



LJMU Research Online

Moreira, A, Saldanha Aoki, M, Carling, C, Alan Rodrigues Lopes, R, Felipe Schultz de Arruda, A, Lima, M, Cesar Correa, U and Bradley, PS

Temporal Changes in Technical and Physical Performances During a Small-Sided Game in Elite Youth Soccer Players.

<http://researchonline.ljmu.ac.uk/id/eprint/6074/>

Article

Citation (please note it is advisable to refer to the publisher's version if you intend to cite from this work)

Moreira, A, Saldanha Aoki, M, Carling, C, Alan Rodrigues Lopes, R, Felipe Schultz de Arruda, A, Lima, M, Cesar Correa, U and Bradley, PS (2016) Temporal Changes in Technical and Physical Performances During a Small-Sided Game in Elite Youth Soccer Players. Asian J Sports Med. 7 (4). ISSN

LJMU has developed [LJMU Research Online](#) for users to access the research output of the University more effectively. Copyright © and Moral Rights for the papers on this site are retained by the individual authors and/or other copyright owners. Users may download and/or print one copy of any article(s) in LJMU Research Online to facilitate their private study or for non-commercial research. You may not engage in further distribution of the material or use it for any profit-making activities or any commercial gain.

The version presented here may differ from the published version or from the version of the record. Please see the repository URL above for details on accessing the published version and note that access may require a subscription.

For more information please contact researchonline@ljmu.ac.uk

<http://researchonline.ljmu.ac.uk/>

1 **Temporal changes in technical and physical performances during a**
2 **small-sided game in elite youth soccer players**

3 *Running head: Technical and physical performance in SSG*

4 **Research Article**

5
6 Alexandre Moreira¹, Marcelo S. Aoki², Chris Carling³, Rafael A. R. Lopes^{1,4}, Ademir F.
7 S. Arruda¹, Marcelo Lima², Umberto C. Corrêa⁵, Paul S. Bradley⁶

8
9 ¹ Department of Sport, School of Physical Education and Sport, Department of Sport,
10 University of Sao Paulo, Sao Paulo, Brazil.

11 ² School of Arts, Sciences and Humanities, University of Sao Paulo, Sao Paulo, Brazil
12 Sao Paulo, Brazil.

13 ³ Institute of Coaching and Performance, University of Central Lancashire, Preston, UK.

14 ⁴ President Laudo Natel Athlete Development Center – São Paulo Futebol Clube, Brazil.

15 ⁵ Department of Pedagogy of Human Body Movement, School of Physical Education
16 and Sport, University of Sao Paulo, Sao Paulo, Brazil.

17 ⁶ School of Sport, Leeds Beckett University, UK.

18
19 Corresponding author

20 Dr Alexandre Moreira

21 School of Physical Education and Sport, University of Sao Paulo, Sao Paulo, Brazil.

22 Av. Prof. Mello Moraes, 65, Cidade Universitária, São Paulo, Brazil. Zip Code 05508-
23 030. E-mail: alemoreira@usp.br

24 Telephone: +55-11-30918789

25 Fax: +55-11-38135091

26
27 *Abstract word count: 221*

28 *Text only word count: 2557*

29 *Number of tables: 2*

30 *Number of figures: 0*

31

32 **ABSTRACT**

33 *Background:* There have been claims that small-sided games (SSG) may generate an
34 appropriate environment to develop youth players' technical performance associated to
35 game-related problem solving. However, the temporal change in technical performance
36 parameters of youth players during SSG is still unknown.

37 *Objectives:* The aim of this study was to examine temporal changes in technical and
38 physical performances during a small-sided game (SSG) in elite soccer players.

39 *Materials and Methods:* Sixty elite youth players (age 14.8 ± 0.2 yr; stature 177 ± 5 cm;
40 body mass 66.2 ± 4.7 kg) completed a 5 v 5 SSG using two repetitions of 8 min
41 interspersed by 3 min of passive recovery. To evaluate temporal changes in
42 performance, the data were analysed across 4 min quarters. Physical performance
43 parameters included the total distance covered (TDC), the frequency of sprints (>18
44 $\text{km} \cdot \text{h}^{-1}$), accelerations and decelerations ($>2.0 \text{ m} \cdot \text{s}^{-2}$ and $-2.0 \text{ m} \cdot \text{s}^{-2}$), metabolic power
45 ($\text{W} \cdot \text{kg}^{-1}$), Bannister's training impulse (TRIMP), TDC: TRIMP, number of impacts, and
46 body load. Technical performance parameters included goal attempts, total number of
47 tackles, tackles and interceptions, total number of passes, and passes effectiveness.

48 *Results:* All physical performance parameters decreased from the first to the last quarter
49 with notable declines in TDC, metabolic power and the frequency of sprints,
50 accelerations and decelerations ($p < 0.05$; moderate to very large ES: 1.08-3.30).
51 However, technical performance parameters did not vary across quarters ($p > 0.05$;
52 trivial ES for 1st v 4th quarters: 0.15-0.33).

