











**Please cite the Published Version**

Martinho, Diogo V , Rebelo, André , Field, Adam , Ribeiro, Alex S , Pereira, Filipa , Bizarro, Bruno , Ribeiro, João , Len, Silvano M , Gouveia, Élvio R  and Sarmento, Hugo   
(2024) The quantification of physical performance and internal training load in youth male soccer players during preseason. *International Journal of Sports Physiology and Performance*, 19 (5). pp. 480-486. ISSN 1555-0265

**DOI:** <https://doi.org/10.1123/ijsp.2023-0312>

**Publisher:** Human Kinetics

**Version:** Accepted Version

**Downloaded from:** <https://e-space.mmu.ac.uk/634044/>

**Usage rights:**  In Copyright

**Additional Information:** Accepted author manuscript version reprinted, by permission, from *International Journal of Sports Physiology and Performance*, 2024, <https://doi.org/10.1123/ijsp.2023-0312>. © Human Kinetics, Inc.

**Enquiries:**

If you have questions about this document, contact [openresearch@mmu.ac.uk](mailto:openresearch@mmu.ac.uk). Please include the URL of the record in e-space. If you believe that your, or a third party's rights have been compromised through this document please see our Take Down policy (available from <https://www.mmu.ac.uk/library/using-the-library/policies-and-guidelines>)



**THE QUANTIFICATION OF PHYSICAL PERFORMANCE AND  
INTERNAL TRAINING LOAD IN YOUTH MALE SOCCER  
PLAYERS DURING PRESEASON**

Journal:	<i>International Journal of Sports Physiology and Performance</i>
Manuscript ID	IJSPP.2023-0312.R2
Manuscript Type:	Original Investigation
Date Submitted by the Author:	17-Jan-2024
Complete List of Authors:	<p>Martinho, Diogo V.; University of Coimbra  Rebello, André; Universidade Lusófona de Humanidades e Tecnologias, CIDEFES, Centro de Investigação em Desporto, Educação Física e Exercício e Saúde  Field, Adam ; Department of Sport and Exercise Science, Manchester Metropolitan University, Manchester, UK  Ribeiro, Alex; University of Coimbra, Research Unity in Sport and Physical Activity (CIDAF, UID/DTP/04213/2020), Faculty of Sport Sciences and Physical Education, PT  Pereira, Filipa; University of Coimbra  Bizarro, Bruno; University of Coimbra  Ribeiro, João; Research Centre in Sports Sciences, Health Sciences and Human Development, University Institute of Maia, Portugal; Department of Performance Optimization, GOD, Sporting Clube de Braga SAD, Portugal  Len, Silvano; Universidad de Ciencias de la Cultura Física y el Deporte Manuel Fajardo  Gouveia, Elvivo; University of Madeira, Department of Physical Education and Sport; Universidade da Madeira Madeira Interactive Technologies Institute, Laboratory of Robotics and Engineering Systems  Sarmiento, Hugo; Faculty of Sport Sciences and Physical Education, University of Coimbra, Portugal,</p>
Keywords:	athlete monitoring, load management, physical assessment, recovery

SCHOLARONE™  
Manuscripts

## THE QUANTIFICATION OF PHYSICAL PERFORMANCE AND INTERNAL TRAINING LOAD IN YOUTH MALE SOCCER PLAYERS DURING PRESEASON

Diogo V. Martinho\*<sup>1,2</sup>, André Rebelo<sup>3,4</sup>, Adam Field<sup>5</sup>, Alex Ribeiro<sup>1</sup>, Filipa Pereira<sup>1</sup>, Bruno Bizarro<sup>1</sup>, João Ribeiro<sup>6,7</sup>, Silvano M. Len<sup>8</sup>, Élvio R. Gouveia<sup>2,9</sup>, Hugo Sarmento<sup>1</sup>

<sup>1</sup>University of Coimbra, Faculty of Sport Sciences and Physical Education, Coimbra, Portugal

<sup>2</sup>Laboratory of Robotics and Engineering Systems, Interactive Technologies Institute, Funchal, Portugal

<sup>3</sup>CIDEFES, Centro de Investigação em Desporto, Educação Física e Exercício e Saude, Universidade Lusófona, Lisboa, Portugal

<sup>4</sup>COD, Center of Sports Optimization, Sporting Clube de Portugal, Lisboa, Portugal

<sup>5</sup>Department of Sport and Exercise Science, Manchester Metropolitan University, Manchester, UK

<sup>6</sup>Research Centre in Sports Sciences, Health Sciences and Human Development, University Institute of Maia, Portugal

<sup>7</sup>Department of Performance Optimization, GOD, Sporting Clube de Braga SAD, Portugal

<sup>8</sup>Universidad de Ciencias de la Cultura Física y el Deporte, La Habana, Cuba

<sup>9</sup>Department of Physical Education and Sport, University of Madeira, Funchal, Portugal

\*Contact author:

Diogo V. Martinho

dvmartinho92@hotmail.com

1 **THE QUANTIFICATION OF PHYSICAL PERFORMANCE AND INTERNAL**  
2 **TRAINING LOAD IN YOUTH MALE SOCCER PLAYERS DURING**  
3 **PRESEASON**

4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32

For Peer Review

### 33 **Abstract**

34 **Purpose:** The monitoring of training loads and quantification of physical performance is  
35 common practice in youth soccer academies to support coaches in prescribing and  
36 programming training for individuals. The interaction between training load and physical  
37 performance is unknown during a preseason period in youth soccer players. The current  
38 study assessed changes in training load and physical assessments across a 4-week  
39 preseason period. The relationship between physical performance and match playing time  
40 in youth male soccer players was also investigated.

41 **Methods:** The training load of 25 professional youth academy male soccer players were  
42 monitored throughout a four-week preseason period. Assessments of power, agility,  
43 speed and aerobic capacity were undertaken in the first training session. Session ratings  
44 of perceived exertion (sRPE) and wellbeing questionnaires were collected during all  
45 training sessions and preseason matches. Playing time during subsequent competitive  
46 matches was recorded.

