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TRAINING AND FITNESS VARIABILITY IN ELITE YOUTH SOCCER: PERSPECTIVES FROM A DIFFICULTY PREDICTION MODEL

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Abstract:

Research within sport science disciplines seeks to enhance performance via the combination of factors that influences the team's periodization. The current study aimed to investigate the variations in training load (TL), and the consequential changes in fitness variables, based on the use of match difficulty prediction model (MDP), level of opposition (LOP), days between matches, and match location during 12 weeks in the competitive period I. Seventeen elite soccer players (age = 17.57 ± 0.49 years; body height 1.79 ± 0.05 m; body weight 72.21 ± 6.96 kg), have completed a Yo-Yo intermittent recovery test, a running-based anaerobic sprint test, a soccer-specific repeated sprint ability, and a vertical jump test to identify changes in players fitness. TL was determined by multiplying the RPE of the session by its duration in minutes (s-RPE). Training monotony, strain, and acute:chronic workload ratio (ACWR) were also assessed. A simple regression model was conducted and the highest variances explained (R^2) were used. The LOP score explained most of the variance in ACWR ($r = 0.606$, $R^2=0.37$). TL declined significantly when compared the match-day by the first three days and the last three days of the week. No significant difference was found in s-RPE between the high and low MDP factor. Strong negative correlations were reported between ACWR and LOP ($r=-0.714$, $p<.01$). In addition, we found a significant improvement in repeated sprint ability, aerobic and anaerobic fitness variables between pre- and post-test in fatigue index ($d=1.104$), best testing time, ideal time, total time and mean-best ($d=0.518$-0.550), and aerobic and anaerobic fitness variables ($p<.05$), respectively. The MDP could facilitate the training prescription as well as the distribution of training intensities with high specificity, providing a long-term youth player's development and allowing teams to maintain optimal fitness leading into more difficult matches.

Key words: *prediction match difficulty, training loads, periodization, football*

Introduction

Research within sport science disciplines seeks to enhance athlete/team performance via its translation of theory into practice (Coutts, 2017; Fullagar, et al. 2019). In elite youth academies, the long-term player development is the main objective across the season, which can be supported by the periodization of training (Brink, Frencken, Jordet, & Lemmink, 2014). The compilation of training cycles is based on a progressive build-up of training dose (Vaeyens, Lenoir, Williams, & Philippaerts, 2008) and on the interaction between load and recovery (de Araujo, Papoti, Dos Reis, de Mello, & Gobatto, 2012). Indeed, the stimulus of training and competition must be sufficient to develop the player, without which performance decrements are likely. Different models of periodization have been developed by including the quality of the opposition, the number of training days between matches, possible travel associated with the game (Cormack, 2001; Kelly & Coutts, 2007) and strategic periodization (Robertson & Joyce, 2018). The combination of these factors influences the periodization of training loads (TL) between matches, and provides a specific information to manipulate the volume and the intensity of skill training sessions, in addition to the balance between training, rest, and recovery. Based on the match difficulty prediction model (MDP), the team preparation could be optimized (Kelly & Coutts, 2007). It was suggested that when facing a home game against weaker opposition, with several days between games, the TL increased accordingly to improve the player's fitness level. In contrast, when a game has an important MDP score (a strong opposition), a reduced TL should be planned for that week (Kelly & Coutts, 2007). The intention is to diminish the detrimental impact of intensive training allowing an enhancement in the physiological adaptations. This process will translate into maximal physiological adjustments and optimal performance potential (Mujika, Halson, Burke, Balagué, & Farrow, 2018). According to previous studies, the nonlinear periodization model could be more common during the in-season period in team sports (Coutts, Reaburn, Murphy, Pine, & Impellizzeri, 2003).

Generally, prescription and monitoring of TL are decided by coaches from their own perceptions of the external load (Coutts, Gomes, Viveiros, & Aoki, 2010) or using intuition, rather than following a specific plan (Cormack, 2001). For instance, a high volume training before important match days has been advocated by coaches believing it to result in additional benefits (Brink & Lemmink, 2018). Whilst another study noted that coaches expressed difficulty in the appropriate determination of the TL to prescribe in competitive phases (Coutts, et al., 2003). Moreover, previous studies have reported that match-to-match variation exists as a consequence of contextual factors, such as playing strategy and formation, strength of the opponent, and environmental conditions (Carling, Bradley, McCall, & Dupont, 2016). Despite the different tactical positions in relation to the specific functions of the game, no statistical differences have been established in players load perception across the different types of the training offered (physical, technical, or tactical) (Redkva, Gregorio da Silva, Paes, & Dos-Santos, 2017). Interestingly, these authors concluded that the session RPE (s-RPE) during the preseason period in professional soccer players was not different between coaches and players. In contrast, results indicate that young elite soccer players perceive training as harder than previously planned by the coach. According to the schedule of games, coaches should carefully plan their training to prepare individual players for each game, to optimize performance, and prevent players from overtraining. In fact, it has been shown that the training loads previously planned by the coach to be completed are often poorly executed by the athlete (Foster, Kara, Esten, Brice, & Porcari, 2001). Indeed, concerns regarding the relationship between TL and individual response in team sports have been raised, with researchers and practitioners highlighting the need for greater clarity (Rago, Brito, Figueiredo, Krustrup, & Rebelo, 2019). Moreover, the perception of how to best translate research into practice may differ between regions of the world (Coutts, et al., 2010). Indeed, research has highlighted that the incorporation of scientific principles could reduce training errors (e.g., injuries or inappropriate training), help to balance the benefits and risks in decision-making (e.g., tactical assistance and recruiting), challenge subjectivity, and integrate athlete and coach preferences into decision making relating to training and performance (Cormack, 2001).