53 *Conclusions:* The data demonstrate that technical performance is maintained despite
54 substantial declines in physical performance during a SSG in elite youth players. This
55 finding may have implications for designing SSG's for elite youth players to ensure
56 physical, technical and tactical capabilities are optimized. Modifications in player
57 number, pitch dimensions, rules, coach encouragement, for instance, should be included
58 taking into account the main aim of a given session and then focused on overloading
59 physical or technical elements.

60

61 **KEY WORDS:** Football; drills; fatigue; passing.

62

63 1. BACKGROUND

64
65 Small-sided games (SSG) are used in elite soccer as a sports-specific training
66 modality to enhance player performance. Their popularity in elite soccer is based on the
67 premise that technical, tactical and physical components are trained concurrently (1–3).
68 Some authors suggest that SSG are effective in aiding identification of players that are
69 also capable of performing well during full sized 11 aside games (4). Moreover, others
70 have claimed that SSG may generate an appropriate environment to develop technical
71 performance associated to game-related problem solving (5). Although research has
72 investigated the physiological responses to various SSG (1,6), the temporal change in
73 technical performance parameters during SSG is still unknown.

74 Research demonstrates that high-intensity running declines from the first to
75 second half of elite senior soccer matches (7,8). Moreover, Bradley & Noakes (9)
76 revealed that high-intensity running during the second half of matches was impacted by
77 the activity of the first half and that running performances were reduced after intensified
78 periods of match play. Similarly, a reduction across halves has been observed for
79 technical variables during matches such as involvements with the ball and passes (10).
80 In contrast, Carling & Dupont (11) reported that elite players were generally able to
81 maintain skill-related performance throughout games despite declines in high-intensity
82 running distance. To maintain skill related performance during matches, it has been
83 suggested that players employ pacing strategies either consciously or subconsciously
84 (9). A pacing strategy in soccer could reduce low-intensity activities such as walking
85 and jogging in an attempt to preserve energy to perform essential high-intensity running
86 actions (12,13) and maintain technical performance.

87 Although pacing may explain the physical performance changes across games and
88 the maintenance of skill-related performance, there is limited data regarding these
89 changes during SSG in elite youth players. Moreover, it is still unknown whether
90 changes in physical performance during SSG deteriorates technical performance in this
91 population, particularly in the last quarter of the SSG as it does in real match play for
92 senior players. This information could have important implications for applied sports
93 scientists given that SSG should not only provide a physical overload stimulus but
94 should also tax players' technical problem solving capabilities. If the SSG fails to
95 achieve one or both of these elements, then the drill should be optimized to provide the

96 correct physical and technical overload that will enable players to improve their overall
97 performance during games.

98
99

100 **2. OBJECTIVES**

101

102 Therefore, the aim of this study was to examine transient changes in technical and
103 physical performances during a SSG in elite soccer players. It was hypothesized that
104 marked declines in physical performance parameters would be evident during the latter
105 stages of the SSG and that these changes would impact on technical performance
106 parameters.

107

108

109 **3. MATERIALS AND METHODS**

110

111 *3.1. Subjects*

112 Sixty elite youth soccer players signed to a professional Brazilian club participated
113 (U14 and U15 teams; age 14.8 ± 0.2 yr; stature 177 ± 5 cm; body mass 66.2 ± 4.7 kg). This
114 sample included defenders: central defenders and fullbacks, $n = 14$; midfielders: central
115 midfielders and wide midfielders, $n = 32$; and attackers, $n = 14$). All players underwent
116 a medical prior to the study and their parents were fully informed of the experimental
117 procedures and associated risks before providing informed consent. The players' typical
118 training schedule comprised of 10-12 sessions per week with each session lasting ~90-
119 120 min. The local University Research Ethics Committee approved the research
120 procedures.

121

122 *3.2. Design*

123 Each player completed a standardized 5 vs 5 SSG using two repetitions of 8 min
124 interspersed by 3 min of passive recovery. In order to avoid from accumulated fatigue
125 due to the habitual schedule of the participants, the assessed SSG were performed on
126 Monday afternoon, ~60h after the previous training session. Each SSG was balanced to
127 ensure similar technical and physical performance levels of the players on each side and
128 players received coach encouragement throughout the session. Players were given
129 instruction to play as intensely as possible and to do their best in order to achieve a high

130 level of technical and tactical performance. As each SSG was balanced taking into
131 account the evaluation of the players by coach, it was expected that the technical
132 positional-dependent would not affect the technical results. To evaluate temporal
133 changes in physical and technical performance, data were analyzed across 4 min
134 quarters. Technical performance was quantified using notational analyses while physical
135 performances were monitored using a Global Positioning System. The SSG was played
136 on a pitch dimension of 45 × 60 m using goalkeepers and full sized goals. There were
137 no other specific playing condition or rule (i.e. limited number of touches, position). All
138 players were familiar with this SSG format as it was habitually used during their weekly
139 training sessions.

