indices* Players completed an indoor submaximal 5-min cycling (Keiser,  
157 California, USA) /5-min recovery test as part of the warm up prior to commencing every  
158 training session.<sup>9</sup> All players were assessed together at a fixed exercise intensity of 130 watts  
159 (85 rpm). The present intensity was selected to minimize anaerobic energy contribution<sup>25</sup> and  
160 to permit a rapid return of heart rate to baseline for short-term HRV measurements. On  
161 completion of exercise the players remained seated in silence for 5-min. HRV expressed as  
162 the square root of the mean of the sum of squares of differences between adjacent normal R-  
163 R intervals (rMSSD, coefficient of variation 28%)<sup>9</sup> and the natural logarithm of the rMSSD  
164 (Ln rMSSD, coefficient of variation 10%)<sup>9</sup> were calculated as previously described<sup>25</sup> using  
165 Polar software (Polar Precision Performance SW 5.20, Polar Electro, Kemple, Finland). Heart  
166 rate recovery (HRR) expressed as the absolute (HRR, coefficient of variation 14%)<sup>9</sup> and  
167 relative (%HRR, coefficient of variation 10%)<sup>9</sup> change in HR between the final 30-sec  
168 (average) of the 5-min cycling test and 60 sec after cessation of exercise were calculated as  
169 previously described.<sup>9,16,25</sup>

170

#### 171 **Statistical Analysis**

172 Data were analysed with general linear models, which allowed for the fact that data were  
173 collected within-subjects over time.<sup>26</sup> Recently, step-wise regression approaches have been  
174 criticised for reliable variable selection in a model.<sup>27,28</sup> Our added problem was the predicted  
175 high multicollinearity between the various independent variables in our study. Therefore, we  
176 used a combination of expert knowledge regarding which variables hold superior  
177 practical/clinical importance<sup>28</sup> and a multicollinearity correlation coefficient of  $>0.5$  for initial  
178 variable selection. Total high-speed running distance was selected in order to provide an  
179 indication of training and match load (independent variable) in the present study. We then  
180 quantified the relationships between the various predictors and outcomes using model I  
181 (unadjusted model) and model II (fully adjusted model from which partial correlation  
182 coefficients and associated 95% confidence intervals for each predictor could be derived). To  
183 calculate acute training load accumulation, the rolling mean 2, 3 and 4-day total high-speed  
184 running distances were then related to the subsequent day's morning-measured fatigue

185 variables. The following criteria were adopted to interpret the magnitude of the correlation (r)  
186 between test measures: <0.1 trivial, 0.1 to 0.3 small, 0.3 to 0.5 moderate, 0.5 to 0.7 large, 0.7  
187 to 0.9 very large, and 0.9 to 1.0 almost perfect.<sup>29</sup> The level of statistical significance was set  
188 at  $p < 0.05$  for all tests.

189

190 **Results**

191

192 Partial correlations, least squares regression slope (B) and significance for the relationship  
193 between total high-speed running distance (over 2-4 days) and morning-measured fatigue  
194 variables are shown in Tables 1-7. Absolute variability in training load and fatigue measures  
195 over the 17 day period can be viewed in a recent publication<sup>9</sup> All players competed in both  
196 matches during the 17-day period with a median of 79 min playing time per player (range =  
197 32-93 min). Variability in ratings of perceived fatigue were correlated to variability in total  
198 high-speed running distance covered on the previous 2, 3 and 4 days ( $p < 0.05$ ; Table 1).  
199 Small-to-moderate correlations were observed for 2 ( $r = -0.31$ ), 3 ( $r = -0.42$ ) and 4 ( $r = -0.28$ )  
200 day cumulative total high-speed running distance. Correlations between variability in  
201 perceived sleep quality and muscle soreness and total high-speed running distance across all  
202 days were trivial to small and not statistically significant (Table 2 and 3).

203 *Insert Tables 1-3 here*

204 Correlations between variability in CMJ and total high-speed running distance across all days  
205 were trivial to small and not statistically significant (Table 4).