In professional soccer, it is of great importance that coaches are aware of the need to monitor load with the aim to enhance performance (aerobic, anaerobic, repeated sprint ability [RSA] and jumping) and reduce injury risk (Gabbett & Whiteley, 2017). Recent studies have reinforced the contribution of RPE to the load monitoring process (Delecroix, McCall, Dawson, Berthoin, & Dupont, 2018). Beyond the correlation demonstrated between RPE and internal load indicators, such as heart rate (Impellizzeri, Rampinini, Coutts, Sassi, & Marcora, 2004) and blood lactate (Coutts, Rampinini, Marcora, Castagna, & Impellizzeri, 2009), it has been demonstrated that the perceived effort of sessions including small-sided games was more important when compared to sessions built upon tactical training and/or technical drills (Campos-Vazquez, et al. 2015). Indeed, controversies exist regarding the efficacy of a sport-specific MDP model in the periodization of training in team sports, such as soccer, and the impact of this model on the long- and short-term periodization plans (Robertson & Joyce, 2018). Therefore, the aims of the current study are (i) to investigate the variations in training load, training monotony and strain, and acute:chronic workload ratio, based on the use of difficulty prediction model, and (ii) to examine the change in fitness and strength variables (e.g., aerobic and anaerobic performance, repeated sprint ability, and vertical jump) in elite junior soccer players after the 1st competitive phase.

Method

Participants

Seventeen under-18 (U18) elite soccer players (age = 17.57 ± 0.49 years, body height 1.79 ± 0.05

m, body weight 72.21 ± 6.96 kg, and BMI = 22.63 ± 1.15 kg/m^2; mean ± SD), playing in the highest league in Tunisia, volunteered to participate in this study. All players had previously undergone medical evaluation and deemed healthy. The first team professional coach was responsible for the training program. The players trained for 5-6 days a week, with 1-2 sessions per day, for about 2-2.5 hours a day. The team competed in the Tunisian premier league. The inclusion criteria were that the players participated in 80% of all training sessions and had been associated with, and trained at, the club for a full year. In addition, the U18 group, including starters and non-starters, was engaged in full-time training for five days per week along with one competitive match per week (90-min duration). No injured players (one injured player excluded from the study sample) or goalkeepers (three goalkeepers) were included in the study (Wrigley, Drust, Stratton, Scott, & Gregson, 2012).

Procedures

According to the protocols established by the club, players performed a battery of physical fitness tests four times (Los Arcos, Martínez-Santos, & Castillo, 2020). According to specificity and the aim of this study, the evaluations conducted in competitive stage I corresponding to T2 (August-September) and T3 (December-January) were used. The battery of physical fitness tests included sprinting, jumping, aerobic running test, and an anaerobic running test. All tests were performed on the same, regular outdoor field, at the same time of the day (5:00 PM–7:00 PM). Testing sessions were performed on separate days to avoid any strenuous exercise in the 24 hours prior each day of testing and started with a standardized warm-up session, consisting of 5-min low intensity running, mobility exercises, strides, and acceleration drills (Los Arcos, et al., 2020).

