Paul, DJ, Bradley, PS and Nassis, GP

Factors Affecting Match Running Performance of Elite Soccer Players: Shedding Some Light on the Complexity

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

Authors: Darren J Paul[1], Paul S Bradley[2] George P Nassis[1,3]

[1]National Sports Medicine Programme, Excellence in Football Project, Aspetar Qatar Orthopaedic and Sports Medicine Hospital, Doha, Qatar.

[2]Carnegie School of Sport, Leeds Beckett University, UK.

[3]School of Physical Education and Sport Science, National and Kapodistrian University of Athens, Athens, Greece

Submission Type: Commentary

Corresponding Author: Darren James Paul

Aspetar - Qatar Orthopaedic and Sports Medicine Hospital,

National Sports Medicine Programme

Excellence in Football Project

PO BOX 29222

Doha, Qatar

International phone: (+974) 4413 2677

Preferred Running Head: Factors Impacting Running Performances in Soccer

Abstract Word Count: 128

Text Only Word Count: 1952

Abstract

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

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

Introduction

In the last decade there has been an exponential rise in time-motion research pertaining to soccer and this has ultimately improved our understanding of the match demands. Studies demonstrate that players regularly transition between brief bouts of high-intensity running and longer periods of low-intensity running.[1,2,3] In addition to these activities, players frequently perform movements such as tackling, jumping and directional changes integrated alongside technical skills. There may be a tendency amongst practitioners to underestimate the game demands as metabolically taxing activities such as accelerations and decelerations are often omitted from these studies. As with any evidence-based framework in sports performance, detailed knowledge of the physical demands of match play is essential for the design and implementation of specific fitness training.[4]

Although time-motion findings have developed our understanding of the physicality of soccer, it's too simplistic to investigate the physical factors in isolation. Rather, it would be advantageous to analyse the contextual interplay between physical, psychological, technical and tactical factors. Moreover, match running performance is highly dependent on many factors that are not often quantified within the research area including match importance, score line, location, opposition standard, recovery days, tactical system, etc.

Research typically uses a reductionist approach whereby match-running performance is examined in detail without any integration of these factors and this ultimately leads to a one-dimensional insight into match performance.[5] Accordingly, some authors[6] advocate a more pragmatic approach when interpreting match running performances due to the difficulty in objectively relating it to match-related fatigue, position-specific requirements, subsequent training prescriptions and ultimately competitive success. Contemporary time motion analysis of soccer still only offers a basic snapshot and it's imperative that future research should attempt to integrate multiple approaches to unravel the complexity of the game and its performance determinants. One research criticism is the focus on establishing causal relationships between isolated performance variables (distances, speeds, passes) in an attempt to predict outcomes.[7] This offers an analysis that is pre-occupied with cataloguing and grouping discrete performance behaviors and fitness indices, with little appreciation of the performance context in which functional actions emerge.[7] Indeed, the emphasis on categorizing performance statistics may, unfortunately, lead sports scientists to focus on outcome behavior and not necessarily the motive or cause.[5] This may culminate in somewhat of a reductionist approach that subsequently alters our interpretation of the data.

Fatigue

The physical demands of competitive match play may result in players experiencing some fatigue and this is construed by game induced decrements in sprinting and jumping test performances at half time and after matches.[8,9] Research demonstrates that running performance declines from the first to the second half of an elite match[10,9] or temporarily after the most intense periods [4,11,12,13]. The reduced distance travelled in the second half could be attributed to fatigue as studies have reported depleted muscle glycogen stores at the end of a match[11,13] with temporary declines after intense periods of match play possibly related to intramuscular acidosis or the accumulation of potassium in the muscle interstitium.[14] The reductions in match running performance may be exacerbated when competing in the challenging environmental conditions, such as the heat. Besides decrements in running performance, Mohr and colleagues[15] reported an average decrease of ~9% for repeated jump performance and nearly a 3% decline in sprint performance. However, given that soccer is a submaximal sport with players likely to be working within their physical capacity it is very difficult to objectively identify fatigue using time-motion analysis. Thus, basing fatigue purely on match running performances is far too simplistic; particularly given that our understanding of physiological responses during elite matches is limited. For instance, it is unknown as to what extent the dynamic responses to match demands prevent total breakdown of any single peripheral physiological system, prematurely or in the final periods of the match.[14] Thus, it would be

