MONITORING PERCEIVED RESPIRATORY AND MUSCULAR EXERTIONS AND PHYSICAL FITNESS IN YOUNG PROFESSIONAL SOCCER PLAYERS DURING A 32-WEEK PERIOD

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Abstract:

The aim of this study was to examine the association of perceived respiratory and muscular exertions and associated training load (TL) for monitoring changes in several aerobic fitness and neuromuscular performance parameters during 32 weeks of soccer training in young professional players. Twenty male soccer players (age=20.6±1.8 years, body height=1.80±.06 m, body mass=73.6±6.7 kg) belonging to the same reserve team of a Spanish La Liga Club participated in this study. Countermovement jump (CMJ), CMJ with arm swing, linear sprint running (over 5 m and 15 m) and an aerobic fitness running test were performed at the start of the pre-season (Test 1) and 32 weeks later (Test 2). During these eight months, after each training session and match, players rated their perceived exertion (sRPE) separately for respiratory (sRPEres) and leg musculature (sRPEmus) effort. Training load was calculated by multiplying the sRPE value by the duration of each training session or match. Accumulated training and match volume (i.e., time) and associated respiratory and muscular training loads were negatively correlated with the changes in aerobic fitness performance after 32 weeks of training (r=-.53/-.62). In addition, accumulated perceived respiratory load was negatively correlated with the changes in 15 m sprint performance (r=-.51/-.53). A high practice volume (time) and associated respiratory and leg muscular TL can impair the long-term improvement of aerobic fitness and sprint performance in professional soccer players.

***Key words:** football, training load, perceived effort, physical performance*

Introduction

The training dose-training response relationship is at the core of sports physiology and performance (Sylta, Tønnessen, & Seiler, 2014). Coaches attempt to prescribe an accurate dosage of training load (TL) to achieve an improvement in athlete's physical fitness performance. However, in a team sport such as soccer, frequent use of group exercises aiming to improve the technical-tactical competence of players generates considerable inter-player TL differences (Akubat, Patel, Barrett, & Abt, 2012; Impellizzeri, Rampinini, & Marcora, 2005; Manzi, Bovenzi, Impellizzeri, Carminati, & Castagna, 2013) and makes it difficult to control the dose-response relationship. Moreover, the variability in the way individuals react to training (Borresen & Lambert, 2009) makes the training process in a soccer team more complex. This suggests how important it is to quantify TL in individual soccer players (Alexiou & Coutts, 2008) and to identify players that respond differently to a similar "dose".

Training load can be assessed by means of both external (e.g., distance, power, velocity, number of repetitions) and internal (e.g., oxygen uptake, heart rate – HR, blood lactate, rate of perceived exertion) indicators of effort intensity (Buchheit, 2014; Sylta, et al., 2014), which are then computed with training time to derive compound load measures (Buchheit, 2014). Among those different methods, overall session-rating of perceived exertion (sRPE) (Foster, et al., 2001) stands out due to its ease, versatility, low cost, and the promptness in the data obtaining (Alexiou & Coutts, 2008). This method has been proposed as a valid and practical tool for evaluating TL in team sports (Casamichana, Castellano, Calleja-Gonzalez, San Román, & Castagna, 2013; Foster, et al., 2001; Scott, Lockie, Knight, Clark, & Janse de Jonge, 2013), as large correlations have been obtained between sRPE- and HR-derived derived measures of exercise intensity/load in soccer training (Campos-Vazquez, et al., 2015). However, despite substantial association between the objective (i.e., HR) and subjective (i.e., sRPE) TL and a large-to-very large correlation between the HR-based TL and changes in some aerobic fitness parameters in response to training in soccer players (Akubat, et al., 2012; Castagna, Impellizzeri, Chaouachi, Bordon, & Manzi, 2011; Castagna, Impellizzeri, Chaouachi, & Manzi, 2013; Manzi, et al., 2013), this dose-response relationship has not been found with sRPE-TL (Akubat, et al., 2012; Brink, Nederhof, Visscher, Schmikli, & Lemmink, 2010). It has been suggested that overall sRPE could represent an oversimplification of the psychophysiological construct making it insufficient to capture the whole range of exercise-related perceptual sensations (Hutchinson & Tenenbaum, 2006). Recently, using a differential perceived load (i.e., respiratory and muscular) in young professional soccer players, substantial associations were found between respiratory and muscular load and changes in some physical fitness parameters (Arcos, Yanci, Mendiguchia, & Gorostiaga, 2014; Los Arcos, Martínez-Santos, Yanci, Mendiguchia, & Mendez-Villanueva, 2015). These measures provide a more detailed quantification of exercise intensity and internal load during training modes commonplace in team sports (McLaren, Smith, Spears, & Weston, 2017).