140

141 3.3. Technical Performance Parameters

142 Video recordings of SSG were collected using two fixed cameras (Panasonic,
143 Brazil; 60 Hz frequency acquisition). One was located 15 m above and to one side of
144 the long axis of the pitch while the other was placed 5 m to one side of the pitch to
145 facilitate player identification. Match analysis software (Gamebreaker[®], Sports Code[®],
146 USA) was used to code technical performance parameters from this video footage
147 (10,14). Technical performance parameters were chosen according to previous
148 recommendations and included: 1- total goal attempts, 2- total number of tackles and
149 interceptions (sum of total number of tackles and total number of interceptions), 3- total
150 number of tackles, 4- total number of interceptions, 5- total number of passes, 6- passes
151 effectiveness (correct passes/total number of passes), 7- total number of headers, 8- total
152 involvement with the ball (individual ball possession), and 9- overall involvement (sum
153 of all events). In order to identify the structure of relationships between technical
154 performance parameters and subsequently reduce the number of events without losing
155 information regarding technical performance, a Principal Component Analysis (PCA)
156 was adopted. Results from PCA revealed 8 factors with initial eigenvalues >1. Those
157 components which demonstrated eigenvalues >2 and that contribute at least 10% of the
158 total variance of the model were therefore considered for further analysis. Four
159 components, that explained together almost 60% of the variance were retained. The
160 most representative variables extracted from the PCA, for each factor, were then
161 retained for analyses. The retained variables were: goal attempts, total number of
162 tackles, tackles and interceptions, total number of passes.

163

164

165 3.4. *Physical Performance Parameters*

166 Each player wore a 15-Hz GPS unit (SPI Elite, GPSports, Canberra, Australia). The
167 GPS units were coupled with a 100 Hz tri-axial accelerometer and was harnessed
168 between the shoulder blades and anchored using an undergarment to minimise
169 movement. Heart rate was recorded during matches using a heart-rate monitor (T14,
170 Polar, Oy, Finland) fitted into the harness. The reliability and validity of these GPS
171 units has been examined (15). Physical performance parameters included the total
172 distance covered (TDC), the frequency of sprints ($>18 \text{ km}\cdot\text{h}^{-1}$; high-intensity run), and
173 accelerations and decelerations ($>2.0 \text{ m}\cdot\text{s}^{-2}$ and $-2.0 \text{ m}\cdot\text{s}^{-2}$, respectively). The
174 classification of high-intensity running, named as “sprints” in the present study, was in
175 accordance with that previously used with youth players (16,17). In addition,
176 calculations were provided for average metabolic power ($\text{W}\cdot\text{kg}^{-1}$) using instantaneous
177 energy cost equations based on accelerated and decelerated running efforts (18,19). Raw
178 heart-rate data ($\text{b}\cdot\text{min}^{-1}$) were analysed to provide the percentage heart-rate peak
179 (%HRpeak). The maximum HR values reached during a Yo-Yo Intermittent Recovery
180 Test Level 1 conducted during the week before the experiment according to previously
181 described methods (20) was considered as 100%. Edwards’s training impulse (TRIMP)
182 score was calculated as described previously (21). Briefly, the time spent in each of 5
183 HR predefined zones were calculated (Zone 1 ≥ 50 -60%; Zone 2 ≥ 60 -70%; Zone 3 \geq
184 70-80%; zone 4 ≥ 80 - 90% and Zone 5 ≥ 90 -100%). The sum refers to the magnitude of
185 internal training load (ITL; arbitrary units; AU) and is calculated from the result
186 between the corresponding score (Zone 1 = 1; Zone 2 = 2; Zone 3 = 3; Zone 4 = 4; Zone
187 5 = 5) for the time spent in each HR zone (e.g., 5 min in Zone 2 = 10 AU).
188 Subsequently, ITL quantification is held by the sum of the products of each zone (e.g., 5
189 min in Zone 2 = 10 AU + 3 min in Zone 3 = 9 AU, ITL = 19 AU), with the aid of the
190 Excel program (Microsoft Corporation©, USA). The total distance covered (TDC) was
191 divided by the TRIMP score to provide the TDC: TRIMP (22,23). These ratios
192 represent the integration of ITL and external training load (ETL) with higher values
193 associated with greater exercise economy (23). The number of impacts and body load
194 (BL) were also determined. Player impact measures and body load were gathered from
195 triaxial accelerometer data provided in g force and sampled at 100 Hz. The measure of
196 impacts is determined from the summed accelerations from 3 accelerometer planes.

