THE INFLUENCE OF PLAYER INTERCHANGE ON THE CUMULATIVE AND RESIDUAL PHYSICAL FATIGUE RESPONSE TO SOCCER-SPECIFIC ACTIVITY

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Introduction

Soccer players are frequently exposed to a high frequency of games and, consequently, short recovery. This high physical demand can increase the risk of injury (Carling et al., 2015). Relative to the limited number of substitutions permitted in soccer, increased player interchanges in other intermittent sports have been associated with a lower physiological load (Moss et al., 2015) and reduced risk of knee flexor (KF) strain injuries (Orchard et al., 2012).

Previously rule changes in soccer have typically focused on reducing contact injuries (Junge and Dvořák 2015). However, more recently, in an attempt to reduce non-contact injuries and improve soccer as a spectacle, the International Football Association Board approved the use of an unlimited "return sub" ruling at the grassroots level and the use of a fourth substitution during extra time of elite soccer.

Given the potential beneficial effects associated with the increased use of player interchanges, the aim of this study was to assess the influence of a player interchange strategy on the cumulative and residual physical fatigue response to a soccer-specific exercise protocol ([SSEP] Page et al., 2015).

Method

Thirteen male semi-professional soccer players (mean ± SD: age 23.2 ± 4.6 yrs, height 181.4 ± 3.8 cm, body mass 81.0 ± 7.8 kg) competing in the fifth tier of English football volunteered to complete this study during the competitive soccer season. The participants completed a total of five trials comprising a familiarisation trial, two experimental trials, and two isokinetic dynamometer based (IKD) follow up assessments. The two counter-balanced experimental trials (separated by a minimum of 96 hours) comprised the completion of a treadmill based SSEP (Page et al., 2015). As identified in figure 1, the control trial (CONT) comprised 6 x 15min bouts with a 15min passive half-time interval. The interchange trial (INT) comprised the completion of 4 x 15min bouts of activity each interspersed by a 15min period of passive recovery.

The two follow up IKD assessments were completed 48 hours after the completion of each experimental trial and comprised the completion of dominant leg eccentric KF (eccKF) strength assessments at 180, 300, and 60 deg·s^{-1}, with passive knee flexion at 60 deg·s^{-1} between each repetition, and a rest period of 30s between each set.