The dose-response relationship has been typically analysed in soccer after short periods of about 6-9 weeks using perceived TL (Arcos, et al., 2014; Los Arcos, et al., 2015) or HR-based TL methods (Akubat, et al., 2012; Castagna, et al., 2011, 2013; Manzi, et al., 2013). These studies have showed, partially at least, that some of these methods are useful for monitoring changes in some aerobic fitness (Akubat, et al., 2012; Castagna, et al., 2011, 2013; Los Arcos, et al., 2015; Manzi, et al., 2013) and neuromuscular (Arcos, et al., 2014; Los Arcos, et al., 2015) performance parameters during pre-competitive (Castagna, et al., 2011, 2013; Los Arcos, et al., 2015; Manzi, et al., 2013) and in-season (Akubat, et al., 2012; Arcos, et al., 2014) periods for up two months. However, practical application of these results might be limited as the validity of those associations for longer periods of soccer training season has not been shown yet.

Therefore, the aim of this study was to examine usefulness of perceived respiratory and muscular TL (i.e., sRPEres-TL and sRPEmus-TL) for monitoring changes in several aerobic fitness and neuromuscular performance variables in young professional soccer players during a period of 32 weeks.

Methods

Participants

Twenty young professional male soccer players, belonging to the same reserve team of a Spanish *La Liga* Club that competed in the Spanish 2nd B division Championship during the 2012/2013 season participated in this study. Only players that participated in each and every physical test (i.e., countermovement jump, CMJ; CMJ arm swing, CMJAS; sprint running test, 5 m and 15 m times; and endurance running test) in both testing sessions were considered. Due to that criteria the group was eventually reduced to 14 players (age=20.6±1.5 years, body height=1.80±.05 m, body mass =73.6±7.4 kg; six defenders, five midfielders, and three forwards). The players had between 0-3 years of competitive experience in this Championship and at least 10 years of soccer training experience. Goalkeepers were excluded from the study. All participants were informed of the research procedures, requirements, benefits and risks before giving their informed consent. The study was conducted according to the Declaration of Helsinki and the study was approved by the local Ethics Committee.

Procedure

This study was performed during the pre-season (five weeks) and in-season (competition) periods (27 weeks), from July to February. Before and after those 32 weeks, players' physical fitness performance was assessed. During the preseason, players trained 5-8 times a week (31 training sessions in total) and played 1-2 friendly matches per week (8 friendly matches in total), while they trained 4-6 times a week (118 training sessions in total) and played an official match per week (26 official matches in total) during the competition period. Furthermore, during the competition period three additional friendly matches were played. In total, 149 training sessions, 11 friendly matches and 26 official matches were measured during the monitored period. Substitutes participated in a supplementary training session after the games.

Physical fitness assessment

Players completed the same physical testing battery twice: on the second day of the first week (T1) and at the start of the 33th week (T2). Before each testing session, a standardized warm-up, consisting of five minutes of self-paced low-intensity running, mobility exercises, strides and acceleration drills, was performed. The players were instructed to avoid any strenuous exercise 24 hours prior to the test sessions. Physical fitness testing included the evaluation of jumping performance (i.e., CMJ, CMJAS), sprinting (5 m and 15 m) and aerobic fitness running test (i.e., lactate thresholds). Testing place, time and order of tasks (i.e., jumps, sprinting and aerobic fitness test) were the same during both sessions.

Jumping tests. The testing session started with the jumping tests using a switching mat (Newtest OY, Oulu, Finland). Two different jump tests were administered in the following order: CMJ and CMJAS. The CMJ jumps were performed according to the procedures proposed by Bosco, Luhtanen, and Komi (1983). The players performed three CMJ and CMJAS (with a minimum of 20 s recovery between each repetition). The best performance (i.e., the greatest jumping height) of each of the jumps was retained for further analysis.

Sprinting speed. Ten minutes after the completion of the jumping tests and after a non-standardized, individual warm-up period that included low-intensity running and several acceleration runs, players undertook a sprint running test. The sprint test consisted of three 15-metre maximal sprints, on an indoor court, with a 120-second rest period between each sprint. Running times were recorded using photocell gates (Newtest OY, Oulu, Finland) placed 0.4 m above the ground with an accuracy of 0.001 s. The subjects commenced the sprint when ready from the standing start 0.5 m behind the line. Stance for the start was consistent for each subject. The time recording was automatically activated as the subject crossed the first gate at the 0 m mark and split times were recorded at 5 m and 15 m (Los Arcos, et al., 2014). The run with the best score was retained for further analysis.

