Original

CUANTIFICACIÓN DE LA CARGA DE ENTRENAMIENTO EN JÓVENES FUTBOLISTAS PROFESIONALES

MONITORING TRAINING LOAD IN YOUNG PROFESSIONAL SOCCER PLAYERS

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RESUMEN

Los objetivos de este estudio fueron conocer la correlación entre la carga de entrenamiento (TL) medida mediante el método de frecuencia cardíaca (HR) de Edwards y la percepción subjetiva del esfuerzo (sRPE), cuantificar y comparar el TL durante diferentes semanas en periodo competitivo y comparar el TL entre diferentes tipos de entrenamiento utilizados asiduamente en fútbol. 19 jóvenes jugadores profesionales de fútbol (edad = 20,95 ± 1,66 años, altura = 1,81 ± 0,63 m, masa corporal = 76,10 ± 7,75 kg) que competían en la 2ª división B del campeonato de Liga española participaron en este estudio.

Se encontró una correlación significativa ($p < 0,001$) entre el TL medido mediante Edwards y el sRPE tanto a nivel respiratorio (0,88 ± 0,06) como muscular (0,84 ± 0,07). De la misma forma, se encontraron diferencias significativas en el sRPE, tanto respiratorio como muscular, durante las distintas semanas de entrenamiento así como en los diferentes tipos de entrenamiento.

Conocer la carga de entrenamiento (TL) es importante en deportes de equipo para ajustar la organización de las sesiones.

Palabras clave: RPE, tipos de entrenamiento, entrenamiento, rendimiento, intensidad.

ABSTRACT

The aims of this study were to find the correlation between Edwards' heart rate (HR) based training load (TL) and session rate of perceived effort (sRPE) TL methods, to quantify and compare the weekly TL using the same weekly training pattern, and compare the TL among the common types of training used in soccer. 19 young professional male soccer players (age = 20.95 ± 1.66 yr, height = 1.81 ± 0.63 m, body mass = 76.10 ± 7.75 kg) from the 2nd B championship division of the Spanish Liga, participated in this study.

A significant correlation ($p < 0.001$) was found between Edwards' HR-based and two (respiratory = 0.88 ± 0.06 and muscular = 0.84±0.07) RPE-based TL methods. Significant differences in weekly and training type's mean team sRPEres-TL and sRPEmus-TL were also found.

Knowledge of the TL is important in team sports to be able to adjust the organization of training sessions.

Keywords: RPE, training types, training, performance, intensity.

INTRODUCTION

The soccer coach plans his training with the principal purpose of developing the soccer players' competence. In order to obtain this aim habitually both "training form" (physical training, technique and skills practices) and "playing form" (small-sided/conditioned games and phase of play activities) are planned in soccer training (Ford, Yates and Williams, 2010). Specifically, coaches combine these types of activities during the weeks and sessions depending on the aspect that they want to improve. Independently of the combination of the activities selected to develop soccer players' competence, the quantification and control of the training load (TL) during the weeks and sessions is necessary to properly distribute practice over time.

In soccer training, as in other sports, the assessment of the team TL is important to be able to assess the response of the players to the practice and to relate it with changes in physical fitness (Impellizzeri, Rampinini and Marcora, 2005). In fact, various studies found an association between TL and changes in physical parameters in soccer (Akubat, Patel, Barret and Abt, 2012, Manzi, Bovenzi, Impellizzeri, Carminati and Castagna, 2013, Castagna, Impellizzeri, Chaouachi, Bordon and Manzi, 2011).

The TL, the multiplication of the physiological stress by the duration (Impellizzeri et al., 2005), has been assessed on many occasions using overall perceived effort (PE) in soccer training. The session rate of perceived effort (sRPE) (Foster et al., 2001) has been found to be a good indicator of the global internal load for soccer training (Impellizzeri, Rampinini, Coutts, Sassi and Marcora, 2004). This method is cheap, simple, lacks reliance on technical expertise or equipment (Alexiou and Coutts, 2008) and shows a strong, and a very strong, correlation between heart rate (HR) based TL and rate of perceived effort (RPE) based TL methods (Alexiou and Coutts, 2008, Casamichana et al., 2013, Impellizzeri et al., 2004) as have been described in soccer training. Therefore, the coach has a lot of reasons to quantify the TL using sRPE.