206 *Insert Table 4 here*

207 Correlations between variability in HRex and total high-speed running distance across all  
208 days were trivial to small and only statistically significant with 4-day cumulative total high-  
209 speed running distance ( $r = 0.28$ ;  $p = 0.02$ ; Table 5).

210 *Insert Table 5 here*

211 Correlations between variability in HRR (%) and Ln rMSSD and total high-speed running  
212 distance for all days were trivial and not statistically significant (Table 6 and 7).

213 *Insert Tables 6 and 7 here*

214 **Discussion**

215

216 The aim of the current study was to determine whether the sensitivity of a range of morning-  
217 measured fatigue variables to changes in training load was influenced by the number of  
218 previous days over which the training load was accumulated in elite soccer players. When  
219 compared with previous data published on the current population, the present findings  
220 indicate that the sensitivity of morning-measured fatigue measures to changes in training load  
221 is generally not improved when compared with training loads beyond the previous days  
222 training.<sup>9</sup>

223 The use of simple perceived ratings of wellness is an efficient and practical approach to  
224 determining the fatigue status of elite team sport athletes.<sup>8-10,30</sup> Previous observations on elite  
225 soccer players showed a moderate-to-strong significant correlation between the players  
226 perceived rating of fatigue and the previous days total high-speed running distance ( $r=-0.51$ ;  
227  $p<0.001$ ).<sup>9</sup> Furthermore, the slope of the regression model indicated that every ~400m  
228 increase in total high-speed running distance led to a one unit decrease (For example a player  
229 may change from very poor level of fatigue to very, very poor level of fatigue following an  
230 additional ~400m total high-speed running distance) in fatigue with 37 % of the variance in  
231 training load explained by all the statistically significant predictors.<sup>9</sup> In contrast, the current  
232 findings demonstrate that the sensitivity of morning-measured perceived fatigue, to changes  
233 in training load is reduced from significantly moderate to significantly small ( $r=-0.42$  to -  
234 0.28) when compared with the training load observed beyond the previous days training.<sup>9</sup>  
235 Indeed, the variance in training load explained by all the statistically significant predictors  
236 decreased to 15% when training load was accumulated over a number (2-4) of days,  
237 highlighting the importance of immediately preceding load in elite soccer players. This  
238 apparent importance of the previous days training load on morning-measured fatigue may to  
239 some extent be explained by the nature of training cycles undertaken by elite soccer players.  
240 During the in-season competition period, players rotate around weekly cycles comprising one  
241 to two matches (very high load) interspersed with training sessions (moderate to high load)  
242 and recovery sessions.<sup>22,31,32</sup> This cycle of daily loading peaks and-troughs within a short  
243 time frame may, therefore, only lead to changes in fatigue status that are largely  
244 representative of the previous days training. The influence of accumulated training load on  
245 morning measured perceived fatigue may be more relevant to endurance based sports where  
246 load is distributed and sustained over extended training blocks.

247 Small significant correlations have been reported between daily perceived ratings of sleep  
248 quality ( $r=0.2$ ) and muscle soreness ( $r=0.3$ ) and the previous days training load during pre-  
249 season training in elite AFL players.<sup>7</sup> In contrast, in EPL players the relationship between  
250 daily training load and perceived ratings of sleep quality and muscle soreness were trivial and  
251 non-significant.<sup>9</sup> Furthermore, in the current study, we demonstrate that the magnitude of  
252 these relationships are not influenced by the number of days over which training load was  
253 accumulated. Muscle soreness has been found to be significantly elevated between 24 and 72-  
254 hours following a soccer match<sup>12,13,33</sup>. Moreover, sleep quality has been seen to decrease  
255 around periods of competition.<sup>34</sup> In the present study, only two match days were included in  
256 the sample of 17-days, consequently, the limited match exposure and training intensity may  
257 not have been sufficient to influence muscle soreness and sleep quality. In a previous study  
258 from the same population of players, match demands accounted for ~40% of total weekly  
259 load, moreover, perceived ratings of wellness were found to be lowest on the day post-match,



260 <sup>10</sup> further showing the debilitating effects of a match on fatigue status. Indeed, the average  
261 daily training load in the current study (RPE-TL 361) is considerably lower than that reported  
262 during an AFL pre-season training camp (RPE-TL 746) where daily readings of muscle  
263 soreness and sleep quality were associated with changes in load. <sup>7</sup> Future work involving a  
264 greater frequency of matches is therefore warranted in order to fully examine the influence of  
265 changes in loading on morning-measured perceived ratings of muscle soreness and sleep.