Aerobic fitness. Finally, the aerobic fitness test consisted of four sub-maximal runs separated by three minutes of recovery run around the artificial soccer pitch (100x50 m). The running speeds were 12 km·h^{-1} (10 min), 13 km·h^{-1} (10 min), 14 km·h^{-1} (10 min) and 15 km·h^{-1} (5 min) for the first, second, third and fourth stage, respectively (Gorostiaga, et al., 2009). Players with previously known low aerobic fitness (four players) started the test at 11 km·h^{-1} (10 min). Running speeds were dictated by audio-cues broadcasted by a pre-programmed computer (Balise Temporelle, Bauman, Switzerland). Immediately after each running stage, hyperaemic earlobe capillary blood samples were obtained for the determination of lactate concentrations $[La]_b$ (Lactate Pro LT-1710, ArkRay Inc Ltd, Tokyo, Japan). Individual data points for the exercise blood lactate values were plotted as a continuous function against time. The exercise lactate curve was fitted with the second degree polynomic function. From the equation describing the exercise blood lactate curve, the velocity associated with the blood lactate concentration of 3 mmol·l^{-1} (V_3) was interpolated (Gorostiaga, et al., 2009). Three variables were considered for further analysis: blood lactate accumulation at 12 km·h^{-1} (Lac12), blood lactate accumulation at 13 km·h^{-1} (Lac13) and running velocity associated with a $[La]_b$ of 3 mmol·l^{-1} (V_3).

Training load

Training and competition internal load data collection started at the beginning of the preseason after T1 (i.e., on the 13th of July) and finished with the last official match before T2 (i.e., on the 26th of February). In order to quantify TL the sRPE-TL method (Foster, et al., 2001) was used. Ten minutes after each training session and each friendly or official match (Los Arcos, et al., 2015) and using Foster's 0-10 scale (Foster, et al., 2001) soccer players were asked by the same person (i.e., their fitness coach) to rate their perceived level of exertion separately for respiratory and leg musculature effort (Arcos, et al., 2014; Los Arcos, Méndez-Villanueva, Yanci, & Martínez-Santos, 2016; Weston, Siegler, Bahnert, McBrien, & Lovell, 2015): rate of perceived respiratory effort (sRPEres) and rate of perceived muscular effort (sRPEmus). Players were allowed to mark a plus sign (interpreted as 0.5 point) alongside the integer value (Algrøy, Hetlelid, Seiler, & Stray Pedersen, 2011; Arcos et al., 2014; Los Arcos, et al., 2015; Seiler & Kjerland, 2006). All players were familiarized with this method. Then, all respiratory and muscular sRPE values, hardness of all sessions, were summed: sumRPEres and sumRPEmus (Arcos, et al., 2014; Los Arcos, et al., 2015). Furthermore, the sRPE-TL, in our case respiratory sRPE-TL (sRPEres-TL) and muscular sRPE-TL (sRPEmus-TL), was calculated multiplying sRPE value by the duration of a training session or match (Foster, et al., 2001). Duration of a training session was recorded for each player from the start to the end of the session, including recovery periods but excluding stretching exercises. The match duration excluded warm-up and in-between half-time rest (Arcos, et al., 2014; Los Arcos, et al., 2015).

