Title: Intensified periods of match play do not affect physiological and perceptual responses in elite youth footballers.

Running Title: Intensified competition and youth football.

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Abstract

Background: To investigate the effect of playing time on physiological and perceptual responses to six, 60 min games played over five days. ***Methods:*** Twenty-eight youth soccer players (age = 14.2 ± 0.2 years; body mass = 58.9 ± 6.8 kg; stature 169.5 ± 7.9 cm) were grouped into low (<75% playing time; LPG, n = 15) and high (≥75% playing time; HPG, n = 13) playing minute groups and monitored daily for lower body power, hydration and perceived wellness. GPS technology was used to assess match running demands in low (LI; <13 $km{\cdot}h^{-1}$) and high (HI; ≥13 $km{\cdot}h^{-1}$) intensity categories along with total distance ($m{\cdot}min^{-1}$). Magnitude based inferences and effect sizes (ES) were used to analyse data. ***Results:*** The HPG performed *most likely* more total (102.0 ± 12.2 cf. 88.5 ± 21.2 $m{\cdot}min^{-1}$; 17.2%; 2.0 ± 1.37) and HI running (26.0 ± 6.7 cf. 20.1 ± 6.8 $m{\cdot}min^{-1}$; 25%; 1.11 ± 0.74). Lower body power was *likely* higher in the HPG whilst differences in perceived wellness ranged from *unclear* to *likely*. Body mass and osmolality were not affected. ***Conclusions:*** Youth players appeared physically and mentally well equipped to deal with the intensified period of competition.

Keywords: Recovery, movement demands, tournament, youth football.

Introduction

Fatigue and the physiological variables that contribute to its occurrence during adult soccer matches have been widely reported [1-3]. Less detailed information is available for youth players [4, 5], especially during periods of intensified competition [6]. The format of competitions such as the Milk Cup (Northern Ireland) comprises consecutive matches over 5-7 days, with multiple matches on the same day. These youth tournaments are popular with recreational and professional teams despite little being known about the physiological response to, and recovery during, such periods of competition.

After a competitive match, performance in measures associated with muscle strength [7, 8], power [9] and speed [10] are impaired for at least 72 hours. During intensified periods of competition perceived wellness [11], high intensity activity [12] and total running distance [13] are negatively affected. Additionally, the completion of three training sessions on consecutive days has been shown to cause hypo-hydration in youth soccer players [14]. It is posited that the physical demands associated with greater playing time prolong the time course of recovery and exacerbate fatigue, compromising performance in matches scheduled toward the latter stages of the competitive period [15]. Adult players within the same squad, but exposed to different amounts of playing time, exhibit different movement demands [16] however this has not been shown for youths.

The physical qualities of youth soccer players have a strong association with movement demands during competition. The YoYo IR1 has a positive correlation with high intensity activities during match play [17]. Physical qualities also discriminate between playing standards [18] and are affected by maturational status [19]. What is poorly understood however, is whether fitness qualities and/or stage of maturation influence performance, team selection and the ability to recover between consecutive matches.

The aims of this study were twofold; firstly, investigate the response of elite youth soccer players to an intensified period of competition involving six games in five days; and secondly, investigate differences in the response of players exposed to high and low playing volumes. It was hypothesised that an intensified period of competition in youth soccer players would elicit reductions in lower body power, perceived wellness and high intensity activity in consecutive games. Additionally, reductions would be greater in players exposed to a higher playing load.

Materials and methods

Participants

Twenty-eight youth soccer academy players (age = 14.2 ± 0.2 years; body mass = 58.9 ± 6.8 kg; stature 169.5 ± 7.9 cm) volunteered to take part in the study. Data were collected as part of the normal practices employed by staff at the academy and which players and their parents had agreed to at the start of the season after being informed of the benefits. The study received institutional ethical approval.

Design

Data were collected during a youth soccer tournament consisting of six 60-minute matches across five days. The tournament was held in Northern Ireland, approximately six hours travel by sea and road from the players' base in Scotland. Games comprised two 30-minute halves interspersed by 10-minutes of recovery for 'half time'. Two games (4 and 5 of 6) were played on the same day. Previous research has used the accrual of 75% playing time as a criterion to reflect tournament demands [6]; this criterion was used in the present study to demarcate high (≥75%; HPG) and low (<75% minutes; LPG) playing minute groups. During the tournament technical coaching staff determined team selection with group allocation performed retrospectively. The average temperature and humidity were 13.7 ± 1.2°C and 80.2 ± 5.2%, respectively.