47 **Results:** T-test and 30-m sprint assessments, conducted on the first day of preseason, were  
48 predictors of sRPE throughout preseason (t-test:  $\chi^2/df = 2.895$ ; poor adjustment; 30-m  
49 sprint:  $\chi^2/df = 1.608$ ; good adjustment). Yoyo test performance was related with changes  
50 in perceived fatigue ( $\chi^2/df = 0.534$ ; very good adjustment). Faster players reported higher  
51 values of sRPE, and players with higher aerobic capacity reported higher levels of fatigue  
52 across preseason. Wellbeing, perceived fatigue, soreness and sRPE decreased across  
53 preseason. Greater match durations were related to higher levels of fatigue during  
54 preseason ( $p < 0.05$ ).

55 **Conclusion:** The current study highlights the relationship between training load, physical  
56 assessments and playing time. Coaches and practitioners can use physical test data at the  
57 start of preseason as an indication of players that report higher sRPE, perceived fatigue  
58 and reduced wellbeing across preseason, supporting decisions around individualized  
59 training prescriptions.

60 **Keywords:** athlete monitoring, load management, physical assessment, recovery

61

62

63

64

65

66

67

68

69

70

71

## 72 **Introduction**

73 In recent years, there has been an increase in the profile of youth soccer<sup>1,2</sup>. According to  
74 recent data derived from 27 European countries, more than half a million U14 year old  
75 participants compete in soccer<sup>3</sup>. However, given the rapid annual changes in growth and  
76 maturation<sup>4</sup>, injury propensity and overreaching in adolescent athletes is higher versus  
77 both adults and younger athletes<sup>5,6</sup>. Therefore, an appropriate balance between training,  
78 competition and recovery is required to minimize injury risk and overreaching in youth  
79 soccer<sup>2</sup>. Injury susceptibility and overreaching in youth soccer players is also likely  
80 attributed to seasonal variations in load, with peaks in injury observed following periods  
81 of inactivity or during rapid spikes in training load<sup>7</sup>, such as during a soccer preseason<sup>7</sup>.  
82 Accordingly, there is growing concern relating to heightened injury and overreaching due  
83 to high training loads across certain periods within a season in youth soccer<sup>8</sup>. Attempts to  
84 quantify the accumulated weekly in-season training load undertaken by young soccer  
85 players have been made<sup>9</sup>. A separate investigation has also assessed the in-season changes  
86 in physical qualities of elite youth soccer players according to maturity status<sup>10</sup>. However,  
87 there is a lack of research quantifying training and match loads across a preseason period  
88 in youth soccer players.

89 Training loads can be measured through external or internal load, depending on  
90 whether measurements are external or internal to the athlete<sup>11</sup>. External loads relate to the  
91 objective measurements of physical work (e.g., distances, speeds, number of  
92 movements)<sup>12</sup>, whereas internal load refers to the stress imposed on the athlete<sup>11</sup>. For  
93 example, the quantification of internal training load is commonly assessed among youth  
94 soccer players using session ratings of perceived exertion (sRPE), with wellbeing  
95 questionnaires used to assess the response to training loads<sup>13,14</sup>. Significant correlations  
96 between physical performance (i.e., sprint, total distance, maximum speed, average  
97 speed) and ratings of perceived exertion (RPE) in training sessions have been found in  
98 adolescent soccer players examined during six weeks of preseason<sup>15</sup>. However, how these  
99 relationships change when match-play is considered and how external load is linked with  
100 internal load and changing perceptions of wellbeing (measured via questionnaires)  
101 remains unknown in youth soccer players<sup>16</sup>. Constructs of wellbeing ratings and sRPE  
102 are sensitive to seasonal variations<sup>17,18</sup> and play a key role in the planning and  
103 periodization of training in soccer. Evidence demonstrating correlations between physical

104 performance, and internal load and wellbeing measures might support soccer academy  
105 practitioners in training load management and scheduling throughout preseason.

106 It appears that practitioners currently prescribe preseason training intensities  
107 based on physical performance tests early in preseason<sup>19,20</sup>, with limited understanding of  
108 how these physical qualities relate to subsequent internal load, and perceptions of fatigue  
109 and wellbeing during a youth soccer preseason. Although using physical assessments to  
110 inform training may have merit, it may not be optimal practice as although some players  
111 may perform well on an isolated test, they may subsequently demonstrate higher levels  
112 of fatigue or wellbeing during an intense preseason period. This may be particularly  
113 prevalent in youth populations given their biological immaturity, with an oversight of  
114 internal load and wellbeing potentially being detrimental in relation to both acute and  
115 recurrent injury risk, leading to future health implications<sup>21</sup>. Therefore, without an  
116 understanding of how speed, power, aerobic capacity, and agility correspond with internal  
117 training load and wellbeing responses, decisions on subsequent training prescriptions in  
118 youth soccer players during preseason are not as well-informed.

119 The aims of the study were to i) examine the relationship between physical  
120 performance at the start of the pre-season period, and internal load and well-being  
121 experienced throughout, and ii) assess whether relationships exist between internal  
122 training load and wellbeing during preseason and match playing time of matches.

123

## 124 **Methods**

125 The current project followed the Declaration of Helsinki and was approved by the Ethical  
126 Committee from the University of Lisbon Faculty of Human Kinetics (CEIFMH, No.  
127 34/2021). All participants were registered with the Portuguese Soccer Federation. The  
128 youth players and legal guardians received detailed information about the study and  
129 provided informed consent before participation.

130

### 131 Sample and procedures

132 The sample included 25 male youth soccer players (age:  $13.3 \pm 0.3$  years, stature:  $1.61 \pm$   
133  $0.01$  m, mass:  $49 \pm 10$  kg) affiliated with the same professional soccer academy.  
134 Goalkeepers were excluded from the present study. The duration of the preseason training

135 period for the youth soccer club was six weeks in total (August–September of the  
136 2022–2023 season). Training load and wellbeing data were collected from players during  
137 the latter four-week period of preseason. A decision was taken to include data from this  
138 specific 4-week period of preseason given that inconsistencies in player attendance were  
139 evident during the initial 2-weeks of preseason. A training and match schedule with short  
140 descriptions of each training session is provided (Supplementary Material 1). The players  
141 completed a battery of physical tests on the first day of preseason. Within the latter four  
142 weeks of preseason, players were assessed across fifteen training days and five friendly  
143 matches. A total of 575 observations were obtained (~23 per participant). Playing time of  
144 the four official matches for each participant were recorded by the performance analyst.  
145 Data were organized into week one, two, three and four, and differences reported between  
146 weeks.