197 Impacts are derived from the vector of the X-Y-Z axes of the tri-axial accelerometer.
198 According to the manufacture, the vector is calculated as the square root of the sum of
199 the squares of each axis. Impacts are therefore reported as a count of events into each
200 zone (using similar logic to speed zone entries). This variable is analyzed using six pre-
201 defined zones of *G* force: Zone 1 (5.0–6.0g), Zone 2 (>6.0-6.5g), Zone 3 (>6.5-7.0g),
202 Zone 4 (>7.0-8.0g), Zone 5 (>8.0-10.0g) and Zone 6 (>10.0g). This zone classification
203 system forms the basis of the analysis performed by the Team AMS (GPSports, SPI
204 Elite, Australia) software and involves the use of the acceleration zone forces provided
205 in “*G*” force by the accelerometer in the GPS. The impact classification system used in
206 this study was based on methods presented previously in young soccer players (16,25),
207 Rugby League (26,27), and Rugby Union (28) and in accordance with manufacturer
208 guidelines (GPSports, Australia). For the purpose of the present study any impact above
209 zone 1 were retained for analysis.

210 Body load provides a measure of total stress resulting from accelerations,
211 decelerations, changes of direction, and impacts. Body load was calculated
212 automatically using a custom algorithm included in the proprietary software provided
213 by the manufacturers (TeamAMS Version 17, GPSports, Canberra, Australia). The
214 body load is derived from the square root of the sum of the squared instantaneous rate
215 of change in acceleration in each of the 3 vectors (*x*-, *y*-, and *z*-axes). The body load was
216 expressed in arbitrary units (AU).

217

218

219 3.5. *Statistical Analysis*

220 Descriptive statistics were calculated on each variable and the Shapiro-Wilk test was
221 used to verify data normality. Analysis of variance (ANOVA) with repeated measures
222 and Friedman tests were used to explore physical and technical performance parameters,
223 respectively, across 4 min periods of the SSG. In the event of a significant difference, a
224 Bonferroni post-hoc test was used to identify any localised effects. Statistical
225 significance was set at $p < 0.05$. Effect sizes (ES) were calculated to determine the
226 meaningfulness of the difference. ES magnitudes were classified as: 0–0.19 trivial; 0.2–
227 0.59 small; 0.6–1.19 moderate; 1.2–1.99 large; >2 very large (24). All data were
228 analysed using the STATISTICA software (StatSoft Version 12) and presented as
229 means and standard deviations (SD).

230

231

232 4. RESULTS

233

234 Table 1 presents the technical and physical performances parameters across 4 min
235 periods of the SSG. Significant changes in TDC ($F= 38.50$, $p < 0.001$), accelerations
236 ($F= 20.05$, $p < 0.001$; $ES = 0.21 - 2.00$), decelerations ($F= 7.05$, $p < 0.001$; $ES = 0.10-$
237 1.08), number of sprints ($F= 18.10$, $p < 0.001$; $ES = 0 - 1.86$), and MP ($F= 41.79$, $p <$
238 0.0001 ; $ES = 0.53-3.30$), body load ($F = 8.49$, $p < 0.001$), impacts ($F = 3.66$, $p < 0.01$)
239 were observed. However, no significant changes were verified for TRIMP ($F = 1.27$, p
240 $= 0.28$) or TDC: TRIMP ($F = 2.37$, $p = 0.07$). TDC was found to decrease from the 1st
241 quarter to all subsequent quarters of the SSG ($p < 0.05$; $ES = 0.79-1.97$). Body load
242 decreased from the 1st to 2nd ($p < 0.05$; $ES = 0.98$) and 4th quarters ($p < 0.05$; $ES = 1.46$),
243 whilst impacts decreased between the 1st and the 4th quarter ($p < 0.05$; $ES = 0.86$).
244 Interestingly, there are no substantial changes (no moderate, large or very large ES)
245 when comparing the 2nd to 3rd quarter, suggesting that the 3 min of passive recovering
246 was sufficient to provide physical recovery for the assessed players.

247

248 INSERT TABLE 1

249

250 In contrast, none of the technical performance parameters significantly changed
251 across the quarters ($p > 0.05$). The ES for the five assessed technical parameters ranged
252 from 0.15 to 0.33 when comparing the 1st to the 4th quarter (Table 2).

253

254 INSERT TABLE 2

255

256

257 5. DISCUSSION

258

259 The aim of this study was to examine temporal changes in technical and physical
260 performance during a SSG in elite youth soccer players. The data demonstrate that
261 physical performance parameters during the 5 vs 5 SSG decreased from the first to the
262 last quarter with notable declines in TDC, metabolic power and the frequency of sprints,
263 accelerations and decelerations. In contrast, technical performance parameters did not
264 statistically vary across the four quarters.

