Exploring the effects of mental and muscular fatigue in soccer players’ performance

Diogo Coutinho, Bruno Gonçalves, Del P. Wong, Bruno Travassos, Aaron J. Coutts, Jaime Sampaio

Research Center in Sports Sciences, Health Sciences and Human Development (CIDESD), CreativeLab Research Community, University of Trás-os-Montes and Alto Douro, Vila Real, Portugal

Sport Science Research Center, Shandong Sport University, Jinan, China

Research Center in Sports Sciences, Health Sciences and Human Development (CIDESD), CreativeLab Research Community, Department of Sports Sciences, University of Beira Interior, Portugal

Human Performance Research Centre, University of Technology Sydney (UTS), Sydney, Australia

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ABSTRACT

This study examined the effects of induced mental and muscular fatigue on soccer players’ physical activity profile and collective behavior during small-sided games (SSG). Ten youth soccer players performed a 5vs5 SSG under three conditions: a) control, playing without any previous activity; b) muscular fatigue, playing after performing a repeated change-of-direction task; c) mental fatigue, playing after completing a 30 min Stroop color-word task. Players’ positional data was used to compute time-motion and tactical-related variables. The muscular fatigue condition resulted in lower distances covered in high speeds (≈27%, 0.3; ± 0.5) than the control condition. From the tactical perspective, the muscular fatigue condition resulted in lower distance between dyads and players spent ≈7% more time synchronized in longitudinal displacements than the control condition (0.3; ± 0.3). Additionally, players spent ≈14% more time synchronized with muscular fatigue than with mental fatigue (0.7; ± 0.3). The mental fatigue condition resulted in a very likely more predictable pattern in the distance between dyads than in muscular fatigue condition (0.4; ± 0.2). Also, the mental fatigue possibly decreased the teams’ stretch index when compared with control (0.2; ± 0.3) and likely increased compared with muscular fatigue (0.5; ± 0.5). The better levels of longitudinal synchronization after muscular fatigue, might suggest the usage of tactical-related tasks after intense exercise bouts. The lower physical performance and time spent longitudinally synchronized after mental fatigue, should alert to consider this variable before matches or training activities that aim to improve collective behavior.

1. Introduction

In team sports such as soccer, player’s movement behavior (physical and tactical) are shaped by the interaction between the performer, the task and the surrounding environmental constraints (Newell, 1986). Accordingly, performance in many team sports is dependent on the players’ ability to identify the appropriate environmental cues that provide opportunities for actions (Travassos, 2014).
such as player fatigue. Fatigue has been described as a reduction in the maximal voluntary muscle force, that results from exercise (Gandevia, 2001). From this perspective, there are two possible explanations that lead to this decrease: i) muscle fatigue, when the impairments in the peak force are related to the processes in the muscle cells that affect the muscle contractile functions (Bishop, 2012; Knicker, Renshaw, Oldham, & Cairns, 2011); or ii) central fatigue, when the decrease in the muscle force output were related with the reduced neural drive from the motor cortex to the motor units (Knicker et al., 2011; Mehta & Agnew, 2012). Based on these considerations, it is possible that physical and tactical behavior of players may be affected during periods of muscular and/or central fatigue.

It has been shown that changes in the players physical performance during soccer matches (Rampinini et al., 2011), which can be linked not only with contextual events such as team strategy or playing positions (Castellano, Blanco-Villaseñor, & Álvarez, 2011), but also as result of the muscular fatigue (Bishop, 2012; Nedelec et al., 2012; Tomazin, Morin, & Millet, 2016). In fact, the demands of soccer matches (Bush, Barnes, Archer, Hogg, & Bradley, 2015), particularly in high intensity actions and accelerations, results in players experiencing transient muscular fatigue (Silva et al., 2017), which affects their activity profile. For example, it was found impairments in running performance occurred following high-intensity intermittent periods during soccer matches (Varley, Elías, & Aughey, 2012). The observed drops in distance covered might reach ~50% less than during the peak period (Bradley et al., 2009). Accordingly, these decreases in the players' activity can be explained by changes in perception of opportunities for action and consequently with changes on tactical movement behavior of players to perform as a team.