On each day player's completed measurements of urine osmolality, body mass, perceived 'wellness' (comprising ratings of fatigue, soreness, stress, sleep and mood), and counter movement jump (CMJ) to assess lower body muscle power. All measures were taken in the morning upon waking and before breakfast. During matches participants were fitted with global positioning system (GPS) devices to assess movement characteristics.

Assessment of physical qualities

Three weeks before the tournament, nineteen players completed assessments of selected physical qualities (n = 8 HPG and n = 12 LPG). All assessments were completed in the early evening during normal squad training and on an artificial synthetic surface. After a warm up, players performed a 15 m maximal effort sprint with split timings at 5, 10 and 15 m from a standing start 0.5 m behind the first timing gate. Data were recorded using electronic timing gates (Smartspeed, Fusion Sport, Australia). Players received three attempts to record their fastest time and wore their own football boots. The Technical Error of measurement for the assessment was 0.03 s. Players then completed the YoYo Intermittent Endurance Level 2 (YoYo IE2), the protocol for which has been described elsewhere [20]. Players were afforded two warnings during the protocol for either failing to arrive on the line at the time denoted by the audio signal or moving off the start line prematurely. The total distance covered was recorded for analysis.

Anthropometry

In the same month as the tournament, each player completed measurements of body mass, stature and seated stature to enable the estimation of individual maturity-offset values [21]. This model, when compared to the Bone Mineral Accrual Study [22], has shown a mean difference in boys of -0.010 years with a standard deviation of 0.489 years [21]. Body mass was assessed daily throughout the tournament using the same set of calibrated scales (SECA 770, Avery Weight-Tronix) with participants wearing lightweight training shorts.

Hydration status

Participants were instructed to collect a urine sample ‘mid flow’ on their first visit to the bathroom upon waking each day. Samples were handed to the researcher within ~30 min and analysed for osmolality using a commercially available device (Osmocheck, Vitech Scientific, UK). This method has been shown to provide a valid and reliable measurement of urine osmolality [23].

Lower body muscle power

Lower body power (W) was assessed using a portable force platform (Force Platform, Ergotest Innovation, Porsgrunn, Norway) connected to a laptop (Dell Inspiron 9100, Dell, United Kingdom) using commercially available software (MuscleLab 4020e, Ergotest Innovation). Participants performed two practice jumps before a third from which data were used for analysis. Participants were instructed to flex the knees to approximately 120 degrees before jumping as high as possible with their hands remaining on their hips. The landing and takeoff positions for jumps were assumed to be the same, with any jumps that deviated from the stated procedure discarded and a further trial performed. Measures of lower body muscle power were taken at the start of each day before breakfast. This method has been shown to provide a valid and reliable measurement of lower body power [11].

Perceived wellness

Each morning participants were asked to rate their 'perceived wellness' based on individual perceptions of fatigue, muscle soreness, stress, sleep and mood. Each category was rated between five (positive perception of wellness) and one (negative perception of wellness). Scores were recorded for each sub-scale and summated to provide an overall rating of perceived wellness. This scale has been used previously with team sports [24]. Measures were taken in private to avoid peer influence on reported scores [25] and immediately before measures of lower body power.

Assessment of movement demands during match play

Movement demands were measured using portable global positioning system (GPS) devices (SPI-Pro; 5 Hz, GPSports, Canberra, Australia) integrated with an in-built 6 g tri-axial accelerometer (100 Hz). For all six matches, a mean ± s of 9 ± 1 (range from 6 to 12) satellites were determined as available for signal transmission using Team AMS V2.1 software (GPSports, Canberra, Australia) and deemed acceptable for assessing human movement [26]. The mean horizontal dilution of precision was 1.58 ± 0.43 and ranged from 0.87 to 2.01 for all recorded matches. Players were fitted with an appropriately sized vest housing the portable GPS unit (mass of 86 g, 0.8 × 0.4 × 0.2 cm) between the scapulae. A standard squad shirt was worn over the vest. A digital watch was synchronised with Greenwich Mean Time and used to record the start and end of each half. These times were used to truncate the raw GPS data file. In addition, the time of substitutions was recorded live and used to further truncate raw data. All data were downloaded to a computer using SPI Ezy V2.1 (GPSports, Canberra, Australia) and analysed using Team AMS V2.1 software (GPSports, Canberra, Australia). This method has been shown to provide a valid and reliable measurement of movement demands [27].

Data were analysed for total distance covered, low intensity running ($<13\ km \cdot h^{-1}$) and high intensity running ($\geq 13\ km \cdot h^{-1}$) in accordance with the methods employed elsewhere [17]. Movement demands were measured in absolute and relative terms according to number of minutes and number of matches played.