265 SSG are considered effective at distinguishing between players that are capable of
266 performing well during competitive 11 aside games (4). This is understandable as SSG
267 have technical, tactical and physical demands similar to those in real match play and
268 factors that impact on the physical and technical performances within SSG could also
269 influence performance during full sized games. The progressive decline in physical
270 performance parameters across the 4 min periods of the SSG observed in the present
271 study resemble the transient reductions observed in running performance during elite
272 matches (9). The similarity between SSG and match play trends could indicate a
273 positive pacing profile which is evident within team sports such as soccer (25,26); or the
274 observed transient reductions might be attributed to fatigue mechanisms due to the
275 multiple intense actions during matches (7).

276 Match-induced fatigue seems evident as physical capacity measures markedly
277 decline after matches compared to baseline measures (27,28), with the accumulation of
278 muscle metabolites and substrate depletion as the prime candidates. It is unclear what
279 caused the decline in physical performance parameters in the SSG used in the current
280 study, especially given that the duration of the SSG was significantly lower than match-
281 play (16 vs 90 min). Research demonstrates that lowering the number of players within
282 a drill (5 vs 5) and adding coach encouragement can increase the physical demands
283 placed on players during SSG (29). Interestingly, the TRIMP, which has been
284 considered as an internal training load indicator (22,23) did not change over the 4 SSG
285 quarters. This result might indicate that internal load was maintained over the quarters
286 despite the declines in external load related to GPS and accelerometer derived
287 parameters. Thus, it is plausible that fatigue mechanisms were responsible for the
288 external output declines observed in this study across quarters but a lack of other
289 physiological data (e.g., blood lactate concentration) or subjective measures (e.g., RPE)
290 makes confirmation difficult.

291 In general, it is reasonable to speculate that if fatigue is present during both match-
292 play and SSG then one might have expected a reduction in the technical proficiency of
293 the players. In fact, research has reported a reduction in involvements with the ball and
294 passes in the second half of match-play (10), while others revealed that players were
295 generally able to maintain skill-related performance throughout games despite declines
296 in high-intensity running distance (11). Thus, to maintain skill related performance
297 during matches and the SSG, players could employ conscious or subconscious pacing
298 strategies (9). A pacing strategy in soccer could spare low-intensity activity such as

299 walking and jogging in an attempt to preserve essential high-intensity running (12,13).
300 Given that technical performance was maintained this is a plausible explanation for the
301 data trends within the present study.

302 Indeed, as the present data demonstrated that that physical performance parameters
303 during the 5 vs 5 SSG decreased from the first to the last quarter with notable declines
304 in physical outputs which are highly metabolically taxing, this result in conjunction with
305 the maintenance of the technical performance indicates that a pacing strategy was
306 probably employed by the players. In this regard and taking into account the reports on
307 declines of football players performance towards the end of the match, Alghannam
308 (2012) provided a comprehensive review aimed to establish the understanding the
309 metabolic limitations of performance and the related mechanisms for the onset of the
310 fatigue, including the issue of the transient fatigue during the match and fatigue towards
311 the end of the match. Alghannam (2012) argue that whilst the causes of fatigue during
312 participation in football remain still ambiguous, it should be highlighted that impaired
313 exercise performance is likely to incorporate numerous factors. Nevertheless, despite
314 this complexity, the current premise behind the likely mechanisms of fatigue during
315 football match may be incorporate the hypothesis that a central metabolic control
316 system may be strongly involved in the peripheral physiological responses (i.e. fluid
317 loss, metabolite accumulation, core temperature). This assumption, in accordance with
318 Alghannam (2012) means that players can be adopting pacing strategies during the
319 match to counteract the potential failure of any peripheral physiological system.

320 Even considering that the technical performance parameters used in the present
321 study are relatively robust and sufficient to monitor technical performance during SSG,
322 it is worth noting that one limitation of the current study was the one-dimensional
323 technical parameters used in the present investigation. For instance, we only included
324 passing frequency and completion rates and not the direction (forward, sideways and
325 backwards) or distribution of passes (passes leading to a goal scoring opportunity),
326 which could have improved understanding of the technical demands of the SSG.

327 The current study used a relatively novel approach for monitoring physical
328 performance parameters by combining traditional time motion analysis measures such
329 as the total distance covered with contemporary measures such as
330 accelerations/decelerations. Using only traditional measures such as the distances
331 covered in various speed categories to determine the physical demands of SSG or elite
332 match play fails to account for the additional energy cost of demanding activities such

Commented [A1]: Abdullah F. Alghannam., *Metabolic Limitations of Performance and Fatigue in Football. Asian Journal of Sports Medicine, Volume 3 (Number 2), June 2012, Pages: 65-73*

333 as accelerations/decelerations and multi-directional movements. For instance, most
334 maximal accelerations do not result in speeds associated with high-intensity running but
335 are metabolically taxing (30). Interesting, in the present study, both the traditional and
336 contemporary factors illustrated similar findings despite some highlighting that such
337 contemporary measures provide a more valid and sensitive method for monitoring
338 potential changes in physical performance during SSG and match-play (31,16).