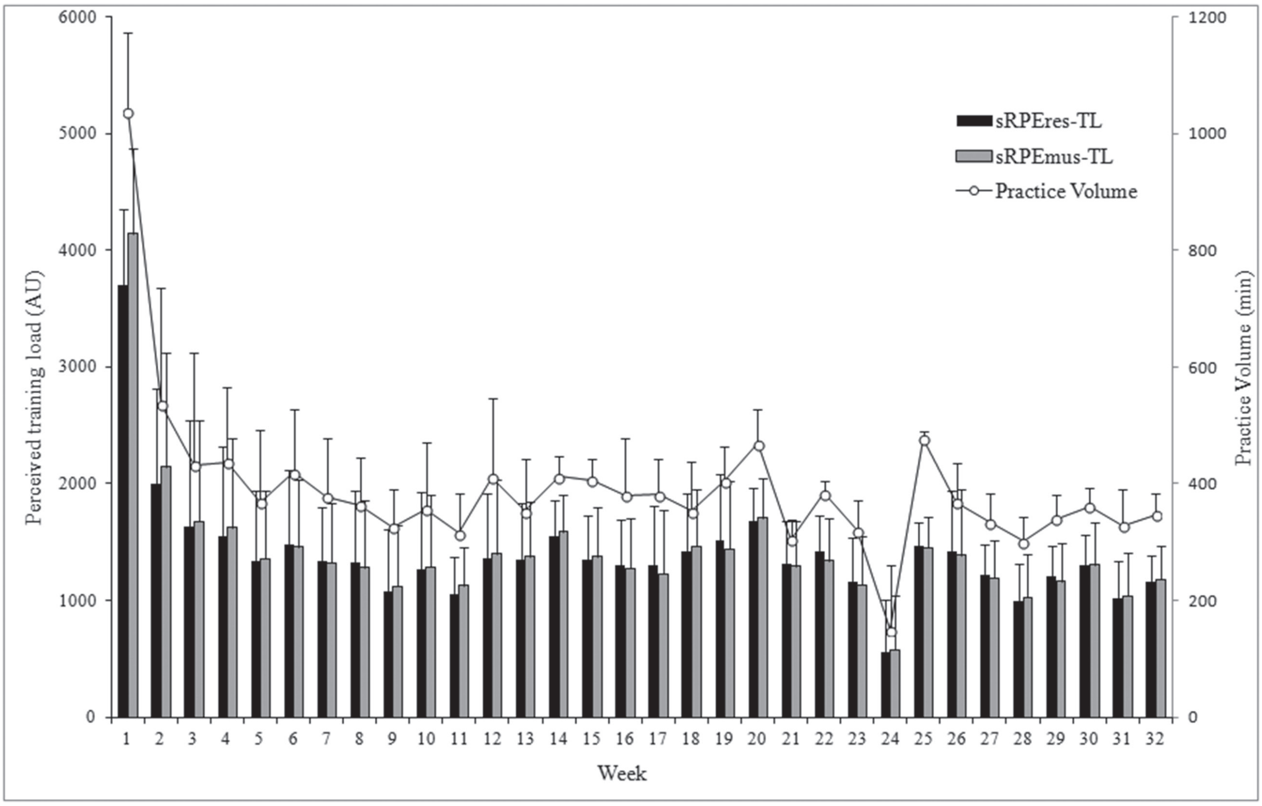
Statistical analysis

Descriptive results are presented as means± standard deviations (SD). We used custom-made spreadsheets to analyse the change in the physical performance from T1 to T2 (Hopkins, 2006). Practical significance was assessed by calculating the Cohen's d effect size (Cohen, 1988). Effect sizes (ES) between <0.2, 0.2-0.6, 0.6-1.2, 1.2-2.0, and 2.0-4.0 were considered as trivial, small, moderate, large and very large, respectively (Hopkins, Marshall, Batterham, & Hanin, 2009). Probabilities were also calculated to establish whether the true (unknown) differences were lower, similar or higher than the smallest worthwhile difference or change (0.2 multiplied by the between-subject SD, based on the Cohen's effect size principle). Quantitative chances of higher or lower differences were evaluated qualitatively as follows: <1%, almost certainly not; 1-5%, very unlikely; 5-25%, unlikely; 25-75%, possible; 75-95%, likely; 95-99%, very likely; >99%, almost certain. If the chance of having higher or lower values than the smallest worthwhile difference were both >5%, the true difference was assessed as unclear. Relationships between total sRPEres-TL, sRPEmus-TL, sumRPEres, sumRPEmus, activity volume and changes in physical fitness performance were examined using correlation coefficients, with 90% confidence limits (CL). The following scale of magnitudes was used to interpret the magnitude of the correlation coefficients: <.1, trivial; =.1-.3, small; <.3-.5, moderate; <.5-.7, large; <.7-.9, very large; and <.9-1.0, almost perfect (Hopkins, et al., 2009). If the 90% CL overlapped small positive and negative values, the magnitude of the correlation was deemed unclear; otherwise the magnitude was deemed to be the observed magnitude (Hopkins, et al., 2009).

Results

Figure 1 displays weekly mean sRPEres-TL, sRPEmus-TL and practice volume during the 32-week period (Figure 1). The weekly mean sumRPEres and sumRPEmus accumulated during the study were 19.1±3.7 AU and 19.3±4.3 AU, respectively.

Very likely moderate (ES=.62±.28) and possibly small (ES=.21±.22) improvements in CMJ and CMJAS performance, respectively, were found



Note. sRPEres-TL: session rating of perceived respiratory exertion training load; sRPEmus-TL: session rating of perceived muscular exertion training load.

Figure 1. Weekly perceived respiratory and muscular training load (AU) and practice volume (min) during the 32-week period, which included both the preseason (5 weeks) and in-season (27 weeks), in elite young male soccer players.

