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Running Performance and Hormonal, Maturity and Physical Variables in Starting and Non-Starting Elite U14 Soccer Players During a Congested Match Schedule

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This study examined changes in match running performance (MRP) in Under-14 soccer players (13.5 ± 0.7 yrs) during a congested match schedule (CMS) (4 matches played within a 5-day period). It also examined the difference in salivary testosterone (sT) concentration, somatic maturation, jumping tests, and Yo-Yo Intermittent Recovery Test Level 1 (Yo-Yo IR1) between the players selected to play (SLG; group who participated in all matches) and players non-selected to play (NSG). A significant difference was observed for the frequency of decelerations (DEC) across matches (match 4 vs. matches 1, 2 and 3; p = 0.05; partial η^2 = 0.20). No difference between matches was observed for total running distance (TRD), high-speed running distance (HSRD), and frequency of accelerations (ACC) (p > 0.05). A wide range for within-player coefficient of variation (CV) values was observed for all MRP variables (range: 10.5 = TRD to 30.6 = HSRD). No difference between SLG and NSG for any of the assessed variables was observed (p > 0.05). The findings suggest that DEC was the most pertinent variable for monitoring changes in MRP during the CMS. In addition, at an elite youth soccer level, the biological maturity and fitness might not influence selection to play.

Key words: *soccer match, testosterone, saliva, athletic performance, deceleration.*

Introduction

In elite soccer, exposure to periods of match congestion is frequently associated with a decline in performance and an increased risk of injury due to the accumulation of fatigue and incomplete recovery. While senior elite players regularly participate in congested schedules, exposure can also occur in elite youth soccer. In certain tournaments, youth players can be exposed to 2 official matches per day (e.g. 25 x 25 min; 10 min half-time interval) over a 3-6 day-time period (Arruda et al., 2015b; Moreira et al.,

2016; Zanetti et al., 2018). In effect, research on the effects of match congestion has shown that participation in consecutive simulated matches over a short time-frame led to a decline in high-intensity running distance (Rowsell et al., 2011). Similarly, Arruda et al. (2015b) demonstrated that the frequency of accelerations (ACC) performed per minute decreased across a very congested match schedule (CMS) at elite youth levels. In contrast, Buchheit et al. (2011) demonstrated that high-intensity running was not negatively affected over a short time-frame in highly trained

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pre-peak height velocity players (PHV). However, activity was "possibly" impaired in post-PHV players suggesting that changes in match running performance (MRP) over the CMS could be influenced by biological maturation. To the best of authors' knowledge, no information exists on the between and within player changes in MRP during official CMSs in elite pre-adolescent players (pre-PHV) and the potential interaction of their biological maturation status.

Research has nevertheless shown that hormonal status, determined by salivary testosterone concentration for example, influences physical and technical performance in adolescent and pre-adolescent soccer players (Di Luigi et al., 2006; Gravina et al., 2008; Moreira et al., 2013, 2017), and differences in puberty-related hormonal patterns can result in perturbations in anthropometric (Campbell et al., 2003; Kiess et al., 1995) neuromuscular function and other physical performance characteristics (Bunc and Psotta, 2001; Eisenmann and Malina, 2003). Indeed, the level of biological maturity has been reported to strongly influence selection processes in youth soccer. It is well-recognised that young soccer players who are advanced in maturity for their age are more likely to be selected into professional academies (Cumming et al., 2017). Evidence has also shown that playing time given to youth players in competition was related to their physical attributes (Deprez et al., 2015). However, there is no evidence that individual biological maturity status might be associated with the selection of elite youth players to play. Similarly, research on tournaments, where successive matches are played in a short time-frame and players deemed by coaches to have the highest potential to 'physically' cope might be favoured for selection, would be pertinent.

This study examined the degree of change in MRP in a cohort of elite under-14 soccer players over the course of a congested match competition. It also investigated the potential link between salivary testosterone (sT) concentration, maturational status, and physical test performances and the selection or not of players to participate in the competition.