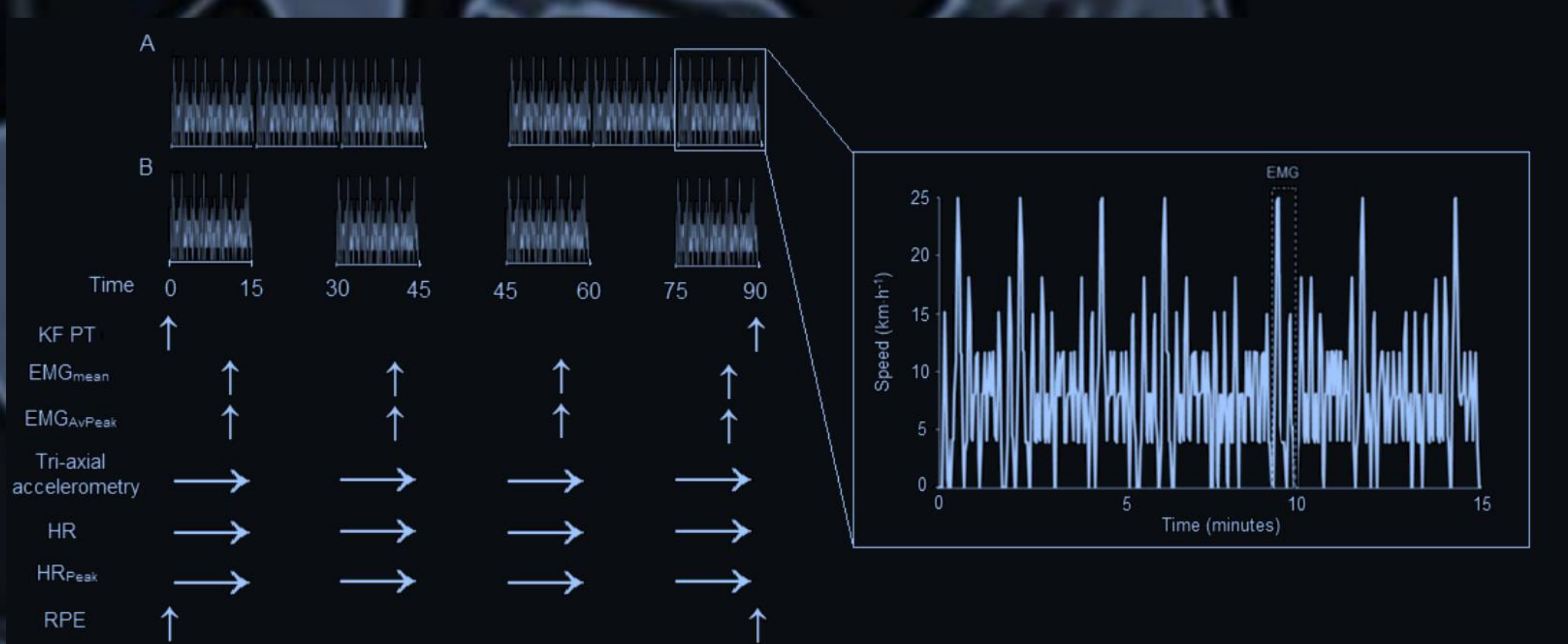

Figure 1: Schematic representation of the two experimental trials (A= control; B= Interchange) and associated measurement points. Vertical arrows depict point measurements, and horizontal arrows depict values recorded across bouts.The zoomed image depicts a schematic representation of a single 15min bout of the SSEP. The dashed line indicates the EMG data collection period.

Average (HR) and peak heart rate (HR_{peak}) were measured at rest and for each 15 minute period of activity. The participant's rating of perceived exertion (RPE) were also recorded as a point reading immediately following each 15 minute period of activity.

Tri-axial PlayerLoad^{TM} (PL_{Total}), planar PlayerLoad^{TM} in the medial-lateral (PL_{ML}), anterior-posterior (PL_{AP}) and vertical (PL_{V}) movement planes, and the relative contributions of the planar PlayerLoad^{TM} measures to PL_{Total} ($PL_{ML\%}$, $PL_{AP\%}$, $PL_{V\%}$) were all quantified for each 15min period of activity.

Mean (EMG_{mean}) and average peak (EMG_{Avpeak}) bicep femoris (BF) electromyography was quantified for a standardised 25km·h^{-1} and 15km·h^{-1} bout during each 15min period of activity.

As previously described, dominant leg eccKF peak torque (PT) was recorded pre- post-, and 48 hours post-trial.

Results

With the exception of $PL_{ML\%}$, the repeated measures general linear model (GLM) identified a significant (P < 0.05) main effect for time for all variables. Values for $PL_{ML\%}$ were consistent at 21.70 ± 1.78 %.

Table 1: Time course of changes (irrespective of trial) in the accelerometry, EMGmean, and EMGAvPeak data.

Time (mins)	0-15	30-45	45-60	75-90
PL_{total} (a.u)	258.03 ± 25.42	266.78 ± 20.60	270.67 ± 21.71[a]	272.58 ± 24.06[a]
PL_{AP} (a.u)	64.57 ± 13.03	66.97 ± 11.65	67.62 ± 11.44[a]	69.61 ± 10.44[a]
PL_{V} (a.u)	136.81 ± 14.30	141.59 ± 14.02	144.37 ± 14.48[a]	143.81 ± 16.10
PL_{ML} (a.u)	56.24 ± 6.06	57.56 ± 5.64	57.96 ± 6.65	58.68 ± 6.55[a]
EMG_{mean} (µV) 15km·h^{-1}	62.61 ± 24.60	53.73 ± 18.32	46.43 ± 19.11[a]	42.51 ± 20.15[a]
EMG_{mean} (µV) 25km·h^{-1}	106.15 ± 26.68	90.38 ± 26.97[a]	86.25 ± 24.21[a]	80.84 ± 25.37[a]
EMG_{Avpeak} (µV) 15km·h^{-1}	152.25 ± 45.03	130.20 ± 39.63[a]	105.35 ± 39.39[ab]	96.49 ± 43.78[ab]
EMG_{Avpeak} (µV) 25km·h^{-1}	225.83 ± 60.76	186.55 ± 57.25[a]	180.56 ± 65.00[a]	163.06 ± 70.77[a]

[abc] denote significant differences with 0-15, 30-45, and 45-60mins respectively.