147

#### 148 Session rating of perceived exertion

149 Internal training load measures were obtained 15–20 minutes following training sessions  
150 and matches using the Borg 10-point scale. Players answered the question “How hard was  
151 the session?” using a mobile application<sup>22</sup>. This strategy minimizes potential sources of  
152 error, including colleague influences and replication of data. The RPE rating was  
153 multiplied by the session minutes to determine the s-RPE<sup>23</sup>.

154

#### 155 Wellbeing questionnaire

156 The wellbeing questionnaire<sup>24</sup> was completed on a mobile application during the morning  
157 of training and match days. The tool includes five dimensions – sleep (time and quality),  
158 fatigue (herein referred to as ‘perceived fatigue’ or ‘perceptions of fatigue’), soreness and  
159 stress – on a five-point Likert scale<sup>25</sup>. Wellbeing was obtained by summing the five  
160 dimensions.

161

#### 162 Physical performance measures

163 A standardized warm-up consisting of running drills and dynamic stretches was executed  
164 before the physical performance measures were taken. The first assessments involved



165 squat and countermovement jumps as indicators of power. For the squat jump, the  
166 participant adopted a half-squat position with hands on hips and were instructed to jump  
167 as fast as possible and to jump for maximum height, with a 2 s pause between the eccentric  
168 and concentric phases of each repetition. Identical verbal prompts were provided for the  
169 countermovement jump, with hands also maintained on hips, but with players initiating  
170 the movement in a fully extended position (i.e., trunk and knees at 0°) before the  
171 countermovement phase. An electronic mat (Globus Ergo Tester, Codognè, Italy) was  
172 used to obtain jump height (cm) and flight time (s). Three efforts of each jump variant  
173 were performed with a 60 s passive rest period between efforts. Following a 5-min break,  
174 agility was measured using the T-test on synthetic turf. Participants navigated cones  
175 placed in a t-shaped route as quickly as possible. The time for each effort was collected  
176 to the nearest 0.01 s with a digital chronometer connected to photoelectric cells (Globus  
177 Ergo Timer Timing System, Codogné, Italy). The best of three efforts was presented for  
178 analyses. Jumping and agility measures were taken in the morning.

179         Following an extensive passive rest period and re-warmup (identical to the  
180 warmup described previously), maximal 10- and 30-m sprint was performed in the  
181 afternoon to assess sprint speed using photoelectric cells (Globus Ergo Timer Timing  
182 System, Codogné, Italy). Two sprints were performed for each distance, separated by 60  
183 s of passive rest, and the best time was retained for analyses. Following a 5-min rest, the  
184 Yoyo Intermittent Recovery Test (level 1) was used to assess aerobic capacity<sup>26</sup>. An audio  
185 signal controlled the speed of progressively increasing shuttle run speeds between 2x20  
186 m cones, which were interspersed with a 10-s active recovery. The test continued until  
187 exhaustion and the player was unable to perform at the required speeds; at which point  
188 the test scores were recorded. Assessments were completed individually, aside from the  
189 Yoyo test, which involved all the team completing the assessment at the same time.

190

### 191 Statistical analysis

192 Intra and inter-individual variation across preseason were tested using the latent growth  
193 curve model<sup>27</sup>. The model estimated two latent parameters: intercept ( $\alpha$ ) and slope ( $\beta$ ).  
194 The intercept represents the values at baseline (week 1), whilst the slope refers to the  
195 trajectories of load and wellbeing across preseason. Intercepts ( $\alpha$ ) were fixed as 1, and  
196 the  $\beta$  ranged between 0 (week 1) and 1 (week 4). The slopes of week 2 and week 3 were

197 not defined since non-linear trajectories of load and wellbeing was expected. For these  
198 variables, simple or non-conditioning growth latent models were developed. The  
199 significance of variance for intercept and slope indicated inter-individual variability at  
200 baseline (week 1) and distinct weekly trajectories for load and wellbeing variables  
201 included in the models, respectively. The covariance between intercept and slope  
202 indicates a relationship between values at week 1 and the level of growth for subsequent  
203 weeks. Significant variance for slope and intercept indicated inter-individual variability.  
204 Explanatory or exogenous variables were included in the model to explain inter-  
205 individual variability derived from simple models. Exogenous variables were physical  
206 tests assessed on the first day of preseason and playing time of matches. Dummy variables  
207 were created based on the mean value (1-below and 2-above mean). Conditioning models  
208 incorporated physical tests or playing time as exogenous variables, and the  $\alpha$  and  $\beta$  were  
209 defined as latent variables. Three different strategies were used to test the impact of  
210 exogenous variables: (1) a multigroup analysis was performed to verify the impact of  
211 exogenous variables; (2) an interpretation normalized chi-squared ( $\Delta\chi^2/df$ ;  $5 < \chi^2/df$ , poor  
212 adjustment;  $2 < \chi^2/df \leq 5$ , reasonable adjustment;  $1 < \chi^2/df \leq 2$ , good adjustment; and  $\chi^2/df$   
213 approximately 1, very good adjustment)<sup>27</sup>; (3) a reduction in the variance of latent  
214 parameters (i.e. constant and slope) demonstrated a substantial reduction in  
215 interindividual variation<sup>28</sup>. Significant models are included in the results section.  
216 Statistical analyses were conducted with the computer software IBM SPSS AMOS  
217 (version 28.0). Significance was set at  $p \leq 0.05$ .