266 Previously, in elite soccer players, a small, positive daily correlation was observed ( $r=0.23$ )  
267 between CMJ height and total high-speed running distance suggesting improved performance  
268 with increased total high-speed running distance. <sup>9</sup> It has been reported that the assessment of  
269 neuromuscular function via the use of jump protocols may be impaired up to 72-hours post-  
270 match. <sup>35,36</sup> However, in the present study, a non-significant trivial to-small relationship was  
271 found between changes in CMJ height and total high-speed running distance accumulation  
272 over 2-4-days. Collectively, the findings from the current study and those from earlier  
273 investigations, <sup>9,37</sup> demonstrate that CMJ height is generally insensitive to acute changes in  
274 workload in elite soccer players. CMJ height alone may be too crude of a measure in order to  
275 detect changes in training load, however, alternative CMJ derived neuromuscular parameters  
276 may hold sensitivity to alterations in load irrespective of the limited change in CMJ height.  
277 For example, neuromuscular parameters (eccentric, concentric, and total duration, time to  
278 peak force/power, flight time:contraction time ratio) derived from CMJ have been found  
279 suitable for detection of neuromuscular fatigue. <sup>38</sup> Reductions in 18 different neuromuscular  
280 variables were found following a high-intensity fatiguing protocol in college-level team sport  
281 athletes. <sup>38</sup> Furthermore, reductions in the flight time contraction time ratio have been found  
282 across a season in AFL players indicating sensitivity to increases in load over time. <sup>39</sup> Future  
283 research is required to investigate whether alternative measures derived from CMJ are  
284 sensitive to changes in training load in elite soccer players.

285 In recent years heart rate (HR) indices (HRV, HRR and HRex) have been used as a popular  
286 method to measure variations in the autonomic nervous system (ANS) in an attempt to  
287 understand athlete adaptation/fatigue status. <sup>14</sup> The use of vagal related time domain indices  
288 such as Ln rMSSD have been found to have greater reliability and are ideal for assessments  
289 over short periods when compared to spectral indices of HRV. <sup>40,41</sup> A small significant  
290 correlation ( $r=-0.2$ ;  $p=0.04$ ) was found between the daily fluctuations in Ln rMSSD and total  
291 high-speed running distance in elite soccer players from an earlier study. <sup>9</sup> In this study, the  
292 slope of the regression model indicated that every ~300m increase in total high-speed running  
293 distance led to a decrease of one unit in HRV i.e. more sympathetic dominance the greater the  
294 training load. <sup>7,9,42</sup> In the current study, non-significant, trivial correlations were observed  
295 between fluctuations in 2, 3 and 4-day total high-speed running distance and changes in  
296 morning-measured HRV, implying no additional effect on HRV beyond the previous days of  
297 training load. The limited relationships may reflect the low loads incurred by players  
298 observed in the current study. Buchheit et al, (2013) found significant daily correlations  
299 ( $r=0.40$ ) with a comparable vagal related parameter HRV (Ln SD1) during a pre-season camp  
300 in AFL players. <sup>7</sup> A possible reason for the small-to-moderate correlation found may be due  
301 to the enhanced training load performed by AFL players. <sup>7</sup> Another potential reason for the  
302 lack of sensitivity observed for HRV in the present study may be due to the inherent variation  
303 of this measure. Indeed, based on data derived from endurance sports it is suggested that the  
304 use of one single data point could be misleading for practitioners due to the high day-to-day  
305 variation in these indices. <sup>43</sup> When data were averaged over a week or using 7-day rolling  
306 averages, sensitivity to training load and performance has been improved compared to a  
307 single assessment point. A similar observation in young Handball players has also been

308 reported when single monthly assessments were found to have less than 20% sensitivity to  
309 training status.<sup>44</sup> Future work is required to observe whether more frequent measures of  
310 HRV improve sensitivity to training load. Furthermore, future research is needed to establish  
311 how HRV responds to more extended and sustained periods of training and match load in  
312 elite soccer players.