Methods

Participants

Twenty-one elite youth soccer players belonging to the academy of a professional soccer club, initially volunteered to participate in this study (13.5 ± 0.7 yrs). The youth players were selected to train and take part in the under-14 age category of the club at the beginning of the season (March). From March to December (when the congested match competition occurred), they participated in the training program without any interruptions, except for a 15-day period of holidays, which occurred during July. Data on anthropometric characteristics (stature, body mass, sitting stature, and leg length), physical performance and salivary testosterone concentration were collected for all the cohort, one week prior to the beginning of the competition (Table 2). All players typically participated in three soccer training sessions per week (strength and conditioning training sessions and technical-tactical sessions) and competed in a weekly single match. They habitually performed one strength training session in the gym per week. This was usually done during the first part of the session followed by soccer-specific technical exercises. Specific conditioning training sessions were composed of high-intensity short running bouts (HIBs) and small-sided-games (SSGs). Players habitually performed HIBs or technical exercises prior to SSG.

Following collection of this information and data related to match participation, players were, retrospectively separated into two groups: (1) a selected group (SLG) and (2) a non-selected group (NSG). The SLG was composed of players who participated in all four assessed matches and completed a minimum 75% of total match time in every match considered for analysis. Consequently, ten outfield players (SLG) were included. Despite not maintaining rigid playing positions, as can be expected in U14 match-play, running performance data from two full backs, two central defenders, four midfielders, and two forwards were analysed.

Written informed consent was obtained from each player and their parents or guardians, respectively, and the study was approved by the local University Ethics Committee. All players underwent a thorough medical assessment to verify their health status prior to participation and were free from illness or injury at the time of this study.

Study design

In a group of elite youth soccer players, one week prior to the beginning of the competition, physical tests (jumping tests and *Yo-Yo Intermittent Recovery Test Level 1 [Yo-Yo IR1])* and anthropometric measurements were conducted. All players were familiar with the tests and experimental procedures as a whole. A morning saliva sample was collected in a fasted state (no food 6–7 h before sampling) one day before the beginning of the competition. Players were woken up approximately 15 min prior to sampling. Each player's MRP was monitored during an official CMS in which four matches (two halves of 35 min interspersed by a 10 min rest interval) were played in five days during the second week of December. The reference team won match 1, drew match 4 and lost matches 2 and 3 (Table 1). No post-match recovery strategies were prescribed during this study period. All matches were played on natural grass, and under temperate conditions (mild temperatures). Precise measures of temperature and humidity were not collected.

Measures

Physical tests

Countermovement (CMJ) and squat jumps (SJ).

Each player performed both a CMJ and a SJ. For the CMJ, the player lowered themselves from an initial standing position to a self-selected position and performed a vertical jump as quickly as possible with maximal effort, keeping their hands placed on their hips. While no restrictions were placed on the knee angle attained during the eccentric phase of the jump, players were instructed to maintain straight legs during the flight. The SJ was performed as a concentric only movement (i.e., no sinking down before the vertical jump) with hand placement on the hips to remove the effects of the arm swing. Three attempts were performed for each type of the jump with a 2-min rest period between jumps. All jumps were performed on an electronic jump mat (Ergojump Jump System 1.0, CEFISE, Brazil). This jump mat provides a valid measure of jump height compared with a criterion system ($r = .967$) (Leard et al., 2007). Pilot testing conducted with players from the present study indicated that this jump mat also provides reliable measures (CV <2.0%). Similar CVs were previously reported for other elite youth soccer players (Moreira et al., 2013).

Yo-Yo Intermittent Recovery Test Level 1 (Yo-Yo IR1)

The Yo-Yo IR1 test was performed according to the protocol described by Bangsbo (1996) and used in previous studies with soccer players (Castagna et al., 2006; Deprez et al., 2015; Moreira et al., 2013). Players performed repeated 20-m shuttle runs, back and forth between the starting and finish lines marked by cones, at progressively increasing speeds dictated by an audio beep emitted from a CD player. Between each shuttle, players had a 10-s period of walking around a cone placed 5 m from the starting line. Failure to complete the shuttle run on two successive occasions resulted in the termination of the test, and the distance covered represented the final test result. Four assistants (researchers and staff members) were each responsible for two players as adopted in previous research (Moreira et al., 2013). The Yo-Yo IRT1 was habitually conducted by the club's coaches during the season for all age-categories and the test leaders were also highly familiar with all testing procedures.