Taking into account that the players have to respond week by week to the official match requirements in the best conditions, it is important to control TL during the week. On the one hand, a knowledge of optimal weekly TL references (Castagna et al., 2011, Manzi et al., 2013) in soccer training over time requires weekly quantification by the coaches to obtain a reference guide and to compare week by week. On the other hand, the coach has to plan a good tapering strategy (Coutts, Chamari, Impellizzeri and Rampinini, 2008, Smith, 2003,) to ensure that the players are in the best condition to play the match. Therefore, the coaches require a correct distribution of soccer activities from the previous match to the next match (Kelly and Coutts 2007), to constitute a sufficient stimulus but permit the necessary rest. However, in team sports the considerable differences that exist among players in TL (Akubat et al., 2012, Castagna et al., 2011, Manzi et al., 2013) makes it more difficult to adjust the practice for the team. For example, Hoff, Wisloff, Engen, Kemi, and Helgerud (2002) stated that soccer players with higher fitness levels did not receive sufficient training stimulus to further increase their fitness when training in a team environment using small-sided games alone. Therefore, not only the mean team TL should be considered but also the individual response to the same training, because maybe coaches could modify training according to the individual player's needs (Alexiou, and Coutts, 2008).

Therefore, the purposes of this study were: 1) to find the correlation between Edwards' HR-based TL method and sRPE-TL; 2) to quantify and compare the weekly training load of the same weekly pattern; and 3) to compare the training load among the common training types used in soccer.

METHODS

Participants

Nineteen young professional male soccer players (age = 20.95 ± 1.66 yr, height = 1.81 ± 0.63 m, body mass = 76.10 ± 7.75 kg) from the same reserve team of a Spanish Liga Club participated in this study. They competed during the 2011–2012 Spanish 2nd B division championship. Players had between 0-3 years of competitive experience in this

championship and at least 10 years of experience in soccer training. Goalkeepers were excluded from the study. Before the commencement of the study, all subjects received written and verbal explanations of the procedure involved in the study informing them of all risks and benefits associated with participation, and written informed consent was obtained from all of them. All the procedures involved in this study were in accordance with the Declaration of Helsinki (2008).

Experimental design

The weekly sRPE-TL (Foster et al., 2001) profile of the players was assessed during 8 in-season weeks (11, 13, 15, 18, 21, 23, 25, 34 match weeks of the League). Weeks were selected randomly, but in all cases the structure was the same: 4 types of sessions distributed over the same days (Table 1).

Table 1. Training schedule of the weekly pattern.

Day	Physical and soccer training	Mean training duration (min)
Sunday	Official match	-
Monday	No training	-
Tuesday	Endurance + Technical/tactical (ETT)	74.02 ± 11.54
Wednesday	Strength + Technical/tactical (STT)	86.03 ± 8.02
Thursday	Technical/tactical (TT)	77.30 ± 8.51
Friday	Tactical/Strategy (TS)	53.25 ± 10.26
Saturday	Official match	-

The types of weeks were: endurance plus technical/tactical session (ETT, 85 training sessions), strength plus technical/tactical session (STT, 56 training sessions), only technical/tactical session (TT, 105 training sessions) and tactical/strategy session (TS, 83 training sessions). Endurance training consisted in continuous running or interval training, while strength training was performed with vertically and/or horizontally oriented exercises (Los Arcos et al., 2013). Players that did not complete all the prescribed training sessions during the week were not taken into account in the analysis.

Procedures

The players reported their RPE using the Foster's 0-10 scale (Foster et al., 2001) 10 min after each training session (Ngo et al., 2012). The players were asked individually for their respiratory (RPEres) and muscular (RPEmus) perceived effort (Aliverti et al., 2011, Borg, Borg, Larsson, Letzter and Sundblad, 2010, Garcin, Vautier, Vandewalle, Wolff and Monod, 1988, Weltman, Weltman, Kanaley, Rogol and Veldhuis, 1998) assigning a value from 0 to 10. Athletes were allowed to mark a plus sign (interpreted as 0.5 points) alongside the integer value (Algrøy, Hetlelid, Seiler and Pedersen, 2011, Foster et al., 2001). To measure the TL, the value of the RPE was multiplied by the training duration (Foster et al., 2001): respiratory sRPE-TL (sRPEres-TL) and muscular sRPE-TL (sRPEmus-TL). The training duration was recorded individually from the beginning of the training session (including the warm-up and recovery periods) to the end of the session (excluding cool-down).