339 Future studies could assess temporal changes during SSG in youth players, using
340 technical, physiological and metabolic parameters in conjunction with traditional time
341 motion analysis measures such as the total distance covered. In addition, it would be
342 included those proposed as contemporary measures, such as accelerations/decelerations,
343 metabolic power, body load, and impacts, in order to extend the knowledge regarding
344 the associations between these internal and external load responses across the SSG. This
345 approach could be useful to a deeper understanding of the factors related to changes in
346 these measures, notably regarding to whether these changes are induced to fatigue or an
347 employed conscious or subconscious pacing strategies.

348 Whilst, the present data adds important and new information regarding the technical
349 and physical SSG performances parameters in elite youth players, there are limitations
350 that should be acknowledged. As only one age-category from a single club was
351 investigated, the present study should be considered as a case study. Then, the results
352 may be specific to this team and might be associated, at least in part, with the training
353 philosophy, in particular for technical and tactical approaches adopted by coaching staff
354 of this club. Moreover, as only one type of SSG format and only one game per players
355 was used in the present study, other formats might induce different results and pacing
356 strategies employed by players. Indeed, it is important to recognize that additional
357 factors such as time/duration, quality opposition, among others, are likely to influence
358 physical performance (32) and therefore could also affect technical performance during
359 distinct SSG formats. Future studies could investigate the effects of manipulating these
360 factors on both physical and technical performance of youth players.

361 The present findings could have implications for sports scientists designing training
362 sessions for elite youth players. For instance, training drills like SSG should overload
363 players' physical, technical and tactical capabilities sufficiently to prepare players for
364 real match-play. Given that physical performance declined while technical performance
365 was maintained, it could be that the technical requirements could be modified in terms
366 of player number, pitch dimension, rules or coach encouragement to fully tax all

367 elements of a player's physical and technical capacity (29). Moreover, it seems prudent
368 that practitioners working with youth players are aware of the importance of monitoring
369 both technical and physical performance during SSG in order to increase the likelihood
370 of achieve the main objectives for a given training session. As the results from the
371 present study suggest that technical and physical performance are taxed differently
372 during the proposed SSG format, the modifications (player number, pitch dimensions,
373 rules, coach encouragement) should be included taking into account the main aim of a
374 given session and then focused on overloading physical or technical elements. For
375 instance, it could be that technical elements are prioritized during a given SSG session
376 over physical factors and vice versa based on the coaches' aim for that session.

377 In summary, the data demonstrate that physical performance parameters during the
378 SSG decreased from the first to the last quarter with notable declines in TDC, metabolic
379 power and the frequency of sprints, accelerations and decelerations. However, technical
380 performance parameters did not vary across quarters.

381

382

383 **ACKNOWLEDGEMENTS**

384

385 The authors would like to thank the President Laudo Natel Athletes Development
386 Center staff for their assistance and great level of commitment to the experimental
387 procedures implemented in this investigation. Special thanks to Prof. Marcelo Massa.

388 This research was supported by FAPESP (*Fundação de Amparo à Pesquisa do Estado*
389 *de São Paulo*; São Paulo Research Foundation, *process*, 2013/24193-2).

390

391 **REFERENCES**

- 392 1. Dellal A, Owen A, Wong DP, Krustup P, van Exsel M, Mallo J. Technical and
393 physical demands of small vs. large sided games in relation to playing position in
394 elite soccer. *Hum Mov Sci.* 2012;31(4):957–69.
- 395 2. Davids K, Araújo D, Correia V, Vilar L. How small-sided and conditioned games
396 enhance acquisition of movement and decision-making skills. *Exerc Sport Sci*
397 *Rev.* 2013;41(3):154–61.
- 398 3. Halouani J, Chtourou H, Gabbett T, Chaouachi A, Chamari K. Small-Sided
399 Games in Team Sports Training. *J Strength Cond Res.* 2014;28(12):3594–618.
- 400 4. Unnithan V, White J, Georgiou A, Iga J, Drust B. Talent identification in youth
401 soccer. *J Sports Sci.* 2012;30(15):1719–26.
- 402 5. Harrison CB, Gill ND, Kinugasa T, Kilding AE. Quantification of physiological,
403 movement, and technical outputs during a novel small-sided game in young team
404 sport athletes. *J Strength Cond Res.* 2013;27(10):2861–8.
- 405 6. Ade JD, Harley JA, Bradley PS. Physiological response, time-motion
406 characteristics, and reproducibility of various speed-endurance drills in elite
407 youth soccer players: small-sided games versus generic running. *Int J Sports*
408 *Physiol Perform.* 2014;9(3):471–9.
- 409 7. Mohr M, Krustup P, Bangsbo J. Match performance of high-standard soccer
410 players with special reference to development of fatigue. *J Sports Sci.*
411 2003;21(7):519–28.
- 412 8. Di Salvo V, Gregson W, Atkinson G, Tordoff P, Drust B. Analysis of high
413 intensity activity in premier league soccer. *Int J Sports Med.* 2009;30(3):205–12.
- 414 9. Bradley PS, Noakes TD. Match running performance fluctuations in elite soccer:
415 Indicative of fatigue, pacing or situational influences? *J Sports Sci.*
416 2013;31(15):1627–38.
- 417 10. Rampinini E, Impellizzeri FM, Castagna C, Coutts AJ, Wisløff U. Technical
418 performance during soccer matches of the Italian Serie A league: effect of fatigue
419 and competitive level. *J Sci Med Sport.* 2009;12(1):227–33.
- 420 11. Carling C, Dupont G. Are declines in physical performance associated with a
421 reduction in skill-related performance during professional soccer match-play? *J*
422 *Sports Sci.* 2011;29(1):63–71.
- 423 12. Edwards AM, Noakes TD. Dehydration: Cause of fatigue or sign of pacing in
424 elite soccer? *Sport Med.* 2009;39(1):1–13.

