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Shedding Some Light on the Complexity**

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1 *Title:* Factors Impacting Match Running Performances of Elite Soccer Players: Shedding Some
2 Light on the Complexity

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36 **Abstract**

37 Time-motion analysis is a valuable data collection technique used to quantify the match running
38 performance of elite soccer players. However, interpreting the reductions in running performance in
39 the second half or temporarily after the most intense period of games is highly complex, as it could
40 be attributed to physical or mental fatigue, pacing strategies, contextual factors or a combination of
41 mutually inclusive factors. Given that research in this domain typically uses a reductionist approach
42 whereby match-running performance is examined in isolation without integrating other factors this
43 ultimately leads to a one-dimensional insight into match performance. Subsequently, a cohesive
44 review of influencing factors does not yet exist. The aim of this commentary is to provide a detailed
45 insight into the complexity of match running performance and the most influential factors.

46 **Key words:** *fatigue, pacing, dynamics, tactics, context*

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87 **Introduction**

88 In the last decade there has been an exponential rise in time-motion research pertaining to soccer
89 and this has ultimately improved our understanding of the match demands. Studies demonstrate
90 that players regularly transition between brief bouts of high-intensity running and longer periods of
91 low-intensity running.^{1,2,3} In addition to these activities, players frequently perform movements
92 such as tackling, jumping and directional changes integrated alongside technical skills. There may
93 be a tendency amongst practitioners to underestimate the game demands as metabolically taxing
94 activities such as accelerations and decelerations are often omitted from these studies. As with any
95 evidence-based framework in sports performance, detailed knowledge of the physical demands of
96 match play is essential for the design and implementation of specific fitness training.⁴
97 Although time-motion findings have developed our understanding of the physicality of soccer, it's
98 too simplistic to investigate the physical factors in isolation. Rather, it would be advantageous to
99 analyse the contextual interplay between physical, psychological, technical and tactical factors.
100 Moreover, match running performance is highly dependent on many factors that are not often
101 quantified within the research area including match importance, score line, location, opposition
102 standard, recovery days, tactical system, etc.

103 Research typically uses a reductionist approach whereby match-running performance is examined
104 in detail without any integration of these factors and this ultimately leads to a one-dimensional
105 insight into match performance.⁵ Accordingly, some authors⁶ advocate a more pragmatic approach
106 when interpreting match running performances due to the difficulty in objectively relating it to
107 match-related fatigue, position-specific requirements, subsequent training prescriptions and
108 ultimately competitive success. Contemporary time motion analysis of soccer still only offers a
109 basic snapshot and it's imperative that future research should attempt to integrate multiple
110 approaches to unravel the complexity of the game and its performance determinants. One research
111 criticism is the focus on establishing causal relationships between isolated performance variables
112 (distances, speeds, passes) in an attempt to predict outcomes.⁷ This offers an analysis that is pre-
113 occupied with cataloguing and grouping discrete performance behaviors and fitness indices, with
114 little appreciation of the performance context in which functional actions emerge.⁷ Indeed, the
115 emphasis on categorizing performance statistics may, unfortunately, lead sports scientists to focus
116 on outcome behavior and not necessarily the motive or cause.⁵ This may culminate in somewhat of
117 a reductionist approach that subsequently alters our interpretation of the data.

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120 **Fatigue**

121 The physical demands of competitive match play may result in players experiencing some fatigue
122 and this is construed by game induced decrements in sprinting and jumping test performances at
123 half time and after matches.^{8,9} Research demonstrates that running performance declines from the
124 first to the second half of an elite match^{10,9} or temporarily after the most intense periods^{4,11,12,13}. The
125 reduced distance travelled in the second half could be attributed to fatigue as studies have reported
126 depleted muscle glycogen stores at the end of a match^{11,13} with temporary declines after intense
127 periods of match play possibly related to intramuscular acidosis or the accumulation of potassium in
128 the muscle interstitium.¹⁴ The reductions in match running performance may be exacerbated when
129 competing in the challenging environmental conditions, such as the heat. Besides decrements in
130 running performance, Mohr and colleagues¹⁵ reported an average decrease of ~9% for repeated
131 jump performance and nearly a 3% decline in sprint performance. However, given that soccer is a
132 submaximal sport with players likely to be working within their physical capacity it is very difficult
133 to objectively identify fatigue using time-motion analysis. Thus, basing fatigue purely on match
134 running performances is far too simplistic; particularly given that our understanding of
135 physiological responses during elite matches is limited. For instance, it is unknown as to what
136 extent the dynamic responses to match demands prevent total breakdown of any single peripheral
137 physiological system, prematurely or in the final periods of the match.¹⁴ Thus, it would be