There was no main effect for trial nor trial*time interaction identified for any of the metrics provided in Table 1.

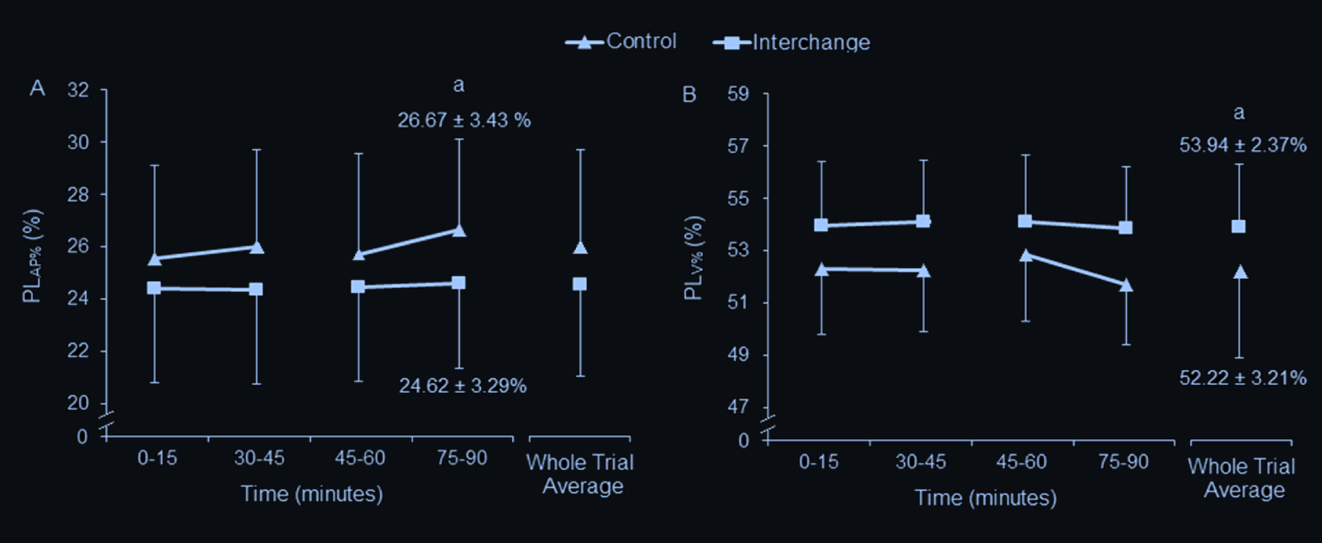

Figure 2. Time course of changes in the $PL_{AP\%}$ (A) and $PL_{V\%}$ (B) data recorded across the two conditions. Whole condition averages are also presented. [a] denotes a significant difference between trials

As identified in Figure 2, significantly (P= 0.03) higher $PL_{V\%}$ values were measured in the INT trial. Significantly (P= 0.02) higher $PL_{AP\%}$ values were also measured at 75-90mins in the CONT trial.

As identified in figure 3, Significantly (P= 0.003) higher HR and HR_{peak}, data was measured in the CONT trial, with significantly (P= 0.01) higher HR and HRpeak data measured at 30-45 and 75-90mins in the CONT trial when compared to the INT trial. Higher HR values were also measured at 45-60 mins in the CONT trial.