The competitive stage I was divided into three months, or mesocycles (12 weeks). Training data were analyzed in relation to the number of days in a week, with only one match a week (macth-day [MD] minus [-] 5; MD-4; MD-3; MD-2; MD-1), plus one day after the match (MD+1) (Oliveira, et al. 2019b). During the sixth week, there was a friendly match with an increased training load (volume and intensity), one week before an important match. Prior to the first training session of each week, the members of the technical committee responsible for the training sessions, technical and fitness coach, achieved an agreement on all activities to be performed during the week in accordance with the main objective approved by the first coach. The main objective was closely related to the MDP performed, both before the commencement of the season and after each match, to determine the level of opposition (Kelly & Coutts, 2007). During the in-season and at the start of each week (first competitive phase analyzed in this study), the prediction of the difficulty of each match (to plan the weekly training load sessions and main objective) can be reviewed according to the renewed team rank. The new rank is based on the results of the previous round. The level of difficulty for each match of the season was calculated based on the sum of three factors, as denoted by Kelly and Coutts (2007). These factors are level of opposition, training days between matches, and match location. Concerning the level of opposition score, each team in the competition is ranked based on the results of the last competition in the previous season or round (respectively on the start and during the competitive season). Based on this rank, the first four teams from the bottom received scores between 3 to 5, the middle four teams 6 to 8, and the top four teams 9 to 12. According to the variation in the number of days between matches (4-8 days), the scores allocated vary from 8 to 1 point, respectively. Concerning the match location, scores are allocated for home and away matches (1 point and 2 points, respectively). Additional points can be added if the team is required to travel significant distances (3 points). Players are asked to rate their perceived exertion after about 30 minutes of the completion of the training on a scale of 1 to 10 using a modified RPE scale (Kelly & Coutts, 2007). The training volume is quantified using total training time (min) (Kelly & Coutts, 2007). The session total time included all the activities, such as warm-up, main activity, return to calm, and intervals between activities or efforts for each session. The training and/or learning sessions were

Table 1. Activities in different training sessions

Physical training	Technical training	Tactical training
~ 15’ warm-up ~ 20-45’ work principal	~ 15’ warm-up ~ 30-60’ work principal	~ 15’ warm-up ~ 30-60’ work principal
Contents: strength training and plyometric session; sprint training; resistance training	Contents: exercises with the ball (pass, dribble, accuracy, shot at goal), body control and agility exercises with the ball	Contents: small-sided games, collective, specific work to develop standard of game and tactical systems
~ 5-10 recovery	~ 5-10 recovery	~ 5-10 recovery

performed respecting the logical structure of the four moments of the game (i.e., defensive organization, offensive organization, defense to offense transition, offense to defense transition). Accordingly, at least one of these four moments of the game was present in every training exercise (Mujika, et al., 2018). The performed training amount in every week, combined with the reviewed MDP score for the following week of both prediction and perception of difficulty, can support the staff in their planning of training sessions. In addition, players received a training program with aerobic, anaerobic, technical, and tactical aspects based on game interventions (Machado, et al. 2019), speed, agility, and strength (Loturco, et al. 2016) (see Table 1).

Yo-Yo intermittent recovery test

The Yo-Yo IR1 consisted of repeated 2 × 20-m of running at a progressively increased speed controlled by audio beeps from a tape recorder. Between each running bout, the participants had a 10-s rest period. When the participant failed to reach the finishing line in time twice, the distance covered was recorded and represented as the test result. The test was performed outdoors (on a 2-m-wide and 20-m-long running lane marked by cones). Six participants performed the test simultaneously, with strong verbal encouragement provided to the subjects throughout the test. Total distance was reported as the performance criterion in the Yo-Yo IR1 (Bangsbo, Iaia, & Krustrup, 2008).

Running-based anaerobic sprint test (RAST) (anaerobic field test)

The test included six maximal speed repeats of 35-m run, with a 10-second interval between each sprint. Initially, the body mass was measured and a 10-m warm-up was performed. The time for each run was measured by two photocells (WITTY, Wireless Training Timer, Version 1.00.06, Italy) and the start of each trial occurred by the order 'go' after 5-s countdowns. Then sprint direction was alternated. Participants were verbally motivated during the tests. Power outputs for each sprint and values for peak power (PP), average power (AP) and minimum power (MP) were calculated automatically and fatigue index (FI) was calculated with the following formula: FI = [(PP–MP)/PP]. Power was determined by the formula below: Power = [body mass (kg) × runing distance^2 (m)] /time^3 (second)] (Hazir, Kose, & Kin-Isler, 2018).

Vertical jump

All participants were familiarized with the CMJ technique before testing. The CMJ technique involved the participants standing in a fully extended position and feet approximately shoulder-width apart. Subsequently, they were instructed to jump as high as possible after performing a countermovement with the same take-off and landing positions. All participants performed four jumps in this familiarization session and three jumps in test sessions. Test session variables were measured by MyJump2 and recorded using iPad 5 (Apple, Inc., USA), by the same researcher (Gallardo-Fuentes, et al. 2016).

