Relationship Between Internal Load Indicators and Changes on Intermittent Performance After the Preseason in Professional Soccer Players

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Abstract

Campos-Vazquez, MA, Toscano-Bendala, FJ, Mora-Ferrera, JC, and Suarez-Arrones, LJ. Relationship between internal load indicators and changes on intermittent performance after the preseason in professional soccer players. *J Strength Cond Res* 31(6): 1477–1485, 2017–The aim of this study was to examine the effects of accumulated internal training load (ITL) during the preseason (4 weeks) on changes in the intermittent performance, in a professional soccer team. Twelve professionals soccer players (Mean ± SD age: 27.7 ± 4.3 years; height: 177.1 ± 6.2 cm; body mass: 73.1 ± 5.2 kg; % body fat [Faulkner]: 10.2 ± 1.2) belonging to a Spanish second division team (2013–2014) participated in this study. The 30-15 intermittent fitness test was performed before and after the preseason, and the speed for the last period completed by each player was recorded (V_{IFT}). During the preseason, the team alternated practice of training sessions (TRNs) with friendly matches (FMs). Session rating of perceived exertion (sRPE), heart rate (HR), and HR reserve were analyzed every TRN and FM to calculate ITL (ITL: sRPE-TL, Edward's-TL and Edward's-TL_{res}). The players' V_{IFT} substantially increased after the preseason period (20.1 ± 0.8 vs. 21.1 ± 0.8 km·h^{-1}; effect size [ES] = 1.15 ± 0.25; almost certainly). The average value of sRPE throughout FMs was substantially greater than the value of the TRNs (7.4 ± 0.9 vs. 5.25 ± 0.2; ES = 2.31 ± 2.45; almost certainly). sRPE-TL, practice volume, and sum of RPE during the preseason were positively and largely correlated (r = 0.70–0.75) with changes on intermittent performance. No relationships were found between HR-derived measures of exercise load and changes on intermittent fitness. The present results suggest that practice volume and subjective measures of TL, related better than HR-based TL methods to changes on intermittent performance after the preseason, in professional soccer players.

Key Words quantification, football, session-RPE, heart rate, intermittent fitness test

Introduction

The preseason is one of the most important periods in the training of soccer teams. Players often begin this stage of the annual plan with a significant degree of detraining after the period between seasons (the off-season) (31). Therefore, during the preseason, teams train to start the long period of competition with the best possible level of fitness (25). To achieve this, the coaches plan high volumes of training in this period (31) and friendly matches (FMs) with opponents at different levels (17). These FMs can be crucial for players to assimilate the model of team play and to adapt to the efforts required by competition.

However, it is possible that adaptation to the training stimulus in the preseason does not happen evenly for all players, as some aspects, such as fitness, external load, age, or body composition, could determine the physiological stress (internal training load, ITL) the players are able to bear, and therefore the training outcome (24). For instance, most of the practice performed in soccer teams are conducted in a group and includes specific soccer training strategies (i.e., small-sided games, conditioning games, etc.) (20). Besides, the participation of the players in competition is usually unequal, with players who barely participate in matches and other players playing all competitive matches. This makes the management of the dose-response relationship difficult and may result in players in the same soccer team that do not receive an appropriate level of training stimulus (3). To control individual physiological responses and avoid undesired training effects, it seems necessary to periodically monitor both daily training load (TL) and fatigue levels (21)

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after the training sessions (TRNs) and the FMs. Daily analysis of this information could help in the design and periodization of TLs to achieve the desired adaptations.

Recently, there have been an increasing number of studies regarding the dose-response relation in soccer players, using for this purpose heart rate (HR)–based TL methods (1,12,13,29). The objective of these studies is to have information about the training dose required during a training period to achieve improvements in fitness and/or performance. Proposals for the assessment of the training dose using HR-based methods, which achieved significant dose-response relationships in the above-mentioned studies were individualized TRIMP (iTRIMP) (1,29) and the time the player remains above their physiological thresholds (12,13). However, both proposals are economically too expensive, and thus limited to teams with greater economic power. Other HR-based methods commonly used in the monitoring of ITL in soccer players (3,11,23) such as Banister's training impulses (TRIMP) (5), Edwards' TL (16), or Stagno's adaptation to team sports ($TRIMP_{MOD}$) (32), have not achieved to date significant dose-response relationships in soccer players (1). Some of them, such as Edward's-TL or $TRIMP_{MOD}$, use maximal HR (HR_{max}) as a reference for establishing different intensity zones. However, owing to the existence of high variability in the HR_{max} and resting HR (HR_{rest}) among the players (14), it may be more appropriate to express the values of HR in relation to reserve HR (HR_{res}) (26). The equation proposed by Karvonen et al. (1957) considers the changes in biorhythms and allows interindividual comparison of the HR response to different forms of training (14). The only use of HR_{max} in the calculation of ITL as in these methods, could have conditioned the absence of significant dose-response relationships.