Anthropometric measurements and maturity status assessment

The stature was measured with a vertical stadiometer (Welmy®, Sao Paulo, Brazil), while body mass was measured using a digital platform scale (Welmy®, Sao Paulo, Brazil) using standardized procedures (Lohman, 1988). Maturity status was assessed according to the methods described by Mirwald et al. (2002) and adopted in previous studies to evaluate maturity status of youth soccer players (Arruda et al., 2015b; Deprez et al., 2015; Moreira et al., 2013). This approach has been proposed as a somatic maturity indicator and predicts the time before or after the peak of height velocity (PHV) from measures of age, stature, body mass, sitting stature, and leg length. Thus, a maturity age of -1.0 indicates that the player was measured 1 year before attaining peak velocity.

Salivary Testosterone collection and analysis

Morning saliva samples were collected in a fasted state one day before the beginning of the competition. Players were woken up approximately 15 min prior to sampling. In a seated position and with the head tilted slightly forward, unstimulated saliva samples were collected using the passive drool method into sterile 15 ml centrifuge tubes over a 5-min period.

The saliva samples were then stored at -80°C until assayed for testosterone concentration. Salivary testosterone (sT) concentrations were measured in duplicate using an enzyme-linked immunosorbent assay (ELISA, Salimetrics™) in accordance with the manufacturer instructions and those used previously with youth soccer players (Arruda et al., 2015a; Moreira et al., 2013, 2016, 2017). The intra-assay coefficient of variation for sT was approximately 3.0%.

Match Physical Performance Variables

Each player wore a 15-Hz GPS unit coupled with a 100 Hz tri-axial accelerometer (SPI Elite, GPSports, Canberra, Australia). Players wore these units regularly during their training sessions and competitions. Each unit was harnessed between the shoulder blades and anchored using an undergarment to minimize movement. This unit provides valid and reliable measures of total and high-intensity distance covered (Johnston et al., 2014). Physical performance variables included the total running distance (TRD), high-speed running distance (HSRD; >19.8 km/h), and the number of accelerations (ACC) and decelerations (DEC) performed (>1.8 m·s^{-2} and -1.8 m·s^{-2}, respectively). The thresholds adopted for determining ACC and DEC actions included low (>1.8 m·s^{-2} to < 2.5 m·s^{-2})-, moderate- (>2.5 m·s^{-2} to < 3.5 m·s^{-2}), and high (> 3.5 m·s^{-2}). These thresholds have previously been used in elite youth soccer players to study the effects of the CMS (Arruda et al., 2015a; Zanetti et al., 2018). All variables were normalized per min of on-field playing time.

Statistical analysis

Descriptive data are reported as means and standard deviation. Data normality was verified by the Shapiro-Wilk test and the homoscedasticity by the Levene's test. Independent sample t tests were then performed to verify differences in means between selected (SLG) and non-selected (NSG) groups for sT, somatic maturity (PHV), jumping (SJ and CMJ), and Yo-Yo IR1 test performance. Effect sizes (ES; Cohen's d) were also provided (Cohen, 1988; Maszczyk et al., 2011). ANOVA with repeated measures, using a Bonferroni correction if necessary (significant F-value) was performed to examine the differences in mean data of the MRP variables across the four assessed matches. The partial eta squared (η^2) was used to represent ES

and was classified as follows: small (0.0099), medium (0.0588), and large (0.1379) (Cohen, 1988). Statistical significance for all analysis was set at *p* ≤ 0.05. All analyses were performed using Statistica 13.0 software.

Results

Table 2 reports data (normalized per minute of on-field playing time) and the within CV for total running distance (TRD), high-speed running distance (HSRD), ACC, and DEC for the four assessed matches. A significant main effect across matches was observed for DEC (F = 2.76; *p* = 0.05; partial η^2 = 0.20 [large effect]). A statistical difference was located for the last compared to the first three assessed matches (*p* < 0.05). DEC significantly decreased during the 4th (last) match compared to all previous matches. Despite this reduction in DEC during the last match, no significant difference between matches was observed for TRD, HSRD, and ACC. However, a trend for a decrease from match to match was observed for these variables. Notably, a large effect (η^2 = 0.15) was observed for ACC, and a η^2 = 0.12 was seen for TRD. Regarding the CV, the within-player CV mean values ranged from 10.5 for TRD, to 30.6 for HSRD, with a CV of 20.9 to ACC, and 18.4 to DEC.