Repeated sprint ability (7 x 34.2 m / 25 s recovery)

A soccer-specific repeated sprint ability (RSA) test, designed by Bangsbo, was used in this study. The protocol was composed of seven successive 34.2 m maximal sprints (including a slalom) (Bangsbo, Nørregaard, & Thorsoe, 1991). Following each running, subjects had 25 seconds of rest consisting of jogging back to the starting line. Across this recovery period, verbal feedback was given (5th, 10th, 15th, and 20th s) and subsequent sprints were initiated after the end of the recovery period with players being positioned behind the starting line (lead foot at 0.3 m). Before that, players performed a 10-minute run and 5-minute warm-up exercises at low intensity. The time for each sprint was recorded to the 0.01 s precision with a digital chronometer connected to photoelectric cells (WITTY, Wireless Training Timer, Version 1.00.06, Italy). A pair of photocells was positioned both on the starting and on the finish line, 0.8 m above the surface (Duarte, et al. 2019). Several indicators of sprinting ability were considered in this study: the best sprint time, mean sprint time (average time of seven sprints), total sprint time (the sum of seven sprints) and best sprint time (best sprint multiplied by seven). A decrement score (%) was also calculated for the seven sprints relative to the ideal time as [(mean sprint time/best sprint time × 100) − 100] (Valente-dos-Santos, et al., 2012). The best sprint time was recorded in separate sessions. The participants who did not achieve at least 95% of the best sprint time (first recorded time) were excluded.

Rating of perceived exertion

Throughout the training sessions, RPE was collected individually, after 15-30 min, using Borg's category ratio scale (CR10) (Foster, et al., 2001). This ensured that the perceived effort reflected the whole session and not the most recent exercise intensity. The whole training load was calculated by multiplying the RPE score (in arbitrary units) by the individual training duration (in min) (s-RPE) (Foster, et al. 2001). All players were familiarized with the procedure and the use of the scale during previous seasons. Based on the obtained s-RPE score, the weekly training load (TL) (the sum of the training loads of all training sessions during the week) was calculated. The training monotony (TM) score was obtained by taking the average load across a 7-day training week (including the day off) and dividing it by its standard deviation (Foster, 1998). Measurements of TM can be used as an indicator of training variability, with a score closer to one showing the highest level of variability (Rossi, Perri, Pappalardo, Cintia, & Iaia, 2019; Wing, 2018). The importance of training variability stems from including both mode and intensity and avoiding stagnant training. Conversely, consecutive medium training load could lead to an increased risk of illness, under-performance, and/or overtraining (Turner, Bishop, Marshall, & Read, 2015). The training strain (TS) can be calculated by multiplying weekly TL by TM, which can provide a sensitive indicator relative to the training load variations and predict athlete illnesses.

The acute:chronic workload ratio

The acute: chronic workload ratio (ACWR) has been used as a tool to allow, firstly, an appropriate calculus in increase or decrease in athlete loading, and, secondly, a measurement of players preparedness. The ACWR could also be used to ensure that the training stimulus was sufficient to promote adaptation and to avoid inappropriate loads (Gabbett, 2016). The acute workload is defined as the total work performed by the players throughout a training week measured using s-RPE data. The acute workload puts emphasis on fatigue, whilst the chronic workload represents the rolling 4-week average of acute workload and is considered as a measurement of fitness (Gabbett, 2016).

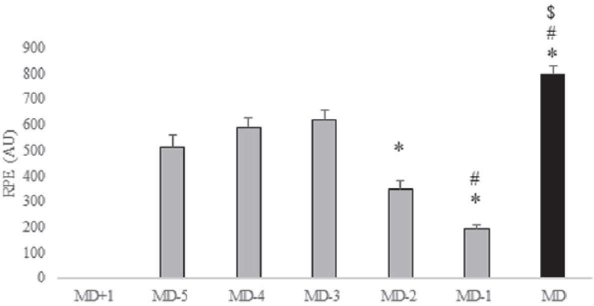
Statistical analyses

Data were reported as mean ± standard deviation. The normality of the data was analyzed using the Kolmogorov-Smirnov test. The intraclass absolute-agreement coefficients (ICCs) from a 2-way mixed-effects model were calculated to determine intra-rater reliability of the weekly training load measurements. Accordingly, ICC values less than 0.5 indicate poor reliability, values between 0.5 and 0.75 indicate moderate reliability, values between 0.75 and 0.9 indicate good reliability, and values greater than 0.90 indicate excellent reliability (Koo & Li, 2016). ICC estimates, and their 95% confidence intervals, were calculated using SPSS statistical package version 23 (SPSS Inc, Chicago, IL). A one-way analysis of variance (ANOVA) was used to examine the differences between weekly training loads. Subsequently, LSD *post-hoc* tests were used to identify differences. A simple regression model was conducted and R^2 was also calculated as an estimate of the proportion of the variance explained for the periodization of training loads with relation to match difficulty prediction. The Pearson product moment correlation was used to assess the association between the variables. The correlation coefficient was classified as: weak to negligible (0 to 0.2), weak (0.2 to 0.4), moderate (0.4 to 0.7), or strong (0.7 to 1.0) (Rowntree, 1981). Paired student's *t*-tests were used to compare group physical capacity between time points (pre-test *vs.* post-test) with standardized differences of effect size. The interpretation of inference magnitudes was used as follows: < 0.01 = very small; 0.1-0.2 = small; 0.5-0.8 = medium; 0.8-1.2 = large; 1.2-2.0 very large; and >2.0 huge (Cohen, 2013). Statistical analyses were conducted using Statistica 12.0 software (Statsoft, Inc., Tulsa, OK, USA), with statistical significance being set, *a priori*, at p<.05.