The heart rate (HR) was registered every 5 s (Polar Team Sport, Polar Electro Oy, Finland) during some training sessions of each type for the calculation of the correlation between HR-based and RPE-based TL methods in general and in each type of training. HR-based TL was calculated using the method proposed by Edwards (1993). This method calculates the TL by multiplying the duration of the training in each zone with a value corresponding to each zone (50-60% of the HRmax = 1, 60-70% of the HRmax = 2, 70-80% of the HRmax = 3, 80-90% of the HRmax = 4, 90-100% of the HRmax = 5). We considered that the HR of the individual anaerobic threshold (IAT) obtained in the submaximal test (Gorostiaga et al., 2009) corresponded to 90% of the HRmax, as cited by Impellizzeri et al. (2004).

Statistical Analysis

The results are expressed as means ± SD. Before using parametric tests, the assumption of normality was verified using the Shapiro–Wilk and Levene tests. Pearson product–moment correlation coefficients with linear regression analysis (and corresponding 95% confidence intervals, 95% CI) were calculated to determine whether there was a significant and overall relationship between sRPE

and HR and for each training type. To interpret the results the threshold values for Pearson product-moment used by Salaj and Marcovic (2011) were used: low ($r \leq 0.3$), moderate ($0.3 < r \leq 0.7$) to high ($r > 0.7$). To compare the TL among weeks and training types one-way ANOVA and post-hoc Bonferroni tests were applied. The coefficient of variation (CV) was calculated to CV: (SD/Mean) x 100 (Atkinson and Nevill, 1998). The statistical analysis was performed with the Statistical Package for Social Sciences (version 20.0, SPSS Inc, Chicago, IL, USA). Significance was set at 0.05 ($p \leq 0.05$).

RESULTS

A significant correlation ($p < 0.001$) was found between Edwards' HR-based and two (respiratory and muscular) RPE-based TL methods for 10 soccer players with at least 20 training sessions where HR was registered. Specifically, the correlation between HR-based method and sRPEres-TL or sRPEmus-TL was 0.88 ± 0.06 (0.77-0.93) and 0.84 ± 0.07 (0.67-0.91) respectively. The correlation between both methods varied in relation to the type of training. A significant correlation ($p < 0.05$) was found in all training types (between 0.40 and 0.59) except between HR-TL and sRPEmus-TL in STT training (Table 2).

Table 2. Relationship between Edwards' HR-based method and sRPE-based TL method.

Training type	sRPEres-TL	sRPEmus-TL
Endurance + Technical/tactical (ETT)	0.558**	0.411**
Strength + Technical/tactical (STT)	0.488**	0.094
Technical/tactical (TT)	0.574**	0.431**
Tactical/strategy (TS)	0.543**	0.445**

**Significant correlation $p < 0.01$; HR = heart rate; sRPE = session rate of perceived effort; TL = training load; sRPEres-TL = respiratory session rate of perceived effort training load; sRPEmus-TL = muscular session rate of perceived effort training load.

Figure 1 and Figure 2 show the team's weekly sRPE-TL means for both levels (respiratory and muscular), of around 900 AU, and the significant differences among weeks in both cases.

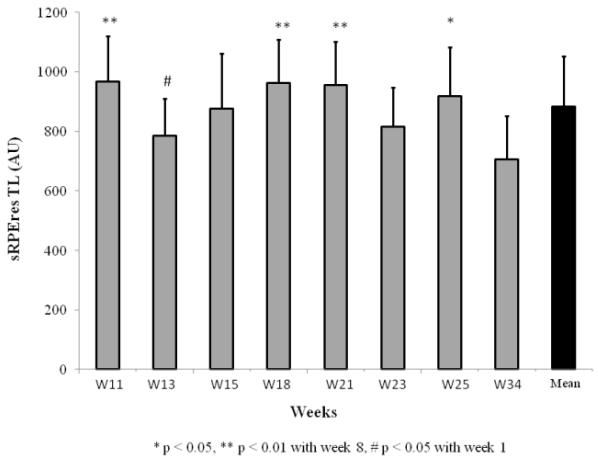


Figure 1. Respiratory session rate of perceived effort training load (sRPEres-TL) differences of the 8 weeks included in the study.