Another much more economical approach to control ITL is the session rating of perceived exertion method (sRPE-TL) (18). This method has been shown to be a valid and reliable tool for monitoring ITL in soccer and other team sports (23). Previous research conducted on young soccer players have analyzed the dose-response relationships between sRPE-TL and changes in physical performance after a training period with divergent results (1,8,20). Nevertheless, to date, there is no study that has analyzed associations between sRPE-TL and changes in physical performance in professional soccer players.

Therefore, the objective of the research was to examine the effects of accumulated ITL (Edward's-TL, Edward's-TL_{res}, sRPE-TL) on changes in the intermittent performance after the preseason in a professional soccer team. In addition, the relationships between various indicators of ITL were discussed during the TRNs and FMs.

Methods

Experimental Approach to the Problem

In this study, a descriptive correlational design was used. Three indicators of ITL were used: the sRPE-TL method, the Edward's-TL, and a new proposal of this method where the values were expressed according to HR_{res} (Edward's-TL_{res}). To analyze dose-response relationships, the intermittent performance was assessed at the beginning and the end of the experimental period.

The study lasted 4 weeks during the preseason (July–August 2013). During this period the team alternated practice of TRNs with FMs. During the experimental period, a total of 21 TRNs were performed lasting an average of approximately 70 minutes (range 30–95 minutes) and 7 FMs were played. Fifty percent of the TRNs were aimed to improve fitness levels, whereas 20% were devoted to technical and tactical training. The day before the FM, prematch activation sessions (11) were conducted, which together represent 30% of the TRNs. In the preseason, a 1-week training camp was organized, during which the team alternated 2-a-day TRNs (morning and evening) with single TRN a day (morning). During the training camp, the dietary regime was strictly monitored by a nutritionist. The TRNs were conducted on 3 different fields (all natural grass) in the same facility on a rotational basis. During the TRNs, players were allowed to consume available isotonic sports drinks ad libitum (during recovery periods). All the FMs were played in the evening, against lower competitive level (first 2 matches) and same or higher competitive level teams (next 5 matches). The involvement of the players in the FMs (volume of minutes) depended on the criteria of the coach.

Subjects

Twelve professional soccer players participated in this study (mean ± SD age: 27.7 ± 4.3 years; height: 177.1 ± 6.2 cm; body mass: 73.1 ± 5.2 kg; % body fat [Faulkner]: 10.2 ± 1.2). All players were from the same team (second division Spanish La Liga) and had an average experience in professional soccer of 6.0 ± 4.1 years. All players signed a declaration of informed written consent before participating in the study. This study was approved by the institutional ethics review committee and followed the recommendations of the Declaration of Helsinki.

Procedures

Two sessions of assessment (in the preexperimental and postexperimental period) were established to assess intermittent performance through the 30-15 Intermittent Fitness Test ($30\text{-}15_{IFT}$) (9). The players were well familiarized with the test because they it has been used during previous seasons as a usual assessment test of intermittent performance. During the test, the HR_{max} of each player was obtained (9) using a HR monitor (Polar Team 2, Polar Electro Oy, Finland), and the speed for the last period completed by each player was recorded (V_{IFT}) (9). In players whose HRs were higher in the course of the TRNs or FMs than the obtained HR_{max} in the $30\text{-}15_{IFT}$, the HR_{max} values shown during the TRNs or FMs were retained and used in the analysis. The HR_{rest} was registered before the test. To do so, the players remained in a supine position for a period of 10 minutes, considering HR_{rest} as the lowest HR during this period (15). This allowed

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the HR values to be recorded during TRNs and FMs as a function of HR_{res} (26). The procedure for determining HR_{rest} was repeated once a week, updating and registering new values of HR_{rest} for calculations of HR_{res} according to the formula proposed by Karvonen et al. (26).

Exercise Intensity and Internal Training Load. Heart rate was recorded every one second using a telemetry system (Polar Team 2, Polar Electro Oy) during all TRNs and FMs. This system allows HR to be monitored in real time, and provides the possibility of expressing HR response as a function of HR_{res} (14). The amount of time that players spent in each TRN or FM between 90–100% of HR_{max} was registered (min >90% HR_{max}). The duration of the TRNs and FMs was recorded from the start (warm-up) to the end, including recovery periods. Internal training load was measured using 3 different methods, 2 based on HR response and 1 based on the rating of perceived exertion (RPE).