218

## 219 Results

220 The mean of the slope indicates the tendency for changes. As reported in Table 1, sRPE,  
221 wellbeing, perceived fatigue and soreness were decreased across the four weeks of  
222 preseason (i.e. the mean slope was negative for all parameters). Differences between  
223 players were found for sRPE ( $V(\text{intercept})=2.982$ ,  $p < 0.01$ ), wellbeing  
224 ( $V(\text{intercept})=0.06$ ,  $p=0.01$ ), perceived fatigue ( $V(\text{intercept})=0.0232$ ,  $p < 0.01$ ) and  
225 soreness ( $V(\text{intercept})=0.09$ ,  $p < 0.01$ ) at baseline (week 1). Substantial inter-individual  
226 variation (i.e., differences between players) was also found across the four weeks of pre-  
227 season for perceived fatigue ( $V(\text{slope})=0.241$ ,  $p=0.02$ ) and soreness ( $V(\text{slope})=0.074$ ,  
228  $p=0.04$ ). A significant covariance between intercept and slope was noted for perceived  
229 fatigue ( $-0.22$ ,  $p=0.01$ ) and soreness ( $-0.05$ ,  $p=0.07$ ). The negative coefficient indicates

230 that players who reported higher values of perceived fatigue or soreness at baseline (week  
231 1) reported smaller fluctuations in these variables across the preseason period. Figures 1  
232 illustrates fluctuations (panel A and C) and intra-individual changes (panel B and D) in  
233 sRPE and wellbeing.

234 [Table 1 – about here]  
235 [Figure 1 – about here]

236  
237 Physical performance and playing time are reported in Table 2. Figure 2 (panel  
238 A, B and, C) represents the conditioning models with exogenous variables (physical tests)  
239 as potential predictors of growth latent models, with solely the significant models  
240 presented. T-test and 30-m sprint, measured on day one of preseason are related with  
241 changes in sRPE throughout preseason (t-test:  $\chi^2/df = 2.895$ ; poor adjustment; 30-m  
242 sprint:  $\chi^2/df = 1.608$ ; good adjustment). The Yoyo test was associated with changes in  
243 perceived fatigue ( $\chi^2/df = 0.534$ ; very good adjustment). In these models, the error  
244 decreased compared with simple models (variance is presented in Table 1). The negative  
245 standardized slope presented in Figure 2 for the t-test and 30-m sprint assessment,  
246 demonstrated that faster players reported higher values of sRPE. Players who performed  
247 better on the Yoyo test also reported higher levels of perceived fatigue across preseason.  
248 The variability of pre-season indicators on playing time (obtained in four competitive  
249 matches) was tested. Only the significant model was represented (Figure 2 – panel D).  
250 Variation in perceived fatigue measured during preseason impacted on playing time in  
251 the four subsequent matches (i.e., higher perceptions of fatigue during the preseason  
252 period were related with longer playing durations – the slope is positive). All constrained  
253 models were significant ( $p < 0.05$ ).

254 [Table 2 – about here]  
255 [Figure 2 – about here]

256  
257  
258  
259  
260  
261  
262  
263  
264  
265  
266  
267  
268

## 269 **Discussion**

270 The findings of this study evaluated changes in internal training load across preseason  
271 and the relationships between physical tests and internal training load in youth soccer  
272 players. The results suggest that sRPE, wellbeing, perceived fatigue, and soreness values  
273 decreased as a function of time over a four-week preseason period. Inter-individual  
274 variations in fatigue and soreness highlighted the heterogeneity in players' responses to  
275 training. Agility and sprint tests were predictors of sRPE, demonstrating that faster  
276 players perceived higher exertion during seasons throughout preseason. Higher Yoyo test  
277 results correlated with greater fatigue during preseason. This suggests that those with  
278 greater aerobic capacity at the beginning of the season reported higher perceptions of  
279 fatigue throughout preseason. Perceived fatigue was also higher for the players with  
280 greater playing time in preseason matches (i.e., those that completed greater match  
281 durations reported higher level of fatigue). The findings can be used for preparing and  
282 monitoring youth soccer players during preseason.

283 The positive correlation between agility, speed and perceived exertion aligns with  
284 previous findings that suggests physical fitness is closely related to perceived training  
285 difficulty in youth soccer players<sup>29</sup>. While enhanced aerobic performance was associated  
286 with increased playing time, it was also correlated with greater perceptions of fatigue,  
287 warranting further investigation. This suggests that players producing superior Yoyo test  
288 scores, subsequently report higher fatigue throughout preseason. Interestingly, those with  
289 superior Yoyo performance were also slower according to the linear sprint speed and  
290 agility data. This is likely attributed to muscle fiber type composition since slow-twitch  
291 muscle fibres are more resistant to fatigue than fast-twitch fibers, but are incapable of  
292 producing high contraction speeds<sup>30</sup>. It is also plausible that this finding could reflect that  
293 those with a greater aerobic capacity also complete a greater quantity of activity during  
294 training and matches than those that are less aerobically conditioned, hence explaining  
295 the higher perceptions of fatigue. This may indicate an optimal balance that must be  
296 maintained between internal training load, player readiness, and recovery in soccer<sup>31,32</sup>.  
297 The positive relationship between greater aerobic capacity and perceptions of fatigue,  
298 emphasizes the need for a comprehensive understanding of individual player responses  
299 to internal training load and highlights the importance of monitoring fatigue as a predictor  
300 of fatigue and match performance<sup>33,34</sup>.

301 The intra and inter-individual changes in sRPE, fatigue, soreness, and wellbeing  
302 emphasize the importance of individualized training programs to manage training loads  
303 in young soccer players during preseason<sup>35,36</sup>. This is supported by the inter-individual  
304 variations in fatigue and soreness, which suggests that a one-size-fits-all approach to  
305 preseason training may not be effective for youth soccer players. Therefore, tailoring  
306 preseason training to an individual players' needs and capacities may enhance wellbeing  
307 and performance of soccer players<sup>37</sup>. The finding that increased playing time in  
308 subsequent matches was related with higher perceptions of fatigue is a novel finding that  
309 suggests a multifaceted interaction between training, recovery, and competitive readiness.  
310 Players would be unlikely to sustain activity at the required intensity when experiencing  
311 fatigue<sup>38</sup>. Therefore, based on the findings, practitioners, coaches, and medical staff in  
312 academies may consider monitoring the duration of training and matches of each player  
313 to identify the those that perhaps require additional aerobic training.