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

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

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

Pacing Strategies

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

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

Contextual and Tactical Factors

Research examining contextual factors such as match status (win/draw/lose) and location (home/away), level of opposition (top, middle and bottom) and match half demonstrates these have an impact on the running and technical profiles of players.[28,29,30,31] For instance, Castellano et al.[30] found that the distance covered when the ball was in play (effective playing time distance) in various movement categories was greater when playing at home vs away and when the opposition team was losing and of a higher tactical standard. Regarding tactical standard, players of less successful teams from the English Premier League cover greater distances in high-intensity than their more successful counterparts.[10] Players of the most successful teams from Italian Serie A, however, perform more high-intensity activities during a game when in possession of the ball compared with players of less successful teams.[31] In England it also seems the high intensity distance covered is greater when moving down from the Premier League to the Championship but not when players moved up.[32] Finally, when compared to international teams, it seems domestic players cover a similar high intensity distance in males[2] but less for females.[33] However, categorization of "successful" and "unsuccessful" and/or "strong" or "weak" opposition tends to be according to their standings within a tournament or end-of-season classification.[27] Both may lack the sensitivity and stability to differentiate changes in behaviour incidence as a function of the quality of the opposition.[27] Hereby a team can lose even after a very good performance (i.e. high numbers of good goal-scoring opportunities, shots, corners, etc.) or win after a poor performance.

Other contextual factors such as score line seem to be important for dictating physical performance. Bradley and Noakes [5] observed that elite players covered similar high-intensity running distances in matches with differing score lines but position-specific trends indicated central defenders covered 17% less and attackers 15% more high-intensity running during matches that were heavily won versus lost. Tactical factors such as the playing formation also seem to be an influential factor on the physical performance of elite players.[34] For instance, no differences were found for the overall running performance of players playing in 4-4-2, 4-3-3 and 4-5-1 but high-intensity running with ball possession in offensive and orthodox formations were ~30-40% higher than defensive formations (4-3-3 and 4-4-2 vs 4-5-1). In contrast, ~20% more distance was covered at high-intensity without possession in defensive versus offensive and orthodox formations. This coincided with the lowest ball possession for the defensive formation compared to the offensive and orthodox formations (44 vs 50%), thus ball possession could have been a factor. The multifactorial nature of soccer denotes that inconsistences will remain when examining the impact of contextual/tactical factors have on workload. Indeed, whilst research has examined the effects of contextual factors on match running performance, only recently has the contextual variability been elucidated [35]. In the study, researchers examined the factors influencing physical and technical variability in the English Premier League. Match performance data were collected from multiple seasons (2005-06 to 2012-13) and consisted of 451 individual players across 3016 observations. The authors concluded that 1) technical parameters varied more from match-to-match than physical parameters 2) variation is position dependent and 3) physical and technical performance are variable regardless of context.

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

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

Conclusion

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

References

1. Carling C, Le Gall F, Dupont G. Analysis of repeated high-intensity running performance in professional soccer. *J Sports Sci*. 2012*;* 30(4): 325–336.
2. Bradley P, Di Mascio M, Peart D, Olsen P, Sheldon B. High intensity activity profiles of elite soccer players at different performance levels. *J Strength Cond Res.* 2010; 24(9): 2343-2351.
3. Bangsbo J, Mohr M, Krustrup P. Physical and metabolic demands of training and match-play in the elite football player. *J Sports Sci.* 2006; 24(7): 665–674.
4. Bradley P, Sheldon W, Wooster B, Olsen P, Boanas P, Krustrup P. High-intensity running in English FA Premier League soccer matches. *J Sports Sci.* 2009; 27(2): 159–168.
5. Bradley P, Noakes T. Match running performance fluctuations in elite soccer: Indicative of fatigue, pacing or situational influences? *J Sports Sci*. 2013a; 31(15): 1627-1638.
6. Carling C. Interpreting physical performance in professional soccer match-play: should we be more pragmatic in our approach? *Sports Med.* 2013; 43(8): 655-663.
7. Mackenzie R, Cushion C. Performance analysis in football: A critical review and implications for future research. *J Sports Sci*. 2013; 31(6): 639–676.
8. Mohr M, Krustrup P, Bangsbo J. Match performance of high-standard soccer players with special reference to development of fatigue. *J Sports Sci.* 2003; 21(7): 519–528.
9. Krustrup P, Zebis M, Jensen JM, Mohr M. Game induced fatigue patterns in elite female soccer. *J Strength Cond Res*. 2010; 24(2): 437-441.
10. Di Salvo V, Gregson W, Atkinson G, Tordoff P, Drust B. Analysis of high intensity activity in Premier League soccer. *Int J Sports Med.* 2009; 30(3): 205-212.
11. Bendiksen M, Bischoff R, Randers MB, Mohr M, Rollo I, Suetta C, Bangsbo J, Krustrup P. The Copenhagen Soccer Test: physiological response and fatigue development. *Med Sci Sports Exerc*. 2012; 44(8): 1595-603.
12. Di Mascio M, Bradley P. Evaluation of the most intense high intensity running period in English FA premier league soccer matches. *J Strength Cond Res*. 2013; 27(4): 909-915.
13. Krustrup. P, Mohr M, Steensberg A, Bencke J, Kjaer M, Bangsbo J. Muscle and blood meatbolites during a soccer game; implications for sprint performance. *Med Sci Sports Exer*.2006; 38(6): 1165-1174.
14. Mohr M, Krustrup P, Bangsbo J. Fatigue in soccer: A brief review. *J Sports Sci*. 2005; 23(6): 593–599.
15. **Mohr** M, Mujika I, Santisteban J, Randers MB, Bischoff R, Solano R, Hewitt A, Zubillaga A, Peltola E, Krustrup P. Examination of fatigue development in elite soccer in a hot environment: a multi experimental approach. Scand J Med Sci Sports. 2010; 20 Suppl 3: 125-132.
16. Lovell R, Barrett S, Portas M, Weston M. Re-examination of the post half time reduction in soccer work rate. *J Sci Med Sport.* 2012; 16(3): 250-254.
17. Marcora S, Staiano W, Manning V. Mental fatigue impairs physical performance in humans. *J Appl Physiol.* 2009; 106(3): 857–864.
18. Knicker A, Renshaw I, Oldham A, Cairns S. Interactive processes link the multiple symptoms of fatigue in sport competition. *Sports Med.* 2011; 41(4): 307-328.
19. Smith MR, Marcora SM, Coutts AJ. Mental fatigue impairs intermittent running performance. *Med Sci Sports Exerc*. 2014; Epub ahead of print.
20. Boksem M, Tops M. Mental fatigue: Costs and benefits. *Brain Res Rev.* 2008; 59(1): 125–139.