Table 1. Results, change in mean (%) and difference of the fitness parameters from Test 1 (T1) to Test 2 (T2). The data are mean (±standard deviation)

	N	T1	T2	Change in mean (%)	ES	MBI	Rating
CMJ (cm)	14	40.9±3.7	43.4±4.0	6.2±2.7	.62±.28	Very likely moderate	99/1/1
CMJAS (cm)	14	48.1±4.4	49.1±4.8	2.1±2.2	.21±.22	Possibly small	52/48/0
5 m sprint (s)	14	.97±.02	.97±.02	.2±.6	.06±.23	Likely trivial	15/81/4
15 m sprint (s)	14	2.31±.05	2.31±.04	.1±.6	.04±.27	Unclear	17/77/7
V_3 ($km{\cdot}h^{-1}$)	14	12.6±.4	12.6±.4	.1±2.0	.03±.61	Unclear	32/42/26
Lac12 ($mmol{\cdot}l^{-1}$)	14	2.35±.63	2.36±.72	-1.1±15.3	.02±.52	Unclear	27/49/23
Lac13 ($mmol{\cdot}l^{-1}$)	14	3.70±.87	3.70±.94	-.3±10.6	.00±.36	Unclear	17/65/17

Note. ES = effect size; MBI = Magnitude-Based Inference; CMJ = countermovement jump; CMJAS = countermovement jump with arm swing; V_3 = running velocity associated with a $[La]_b$ of $mmol{\cdot}l^{-1}$; Lac12 = lactate concentration after 10 min running at 12 $km{\cdot}h^{-1}$; Lac13 = lactate concentration after 10 min running at 13 $km{\cdot}h^{-1}$.

Table 2. Within-player correlations (±90% confidence limits) between sRPEres-TL, sRPEmus-TL, sumRPEres, sumRPEmus and training volume, and changes in physical fitness performance from T1 to T2

	n	sRPEres-TL (AU)	sRPEmus-TL (AU)	sumRPEres (AU)	sumRPEmus (AU)	Practice Volume (min)
D (%) CMJ	14	.10;±.46 Unclear	.13;±.45 Unclear	.18;±.45 Unclear	.12;±.45 Unclear	.36;±.41 Unclear
D (%) CMJAS	14	.31;±.42 Unclear	.30;±.43 Unclear	.46;±.38 Likely moderate	.34;±.42 Unclear	.32;±.42 Unclear
D (%) 5 m	14	-.36;±.41 Unclear	-.16;±.45 Unclear	-.37;±.41 Unclear	-.15;±.45 Unclear	.05;±.46 Unclear
D (%) 15 m	14	-.53;±.35 Likely large	-.34;±.42 Unclear	-.51;±.36 Likely large	-.24;±.44 Unclear	-.23;±.44 Unclear
D (%) V_3	14	-.57;±.33 Very likely large	-.47;±.37 Likely moderate	-.43;±.39 Likely moderate	-.26;±.43 Unclear	-.57;±.33 Very likely large
D (%) Lac12	14	-.34;±.42 Unclear	-.14;±.45 Unclear	-.16;±.45 Unclear	.1;±.46 Unclear	-.62;±.31 Very likely large
D (%) Lac13	14	-.61;±.31 Very likely large	-.55;±.34 Very likely large	-.49;±.37 Likely moderate	-.34;±.42 Unclear	-.61;±.31 Very likely large

Note. TL = training load; sRPEres-TL = respiratory session-rate of perceived exertion; sRPEmus-TL = muscular session-rate of perceived exertion; sumRPEres = sum of all respiratory perceived efforts; sumRPEmus = sum of all muscular perceived efforts; CMJ = countermovement jump; CMJAS = countermovement jump with arm swing; V_3 = running velocity associated with a $[La]_b$ of $mmol \cdot l^{-1}$; Lac12 = lactate concentration after 10 min running at 12 $km \cdot h^{-1}$; Lac13 = lactate concentration after 10 min running at 13 $km \cdot h^{-1}$.

from Test 1 to Test 2, while the changes in the rest of the variables (i.e. acceleration and aerobic fitness) were trivial (Table 1).

The associations between perceived respiratory and muscular exertion/TL values and changes in physical fitness performance are shown in Table 2.