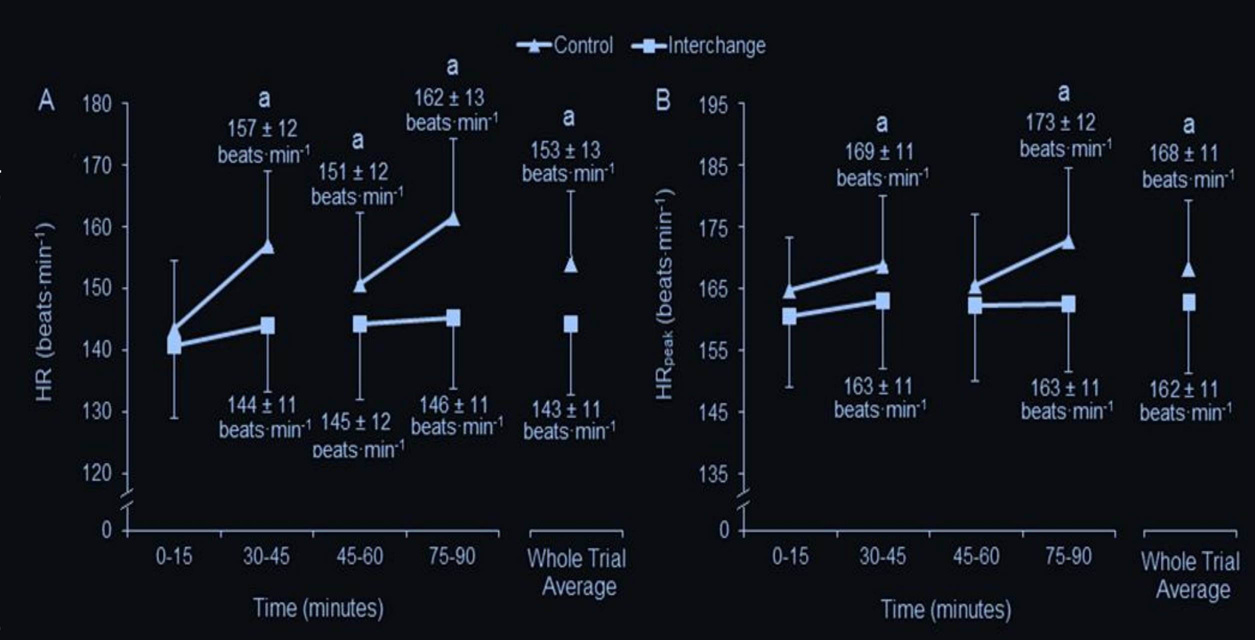

Figure 3. Time course of changes in the HR (A) and HR_{peak} (B) data recorded across the two conditions. Whole condition averages are also presented. [a] denotes a significant difference with the INT condition.

Significantly (P< 0.001) higher RPE data was also measured in the CONT trial (CONT RPE= 13 ± 2 a.u; INT RPE= 12 ± 2 a.u), with significantly higher RPE data measured at 30-45 and 75-90mins in the CONT trial (30-45= 13 ± 2 a.u; 75-90= 15 ± 3 a.u) when compared to the INT trial (30-45= 12 ± 2 a.u; 75-90= 13 ± 2 a.u).