The effects of muscular fatigue in team tactical behavior can be demonstrated through changes in positioning and decision-making (Sampaio, Gonçalves, Rentero, Abrantes, & Leite, 2014; Smits, Pepping, & Hettinga, 2014). For example, Sampaio, Gonçalves, et al. (2014), used the Yo-Yo intermittent recovery level 2 as additional fatiguing task, to analyze how the increased muscular fatigue impacted the players movement behavior during a simulated basketball game. The results showed a higher regularity in players positioning at faster speeds after the additional fatigue task. Higher regularity in players positioning was reported during the progression of each half and was reported to be attributed to accumulated muscular fatigue (Duarte, Araujo, Folgado, et al., 2013). In fact, the increase of players positioning regularity towards the end of soccer matches have been linked earlier with muscular fatigue (Duarte, Araujo, Correia, et al., 2013; Duarte, Araujo, Folgado, et al., 2013). While these studies add important findings, they did not have the aim of assess the impact of muscular fatigue on the players positioning, but rather understand how the collective behavior dynamics evolve across a competitive match. Additionally, these studies did not induce fatigue prior to the game, or directly assess the presence of fatigue. Therefore, at present, it remains unclear how muscular fatigue may constraint players movement behavior in soccer. Considering that soccer players are likely to experience periods of transient muscular fatigue (Bradley et al., 2009; Silva et al., 2017; Varley et al., 2012), a better understanding on how players movement behavior changes might provide useful information to the coaches to prepare the players to deal with these scenarios.

From the individual constraints perspective, the mental fatigue may also affect players' behavior. Mental fatigue has been described as psychobiological stated characterized by acute increases in the subjective ratings of mental fatigue and mental effort and cognitive impairments in the ability to maintain attentional focus (Shou & Ding, 2013), identify and use visual cues (Boksem, Meijman, & Lorist, 2006), and assess and adjust actions (Lorist, Boksem, & Ridderinkhof, 2005), which results from experiencing long periods of demanding cognitive activity (Smith, Marcara, & Coutts, 2015; Van Cutsem et al., 2017). Accordingly, previous studies on soccer players have shown that mental fatigue can reduce the technical performance, as well as the physical performance, mainly at low intensities (Badin, Smith, Conte, & Coutts, 2016; Smith, Coutts, et al., 2016; Smith, Zeuwts, et al., 2016). Indeed laboratory studies showed that the mental fatigue – induced through a 30-min Stroop color-word task – increased perception of effort during physical activity and reduced soccer-specific running capacity, short passing and shooting performance (Smith, Coutts, et al., 2016), and also reduced the speed and accuracy of soccer-specific decision-making tasks (Smith, Zeuwts, et al., 2016).

The majority of studies have used laboratory environments to explore the effects of mental fatigue in soccer (Smith, Coutts, et al., 2016; Smith, Zeuwts, et al., 2016). However, given the complex and unique nature of soccer, different results may emerge when analyzing the effects of mental fatigue under more practical approaches. In this regard, a field study showed that mental fatigue impaired technical but not physical performance during soccer game-based situations in youth players (Badin et al., 2016). More recently, Coutinho et al. (2017) used a motor coordination task to induce mental fatigue and analyzed how players physical and movement behavior was affected by the mental fatigue. While no effects were found in the physical variables, the team movement behavior results showed decreases in movement synchronization and in positional adjustments such as speed of contraction, when mentally fatigued. However, in these two field studies only one team was mentally fatigued, which might have attenuated the mental fatigue effects. That is, considering the coupling tendencies that emerge between confronting teams, it is likely that the behavior of one team influenced the opposing team to behave in a similar way (Duarte, Araujo, Correia, et al., 2013). In this sense, it is possible that the mental fatigued team might have been constrained to act in a synchronized manner with the opponents (without mental fatigue), and consequently might have decreased the potential effects of mental fatigue. Therefore, additional research is required to better understand the magnitude of the effects of the mental fatigue on players physical and tactical performances.

Overall, research has shown that soccer players' behavior is highly sensitive to environmental, task and individual constraints. In fact, several reports have shown that players' movement behaviors emerge as consequence of changes in task constraints during small-sided games (SSG) (Ade, Harley, & Bradley, 2014; Aguilar, Gonçalves, Botelho, Lemmink, & Sampaio, 2015; Gonçalves, Marcelino, Torres-Ronda, Torreys, & Sampaio, 2016; Hill-Haas, Dawson, Impellizzeri, & Coutts, 2011; Sampaio, Lago, Gonçalves, Macas, & Leite, 2014; Travassos et al., 2014). The SSG are modified games, that are usually performed in smaller pitches, involving a smaller number of players and with adapted rules (Hill-Haas et al., 2011). Accordingly, the SSG have been extensively used to manipulate the tasks constraints, while capturing the players physical, technical and tactical performances (Aguilar et al., 2015; Badin...
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