Practice volume correlated negatively and largely with the change in the V_3 (Figure 2A), Lac12 (Figure 2B) and Lac13 (Figure 2C) values. Furthermore, sRPEres-TL and sRPEmus-TL correlated largely and negatively with the change in Lac13, whereas the changes in 15 m sprint time correlated with sRPEres-derived measures (r=-.53/-.51) after 32 weeks of soccer training

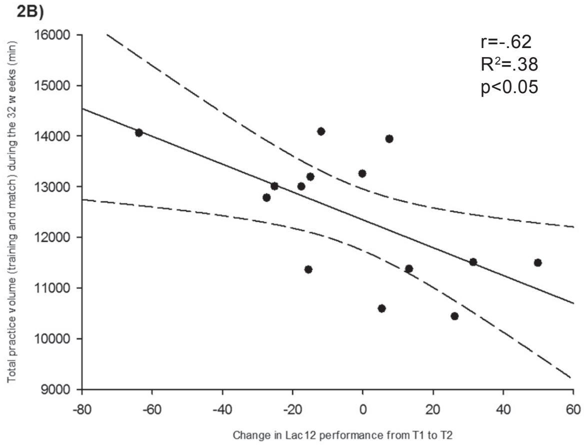


Figure 2B. The relationship between practice volume (time) and percentage change in lactate concentration at 12 km·h⁻¹ (Lac12) performance from Test 1 (T1) to Test 2 (T2).

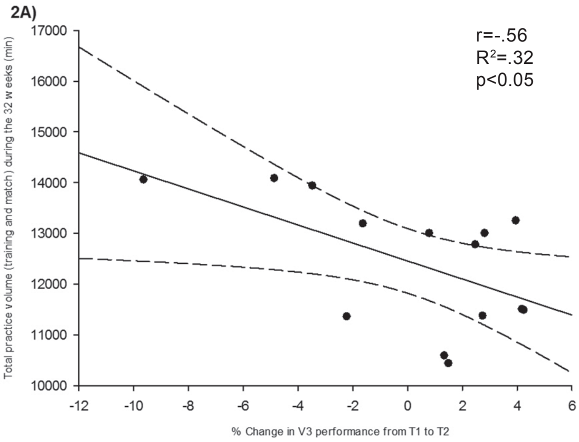


Figure 2A. The relationship between practice volume (time) and percentage change in V3 performance from Test 1 (T1) to Test 2 (T2).

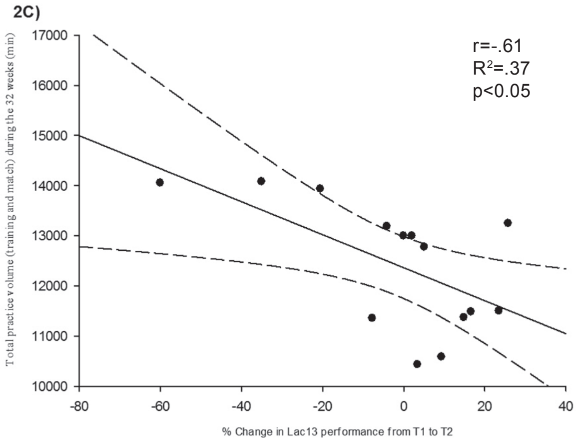


Figure 2C. The relationship between practice volume (time) and percentage change in lactate concentration at 13 km·h⁻¹ (Lac13) performance from Test 1 (T1) to Test 2 (T2).

Discussion and conclusions

The aim of this study was to examine usefulness of the perceived exertion-derived TL measures for monitoring changes in several aerobic fitness and neuromuscular parameters during 32 weeks of soccer training in young professional players. The main findings of the present study were: a) almost all correlations between perceived TL and changes in neuromuscular performance were unclear, and b) the accumulated practice volume (i.e. training plus competition time) was the variable that correlated better with the change in aerobic fitness variables.

Several studies have previously investigated the association between training volume, and its associated TL, and changes in different aerobic fitness and neuromuscular parameters in soccer players. However, all of them have analysed periods shorter than 10 weeks (Akubat, et al., 2012; Arcos, et al., 2014; Brink, et al., 2010; Castagna, et al., 2011, 2013; Los Arcos, et al., 2015; Manzi, et al., 2013). In the present study, after 32 weeks of soccer training and matches, very large and negative associations (r=-.57/-.62), were found between practice volume (i.e. training plus competition time) and changes in aerobic fitness parameters (Figures 2A, 2B and 2C). That is, the players who accumulated a higher training volume (i.e. those who trained and competed in most of the games during the season) were more likely not to improve or to worsen physical fitness parameters. In contrast, Brink et al. (2010) found that a bigger training volume would lead to better interval endurance capacity in young elite soccer players (17±.5 years of age). However, the comparison between studies is difficult because players investigated in the present study were adult professionals (vs. young academy players in Brink et al., 2010). Moreover, aerobic fitness tests were different between the two studies and the period of time under study (32 weeks vs. full competition season) was not the same. In addition to practice volume, a large and negative association was found between sRPEres-TL and sRPEmus-TL and changes in Lac13 (r=-.55/-.61) (Table 2). These results are in agreement with previous findings after a 9-week pre-season training period where the young professional soccer players who accumulated higher perceived muscular TL were most likely to show impaired aerobic fitness performance (Los Arcos, et al., 2015). Overall, despite that the magnitude of the association indicates that only ~30% of the variance in aerobic fitness changes can be either explained by practice volume and perceived respiratory or muscular TL, such magnitude can be relevant in a practical setting. It is important to note, however, that similar training volumes and associated perceived TLs can actually lead to completely divergent physical fitness results taking into account that nature of the load (i.e. specific training contents) can arguably have a greater impact on physical fitness adaptations than its magnitude. Thus, before a detailed description of actual training contents and the way they have been delivered to the players any further discussions on the potential dose-response relationship in soccer remains purely speculative.