Table 3 reports mean and standard deviation (SD) values for the stature, body mass, PHV, CMJ, SJ, Yo-Yo IR1, and sT of selected (SLG) and non-selected (NSG) groups. No significant difference was observed between groups for any of the investigated variables.

Discussion

The present study examined the degree of change in MRP in U14 players during a congested period and the potential influence of sT, maturational status, and physical test performances on the selection of players to play. The main finding was a significant decline in the number of DEC in the final match, suggesting that the accumulation of fatigue negatively affected players' capacity to perform these actions. In addition, no significant change was found for the other MRP measurements. Although, a trend for a decrease from match to match was observed for these variables. Finally, sT concentration, biological maturity status, and test performances (jumping tests and Yo-Yo IR1) did not differ between players who were selected to play (SLG)

and those not selected (NSG).

The present results showed that out of several running activity variables examined, only the frequency of DEC significantly declined in the final match over a congested schedule in elite youth players although a trend for a decrease from match to match was observed for TRD and HSRD. These findings are in line with those reported by Arruda et al. (2015b) in elite U15 soccer players. The TRD and the number of high-speed runs were not impacted by an international congested tournament although a decrease in ACC frequency was observed across the competition. In senior professional players, Dupont et al. (2010) reported no changes for TRD, HSRD, sprint distance, and the number of sprints across one or two matches played per week, while Dellal et al. (2015) also demonstrated a lack of difference across six successive matches played in a short time-frame.

Table 1

Competition Schedule and Results

Match	Day of the competition	Result	Assessed-team match outcome
1	December 14	1-0	Won
2	December 15	0-2	Lost
3	December 16	0-3	Lost
4	December 18	2-2	Draw

Table 2

Data normalized per minute of on-field playing time (mean ± SD) and within the players coefficient of variation (CV) for total running distance (TRD), high-speed running distance (HSRD), accelerations (ACC), and decelerations (DEC) for the 4 assessed matches.

	Match 1	Match 2	Match 3	Match 4	F-value	p	partial η^2	CV
TRD (m/min)	93 ± 4	100 ± 19	103 ± 10	92 ± 7	1.62	0.20	0.12	10.5 ± 8.2
HSRD (m/min)	4.9 ± 1.9	5.7 ± 2.1	4.7 ± 1.7	4.5 ± 2.6	0.55	0.64	0.04	30.6 ± 20.3
ACC (n/min)	1.3 ± 0.1	1.4 ± 0.2	1.5 ± 0.4	1.2 ± 0.3	1.85	0.15	0.14	20.9 ± 11.5
DEC (n/min)	1.4 ± 0.1	1.4 ± 0.3	1.4 ± 0.3	1.1 ± 0.2*	2.76	0.05	0.20	18.4 ± 8.4

* different to match 1, 2 and 3 (p = 0.05)

Table 3
Anthropometric and screening measures of players (n = 21; Mean ± SD).

Variable	SLG	NSG	t-value; p-value	ES
Stature (cm)	164.6 ± 6.6	170.4 ± 7.2	1.87;0.07	0.84
Body mass (kg)	56.8 ± 6.1	61.6 ± 8.8	1.36; 0.19	0.64
PHV (yr)	0.03 ± 0.77	-0.36 ± 2.12	0.55; 0.59	0.27
CMJ (cm)	36.1 ± 3.5	38.5 ± 2.8	1.73; 0.10	0.76
SJ (cm)	33.8 ± 3.4	35.3 ± 2.8	1.06; 0.30	0.48
Yo-Yo IR1 (m)	1696 ± 412	1644 ± 253	0.34; 0.73	0.16
sT (pmol·l⁻¹)	221 ± 72	191 ± 50	1.06; 0.30	0.49

CMJ = countermovement jump; SJ = squat jump; Yo-Yo IRT1 = Yo-Yo Intermittent Recovery Test Level 1; sT = salivary testosterone; ES = effect size.