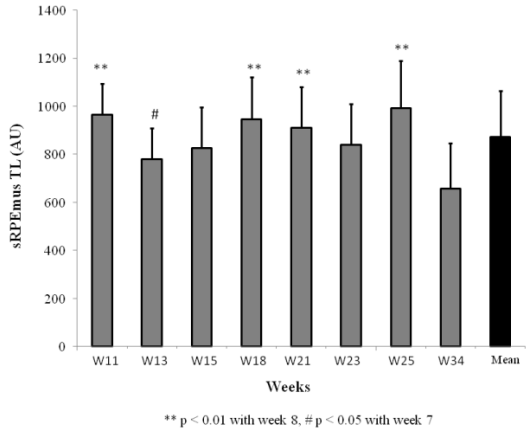


Figure 2. Muscular session rate of perceived effort training load (sRPEres-TL) differences of the 8 weeks included in the study.

Furthermore, the inter-player variability, coefficient of variation (CV) for weekly sRPEres-TL and sRPEmus-TL was between 12.99 and 27.57 (Table 3).

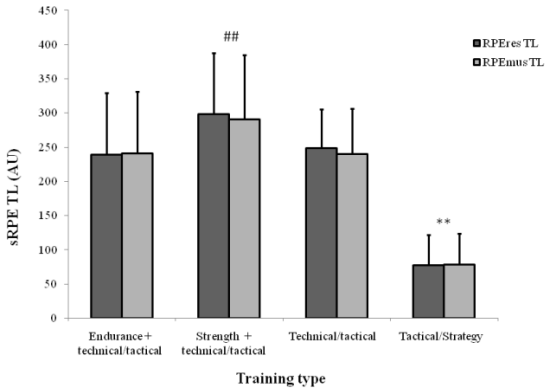
Figure 3 shows the sRPEres-TL and sRPEmus-TL for each training type during the week and the differences among days.

Inter-player variability (CV) in each training type ranged from 18.55 to 46.82 (Table 4).

Table 3. Inter-player variability (CV) for each week (data are presented as CV, % of all players).

Weeks	sRPEres-TL	sRPEmus-TL
W11	15.2	12.9
W13	15.1	15.7
W15	20.4	20.0
W18	14.8	18.1
W21	14.6	18.0
W23	15.5	19.2
W725	17.2	19.2
W34	19.6	27.5
Mean ± SD	16.5 ± 2.2	18.8 ± 4.1

CV = coefficient of variation; W = week, SD = standard deviation; sRPEres-TL = respiratory session rate of perceived effort training load; sRPEmus-TL = muscular session rate of perceived effort training load.



** p < 0.01 between Tactical/strategy and both training types, ## p < 0.01 between Strength + technical/tactical and Endurance + technical/tactical training or Technical/tactical training.

Figure 3. Respiratory or muscular session rate of perceived effort training load (sRPE-TL) differences among training types.

Table 4. Inter-player variability (CV) for each training type (data are presented as CV, % of all players).

Training type	sRPEres-TL	sRPEmus-TL
Endurance + Technical/tactical (ETT)	27.7	28.16
Strength + Technical/tactical (STT)	26.86	28.90
Technical/tactical (TT)	18.55	23.94
Tactical/strategy (TS)	43.71	46.82

CV = coefficient of variation; sRPEres-TL = respiratory session rate of perceived effort training load; sRPEmus-TL = muscular session rate of perceived effort training load.

DISCUSSION

The main contribution of this study was to quantify the TL measured by respiratory and muscular sRPE in professional soccer players over 8 weeks' in-season training. A high correlation was found between Edwards' HR-based TL and sRPEres-TL or sRPEmus-TL in young professional soccer players in training, however, this correlation was lower when analyzing it with respect to the training types. Mean team weekly sRPE-TL (respiratory and muscular) in–season was around 900 AU after the completion of 4 training sessions, although significant differences among weeks were found. With respect to the weekly structure a tapering strategy was found where the highest TL was described in the middle of the week. However, soccer training implies a high TL inter-player variability in general and especially in pre-match training.

