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Original research

The biomechanical and physiological response to repeated soccer-specific simulations interspersed by 48 or 72 hours recovery

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ABSTRACT

Purpose: To assess the residual fatigue response associated with the completion of two successive soccer-specific exercise protocols (SSEP).
Methods: Twenty male soccer players were pair-matched before completing SSEPs, interspersed by either 48 or 72 h. Outcome variables were measured every 15 min, and comprised uni-axial measures of PlayerLoad, mean (HR) and peak heart rate (HR_{peak}), blood lactate concentration, mean and peak ($\dot{V}O_{2peak}$) oxygen consumption, and rating of perceived exertion (RPE).
Results: No significant ($P > 0.05$) group interactions were identified for any outcome variables. Uni-axial (and total) PlayerLoad exhibited a significant ($P < 0.05$) main effect for time, with the exception of the relative contribution of medial lateral PlayerLoad™. Total PlayerLoad during the final 15 min (222.23 ± 15.16 a.u) was significantly higher than all other time points. All other outcome variables also exhibited a significant main effect for time, with HR, HR_{peak} and $\dot{V}O_{2peak}$ also exhibiting significantly higher values in the first trial. There was also a significant ($P = 0.003$) trial*time interaction for RPE.
Conclusions: With equivalence at baseline, there was no difference in the fatigue response associated with two SSEPs interspersed by either 48 or 72 h recovery. The current study has implications for the design and micro management of training and competition schedules.

1. Introduction

Fixture congestion is a contemporary concern within soccer (Carling et al., 2015) with implications for performance (Carling, Le Gall, & Dupont, 2012; Odetoyinbo, Wooster, & Lane, 2007; Rollo, Impellizzeri, Zago, & Laia, 2014) and injury risk (Dellal, Lago-Peñas, Rey, Chamari, & Orhant, 2015; Dupont et al., 2010; Ekstrand, Hägglund, & Waldén, 2011; Nédélec et al., 2013). The most successful teams are often required to compete in the largest number of competitions (Dupont et al., 2010), with the 2015 UEFA Champions League winners playing in 60 matches across the 2014–2015 season. Due to the high frequency of matches associated with modern soccer (Krustrup et al., 2006; Nédélec et al., 2013), players are often required to compete with only two to three days recovery (Carling et al., 2015; Dellal et al., 2015; Dupont et al., 2010; Rollo et al., 2014). Previous fixture congestion literature has identified no differences in physical performance when successive matches are performed with a minimum of 72 h recovery (Folgado, Duarte, Marques, & Sampaio, 2015). However, periods of fixture congestion also appear to expose players to increased risk of injury when successive matches are interspersed by less than 96 h (Dellal et al., 2015; Dupont et al., 2010), thus suggesting an issue with mechanical and muscular recovery. At both elite and sub-elite levels, a minimum of 48 h is typically allowed between subsequent matches (Odetoyinbo et al., 2007).

The physical response to (Krustrup et al., 2006; Mohr, Krustrup, & Bangsbo, 2003) and the time course of recovery from a single bout of soccer-specific activity (Ispirlidis et al., 2008; Magalhäes et al., 2010) has been well considered, but not the physical response associated with successive bouts of soccer-specific activity. The majority of literature associated with fixture congestion in soccer has typically used time motion analyses to assess the physical fatigue response (Carling, Orhant, & Legall, 2010; Dellal et al., 2015; Dupont et al., 2010; Folgado et al., 2015; Odetoyinbo et al., 2007). Although soccer match-play offers high ecological validity, there are restrictions on data collection (Rollo et al., 2014; Stølen, Chamari, Castagna, & Wisløff, 2005) and matches are susceptible to contextual factors (Rollo et al., 2014). As such, previous literature has often reported equivocal findings in relation to the

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impact of short-term fixture congestion on injury risk and performance. It has, therefore, recently been suggested that standardised soccer-specific exercise protocols (SSEP) could provide a unique opportunity to assess the physical mechanisms associated with repeated bouts of soccer-specific activity (Carling et al., 2015). In relation to the current study, assessment of physical mechanisms is considered in relation to both the physiological and mechanical response.

Recently, in an attempt to quantify the physical demand associated with intermittent team sports, PlayerLoad™ data has been calculated from tri-axial accelerometer function of Catapult (Catapult Innovations, Scoresby, Australia) GPS devices (Barron, Atkins, Edmundson, & Fewtrell, 2014; Boyd, Ball, & Aughey, 2011; Scott, Lockie, Knight, Clark, & Janse De Jonge, 2013). The high sample rate (100 Hz) of the accelerometer in relation to the GPS (typically 5–10 Hz), and the capacity to measure movement in three planes, provides scope to further evaluate the mechanical response to exercise (Barrett, Midgley, & Lovell, 2014). The International Football Association Board (IFAB) has also recently approved the use of GPS technologies during competitive matches, thus allowing a method of assessing the within-match physical fatigue response. Based on previous literature (Page, Marrin, Brogden, & Greig, 2015), PlayerLoad™ appears to be sensitive enough to detect fatigue induced differences in movement efficiency during the completion of soccer-specific activity, and may therefore offer an additional and novel opportunity to detect temporary, cumulative, and residual physical fatigue during periods of short-term fixture congestion.