21. McGarry T, Anderson D, Wallace S, Hughes M, Franks IM. Sport competition as a dynamical self-organizing system. *J Sports Sci.* 2002; 20(10): 771–781.
22. Roca A, Williams A, Ford P. Developmental activities and the acquisition of superior anticipation and decision making in soccer players. *J Sports Sci.* 2012; 30(15): 1643–1652.
23. Boksem M, Meijman T, Lorist, M. Mental fatigue, motivation and action monitoring. *Biol Psychol*. 2006; 72(2): 123–132.
24. Drust B, Atkinson G, Reilly T. Future perspectives in the evaluation of the physiological demands of soccer. *Sports Med*. 2007; 37(9): 783-805.
25. Edwards A, Noakes T. Dehydration: cause of fatigue or sign of pacing in elite soccer? *Sports Med.* 2009; 39(1): 1–13.
26. Waldron M, Highton J. Fatigue and pacing in high intensity intermittent team sport: an update. *Sports Med*. 2014; 44(12):1645-1658.
27. Rampinini E, Impellizzeri F, Castagna C, Abt G, Chamari K, Sassi A, Marcora S. Factors influencing physiological responses to small-sided soccer games. *J Sports Sci.* 2007; 25(6): 659–666.
28. Lago-Penas C, Lago-Ballesteros J. Game location and team quality effects on performance profiles in professional soccer. *J Sports Sci Med.* 2011; 10(3): 465-571.
29. Lago-Penas C, Casais L, Dominguez E, Sampaio J. The effects of situational variables on distance covered at various speeds in elite soccer. *Eur J Sport Sci.* 2010; 10(2), 103–109.
30. Castellano J, Blanco-Villaseñor A, Álvarez D. Contextual variables and time-motion analysis in soccer. *Int J Sports Med*. 2011; 32(6): 415–421.
31. Rampinini E, Impellizzeri F, Castanga C, Coutts A, Wisloff U. Technical performance during soccer matches of the Italian Serie A league: effect of fatigue and competitive level. *J Sci Med Sport.* 2009; 12(1): 227-233.
32. Bradley P, Carling C, Gomez Diaz A, Hood P, Barnes C, Ade J, Boddy M, Krustrup P, Mohr M. Match performance and physical capacity of players in the top three competitive standards of English professional soccer. *Hum Mov Sci.* 2013b; 32(4): 808-821.
33. Mohr M, Krustrup P, Andersson H, Kirkendal D, Bangsbo J. Match activities of elite women soccer players at different performance levels. *J Strength Cond Res.* 2008; 22(2): 341-349.
34. Bradley P, Carling C, Archer D, Roberts J, Dodds A, Di Mascio M, Paul D, Diaz A, Peart D, Krustrup, P. The effect of playing formation on high-intensity running and technical profiles in English FA Premier League soccer matches. *J Sports Sci.* 2011; 8: 821–830.
35. **Bush** MD, Archer DT, Hogg R, Bradley PS. Factors influencing physical and technical variability in the English Premier League. Int J Sports Physiol Perform. 2015. Epub ahead of print