Despite the separation between respiratory and muscular level, a very high correlation was found between Edwards' HR-based TL and sRPEres-TL (r = 0.88 ± 0.06) or sRPEmus-TL (r = 0.84 ± 0.07) in professional young soccer players. Similarly, Borg et al. (2010) found a very good relationship between psychophysical ratings and HR for leg fatigue (r = 0.80) and breathlessness (r = 0.70) rated on the CR10 in healthy subjects. Specifically in soccer studies where overall sRPE-TL was used, in concordance with our results, a high (Casamichana et al., 2013, Impellizzeri et al., 2004) and a very high (Alexiou and Coutts, 2008) correlation was found between the same HR-based method and sRPE-TL. Therefore, the separation between respiratory and muscular levels did not impede the very high correlation between the HR-TL method and sRPEres-TL or sRPEmus-TL in soccer training. However, this correlation should be considered with caution in relation to the sessions where strength exercises are added to the soccer training due to the non correlation between HR-TL and sRPEmus-TL in STT training. As various research studies have shown, explosive exercises based on short and fast actions at high intensity and dependent on the anaerobic metabolism are not well expressed by the HR and in those cases the muscular system could be affected without expressing the same stress in the central system (Alexiou and Coutts, 2008, Algrøy et al.,

2011, Impellizzeri et al., 2004, Little and Williams, 2006, Rebelo et al., 2012).

Mean team weekly sRPE-TL (respiratory and muscular) in–season for our professional soccer players, at 900 AU, was lower than the overall sRPE-TL described in young soccer players (Impellizzeri et al., 2006, Wrigley et al., 2012). However, comparison with these studies should be made with caution because in our case only 4 training sessions were performed, while in their weekly structure between 6 and 8 sessions were performed. Interestingly, in spite of the weekly structure being the same, significant differences in mean team weekly sRPEres-TL and sRPEmus-TL were found (Figures 1 y 2). The training load in the weeks included in the study, demonstrated fluctuations and differences among the same specific weeks. Coutts et al. (2008) also showed a fluctuating trend during the competitive soccer period, and demonstrated that the variation of the TL during the season is often large, and therefore there are usually low monotony values for football players, differing from the traditional progressive planning of the endurance sports and focusing more on the following week or microcycle plan, rather than preparing the athlete to achieve a distant objective. If we analyze inter-player variability in sRPE-TL during the weeks, we find a CV that ranged between 12.99% and 27.57%. Therefore, considerable differences among players were found in soccer training as occurs in other team sport studies (Akubat et al., 2012, Stagno, Thatcher and Van Someren, 2007). These differences among players can be the consequence of the practice in group training where the stimulus varies among the different players.

If we analyse the weekly structure (Figure 3) we can see that the largest sRPEres-TL and sRPEmus-TL is described in the middle of the week (Wednesday, STT training), three days after the previous match and also 3 days before the next match. This result could be taken as optimal because previous studies have found that to recover different physical abilities (i.e jumping, sprinting, peak power) after a match, at least 48 hours of rest is necessary (Ascensao et al., 2008, Hoffman, Nusse and Kang, 2003, Ispirlidis et al., 2008, Rampinini et al., 2011). Furthermore, the day before the match the TL was significantly less than the other sessions to avoid an excessive TL near to competition (Coutts et al., 2008). Therefore, the TL pattern that has been described during the week followed the tapering strategy (Smith, 2003). However, pre-match (Friday) TS training was the training with the highest CV (Table 4), where intensity and the TL is low and all players are involved in the same task. The sum of the TL during the week, that as stated above is very variable between players, maybe conditions the perceived effort at the end of the week.

CONCLUSIONS

In conclusion, the TL varies over the weeks and the competition conditions its distribution during the week; however, the characteristics of soccer training produce remarkable differences among players and make it difficult to control the stimulus for the whole group. Despite this, the quantification of TL is important in team sports to adjust the training organization in general and to include or eliminate activities for players who experience excessive or insufficient stimulus.

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