314 The current study provides meaningful insights into physical performance and  
315 training loads in youth soccer players, yet there are several limitations that must be  
316 considered. While the measurement tools used are widely accepted, they may have  
317 intrinsic limitations. For example, self-reported measures such as wellbeing  
318 questionnaires might be influenced by reporting bias, and the use of tests like the Yoyo  
319 Intermittent Recovery Test Level 1 may not capture all aspects of players' fitness. The  
320 study did not directly assess offseason training programs, leaving an area unexplored that  
321 could provide valuable insights into preparation and performance. The focus on a single  
322 preseason may overlook potential long-term developmental aspects and the cumulative  
323 effects of sequential seasons on player performance and wellbeing. Further investigations  
324 that include more diverse samples and direct examinations of offseason training could  
325 lead to a more comprehensive understanding of youth soccer players.

326

### 327 **Practical applications**

328 The findings of the current study offer valuable applications for coaches, players, and  
329 academics. The observed correlation between the Yoyo test performance and subsequent  
330 playing time emphasizes the significance of aerobic capacity in youth soccer. It is likely  
331 that players with higher aerobic capacity have enhanced physical outputs, and as such,  
332 undertake a greater quantity of actions and technical involvements, resulting in them

333 being selected more frequently by the coach. This is substantiated given that technical  
334 performance has shown to decline between the first and second half in line with physical  
335 fatigue<sup>39</sup>. Coaches can use this information to design their training protocols, particularly  
336 in the preseason and offseason. For instance, incorporating exercises that improves  
337 aerobic endurance might enhance a player's match time in the competitive season. Given  
338 the ease of application for the Yoyo test, it serves as a practical tool to monitor players'  
339 fitness levels throughout the season. The study also highlighted the importance of  
340 managing load effectively, with coaches advised to pay careful attention to players'  
341 perceived exertion and signs of fatigue. The use of wellbeing questionnaires could also  
342 be a valuable tool, enabling more objective monitoring of players' responses to training  
343 and competition.

344 These results also possess implications for the offseason period. The offseason is  
345 typically used as a time for rest and recovery; however, the findings suggest it may be  
346 useful for preparing youth soccer players for the demands of the competitive season akin  
347 with previous guidelines<sup>40</sup>. Training programs designed for the offseason that focus on  
348 enhancing aerobic capacity could be vital in optimizing player readiness for preseason  
349 training and matches, enabling higher intensities during play<sup>25</sup>. The importance of  
350 training during the offseason emphasizes the need for coaches and sports scientists to take  
351 a year-round view of player development, rather than seeing the offseason solely as  
352 downtime<sup>41</sup>. The present study corroborates the need for further research into youth  
353 soccer training and performance, such as through longitudinal studies tracking training  
354 loads over multiple seasons in youth soccer players.

355

## 356 **Conclusion**

357 The present study reveals relationships between preseason physical tests, internal load  
358 parameters, and playing time during preseason in youth soccer players. The data suggests  
359 that sRPE, perceived fatigue and soreness increase across the preseason period.  
360 Heterogeneity in perceived fatigue and soreness were apparent, with players that report  
361 higher perceptions of fatigue and soreness on the first day of preseason, experiencing  
362 smaller fluctuations in these variables across preseason. This suggests that players should  
363 utilize the offseason period to ensure they are prepared and conditioned for preseason,  
364 perhaps leading to lesser ratings of fatigue and soreness throughout this period. These



365 findings suggest that individualized training programs and careful management of  
366 internal training load are required. The results of this study enrich our understanding of  
367 youth soccer preparation and performance, offering applications for practitioners and  
368 directions for future research. The insights provided could lead to more effective training  
369 programs, enhanced player wellbeing, and elevated performance.

370

### 371 **Funding**

372 This research was funded by the Portuguese Recovery and Resilience Program (PRR),  
373 IAPMEI/ANI/FCT under the Agenda C645022399-00000057 (eGamesLab).

374

### 375 **References**

- 376 1. Clemente FM, Sarmiento H, Costa IT, Enes AR, Lima R. Variability of Technical  
377 Actions During Small-Sided Games in Young Soccer Players. *J Hum Kinet.* 2019;69:201-  
378 212. doi:10.2478/hukin-2019-0013
- 379 2. Sarmiento H, Clemente FM, Harper LD, Costa ITD, Owen A, Figueiredo AJ. Small  
380 sided games in soccer—a systematic review. *Int J Perform Anal Sport.* 2018;18(5):693-  
381 749.
- 382 3. Emmonds S, Till K, Weaving D, Burton A, Lara-Bercial S. Youth Sport Participation  
383 Trends Across Europe: Implications for Policy and Practice [published online ahead of  
384 print, 2023 Jan 25]. *Res Q Exerc Sport.* 2023;1-12. doi:10.1080/02701367.2022.2148623
- 385 4. Emmet D, Roberts J, Yao KV. Update on preventing overuse injuries in youth  
386 athletes. *Curr. Phys. Med. Rehabil.* 2022;10(3), 248-256.
- 387 5. Towlson C, Salter J, Ade JD, et al. Maturity-associated considerations for training  
388 load, injury risk, and physical performance in youth soccer: One size does not fit all. *J*  
389 *Sport Health Sci.* 2021;10(4):403-412. doi:10.1016/j.jshs.2020.09.003
- 390 6. van der Sluis A, Elferink-Gemser MT, Coelho-e-Silva MJ, Nijboer JA, Brink MS,  
391 Visscher C. Sport injuries aligned to peak height velocity in talented pubertal soccer  
392 players. *Int J Sports Med.* 2014;35(4):351-355. doi:10.1055/s-0033-1349874
- 393 7. Read PJ, Oliver JL, De Ste Croix MB, Myer GD, Lloyd RS. The scientific  
394 foundations and associated injury risks of early soccer specialisation. *J Sports Sci.*  
395 2016;34(24):2295-2302. doi:10.1080/02640414.2016.1173221
- 396 8. Bergeron MF. Youth sports in the heat: recovery and scheduling considerations for  
397 tournament play. *Sports Med.* 2009;39(7):513-522. doi:10.2165/00007256-200939070-  
398 00001
- 399 9. Wrigley R, Drust B, Stratton G, Scott M, Gregson W. Quantification of the typical  
400 weekly in-season training load in elite junior soccer players. *J Sports Sci.*  
401 2012;30(15):1573-1580. doi:10.1080/02640414.2012.709265