313 In the present study, small significant increases in HRex were associated with increases in 4-  
314 days accumulated total high-speed running distance. Contrastingly, Buchheit et al. (2013)  
315 found a large negative correlation between daily training load and HRex suggesting a  
316 reduction in heart rate following increases in training load.<sup>7</sup> However, this data was collected  
317 during a short pre-season AFL training camp in the heat where environmental and/or training  
318 induced changes in plasma volume are more likely responsible than alterations stemmed  
319 solely from the previous days training load.<sup>7</sup> Reductions in heart rate have also been  
320 observed in athletes involved in extremely high training loads.<sup>45</sup> Indeed, HRex during  
321 intensified training intensities showed significant reductions in overreached triathletes. Le  
322 Meur and colleagues (2013) suggested the cause of this reduction in heart rate to be a hyper-  
323 activation of the parasympathetic nervous system via central, cardiac and/or periphery  
324 mechanisms.<sup>46,47</sup> In contrast to Le Meur and colleagues (2013) the results of the current  
325 study suggest, although, speculative, an acute stimulation of the sympathetic nervous system  
326 thus increasing HRex following a short continued period of training. Indeed, both in  
327 recreational marathon runners and world class rowers, a significant increase in sympathetic  
328 dominance following a training block in the lead up to competition has been observed.<sup>48,49</sup>

329 Sensitivity between HRR% and 2-4 day THIR accumulation was trivial and non-significant  
330 in the present study. Previous data also failed to find a relationship between daily HRR% and  
331 total high-speed running distance over a 17-day competitive period.<sup>9</sup> In contrast, previous  
332 studies have observed responses between both acute and chronic training load and HRR.  
333 Borresen and Lambert (2007) found that HRR decreased with an increase in training load and  
334 subsequently a tendency for a faster HRR with a decrease in training load. The authors  
335 speculate, however, that the reduced HRR with an increase in training load may be explained  
336 by the severe increase in training load (TRIMP increased by 55%), potentially inducing  
337 overreaching, and hence a parasympathetic predominance as previously discussed<sup>45</sup>. The use  
338 of HRex and HRR in healthy athletes to predict changes in performance or fatigue should be  
339 treated with caution and interpreted together with other measures of fatigue, such as  
340 perceived ratings of wellness.<sup>14,50</sup> As a consequence, if HR-derived assessments of  
341 fatigue/adaptation are to be effective in team sports, a higher volume of assessments may be  
342 required as previously discussed. However, undertaking such measures may prove difficult  
343 with the large volume of athletes engaged in team sports.<sup>14</sup>

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350 **Practical Applications**

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352 Perceived ratings of fatigue show particular promise as simple, non-invasive assessments of  
353 fatigue status in elite soccer players during an in-season competitive phase. The present  
354 findings also indicate that the sensitivity of morning-measured fatigue variables to changes in  
355 training load is generally not improved when compared with training loads beyond the  
356 previous days training, therefore, it is likely to be most effective when taken on a daily basis.  
357 Future research is needed to determine the acute and longitudinal usefulness of HRex, HRR  
358 and vagal related HRV as a monitoring tool in team sports.

359

360 **Conclusion**

361 The sensitivity of morning-measured fatigue variables to changes in training load is not  
362 improved when compared with training loads beyond the previous days training. Perceived  
363 ratings of fatigue shows the most promise as a simple, non-invasive assessment of fatigue  
364 status in elite soccer players in detection of acute load fluctuations during an in-season  
365 competitive phase compared to the other markers of fatigue measured.