Only few studies have examined the association between perceived TL and changes in neuromuscular parameters in team sports (Arcos, et al., 2014; Gabbett & Domrow, 2007; Los Arcos, et al., 2015). For example, Gabbett and Domrow (2007) reported a negative overall sRPE-TL vs. agility performance association during the early competition training phase in sub-elite rugby players. Similarly, Arcos et al (2014) found a large negative correlation between the sumRPEmus and changes in 15 m sprint running velocity (r=-.59) during in-season training (i.e., a 9-week period) in professional soccer players. Lastly, Los Arcos et al. (2015) reported large and negative associations between sRPEmus/sumRPEmus and changes in single-leg CMJ performance (r=-.52/-.61) after a pre-season training (i.e., a 9-week period). In the present study, changes in 15 m sprint time were correlated with sRPEres-derived measures (r=-.53/-.51) after 32 weeks of soccer training, leaving most of the other associations between changes in neuromuscular factors and practice volume and associated TL measures unclear. Thus, differential sRPE might also provide some indications of the training responses of more neuromuscular-oriented variables in soccer players.

Present results suggest that an excessive accumulation of practice volume, and its associated differentiated perceived TL during a long period, can impair aerobic fitness performance in soccer players. Moreover, an excessive perceived respiratory TL might also negatively affect changes in 15 m sprint time. Although the explained shared variance was less than 30% and caution is warranted when interpreting the data, the simple sum of training minutes can provide practical information for monitoring changes in aerobic fitness performance in long-term training in professional soccer players. Moreover, the monitoring of differential sRPE may provide additional information on possible long-term adaptations of both aerobic fitness and neuromuscular performance variables. Lastly, rather small changes in fitness variables can partly explain weak associations between TL variables and changes in fitness variables.

References

Akubat, I., Patel, E., Barrett, S., & Abt, G. (2012). Methods of monitoring the training and match load and their relationship to changes in fitness in professional youth soccer players. *Journal of Sports Sciences*, *30*(14), 1473-1480.

Alexiou, H., & Coutts, A.J. (2008). A comparison of methods used for quantifying internal training load in women soccer players. *International Journal of Sports Physiology and Performance*, *3*(3), 320-330.

Algrøy, E.A., Hetlelid, K.J., Seiler, S., & Stray Pedersen, J.I. (2011). Quantifying training intensity distribution in a group of Norwegian professional soccer players. *International Journal of Sports Physiology and Performance*, *6*(1), 70-81.

Arcos, A.L., Yanci, J., Mendiguchia, J., & Gorostiaga, E.M. (2014). Rating of muscular and respiratory perceived exertion in professional soccer players. *Journal of Strength and Conditioning Research*, *28*(11), 3280-3288.

Borresen, J., & Lambert, M.I. (2009). The quantification of training load, the training response and the effect on performance. *Sports Medicine*, *39*(9), 779-795.

Bosco, C., Luhtanen, P., & Komi, P.V. (1983). A simple method for measurement of mechanical power in jumping. *European Journal of Applied Physiology and Occupational Physiology*, *50*(2), 273-282.

Brink, M.S., Nederhof, E., Visscher, C., Schmikli, S.L., & Lemmink, K.A.P.M. (2010). Monitoring load, recovery, and performance in young elite soccer players. *Journal of Strength and Conditioning Research*, *24*(3), 597-603.

Buchheit, M. (2014). Monitoring training status with HR measures: Do all roads lead to Rome? *Frontiers in Physiology*, *5*, 73.

Campos-Vazquez, M.A., Mendez-Villanueva, A., Gonzalez-Jurado, J.A., León-Prados, J.A., Santalla, A., & Suarez-Arrones, L. (2015). Relationships between RPE- and HR-derived measures of internal training load in professional soccer players: A comparison of on-field integrated training sessions. *International Journal of Sports Physiology and Performance*, *10*(5), 587-592.