- 425 13. Jones S, Drust B. Physiological and technical demands of 4 v 4 and 8 v 8 games
426 in elite youth soccer players. *Kinesiology*. 2007;39:150–6.
- 427 14. Waldron M, Worsfold P. Differences in the game specific skills of elite and sub-
428 elite youth football players: implications for talent identification. *Int J Perform*
429 *Anal Sport*. 2010;9–24.
- 430 15. Johnston RJ, Watsford ML, Kelly SJ, Pine MJ, Spurrs RW. Validity and interunit
431 reliability of 10 hz and 15 hz gps units for assessing athlete movement demands.
432 *J Strength Cond Res*. 2014;28(6):1649–55.
- 433 16. Arruda AF, Carling C, Zanetti V, Aoki MS, Coutts AJ, Moreira A. Effects of a
434 very congested match schedule on body load impacts, accelerations, and running
435 measures in youth soccer players. *Int J Sports Physiol Perform*. 2015;10:248–52.
- 436 17. Castagna C, Manzi V, Impellizzeri F, Weston M, Carlos J. Relationship between
437 endurance field tests and match performance in young soccer players. *J Strength*
438 *Cond Reserach*. 2010;24(12):3227–33.
- 439 18. di Prampero PE, Fusi S, Sepulcri L, Morin JB, Belli A, Antonutto G. Sprint
440 running: a new energetic approach. *J Exp Biol*. 2005;208(Pt 14):2809–16.
- 441 19. Osgnach C, Poser S, Bernardini R, Rinaldo R, di Prampero PE. Energy cost and
442 metabolic power in elite soccer: a new match analysis approach. *Med Sci Sports*
443 *Exerc*. 2010;42(1):170–8.
- 444 20. Krustup P, Mohr M, Amstrup T, Rysgaard T, Johansen J, Steensberg A, et al.
445 The yo-yo intermittent recovery test: physiological response, reliability, and
446 validity. *Med Sci Sport Exerc*. 2003;35(4):697–705.
- 447 21. Gomes R V, Moreira A, Lodo L, Capitani CD, Marcelo S, Aoki MS. Ecological
448 validity of session RPE method for quantifying internal training load in tennis.
449 *Int J Sport Sci Coach*. 2015;10(4):729–37.
- 450 22. Akubat I, Barrett S, Abt G. Integrating the internal and external training loads in
451 soccer. *Int J Sports Physiol Perform*. 2014;9(3):457–62.
- 452 23. Kempton T, Sirotic AC, Coutts AJ. An integrated analysis of match-related
453 fatigue in professional rugby league. *J Sports Sci*. 2015;33(1):39–47.
- 454 24. Hopkins WG. Measures of reliability in sports medicine and science. *Sport Med*.
455 2000;30(1):1–15.
- 456 25. Waldron M, Highton J. Fatigue and pacing in high-intensity intermittent team
457 sport: an update. *Sport Med*. 2014;44:1645–58.
- 458 26. Abbiss CR, Laursen PB. Describing and understanding pacing strategies during

- 459 athletic competition. *Sports Med.* 2008;38(3):239–52.
- 460 27. Krstrup P, Zebis M, Jensen JM, Mohr M. Game-induced fatigue patterns in elite
461 female soccer. *J Strength Cond Res.* 2010;24(2):437–41.
- 462 28. Mohr M, Krstrup P, Nybo L, Nielsen JJ, Bangsbo J. Muscle temperature and
463 sprint performance during soccer matches - Beneficial effect of re-warm-up at
464 half-time. *Scand J Med Sci Sport.* 2004;14(3):156–62.
- 465 29. Rampinini E, Coutts AJ, Castagna C, Sassi R, Impellizzeri FM. Variation in top
466 level soccer match performance. *Int J Sports Med.* 2007;28(12):1018–24.
- 467 30. Varley MC, Gabbett T, Aughey RJ. Activity profiles of professional soccer,
468 rugby league and Australian football match play. *J Sports Sci.* 2014;32(20):1858–
469 66.
- 470 31. Carling C, Gregson W, McCall A, Moreira A, Wong DP, Bradley PS. Match
471 running performance during fixture congestion in elite soccer: research issues and
472 future directions. *Sport Med.* 2015;45:605–13.
- 473 32. Lago C. The influence of match location, quality of opposition, and match status
474 on possession strategies in professional association football. *J Sports Sci.*
475 2009;27(13):1463–9.
- 476