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- 525

526 Table 1: Partial correlations (95% CI), least squares regression slope (B) and significance for  
 527 the relationship between morning-measured perceived fatigue and total high-speed running  
 528 distance over the previous 2, 3 and 4-days.

	Correlation Coefficient (95% CI)	Magnitude	B	P-value
2-day	-0.31 (-0.51 to -0.78)	Small	149.167	p=0.01
3-day	-0.42 (-0.61 to -0.18)	Moderate	166.509	p<0.001
4-day	-0.28 (-0.52 to -0.01)	Small	108.53	p=0.03

529

530 Table 2: Partial correlations (95% CI), least squares regression slope (B) and significance for  
 531 the relationship between morning-measured perceived sleep quality and total high-speed  
 532 running distance over the previous 2, 3 and 4-days

	Correlation Coefficient (95% CI)	Magnitude	B	P-value
2-day	-0.03 (-0.27 to 0.21)	Trivial	-10.633	p=0.83
3-day	-0.1 (-0.35 to 0.16)	Trivial	-9.869	p=0.81
4-day	0.04 (-0.27 to 0.28)	Trivial	15.774	p=0.75

533

534 Table 3: Partial correlations (95% CI), least squares regression slope (B) and significance for  
 535 the relationship between morning-measured perceived muscle soreness and total high-speed  
 536 running distance over the previous 2, 3 and 4-days

	Correlation Coefficient (95% CI)	Magnitude	B	P-value
2-day	-0.19 (-0.41 to 0.05)	Trivial/Small	-58.443	p=0.12
3-day	-0.16 (-0.40 to 0.10)	Trivial	-36.258	p=0.23
4-day	-0.13 (-0.4 to 0.15)	Trivial	-28.05	p=0.37

537

538



539 Table 4: Partial correlations (95% CI), least squares regression slope (B) and significance for  
 540 the relationship between morning-measured countermovement jump performance and total  
 541 high-speed running distance) over the previous 2, 3 and 4 days

	Correlation Coefficient (95% CI)	Magnitude	B	P-value
2-day	0.13 (-0.11 to 0.36)	Trivial	24.944	p= 0.29
3-day	0.21 (-0.05 to 0.42)	Small	31.478	p=0.11
4-day	0.23 (-0.05 to 0.48)	Small	34.02	p=0.10

542

543

544 Table 5: Partial correlations (95% CI), least squares regression slope (B) and significance for  
 545 the relationship between morning-measured sub-maximal heart rate and total high-speed  
 546 running distance over the previous 2, 3 and 4 days

	Correlation Coefficient (95% CI)	Magnitude	B	P-value
2-day	0.18 (-0.06 to 0.40)	Trivial	5.17	p=0.10
3-day	0.21 (-0.05 to 0.44)	Small	4.863	p=0.07
4-day	0.28 (0.05 to 0.52)	Small	5.948	p=0.02

547

548 Table 6: Partial correlations (95% CI), least squares regression slope (B) and significance for  
 549 the relationship between morning-measured Ln rMSSD (HRV) and total high-speed running  
 550 distance over the previous 2, 3 and 4-days.

	Correlation Coefficient (95% CI)	Magnitude	B	P-value
2-day	<-0.01 (-0.25 to 0.29)	Trivial	-1.31	p= 0.99
3-day	<0.01 (-0.27 to 0.25)	Trivial	9.426	p=0.91
4-day	-0.15 (-0.41 to 0.13)	Trivial	-95.337	p=0.279

551

552

553 Table 7: Partial correlations (95% CI), least squares regression slope (B) and significance for  
554 the relationship between morning-measured heart rate recovery (HRR%) and total high-speed  
555 running distance over the previous 2, 3 and 4-days

	Correlation Coefficient (95% CI)	Magnitude	B	P-value
2-day	<0.1 (-0.14 to 0.33)	Trivial	0.178	p=0.97
3-day	<0.1 (-0.16 to 0.35)	Trivial	1.138	p=0.76
4-day	-0.03 (-0.23 to 0.32)	Trivial	-1.584	p=0.68

556