Internal training load calculation was performed as proposed by Edwards (1993) (Edward's-TL), which includes the total volume of training intensity, considering 5 zones of different intensity. The calculation was performed for each TRN or FM by multiplying the accumulated duration in each HR zone (min) for a value assigned to each intensity zone (90–100% HR_{max} = 5; 80–90% HR_{max} = 2; 70–80% HR_{max} = 3; 60–70% HR_{max} = 2; 50–60% HR_{max} = 1) and then adding the results.

In addition, the ITL was calculated as proposed by Edwards (1993), but the values were expressed according to HR_{res} (Edward's-TL_{res}). Thus, the calculation for each TRN or FM was performed by multiplying the accumulated duration in each HR_{res} zone (min) for a value assigned to each intensity zone (90–100% HR_{res} = 5; 80–90% HR_{res} = 2; 70–80% HR_{res} = 3; 60–70% HR_{res} = 2; 50–60% HR_{res} = 1) and then adding the results.

Finally, ITL was quantified by analyzing the RPE of each TRN or FM. Each athlete's sRPE was collected 30 minutes after each TRN of FM using the Borg Scale-10 (7) with which all athletes were previously habituated. For this purpose, the fitness coach was asking the player how demanding was the TRN/FM for them. Afterward, the players had to choose a value between 0 (none) and 10 (máximum). Subsequently, the RPE value was multiplied by the total duration of the TRN or FM (min), according to Foster et al. (18) to estimate the RPE-derived ITL (sRPE-TL). In addition, all training and match sRPE were summed (sum of RPE).

Total Quality Recovery. To monitor recovery, 30 minutes before each TRN or FM, the total quality recovery (TQR) scale (27) was presented to the players. The players were asked to select a scale value between 6 and 20 to assess their level of recovery, with 6 being the value associated with poorer recovery and 20 with excellent recovery (27).

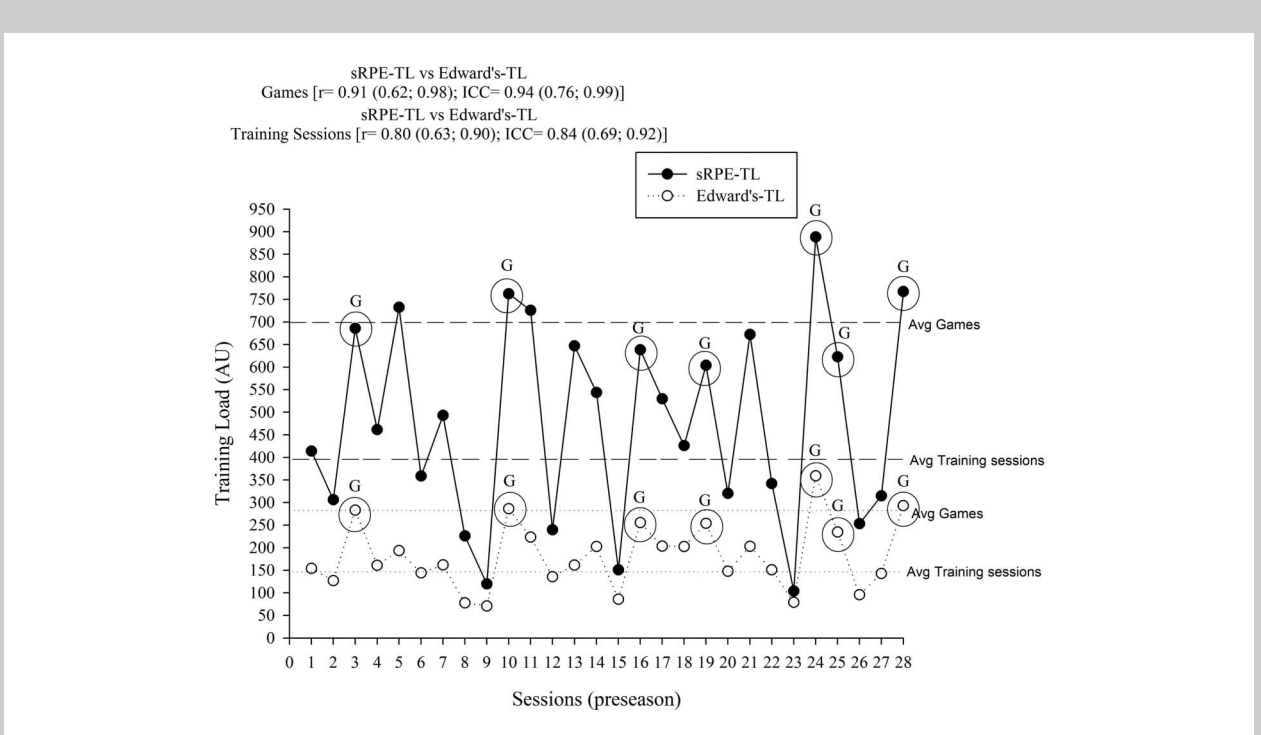

Figure 1. Evolution of internal training load during the preseason and within-individual correlations between internal training load methods in training sessions and games (G: friendly matches; 90% confident limits). Edward's-TL = Edwards training load; sRPE-TL = session rating of perceived exertion training load.