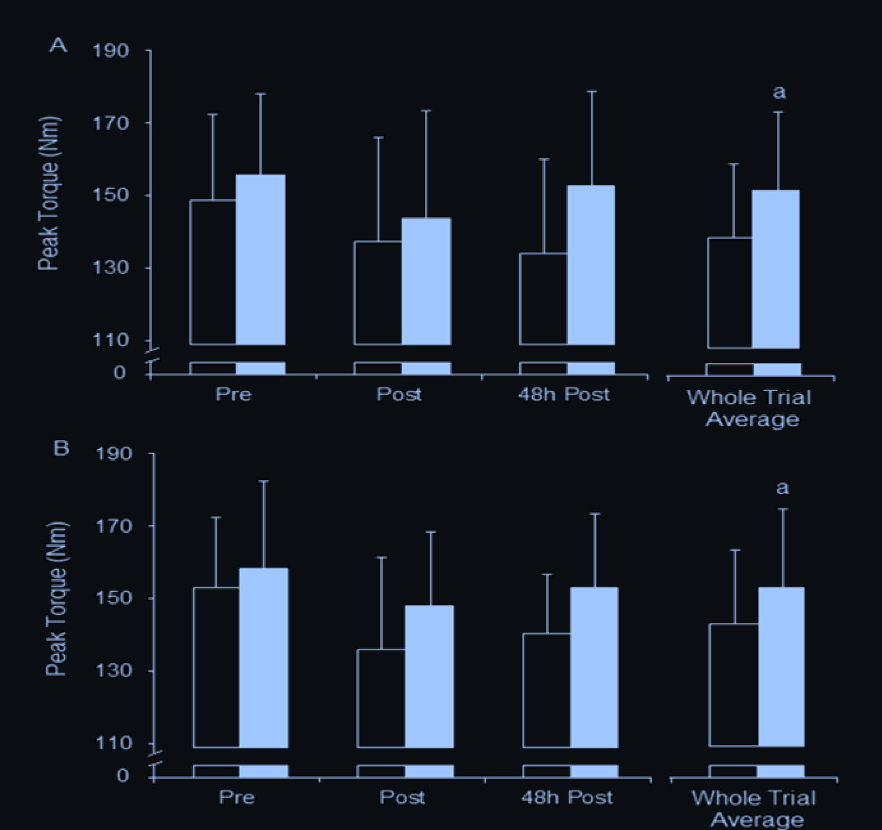

Figure 4 Time course of changes in the eccKF PT data recorded at 180 (A) and 300 (B) deg·s^{-1} in the two conditions (■= INT; □= CONT). Whole condition averages are also presented. [a] denotes a significant difference with the CONT condition.

The GLM identified significantly higher PT values measured pre-trial (60 deg·s^{-1}= 147.2 ± 29.9 Nm; 180 deg·s^{-1}= 153.2 ± 22.6 Nm; 300 deg·s^{-1}= 156.7 ± 21.6 Nm) when compared to post-trial (60 deg·s^{-1}= 136.0 ± 31.0 Nm; 180 deg·s^{-1}= 141.8 ± 28.8 Nm; 300 deg·s^{-1}= 143.0 ± 23.3 Nm) and 48h post-trial (60 deg·s^{-1}= 136.8 ± 28.7 Nm; 180 deg·s^{-1}= 144.7 ± 27.4 Nm; 300 deg·s^{-1}= 147.7 ± 19.1 Nm).

As identified in Figure 4, significantly higher PT data was measured at 180 (P= 0.04) and 300 (P= 0.04) degs·s^{-1} in the INT trial (180 deg·s^{-1}= 152.1 ± 25.9 Nm; 300 deg·s^{-1}= 154.1 ± 21.5 Nm) when compared to the CONT trial (180 deg·s^{-1}= 141.3 ± 26.3 Nm; 300 deg·s^{-1}= 144.1 ± 21.3 Nm).

Summary and conclusion

The inclusion of player interchanges in soccer has potential benefits for reducing the cumulative physiological (HR and HR_{peak}) and perceptual (RPE) response to soccer-specific activity. Prior knowledge of the substitution strategy may result in players making anticipatory modifications to their running technique, with the interchange trial eliciting a running technique more mechanically suited to the HI bouts and less economical during the low intensity bouts of exercise. The interchange trial negated fatigue induced increases in sagittal plane loading, with implications for reduced injury risk and improved performance (Bradley et al., 2009) during the latter stages of match-play. However, the interspersing periods of passive recovery were not of sufficient duration to recover BF muscle activity.

The post-exercise rate of recovery associated with the moderate and fast speed eccKF PT data was greater in the interchange trial, with implications for training periodization and injury management, and supporting observations of Orchard and colleagues (Orchard et al., 2012). The use of player interchanges would be particularly beneficial during periods of congested match-play (Dupont et al., 2010).

Due to the novel nature of the current study there is scope for future research to investigate different durations and frequencies of interchanges. Moreover, future research could also focus on the implementation of acute recovery strategies during the interspersing recovery periods. Although the current data has been recorded using male semi-professional soccer players, the observations have implications for novice, youth, and female soccer players.

Carling, C et al., (2015) *Sports Med*, 45(5): 605-613; Bradley, P.S et al., (2009) *J Sport Sci*, 27:159-68; Dupont, G et al., (2009) *Am J Sports Med*, 38: 1752-1758; Junge, A et al., (2015). *Br J Sports Med*, 49: 599-602; Moss, S.L et al., (2015). *J Strength Cond Res*, 29(10): 2697-2707; Orchard, J.W et al., (2012). *J Sci Med Sport*, 15: 201-206; Page, R.M et al., (2015). *J Strength Cond Res*, 29(10): 2860-2866