Results

Match difficulty prediction and weekly training loads

Inter-rater reliability for weekly training load measurements was moderate (ICC = 0.54, 95% CI = -0.03-0.85). There was a significant main effect of weekly periodization of training loads ($F_{(5.55)}$ = 41.47, p<.001; η^2 = 0.79). The *post-hoc* test revealed that the TL declined significantly after the match day (MD) when compared to the first three days of the week i.e., MD-5; MD-4 and MD-3, and the last three days of the week, i.e., MD-2; MD-1. The TL of the MD-5 differed significantly from the last days of the week, i.e., MD-5; MD-4 and MD-3 at p<.05, p<.001, and p<.001, respectively. On MD-4 and MD-3, there was a significant difference when compared to the s-RPE of the three last days at p<.001 (Figure 1). Moreover, *post-hoc* testing indicated that the TL of the MD-2 differed significantly from the day before the match (p<.001) and the match day (p<.001), respectively (see Figure 1). Finally, the match day differed significantly (797.04 ± 116.25 AU) from the MD-1 (190.29 ± 59.3 AU; p<.001).



Note. *significantly different from MD-5, MD-4 and MD-3 at p<.05; #significantly different from MD-2 at p<.05; $ significantly different from MD-1 at p<.05

Figure 1. Weekly periodization determined using mean weekly rating perceived exertion-based training load (session-RPE); A.U., arbitrary unit; MD = match-day; MD-5 = five days before the match; MD-4 = four days before the match; MD-3 = three days before the match; MD-2 = two days before the match; MD-1= one day before the match; MD+1= first day after the match.

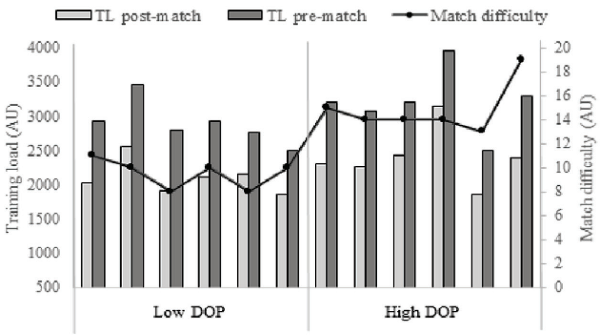


Figure 2. Match difficulty opposition (Low DOP: low difficulty opposition perception and high DOP: high difficulty opposition perception) versus mean weekly rating of perceived exertion-based training load (session-RPE) pre- and post-match. AU = arbitrary units.

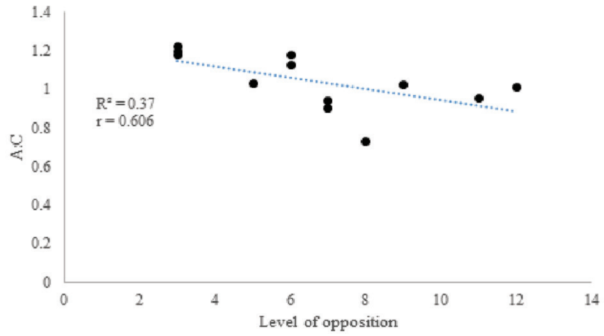


Figure 3. Relationship between level of opposition and acute:chronic workload ratio (ACWR).

No significant difference ($F_{(1.10)} = 1.97$, $p = 0.19$; $\eta^2 = 0.25$) was found between training loads and high- and low-difficulty prediction games for both pre- and post-games (Figure 2).

The relationships between level of opposition (LOP) and acute:chronic workload ratio (ACWR) measures are presented in Figure 3. The moderate relationship with the score of the LOP factors and ACWR ($r=0.606$, $R^2=0.37$) explained most of the variance. Figure 3 depicts the linear relationship between LOP and ACWR. The LOP yielded the strongest relationship over all the measured factors and explained the most variance across all variations in the ACWR workload ratio.