138 erroneous to derive reductions in match running performances across selected periods as fatigue. It
139 may simply represent a statistical artifact, rather than any physiological impairment.¹⁶

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141 Soccer not only taxes the aerobic and anaerobic energy systems but also taxes players mentally.
142 Once again research typically uses a reductionist approach examining primarily physical fatigue
143 with limited consideration to mental decrements, despite soccer being primarily a skill based sport.
144 The importance of sustained concentration, perceptual ability and decision-making during a match
145 makes this one-dimensional approach somewhat surprising. Although disparity may exist, mental
146 fatigue has been defined as a psychobiological state caused by prolonged periods of demanding
147 cognitive activity, and is characterized by subjective feelings of tiredness, impaired attention and
148 decision-making.^{17,18} Whilst the decline in match running performance is often attributed to a
149 player's physical capacity, it is possible that mental fatigue interacts with processes that limit
150 physical ability. A constraint of the player's capacity and/or drive impulse to perform high-intensity
151 actions may manifest during a game¹⁸. For instance, Smith et al.¹⁹ recently examined the effect of
152 experimentally induced mental fatigue on performance during a 45-min self-paced, intermittent,
153 team sports simulation test. The objective was to identify potential physiological and psychological
154 mechanisms underpinning any change in performance. The findings demonstrated that mental
155 fatigue increases the perception of effort and reduces overall and low intensity running during
156 intermittent running.

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158 Mental fatigue has been hypothesized as an effort/reward imbalance: one will continue working as
159 long as the invested effort results in sufficient rewards.²⁰ This itself is likely a multi-faceted
160 paradigm whereby as the action of a game unfolds, expectations integrate with contextual factors
161 (e.g. score or time in a match), phase of play (e.g. team in possession) as well as the athlete (e.g. age,
162 fitness and skill level) opponent (e.g. position) and environmental characteristics (e.g. temperature)
163 to provide a confirmation or modification of the anticipated response.²¹ However, when the
164 perceived effort becomes too great, and the reward no longer compares to this, the motivation to
165 continue will dissipate. This will possibly result in reduced task involvement.²⁰ Alternatively, when
166 the given situation is unbalanced and uncontrollable, individuals may need to override signals of the
167 imminent fatigue.²² The ability to override this signal could be adaptive, as may be the case in
168 uncompromising situations where the importance of the emergency outweighs the possible costs.²³
169 For example, when a player is under constant pressure from an opponent for an extended period of
170 time. Thus, the decline in match running performance, could be derived from mental, rather than
171 physical fatigue conducive of an effort/reward imbalance.

172 173 **Pacing Strategies**

174 Some suggest that reductions in match running performance could be due to players employing
175 conscious or subconscious pacing strategies to enable physical and technical performance to be well
176 maintained throughout the latter stages of the match.^{24, 25} The overarching notion being within the
177 context of their designated positional responsibilities in a team, players decide when and how to
178 respond to the diverse challenges posed in a game.²⁶ Observations demonstrate that players will
179 seldom cease participating in a match prematurely due to exhaustion. This is likely moderated by
180 the player and influenced by a number of factors including experience, environment and an array of
181 contextual factors (scoreline, etc). Hence, a drop in the distance covered, whilst often interpreted as
182 a manifestation of fatigue can just as easily be viewed as a player preserving their physical
183 readiness for when the game demands increase.⁸ Practically this may seem the case when the
184 outcome has already been decided and another match will follow in a few days, as is the case during
185 a congested fixture. Supposedly, various pacing profiles exist that characterize match-running
186 performance among players. Whole-match players supposedly adopt a 'slow-positive' pacing
187 profile, characterised by a gradual decline in total and high-intensity running²⁶. In contrast, part-
188 match players are considered to select either 'all-out' or 'reserve' strategies, depending on their role

189 in the match.²⁶ Although this ‘all out’ end spurt may not always be a common event.⁵ The coaches’
190 instructions may also be a mediating factor for the part match, but also whole match players.
191 Indirect evidence of this can be somewhat extrapolated by research showing coaches instructions to
192 affect the physical demands of soccer activity.²⁷

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194 **Contextual and Tactical Factors**