Heart rate

Heart rate ($b \cdot min^{-1}$) was recorded for each player during match play using a heart rate monitor (Polar Electro Oy, Kempele, Finland) and reported as a percentage of the player’s pre-determined heart rate peak (HRpeak). HRpeak values were determined from the highest value attained during the last YoYo IE2 assessment

Statistical analysis

Effect sizes (ES) ± confidence limits, relative change (in percentages) expressed as the transformed (natural logarithm) & change ± 90% confidence limits, and magnitude based inferences were calculated for all physiological and performance outcome measures associated with the standardised and self-selected recovery trials . Where appropriate, data were log transformed for analysis to reduce bias arising from nonuniformity error. Threshold probabilities for a substantial effect based on the 90% confidence limits were <0.5% most unlikely, 0.5-5% very unlikely, 5-25% unlikely, 25-75% possibly, 75-95% likely, 95-99.5% very likely, and >99.5% most likely. Thresholds for the magnitude of the observed change for each variable were determined as the between participant SD x 0.2, 0.6 and 1.2 for a small, moderate and large effect, respectively. Effects with confidence limits across a likely small positive or negative change were classified as unclear. Within group comparison were made against day one which was taken as the baseline measure.

Results

There were *unclear* differences in age (<0.0%, 0.0 ± 0.61; 14.2 ± 0.21 cf. 14.2 ± 0.21 years) and maturation (2.1%, 0.03 ± 0.78; 0.67 ± 0.45 cf. 0.78 ± 0.6 years) between the HPG and LPG respectively. *Unclear* differences were apparent between the HPG (n=8) and LPG (n=12) for distance covered in the YoYo IE2 (2.9%, 0.13 ± 0.8; 1640

± 339 m cf. 1596 ± 316 m) and time to complete a 15 m sprint (2.0%, 0.74 ± 1.17; 2.58 ± 0.06 s cf. 2.53 ± 0.12 s), respectively.

Between group changes in osmolality can be viewed in table 1. A *Possible* increase in osmolality was detected between day one and two in the HPG (19.4%; 0.35 ± 0.64). All other within group comparisons were *unclear*. There was a *likely* reduction in osmolality in the LPG between day one and four (25.3%; 0.66 ± 0.72). All other within group comparisons were *unclear*. Within group comparisons for body mass were *most likely trivial*. Between group data for lower body power data are presented in Table 2 whilts within group changes are detailed in figure 1.

INSERT TABLE 1 NEAR HERE

INSERT FIGURE 1 NEAR HERE

INSERT TABLE 2 NEAR HERE

Between group differences for perceived wellness and its sub-components are displayed in table 3. Fatigue was *possibly* higher within in the HPG group on day three (16.4%, 0.34 ± 0.46) but *likely* lower on day five (26.7%, ES 0.52 ± 0.41). There were *unclear* changes within the LPG. Sleep quality was *likely* reduced in the HPG on day two (20.2%, ES 0.59 ± 0.53). All other within group comparisons for sleep quality in the HPG and LPG were *unclear*. Soreness *likely* decreased in the HPG on days four (47.5%, ES 0.82 ± 0.74) and five (49.1%, ES 0.85 ± 0.65) whilst *likely* decreasing within the LPG on day three (31.5%, ES 0.69 ± 0.69). All other within group comparisons for soreness were *unclear*. Within group changes were either *unclear* or *possible* for stress and mood.

INSERT TABLE 3 NEAR HERE

Playing minutes were *most likely* higher in the HPG (41.2%, 3.71±1.04; 307.8 ± 46.2 cf. 169.7 ± 36.2) than LPG, respectively.

Movement demands are displayed in table 4. Total distance was *most likely* higher in the HPG and very likely higher when assessed as metres per minute and metres per game. Low intensity total distance and relative to metres per game was *very likely* higher in the HPG whilst *likely* higher for $m.min^{-1}$. High intensity distance was *most likely* higher in the HPG and very likely higher in relative terms (m.game and $m.min^{-1}$).

INSERT TABLE 4 NEAR HERE

There were unclear differences in average heart rate response during match play between the HPG (168.5 ± 8.27 bpm^{-1}) and LPG (169.3 ± 8.01 bpm^{-1}; 0.1%, ES 0.02 ± 0.59).

Discussion

This is the first study to investigate the effect of six games played over five days on the physiological, perceptual and match running demands of elite youth soccer players. Furthermore, players were separated into a high and low playing minute group to investigate the effect of playing volume on responses to an intensified period of competition. The HPG performed *very likely* more total and high intensity running ($m.min^{-1}$) and *likely* higher lower body power than the LPG, with the exception of day five. No such between group differences were detected in body mass, osmolality or perceived wellness although sleep quality was *likely* and *very likely* impaired in the HPG on days two and three respectively. Our findings indicate that youth players are able to tolerate the demands of intensified competition and maintain running performance during match play.