Correlations between the parameters measured

Strong and moderate negative correlations were reported between ACWR and LOP ($r = -0.714$, $p<.01$) and chronic workload ($r = -0.606$, $p<.05$) (see Table 2). The average load, mean load, and

Table 2. Relationship between the training load variables and match difficulty prediction indicators

		Training loads							Match difficulty prediction				
		T L	M T	S D	T M	T S	C W	ACWR	LOP	DBM	Location	Total	Results
Training loads	T L	1	**.863** **	.309	.522	**.853** **	.036	.263	-.155	.306	.339	.074	-.199
	M L	**.863** **	1.00	.430	.519	**.764** **	.115	.152	-.196	.151	.113	-.092	.162
	S D	0	0.43	1	-.539	-0.18	.220	-.109	.191	.306	-.101	.253	-.082
	T M	1	0.52	-.539	1	**.888** **	-.165	.309	-.380	-.137	.177	-.343	.195
	T S	**.853** **	**.764** **	-.178	**.888** **	1.00	-.055	.309	-.326	.089	.291	-.177	-.003
	C W	0	0.12	.220	-.165	-0.05	1	**-.714** **	.390	-.359	-.133	.190	-.051
	ACWR	0	0.15	-.109	.309	0.31	**-.714** **	1	**-.606** *	.178	.364	-.381	-.004
Match difficulty prediction	LOP	0	-0.20	.191	-.380	-0.33	.390	**-.606** *	1	-.088	-.138	**.849** **	-.259
	DBM	0	0.15	.306	-.137	0.09	-.359	.178	-.088	1	.255	.356	-.236
	Location	0	0.11	-.101	.177	0.29	-.133	.364	-.138	.255	1	.281	.051
	Total	0	-0.09	.253	-.343	-0.18	.190	-.381	**.849** **	.356	.281	1	-.308
	Results	0	0.16	-.082	.195	0.00	-.051	-.004	-.259	-.236	.051	-.308	1

Note. AL: average load; ML: mean load; TM: training monotony; TS: training strain; CW: chronic workload; ACWR: chronic workload ratio; LOP: level of opposition; DBM: days between matches.

Table 3. Short-term changes in physical-fitness variables

		Pre	Post	Δ (Δ%)	t test	p value	Cohen's d
CMJ	VJ (cm)	40.76±4.13	46±5.01	6(14%)	7.85	0.00***	1.9
RSA	BTT (s)	6.3±0.19	6.02±0.46	-0.28 (-4.5%)	2.27	0.038*	0.55
	FI (%)	5.18±1.56	3.36±1.41	-1.82 (-35.2%)	4.55	0.000***	1.1
	TT (s)	46.9±2.12	45.4±2.59	-1.5 (-3.3%)	2.13	0.049*	0.52
	IT (s)	44.1±1.34	42.8±2.74	-1.3 (-3%)	2.23	0.041*	0.54
	Mean-Best (s)	2.14±0.71	1.66±0.73	-0.48 (-22.5%)	2.17	0.045*	0.53
Yo-Yo IR1	MAS	18.25±0.91	18.65±84	0.4 (2.2%)	2.13	0.049*	0.52
	VO_{2max} ($ml \cdot min^{-1} \cdot kg^{-1}$)	63.6±3.39	65.1±2.53	1.6 (2.4%)	2.49	0.024*	0.6
RAST	Max PO ($W \cdot kg^{-1}$)	649.6±74.14	722±118.9	72.4 (11.2%)	2.81	0.013*	0.682
	Min PO ($W \cdot kg^{-1}$)	414.2±57	444.6±53	30.4 (7.3%)	2.21	0.042*	0.537
	APO ($W \cdot kg^{-1}$)	514.7±64.9	559.4±52.4	44.7 (8.7%)	2.75	0.014*	0.667
	FI (%)	8.24±2.5	6.41±2.3	-1.83 (-22.2%)	3.08	0.007**	0.748
	Ana. C	3082±346.9	3362±356.3	279 (9.1%)	2.92	0.010**	0.709

Note. CMJ: counter movement jump; VJ: vertical jump; RSA: repeated sprint ability; BTT: best testing time; FI: fatigue index in percent; IT: ideal time; TT: total time; MAS: maximal aerobic speed; VO2max: maximal oxygen uptake; RAST: running-based anaerobic sprint test; Max PO: maximum power output; Min PO: minimal power output; APO: average power output; FI: fatigue index; Ana C: anaerobic capacity.

monotony were strongly correlated with strain values (r = 0.853, 0.764 and 0.888, all p<.01, respectively) (see Table 2). A strong correlation (r = 0.863, p<.01) was found between mean load and average load (see Table 2).