Casamichana, D., Castellano, J., Calleja-Gonzalez, J., San Román, J., & Castagna, C. (2013). Relationship between indicators of training load in soccer players. *Journal of Strength and Conditioning Research*, *27*(2), 369-374.

Castagna, C., Impellizzeri, F.M., Chaouachi, A., Bordon, C., & Manzi, V. (2011). Effect of training intensity distribution on aerobic fitness variables in elite soccer players: A case study. *Journal of Strength and Conditioning Research*, *25*(1), 66-71.

Castagna, C., Impellizzeri, F.M., Chaouachi, A., & Manzi, V. (2013). Preseason variations in aerobic fitness and performance in elite-standard soccer players: A team study. *Journal of Strength and Conditioning Research*, *27*(11), 2959-2965.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Erlbaum Associates.

Foster, C., Florhaug, J.A., Franklin, J., Gottschall, L., Hrovatin, L.A., Parker, S., Doleshal, P., Dodge, C. (2001). A new approach to monitoring exercise training. *Journal of Strength and Conditioning Research*, *15*(1), 109-115.

Gabbett, T.J., & Domrow, N. (2007). Relationships between training load, injury, and fitness in sub-elite collision sport athletes. *Journal of Sports Sciences*, *25*(13), 1507-1519.

Gorostiaga, E.M., Llodio, I., Ibáñez, J., Granados, C., Navarro, I., Ruesta, M., Bonnabau, H., & Izquierdo, M. (2009). Differences in physical fitness among indoor and outdoor elite male soccer players. *European Journal of Applied Physiology*, *106*(4), 483-491.

Hopkins, W.G. (2006). Spreadsheets for analysis of controlled trials with adjustment for a predictor. *Sportscience*, *10*, 46-50.

Hopkins, W.G., Marshall, S.W., Batterham, A.M., & Hanin, J. (2009). Progressive statistics for studies in sports medicine and exercise science. *Medicine and Science in Sports and Exercise*, *41*(1), 3-13.

Hutchinson, J.C., & Tenenbaum, G. (2006). Perceived effort — Can it be considered gestalt? *Psychology of Sport and Exercise*, *7*, 463-476.

Impellizzeri, F.M., Rampinini, E., & Marcora, S.M. (2005). Physiological assessment of aerobic training in soccer. *Journal of Sports Sciences*, *23*(6), 583-592.

Los Arcos, A., Martínez-Santos, R., Yanci, J., Mendiguchia, J., & Mendez-Villanueva, A. (2015). Negative associations between perceived training load, volume and changes in physical fitness in professional soccer players. *Journal of Sports Science and Medicine*, *14*(2), 394-401.

Los Arcos, A., Méndez-Villanueva, A., Yanci, J., & Martínez-Santos, R. (2016). Respiratory and muscular perceived exertion during official games in professional soccer players. *International Journal of Sports Physiology and Performance*, *11*(3), 301-304.

Los Arcos, A., Yanci, J., Mendiguchia, J., Salinero, J.J., Brughelli, M., & Castagna, C. (2014). Short-term training effects of vertically and horizontally oriented exercises on neuromuscular performance in professional soccer players. *International Journal of Sports Physiology and Performance*, *9*(3), 480-488.

Manzi, V., Bovenzi, A., Impellizzeri, F.M., Carminati, I., & Castagna, C. (2013). Individual training-load and aerobic-fitness variables in premiership soccer players during the precompetitive season. *Journal of Strength and Conditioning Research*, *27*(3), 631-636.

McLaren, S.J., Smith, A., Spears, I.R., & Weston, M. (2017). A detailed quantification of differential ratings of perceived exertion during team-sport training. *Journal of Science and Medicine in Sport*, *20*(3), 290-295.

Scott, B.R., Lockie, R.G., Knight, T.J., Clark, A.C., & Janse de Jonge, X.A.K. (2013). A comparison of methods to quantify the in-season training load of professional soccer players. *International Journal of Sports Physiology and Performance*, *8*(2), 195-202.

Seiler, K.S., & Kjerland, G.Ø. (2006). Quantifying training intensity distribution in elite endurance athletes: Is there evidence for an «optimal» distribution? *Scandinavian Journal of Medicine and Science in Sports*, *16*(1), 49-56.

Sylta, O., Tønnessen, E., & Seiler, S. (2014). From heart-rate data to training quantification: A comparison of 3 methods of training-intensity analysis. *International Journal of Sports Physiology and Performance*, *9*(1), 100-107.

Weston, M., Siegler, J., Bahnert, A., McBrien, J., & Lovell, R. (2015). The application of differential ratings of perceived exertion to Australian Football League matches. *Journal of Science and Medicine in Sport*, *18*(6), 704-708

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