195 Research examining contextual factors such as match status (win/draw/lose) and location
196 (home/away), level of opposition (top, middle and bottom) and match half demonstrates these have
197 an impact on the running and technical profiles of players.^{28,29,30,31} For instance, Castellano et al.³⁰
198 found that the distance covered when the ball was in play (effective playing time distance) in
199 various movement categories was greater when playing at home vs away and when the opposition
200 team was losing and of a higher tactical standard. Regarding tactical standard, players of less
201 successful teams from the English Premier League cover greater distances in high-intensity than
202 their more successful counterparts.¹⁰ Players of the most successful teams from Italian Serie A,
203 however, perform more high-intensity activities during a game when in possession of the ball
204 compared with players of less successful teams.³¹ In England it also seems the high intensity
205 distance covered is greater when moving down from the Premier League to the Championship but
206 not when players moved up.³² Finally, when compared to international teams, it seems domestic
207 players cover a similar high intensity distance in males² but less for females.³³ However,
208 categorization of “successful” and “unsuccessful” and/or “strong” or “weak” opposition tends to be
209 according to their standings within a tournament or end-of-season classification.²⁷ Both may lack
210 the sensitivity and stability to differentiate changes in behaviour incidence as a function of the
211 quality of the opposition.²⁷ Hereby a team can lose even after a very good performance (i.e. high
212 numbers of good goal-scoring opportunities, shots, corners, etc.) or win after a poor performance.

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214 Other contextual factors such as score line seem to be important for dictating physical performance.
215 Bradley and Noakes⁵ observed that elite players covered similar high-intensity running distances in
216 matches with differing score lines but position-specific trends indicated central defenders covered
217 17% less and attackers 15% more high-intensity running during matches that were heavily won
218 versus lost. Tactical factors such as the playing formation also seem to be an influential factor on
219 the physical performance of elite players.³⁴ For instance, no differences were found for the overall
220 running performance of players playing in 4-4-2, 4-3-3 and 4-5-1 but high-intensity running with
221 ball possession in offensive and orthodox formations were ~30-40% higher than defensive
222 formations (4-3-3 and 4-4-2 vs 4-5-1). In contrast, ~20% more distance was covered at high-
223 intensity without possession in defensive versus offensive and orthodox formations. This coincided
224 with the lowest ball possession for the defensive formation compared to the offensive and orthodox
225 formations (44 vs 50%), thus ball possession could have been a factor. The multifactorial nature of
226 soccer denotes that inconsistencies will remain when examining the impact of contextual/tactical
227 factors have on workload. Indeed, whilst research has examined the effects of contextual factors on
228 match running performance, only recently has the contextual variability been elucidated³⁵. In the study,
229 researchers examined the factors influencing physical and technical variability in the English Premier
230 League. Match performance data were collected from multiple seasons (2005-06 to 2012-13) and
231 consisted of 451 individual players across 3016 observations. The authors concluded that 1) technical
232 parameters varied more from match-to-match than physical parameters 2) variation is position
233 dependent and 3) physical and technical performance are variable regardless of context.

234 It seems likely that no single study can comprehensively measure and control for all extraneous
235 influences. This should not deter researchers, however, from exploring this area with the possibility
236 of at least establishing a hierarchy with regards to these factors. To gain a better understanding it
237 would appear that more robust research design are necessary. That being, studies of large samples
238 as well as, for example, mixed model analysis using multivariate statistical analyses. This review
239 clearly indicates the complexity of match play and that sports scientists and coaches need to

240 consider various contextual and technical factors before making inferences on time-motion data
241 supplied by match analysis companies.

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244 **Conclusion**

245 The match running performance of elite soccer players has been extensively studied over the last
246 two decades. It seems that this is impacted by a multitude of factors encompassing fatigue
247 (physical and mental), pacing, contextual, tactical and quite probably, several other factors.
248 Physical fatigue, contextual and tactical factors in particular have gained the most attention whilst
249 other areas are underdeveloped. Collectively, it seems our knowledge has advanced and our
250 understanding developed in accordance. However, results from time motion analysis can often be
251 misconstrued, particularly when viewed in isolation. For example, understanding how the
252 individual interacts with the actual environment is unknown and a likely important factor.
253 Practitioners are advised to carefully consider the implications of research studies for the field
254 setting whilst our understanding and knowledge continues to develop and researchers should
255 endeavor to provide more inter-disciplined understanding of the factors impacting match-running
256 performance.

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