Changes in the measured parameters

Means ± SD and magnitude of within-group changes for all the variables, in all conditions pre- and post-intervention, are shown in Table 2. With regards to repeated sprint ability, fatigue index showed the greatest improvement (p<.001) between pre- (T2) and post-test (T3), with a large effect size (d = 1.104). Concerning the best testing time, ideal time, total time, and mean-best all showed a medium effect size (d = 0.518-0.550) (see Table 3). For maximal aerobic speed and maximal oxygen uptake (VO2max), there were significant changes observed (p<.05), with moderate effect sizes (d = 0.516-0.603). All anaerobic measurements showed significant changes with a medium effect size (d = 0.537-0.748) (see Table 3). There were significant differences observed between pre- and post-test for maximum power output, minimal power output, and average power output (p<.05). In terms of fatigue index and anaerobic capacity, there were significant improvements observed (p<.01). For repeated sprint ability, sprint decrement showed the greatest improvement (p<.001) between pre- and post-test, with a large effect size (d = 1.104). For jumps and lower body strength, there was a significant improvement (14%) observed, with a very large effect size (d = 1.9) (see Table 3).

Discussion and conclusions

The aims of this study were (i) to investigate the variations in training load, training monotony and strain, and acute:chronic workload ratio across the phase I of the competitive period, based on the difficulty prediction (DP) model, and (ii) to examine the changes in aerobic and anaerobic assessments, and strength indices. To our knowledge, this is the first attempt to investigate the use of the DP model in the periodization of youth soccer players training. Our findings suggest that the DP model could be used to determine training loads in youth soccer players. Moreover, a significant positive relationship was found between the LOP factor and acute:chronic work load ratio (ACWR), during the first in-season period. Furthermore, utilizing the DP model to model TL could result in significant improvements in aerobic and anaerobic fitness as well as strength.

In this study, the predicted level of difficulty model used to determine the TL for the week, as well as the first in-season period's periodization with weekly planning using s-RPE, revealed a distinct load pattern, with load decreasing before a more difficult match and increasing before a less difficult match. In previous studies, it has been suggested that non-linear, undulating models across the in-season period may contribute to optimizing training adaptation and performance in team sports (Kelly & Coutts, 2007). This highlights the importance of the periodization model, in addition to the TL quantification variables. Moreover, in this study, we compare TL (weekly training loads pre-and post-match) with the prediction of a difficult and less difficult match. Accordingly, our findings show no differences in TL (pre- and post-match) between the predicted more and less difficult match (see Figure 2). Indeed, these results corroborate the previous suggestion indicating that this model could facilitate training prescription, as well as the distribution of training intensities, with high specificity, across the in-season period (Mujika, et al., 2018), thereby allowing teams to maintain optimal fitness leading to a more difficult match.

The weekly periodization pattern in this study showed similarity to previous weekly training contents. Detailed weekly training periodization across the first in-season period is shown in Figure 1. Previous studies, including a typical week (six full days between matches), in English league teams showed that the last day before the match day (MD-1) is typically showing the lowest training load, in comparison with the rest of the training days (Akenhead, Harley, & Tweddle, 2016; Anderson, et al. 2016). In addition, in elite soccer players, a recent study observed that the noticeable variation in s-RPE on MD-1 (significantly reduced training load compared to the rest of the week) is also associated with a variation in the external TL. Moreover, our study showed that the highest training load was on the second training session of the week. Previous studies have noted similar findings, with the highest TL in both MD-4 and MD-3 (Akenhead, et al., 2016; Anderson, et al., 2016). Conversely, another study has reported the highest TL on the first training session of the week (MD-4) (Stevens, de Ruiter, Twisk, Savelsbergh, & Beek, 2017). It is interesting to note that, in the current study, no difference was found between the first 3-training sessions of the week. Corroborating the findings of our study, Clemente et al. (2019) noted that the greatest load and acquisition day occur in the middle of the week. Such evidence highlights the importance of the distribution of training load between sessions, respecting the model of periodization, to allow recovery, especially before a match day (Clemente, et al., 2019). It has been shown that differences exist in the TL distribution between high-level football teams (Stevens, et al., 2017), whilst age-related increases in the intensity of training should also be considered (Hazir, et al., 2018). Similar patterns as in our study have been observed in a previous study (Machado, et al., 2019), where two days of light intensity sessions were used before the match in order to recover from the high TL in the preceding days. This tapering strategy has frequently been shown as the most effective approach to enhancing performance in endurance sports.

Regarding internal TL, official matches tend to be quantified as the most demanding sessions of the week, which is in line with previous work (Oliveira, et al. 2019a). Moreover, quantified TL, measured by s-RPE TL, provides relevant information on training periodization based on the level of DP. The average s-RPE TL during microcycles was 436 A.U. (356-566 A.U.). This value in this study was higher than reported by Oliveira et al. (2019a) but concordant with those reported by Casamichana, Castellano, Calleja-Gonzalez, San Román, and Castagna (2013) (462.4 ± 237.9 A.U.). The increases in TL that occurred in our study could be explained, firstly, by the high intensity of U18 training leading to an increase in the volume of sessions, and secondly, the increase in high-intensity actions and the development of power-related actions (Rebelo, Silva, Rago, Barreira, & Krustrup, 2016).