Given the potentially detrimental effects associated with periods of short-term fixture congestion, the aim of this current study was to quantify the physical fatigue response associated with two successive SSEPs interspersed by 48 h or 72 h recovery, relevant to the demands of the modern player. It was hypothesised that there would be a significant residual mechanical fatigue response when two successive SSEPs were interspersed with 48 h recovery, but not following a 72 h recovery period. It was also hypothesised that there would be no significant residual physiological fatigue response observed during a second SSEP when compared to a first SSEP completed 48 or 72 h previously.

2. Method

2.1. Participants

Twenty male semi-professional soccer players volunteered to complete this study during the English competitive soccer season. The physical and anthropometrical characteristics of the participants are shown in Table 1. The inclusion criteria specified that players demonstrated the capacity to complete a 30 min familiarisation sessions specific to the SSEP, were outfield players, and were injury free for a minimum of 6 months prior to testing. Additional to weekly matches, the participants were also required to have completed typical training volumes equating to >4 h wk^{-1} during the preceding soccer season. All participants were paid semi-professional soccer players competing in the fifth tier of English football.

Prior to the start of each experimental trial, participants were required to undergo a comprehensive health screening procedure to further assess the participant's eligibility and also highlight potential risks. The comprehensive health screening procedure was completed by the lead researcher and comprised a health, physical activity, and pre-exercise control questionnaire. Both heart rate and blood pressure were also measured (Omron, Mx3 plus, Netherlands), values of >90 b min^{-1} and >140 mmHg/90 mmHg respectively were contraindications to exercise. Participants were informed of the risks and procedures involved in testing and were required to provide written informed consent prior to the commencement of the study. The experimental protocol was previously approved by the local university ethics committee and conformed to the Declaration of Helsinki. All equipment was risk assessed and calibrated in accordance to the manufacturers guidelines prior to testing commencing.

Table 1
The physical and anthropometrical characteristics of the two groups (48 h and 72 h), and the physical response to a 30 min familiarisation trial.

	Groups	
	48 h ($N = 10$)	72 h ($N = 10$)
Age (years)	22.10 ± 2.69	21.60 ± 2.12
Height (cm)	176.63 ± 5.80	179.82 ± 6.17
Mass (kg)	74.47 ± 5.68	77.44 ± 8.21
Average HR (beats min^{-1})	146 ± 14	142 ± 11
Peak HR (beats min^{-1})	162 ± 13	157 ± 12
Average Vo_2 (ml kg^{-1} min^{-1})	33.71 ± 2.11	32.71 ± 2.65
Peak Vo_2 (ml kg^{-1} min^{-1})	45.92 ± 3.53	45.79 ± 4.40
Bla (mmol L^{-1})	2.2 ± 0.7	2.2 ± 1.0
PlayerLoad™ (a.u)	209.13 ± 10.59	205.58 ± 12.88
RPE (a.u)	10 ± 1	11 ± 2

2.2. Experimental design

A between-subjects matched-pairs design was utilised, with participants being matched for: age, playing position, height, mass, and the physical response to a 30 min familiarisation trial. Independent T-tests were conducted for all measures reported in Table 1, with no significant differences being observed between the two groups (P values ranged between 0.24 and 0.94). Thereafter, one participant from each pair was randomly assigned to the 48 h recovery group ($N = 10$) and one to the 72 h recovery group ($N = 10$).

Participants were required to attend the laboratory on three occasions to complete a familiarisation trial followed by two experimental trials. A minimum of 96 h interspersed the familiarisation trial and the start of the first experimental trial. Thereafter, the participants then completed the second experimental trial following their prescribed recovery duration (48 h or 72 h). The familiarisation trial comprised 2 × 15 min bouts of the SSEP. The experimental trials consisted of the completion of two identical treadmill based SSEP (Page et al., 2015). The SSEP was utilised to ensure mechanistic rigour by standardising both the locomotion and speed profile performed by the participants. By ensuring each bout of activity was standardised between trials, any observed differences in the dependant variables were attributable to the different recovery durations (48 h vs. 72 h) and not due to differences in speed profiles performed across the two trials. It was identified that although free-running SSEPs may offer increased ecological validity when compared to treadmill-based protocols, free-running SSEPs do not typically standardise the running speeds performed by the participants and, consequently, this makes it more difficult to mechanistically interpret the differences in the physical fatigue response. The SSEP was based on notational analysis of match-play incorporating six locomotion categories (Mohr et al., 2003). The protocol was developed to replicate the clustering of high intensity efforts interspersed with low intensity activity as observed during match-play (Spencer et al., 2004). Fig. 1 provides a schematic representation of the velocity profile associated with a 15 min bout, and this exercise bout was repeated 6 times across each 90 min test, with a 15 min passive rest period interspersing the 3rd and 4th bouts to simulate half-time (HT). Due to the restraints of the treadmill, backwards running was integrated with low intensity running at a velocity of 11.6 km h^{-1}, and