- 402 10. Johnson DM, Cumming SP, Bradley B, Williams S. How much training do English  
403 male academy players really do? Load inside and outside of a football academy. *Int J*  
404 *Sports Sci Coach*. 2023;18(4):1123–1131. doi:10.1177/17479541221101847  
405
- 406 11. Impellizzeri FM, Marcora SM, Coutts AJ. Internal and External Training Load: 15  
407 Years On. *Int J Sports Physiol Perform*. 2019;14(2):270-273. doi:10.1123/ijssp.2018-  
408 0935  
409
- 410 12. Jaspers A, Brink MS, Probst SG, Frencken WG, Helsen WF. Relationships Between  
411 Training Load Indicators and Training Outcomes in Professional Soccer. *Sports Med*.  
412 2017;47(3):533-544. doi:10.1007/s40279-016-0591-0  
413
- 414 13. Noon MR, James RS, Clarke ND, Akubat I, Thake CD. Perceptions of well-being and  
415 physical performance in English elite youth footballers across a season. *J Sports Sci*.  
416 2015;33(20):2106-2115. doi:10.1080/02640414.2015.1081393  
417
- 418 14. Rodríguez-Marroyo JA, Antoñan C. Validity of the session rating of perceived  
419 exertion for monitoring exercise demands in youth soccer players. *Int J Sports Physiol*  
420 *Perform*. 2015;10(3):404-407. doi:10.1123/ijssp.2014-0058  
421
- 422 15. Lechner S, Ammar A, Boukhris O, et al. Monitoring training load in youth soccer  
423 players: effects of a six-week preparatory training program and the association between  
424 external and internal loads. *Biol Sport*. 2023;40(1):63-75.  
425 doi:10.5114/biolSport.2023.112094  
426
- 427 16. Schmikli SL, Brink MS, de Vries WR, Backx FJ. Can we detect non-functional  
428 overreaching in young elite soccer players and middle-long distance runners using field  
429 performance tests?. *Br J Sports Med*. 2011;45(8):631-636.  
430 doi:10.1136/bjism.2009.0674627  
431
- 432 17. Noon MR, James RS, Clarke ND, Akubat I, Thake CD. Perceptions of well-being and  
433 physical performance in English elite youth footballers across a season. *J Sports Sci*.  
434 2015;33(20):2106-2115. doi:10.1080/02640414.2015.1081393  
435
- 436 18. Fanchini M, Ferraresi I, Modena R, Schena F, Coutts AJ, Impellizzeri FM. Use of  
437 CR100 Scale for Session Rating of Perceived Exertion in Soccer and Its  
438 Interchangeability With the CR10. *Int J Sports Physiol Perform*. 2016;11(3):388-392.  
439 doi:10.1123/ijssp.2015-0273  
440
- 441 19. Morris R, Emmonds S, Jones B, Myers TD, Clarke ND, Lake J, Ellis M, Singleton D,  
442 Roe G, Till K. Seasonal changes in physical qualities of elite youth soccer players  
443 according to maturity status: comparisons with aged matched controls. *Sci. Med Footb*.  
444 2018;2(4):272-80.  
445
- 446 20. McQuilliam SJ, Clark DR, Erskine RM, Brownlee TE. (2023). Physical testing and  
447 strength and conditioning practices differ between coaches working in academy and first  
448 team soccer. *Int J Sports Sci Coach*. 2013;18(4):1045–1055.  
449 doi:10.1177/17479541231155108  
450



- 451 21. Swain M, Kamper SJ, Maher CG, Broderick C, McKay D, Henschke N. Relationship  
452 between growth, maturation and musculoskeletal conditions in adolescents: a systematic  
453 review. *Br J Sports Med.* 2018;52(19):1246-1252. doi:10.1136/bjsports-2017-098418  
454
- 455 22. Borg G. Perceived exertion as an indicator of somatic stress. *Scand J Rehabil Med.*  
456 1970;2(2):92-98.  
457
- 458 23. Foster C, Boullosa D, McGuigan M, et al. 25 Years of Session Rating of Perceived  
459 Exertion: Historical Perspective and Development. *Int J Sports Physiol Perform.*  
460 2021;16(5):612-621. doi:10.1123/ijsp.2020-0599  
461
- 462 24. Hooper SL, Mackinnon LT. Monitoring overtraining in athletes.  
463 Recommendations. *Sports Med.* 1995;20(5):321-327. doi:10.2165/00007256-  
464 199520050-00003  
465
- 466 25. McLean BD, Coutts AJ, Kelly V, McGuigan MR, Cormack SJ. Neuromuscular,  
467 endocrine, and perceptual fatigue responses during different length between-match  
468 microcycles in professional rugby league players. *Int J Sports Physiol Perform.*  
469 2010;5(3):367-383. doi:10.1123/ijsp.5.3.367  
470
- 471 26. Bangsbo J, Iaia FM, Krstrup P. The Yo-Yo intermittent recovery test : a useful tool  
472 for evaluation of physical performance in intermittent sports. *Sports Med.* 2008;38(1):37-  
473 51. doi:10.2165/00007256-200838010-00004  
474
- 475 27. Byrne BM. Structural Equation Modeling with AMOS: Basic Concepts, Applications,  
476 and Programming. New York, NY: Routledge; 2016.  
477
- 478 28. Marôco J. Análise de equações estruturais: Fundamentos teóricos, software &  
479 aplicações. ReportNumber, Lda; 2014.  
480
- 481 29. Gil-Rey E, Lezaun A, Los Arcos A. Quantification of the perceived training load and  
482 its relationship with changes in physical fitness performance in junior soccer players. *J*  
483 *Sports Sci.* 2015;33(20):2125-2132. doi:10.1080/02640414.2015.1069385  
484
- 485 30. Lievens E, Van Vossel K, Van de Castele F, et al. Muscle Fibre Typology as a Novel  
486 Risk Factor for Hamstring Strain Injuries in Professional Football (Soccer): A Prospective  
487 Cohort Study. *Sports Med.* 2022;52(1):177-185. doi:10.1007/s40279-021-01538-2  
488
- 489 31. Figueiredo DH, Figueiredo DH, Moreira A, Gonçalves HR, Dourado AC. Dose-  
490 Response Relationship Between Internal Training Load and Changes in Performance  
491 During the Preseason in Youth Soccer Players. *J Strength Cond Res.* 2021;35(8):2294-  
492 2301. doi:10.1519/JSC.0000000000003126  
493
- 494 32. Pereira LA, Freitas TT, Zanetti V, Loturco I. Variations in Internal and External  
495 Training Load Measures and Neuromuscular Performance of Professional Soccer Players  
496 During a Preseason Training Period. *J Hum Kinet.* 2022;81:149-162. Published 2022 Feb  
497 10. doi:10.2478/hukin-2022-0012  
498
- 499 33. Halson SL. Monitoring training load to understand fatigue in athletes. *Sports Med.*  
500 2014;44 Suppl 2(Suppl 2):S139-S147. doi:10.1007/s40279-014-0253-z