Regarding monotony index, the values found in this study (range between 1.3 and 1.7 A.U. and a mean of 1.5 A.U.) was congruent to the values (1.21-1.26 A.U.) reported by Aquino et al. (2016), across different phases of the season, and to the values found in Clemente et al. (2019a) (range between 0.9 and 3.8 A.U., with a mean of 2 A.U.). As a derivative of RPE, monotony index has been used to measure day-to-day variability, and asserted to indicate a risk of illness and over-training with a value index greater than 2 (A.U.). Interestingly, as noted previously, it seems that monotony index could be sensitive to the specificity of the periodization training method with an emphasis on technical-tactical ability, the distribution of TL (Aquino, et al. 2016), and the method used to facilitate TL increases (Clemente, et al. 2019a).

The most important findings of this study were both the significant positive correlation between the ACWR and the LOP, across the in-season phase, and that the LOP factor could explain the most variance of the ACWR variation ($R^2 = 0.37$). Several studies have previously reported that the calculation of the ACWR lead to the identification of the so-called sweet spot in the TL ratio (range between 0.8 and 1.3) (Wang, Vargas, Stokes, Steele, & Shrier, 2020). Moreover, this working range could indicate a sufficient training stimulus to promote players adaptation and readiness (Gabbett & Whiteley, 2017). In line with the results reported in literature, the ACWR mean values of this study were consistent (range between 0.82 and 1.25 and mean of 1.02) (Gabbett & Whiteley, 2017). Recent literature has demonstrated that the calculation of the ACWR may be an appropriate option to maintain players' fitness, with reference to physical demands in competitions (Gabbett & Whiteley, 2017), to balance the TL, and avoid imbalance in chronic TL and reductions in players' fitness (Martín-García, Díaz, Bradley, Morera, & Casamichana, 2018). Considering our findings, together with those reported in literature, it may be postulated that the ACWR provides an adequate tool to manage the in-season loads, in reference to the difficulty prediction periodization model.

Monitoring training in this study was performed using the DP model. The response to the loading measures after the first in-season period was significantly different from the pre-test. Concerning the vertical jump, the results showed significant improvement at post-test vs. pre-test (p<.001). Furthermore, the comparison between pre- and post-test showed an improvement in all measured RSA parameters; BTT (6.3±0.19 and 6.02±0.46), FI (5.18 ± 1.56 and 3.36 ± 1.41), TT (46.9 ± 2.12 and 45.4 ± 2.59), IT (44.1 ± 1.34 and 42.8 ± 2.74), and mean-Best (2.14 ± 0.71 and 1.66 ± 0.73). The MAS and the VO2max both showed a significant improvement at post-test compared to pre-test (2.2% and 2.4%, respectively), with medium effect sizes (0.52 and 0.6, respectively). Finally, the Max P, Min P, AP, FI, and Ana C showed a significant improvement in post-test compared to pre-test (11.2%, 7.3%,8.7%, -22.2%, 9.1%; respectively). Due to the limited scientific support, and especially in soccer (Robertson & Joyce, 2018), it is difficult to compare our results (improvement in fitness). It has been established that the use of this model of periodization, throughout the competitive season, allows the team to maintain optimal fitness levels. This study provides a novel finding, that the perceived match difficulty model could provide enhancements in the players' fitness levels (Robertson & Joyce, 2018).

Although the current work presents a novel addition to literature, there are some limitations that should be considered in the interpretation of our results. One of the main limitations is size of the sample. Indeed, it is logistically and practically problematic to recruit and monitor multiple teams, particularly of elite level. Some previous studies have reported that it is extremely difficult to monitor more than one team at a time (Clemente, et al. 2019a). Another limitation of the present study is the use of the data only of the first in-season phase. Indeed, important findings could be drawn with the integration of games played in cup and tournaments, in addition to the multiple phases of the season. Future studies should endeavor to include more participants, however logistically challenging, and an extended number of games should be monitored to support the use of multi-linear regressions to explain the factors that may influence difficulty match prediction in soccer teams.

Results from this study build up upon previous research to enhance the use of the DP model in an elite youth soccer team. Indeed, this study demonstrates that this model can facilitate the training prescription as well as the distribution of training intensities with the high specificity of soccer activity and tapering strategy across the in-season. Moreover, the perceived match difficulty model may permit teams to maintain optimal fitness preceding difficult matches and facilitate an improvement in fitness levels. Finally, this study provides further impetus for more advanced application of this model of periodization throughout the regular in-season, and with different fixtures, tournaments, and stages of the season.

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