477 **Table 1.** Technical and physical performance parameters during the various
 478 periods of the SSG (mean \pm SD).
 479

Variable	1 st quarter	2 nd quarter	3 rd quarter	4 th quarter
<i>Technical Performance</i>				
Goal attempts	0.5 \pm 0.7	0.9 \pm 0.8	0.4 \pm 0.5	0.6 \pm 0.6
Passes	5.1 \pm 2.7	3.9 \pm 2.8	3.6 \pm 1.7	4.4 \pm 1.5
Tackles/Interceptions	2.3 \pm 2.3	2.6 \pm 1.3	2.1 \pm 1.1	2.6 \pm 1.0
Tackles	4.3 \pm 2.1	3.6 \pm 2.2	3.3 \pm 1.4	4.0 \pm 1.3
<i>Physical Performance</i>				
TDC (m)	596 \pm 92 ^c	489 \pm 58 ^b	543 \pm 42 ^d	462 \pm 44
Accelerations (n)	19.2 \pm 3.9 ^a	13.5 \pm 3.9	14.3 \pm 3.7 ^d	11.3 \pm 4.0
Decelerations (n)	11.7 \pm 3.1 ^a	8.8 \pm 3.0	9.1 \pm 2.4	8.5 \pm 2.8
Sprints (n)	13 \pm 3 ^a	9.1 \pm 2.5 ^d	9.1 \pm 2.7 ^d	7.6 \pm 2.8
Body load (AU)	14.9 \pm 3.7 ^c	11.1 \pm 4.0	12.5 \pm 3.1	10.3 \pm 2.6
Impacts (n)	69 \pm 28 ^d	52 \pm 28	54 \pm 21	47 \pm 23
MP (W·kg ⁻¹)	13.5 \pm 0.9 ^a	10.9 \pm 1.5	12.1 \pm 1.1 ^d	10.2 \pm 1.1
TRIMP (AU)	13.2 \pm 4.5	15.0 \pm 5.4	14.5 \pm 4.4	15.7 \pm 4.5
TDC: TRIMP	54.8 \pm 32.8	42.2 \pm 30.4	43.8 \pm 24.2	34.9 \pm 22.5

480 TDC = total distance covered; n = number; MP = Average metabolic power; TDC:
 481 TRIMP = total distance covered divided by Edward's training impulse. ^a = sign diff to
 482 2nd, 3rd and 4th quarters; ^b=sign. diff. to 1st and 3rd quarters; ^c = sign diff to 2nd and 4th; ^d =
 483 sign diff to 4th quarter

484
 485
 486
 487
 488
 489
 490
 491
 492
 493

494 **Table 2.** Effect sizes (ES) for technical and physical performance parameters during
 495 the 4 periods of the SSG.

Variable	1 st 2 nd	to	1 st 3 rd	to	1 st 4 th	to	2 nd 3 rd	to	2 nd 4 th	to	3 rd 4 th
<i>Technical Performance</i>											
Goal attempts	-0.53		0.16		-0.15		0.76		0.42		-0.36
Passes	0.43		0.68		0.33		0.13		-0.23		-0.5
Tackles/Interceptions	-0.16		0.11		-0.18		0.41		0		-0.47
Passes effectiveness	0.19		0.77		0.17		0.42		-0.07		-0.70
<i>Physical Performance</i>											
TDC (m)	1.42		0.79		1.97		-1.08		0.52		1.88
Accelerations (n)	1.46		1.28		2.00		-0.21		0.55		0.77
Decelerations (n)	0.95		0.94		1.08		-0.11		0.10		0.23
Sprints (n)	1.41		1.36		1.86		0		0.56		0.54
Body load (AU)	0.98		0.70		1.46		-0.39		0.24		0.77
Impacts (n)	0.60		0.61		0.86		-0.08		0.19		0.31
MP (W·kg ⁻¹)	2.16		1.40		3.30		-0.92		0.53		1.72
TRIMP	0.36		0.29		0.55		-0.10		0.14		0.26
TDC: TRIMP	0.39		0.38		0.72		-0.05		0.27		0.38

496 TDC = total distance covered; n = number; MP = Average metabolic power; TRIMP =
 497 Edwards' training impulse; TDC: TRIMP = total distance covered divided by Edward's
 498 training impulse. ES: 0–0.19 trivial; 0.2–0.59 small; 0.6–1.19 moderate; 1.2–1.99 large;
 499 >2 very large.

500
 501
 502