- 501  
502 34. Thorpe RT, Atkinson G, Drust B, Gregson W. Monitoring Fatigue Status in Elite  
503 Team-Sport Athletes: Implications for Practice. *Int J Sports Physiol Perform.*  
504 2017;12(Suppl 2):S227-S234. doi:10.1123/ijsp.2016-0434  
505  
506 35. Douchet T, Paizis C, Carling C, Cometti C, Babault N. Typical weekly physical  
507 periodization in French academy soccer teams: a survey. *Biol Sport.* 2023;40(3):731-740.  
508 doi:10.5114/biol sport.2023.119988  
509  
510 36. Marynowicz J, Kikut K, Lango M, Horna D, Andrzejewski M. Relationship Between  
511 the Session-RPE and External Measures of Training Load in Youth Soccer Training. *J*  
512 *Strength Cond Res.* 2020;34(10):2800-2804. doi:10.1519/JSC.0000000000003785  
513  
514 37. Ramírez-Campillo R, Meylan C, Alvarez C, et al. Effects of in-season low-volume  
515 high-intensity plyometric training on explosive actions and endurance of young soccer  
516 players. *J Strength Cond Res.* 2014;28(5):1335-1342.  
517 doi:10.1519/JSC.0000000000000284  
518  
519 38. Reilly T, Drust B, Clarke N. Muscle fatigue during football match-play. *Sports Med.*  
520 2008;38(5):357-367. doi:10.2165/00007256-200838050-00001  
521 39. Rampinini E, Impellizzeri FM, Castagna C, Coutts AJ, Wisløff U. Technical  
522 performance during soccer matches of the Italian Serie A league: effect of fatigue and  
523 competitive level. *J Sci Med Sport.* 2009;12(1):227-233.  
524 doi:10.1016/j.jsams.2007.10.002  
525  
526 40. Lyakh V, Mikołajec K, Bujas P, Witkowski Z, Zając T, Litkowycz R, Banyś D..  
527 Periodization in team sport games-A review of current knowledge and modern trends in  
528 competitive sports. *J Hum Kinet.* 2016;54:173.  
529  
530 41. Clemente FM, Ramirez-Campillo R, Sarmiento H. Detrimental Effects of the Off-  
531 Season in Soccer Players: A Systematic Review and Meta-analysis. *Sports Med.*  
532 2021;51(4):795-814. doi:10.1007/s40279-020-01407-4  
533  
534  
535

## 536 **Figure legend**

537  
538 **Figure 1.** Session ratings of perceived exertion (panel A) and wellbeing (panel C) in  
539 addition to intra-individual changes across the four weeks of the pre-season (panels B and  
540 D).  
541

542 **Figure 2.** Latent growth curve models for session ratings of perceived exertion and  
543 fatigue.

**Table 1.** Latent growth models for session ratings of perceived exertion, well-being, fatigue and soreness

<b>Simple model</b>	<b>sRPE</b>	<b>well-being</b>	<b>fatigue</b>	<b>soreness</b>
<b>Intercept</b>				
mean	356.2 (p<0.01)	1.832 (p<0.01)	2.347 (p<0.01)	31.1 (p<0.01)
variance	2.892 (p<0.01)	0.06 (p=0.01)	0.232 (p<0.01)	0.09 (p<0.01)
<b>Slope</b>				
mean	-29.36 (p=0.01)	-0.09 (p<0.01)	-0.292 (p=0.01)	-2.073 (p<0.01)
variance	-55.2 (p=0.62)	0.01 (p=0.15)	0.241 (p=0.02)	0.074 (p=0.04)
<b>Intercept and slope</b>				
covariance	3.11 (p=0.98)	-0.10 (p=0.25)	-0.22 (p=0.01)	-0.05 (p=0.07)

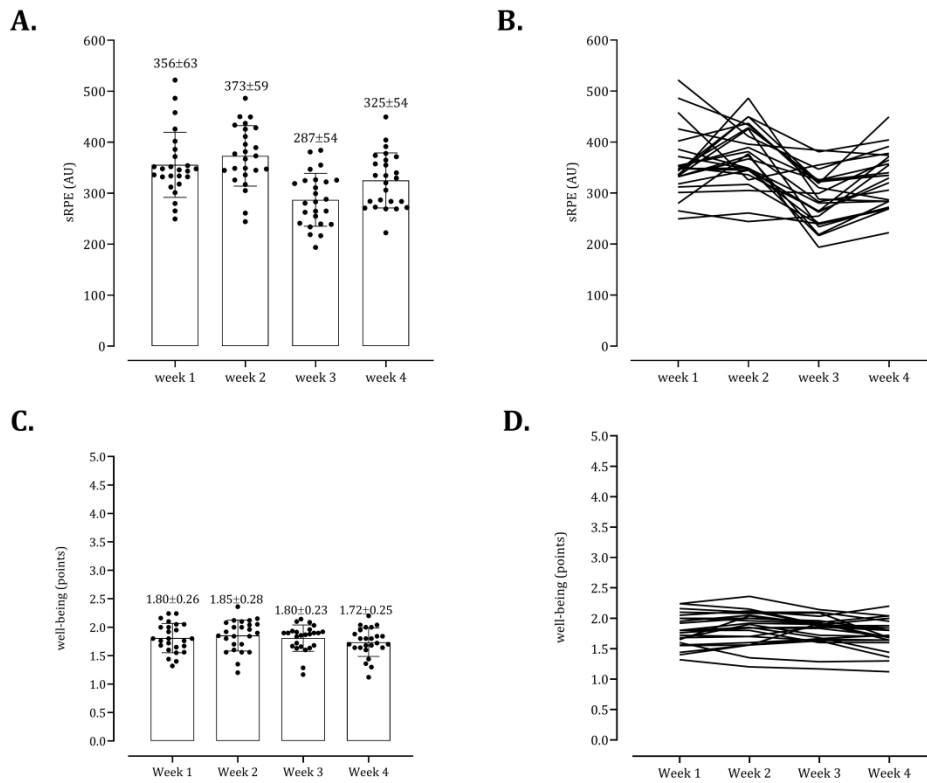
sRPE (session rating of perceived exertion)