Players arrived at the tournament appropriately hydrated [28] and remained so during the five days. These findings are in contrast to those presented previously in youth soccer players who reported consistent hypo-hydration during consecutive training sessions and competitive match play in differing environmental conditions (13 – 34°C) [14, 29, 30].

Reductions in CMJ performance represent the development of neuromuscular fatigue and have been reported in adult team sport players during short periods of intense competition [10, 31]. In the present study *trivial* changes in CMJ from baseline were reported over time with the exception of day five where *possible* reductions and *likely* increases were noted in the HPG and LPG respectively. Reductions in lower body power showed a *moderate* correlation with playing time [32] in adult players however in the present study the HPG recorded *likely* higher lower body power than the LPG on days one through four. Impairments of muscle function after muscle damaging exercise are much less severe in children compared to adults [33]. Moreover, regular training and competition in this group of players throughout the year may have protected muscle function via the repeated bout effect [34]. Therefore, that CMJ was unchanged after what would be considered to be damaging exercise is not unsurprising and might be viewed as evidence of differences in neuromuscular characteristics between adults and children [33, 35].

Perceptions of wellness are impaired by intensified periods of competition and training in adult [11, 31, 36] and youth team sport players [37]. In the present study sleep quality was affected to a greater degree in the HPG on days two and three. Finding ways to improve sleep quality in young players during periods of high playing load would seem beneficial. Perceived muscle soreness (a sub-scale of perceived wellness) showed likely improvements in the HPG on days four and five, matched by likely reductions in fatigue on day five. These changes are consistent with preserved muscle function and the notion of less severe symptoms of tissue damage in young people [33].

When movement demands were assessed in relative terms ($m \cdot min^{-1}$ and $m \cdot game^{-1}$), the HPG performed *very likely* more high intensity and total running than the LPG. Whilst similar findings have been reported elsewhere [6] they are contrary to the initial hypothesis that suggested high intensity activity would be reduced in the HPG as a consequence of a greater playing load. Between group differences in movement demands cannot be explained by maturity offset, age or performance in the YoYoIE2, where *trivial* differences were observed between groups. Despite positive maturity offset values in the present study, players could not be described as fully mature. It is possible that some of the physiological changes associated with this period of growth, including a greater proportion of type II fibres [38] and reduction in the rate of phosphocreatine resynthesis [39], were not yet fully developed, facilitating recovery across the six games.

Soccer players amassing less playing time as a result of being introduced as substitutes perform more relative high intensity running and total running [40] than those that start and contest the full match. In contrast, results from the present study showed less relative total and high intensity running in the LPG. This differences may have been caused by tactical constraints [3, 41] or the exposure to a greater amount of game time providing a stimulus that allowed the HPG to be better prepared for subsequent games [41]. Similar findings have been reported for adult players over the course of a season with starters performing more high intensity running in both training and competition than fringe players [16].

Conclusions

Results from the present study show that an intensified period of competition (five games in six days) does not affect lower body power, urine osmolality or perceived wellness in elite youth soccer players. In addition, players within a HPG and who were exposed to a greater playing load performed more total and high intensity running distances relative to minutes played than those in a LPG. These data suggest that during periods of intensified competition elite youth players are able to recovery effectively between games and maintain running performance.

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Table 1. Means ± SD for body mass (kg), hydration (mmOsm) and lower limb power (W) assessed each morning for high (HPG) and low (LPG) playing minute groups.

Table 2. Means ± SD for lower body power (W) for high (HPG) and low (LPG) playing minute groups.

Table 3. Means ± SD for perceived wellness scores between high (HPG) and low (LPG) playing minute groups

Table 4. Means ± SD for game time, total distance, low intensity running (<13 $km \cdot h^{-1}$; LIR) and high intensity running (≥13$km \cdot h^{-1}$; HIR) for high (HPG) and low (LPG) playing minute groups across five matches.

Figure 1. Changes in lower body power for high (HPG) and low (LPG) playing minute groups across five days of an intensified competition period. Effect sizes correspond to differences between groups. HPG = ≥ 75% playing time LPG = < 75% playing time. Effect sizes (ES) classified as trivial (<0.2), small (<0.6), moderate (<1.2) and large (>2.0) (Hopkins et al., 2009). Likelihood of change data represents comparison to performance on day one.