The DEC contributes a substantial part of the total external load across all player positions (Dalen et al., 2016) and therefore can be considered pertinent for monitoring alteration in MRP, notably across congested periods. This result regarding DEC leads us to suggest that accumulated fatigue and the inherent muscle damage incurred when playing successive matches in a short time-frame negatively affect this aspect of running performance in elite pre-adolescent players. Guilhem et al. (2016), for example, demonstrated that the strain applied to human muscle fibres during eccentric contractions strongly influenced the magnitude of muscle damage. Eccentric contractions are inherent to actions involving DEC, and studies in professional soccer players (Nedelec et al., 2014) and other team sports (Lakomy and Haydon, 2004) have shown the association between neuromuscular fatigue and DEC. Nedelec et al. (2014) studying professional soccer players, reported that neuromuscular fatigue observed post-match was dependent upon the number of sprints and hard changes in direction performed during the match. Lakomy and Haydon (2004) showed that the DEC component was associated with fatigue and performance during repeated sprint efforts in male elite hockey players. Combined, these results indicate the relevance of monitoring hard changes in direction, ACC and

DEC events to better enable estimations of post-match fatigue during matches and subsequently inform recovery strategies.

It is also important to highlight the usefulness of within player variation measures (CV) to examine changes from match to match. A wide range for within player CVs was observed in the present study; CV of 10.5% for TRD and 30.6% for HSRD, adding pertinent information to the literature regarding within variation in elite pre-adolescent soccer players during a congested match competition. Recently, Doncaster and Unnithan (2019) demonstrated a large variation in match physical performance measurements among youth players during three, 2 x 20 min, 11 vs. 11 matches. Indeed, Carling et al. (2012) investigating the effects of a prolonged period of fixture congestion (8 successive matches over a 26-day period) in senior professional soccer players, reported not too dissimilar mean CV values compared to those observed herein: 5.7% and 33.5%, for total distance run and that performed at high-intensities, respectively. The present results add to these findings as they not only demonstrate that individual variation should be used to interpret a possible change from match to match in elite youth players, but show that a high within player variation exists in youth congested match competition, notably, for HSRD.

Biological maturity status has been

reported to affect selection policies in youth soccer (Cumming et al., 2017) and other team sports (Saavedra et al., 2020; Lago-Fuentes et al., 2020), and playing time given to youth players during competition has been reported to be related to their individual physical attributes (Deprez et al., 2015). On this basis, these findings would suggest that in the present study, such differences would also exist between the SLG and NSG for sT, PHV, and fitness performance. However, no difference between the SLG and NSG for any of these variables was observed. These results are in agreement with those presented by Gravina et al. (2008) in youth Spanish soccer players. The authors reported no significant difference in salivary testosterone concentration, anthropometric measurements, aerobic capacity, and in countermovement and vertical jump performances at the beginning of the season, between first team players (starting players) and reserves. Recently, Hoppe et al. (2020) also reported no difference between starting and non-starting U17 and U19 German elite junior soccer players, for fat-free mass, VO2max, respiratory exchange ratio, running economy, and physical performance measures, such as time to exhaustion, one repetition maximum in the bench press, and jumping capacity. The current results add to this literature, suggesting that at the highest performance level, means in elite youth players, at least in those U14 elite soccer players participating in a congested match competition, the factors associated with hormonal concentration, anthropometric measurements and physical performance may not be the most appropriate variables for discriminating the selection of players to participate in the matches.

The present investigation adds novel information to the existing literature on match congestion in elite youth soccer. Indeed, it is important to highlight that the present findings are representative of elite male U14 players playing in a very unique CMS which has not been previously addressed. However, some limitations should be acknowledged. As players from only one team were assessed, caution is required in making inferences regarding the results and in applications for other elite soccer settings and further data on other congested periods are necessary. Match-to-match variations in performance might have been influenced by contextual factors such as the tactical strategies adopted by the coaching staff, the influence of the opposition teams and the match score and the outcome.

In summary, present findings demonstrate that the DEC was the sole running performance metric identified as discriminating between matches during a CMS, suggesting that this parameter may be used to monitor changes in match performance during CMSs in youth, pre-adolescent players. No difference between matches was detected for TRD, HSRD, and ACC, despite a trend for a decrease from match to match for these variables. A wide range of the within-player CV was observed for all MRP variables. Owing to the observed large within players' CV, coaches should be aware to use within player variation metrics for interpreting changes from match to match. Finally, no difference was observed between starting and non-starting players for sT concentration, maturity status, and performance tests (jumping tests and Yo-Yo IR1).

Acknowledgements

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