**Table 2.** Physical performance responses on the first day of preseason and playing time throughout the matches during preseason

Variable	Descriptive statistics	
	Mean $\pm$ SD (95% CI)	SEM
Squat jump (cm)	30.7 $\pm$ 4.4 (28.8 to 32.5)	0.8
Countermovement jump (cm)	30.5 $\pm$ 3.5 (29.1 to 32.0)	0.7
T-test (s)	10.2 $\pm$ 0.3 (10.0 to 10.4)	0.06
Yoyo Intermittent Recovery Test (level)	26 $\pm$ 6 (24 to 29)	1.1
Playing time (min)	32.5 $\pm$ 25.2 (20.8 to 42.8)	5.2

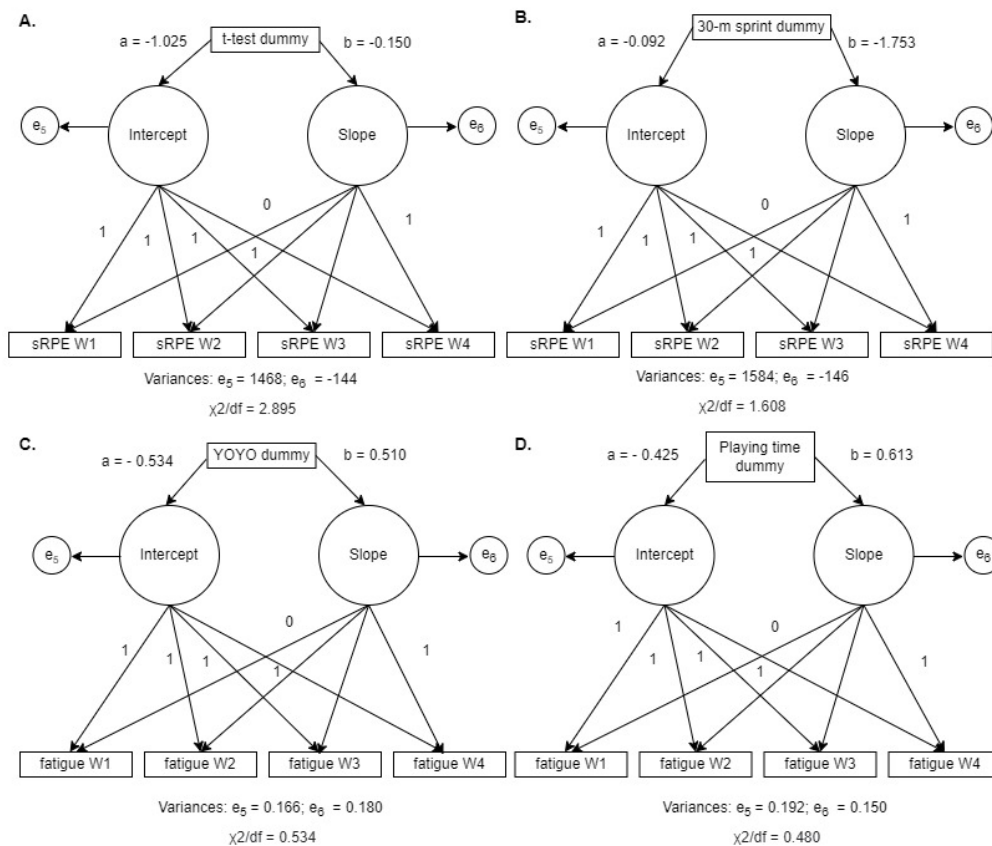
95% CI (95% confidence intervals), SEM (standard error of mean)

For Peer Review



Session ratings of perceived exertion (panel A) and well-being (panel C) in addition to intra-individual changes across the four weeks of the pre-season (panels B and D).

234x206mm (600 x 600 DPI)



Latent growth curve models for session ratings of perceived exertion and fatigue.

283x244mm (72 x 72 DPI)

**Supplementary Material 1.** Training and match schedule over the last 4-weeks of preseason.

<b>Week</b>	<b>Monday</b>	<b>Tuesday</b>	<b>Wednesday</b>	<b>Thursday</b>	<b>Friday</b>	<b>Saturday</b>
1	<b>Rest</b>	<b>Training</b> (small-sided games)	<b>Training</b> (offensive and defensive organization and 1 vs. 1 contests)	<b>Training</b> (tactical drills during a match scenario)	<b>Training</b> (speed drills and offensive organization)	<b>Training</b> (offensive pressing drill)
2	<b>Rest</b>	<b>Rest</b>	<b>Training</b> (positional drills)	<b>Training (M)</b> (individual technique training and timings of entry in deep space <b>Match (A)</b> )	<b>Training</b> (offensive pressing drill and organization from goal kicks)	<b>Match (A)</b>
3	<b>Rest</b>	<b>Training</b> (defending crosses and timing of finishing)	<b>Training</b> (positional drills)	<b>Training</b> (offensive organization)	<b>Training</b> (speed drills)	<b>Rest</b>
4	<b>Rest</b>	<b>Training</b> (small-sided games)	<b>Training</b> (tactical drills during a match scenario)	<b>Training</b> (offensive pressing drill and organization from goal kicks)	<b>Match (A)</b>	<b>Match (M)</b> <b>Match (A)</b>

M (morning), A (afternoon).