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This method has previously been used with soccer players (8).

A total of 326 individual records (252 TNRs and 74 FMs) met all the requirements and were included in the analysis.

Statistical Analyses

Data in are presented as mean ± SD. Possible differences between TRNs and FMs were analyzed for practical significance using magnitude-based inferences by prespecifying 0.2 between-subject SDs as the smallest worthwhile

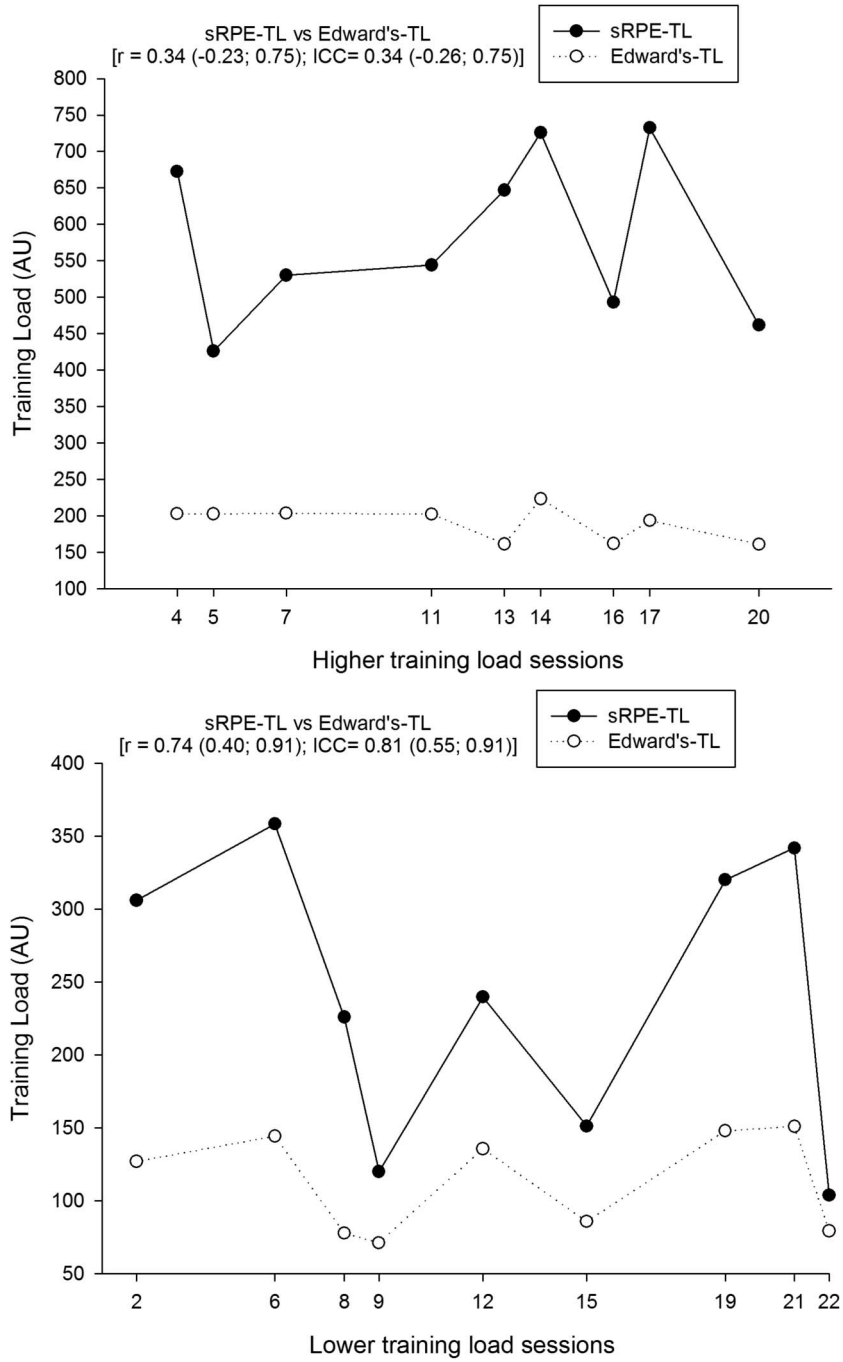

Figure 2. Within-individual correlations between internal training load methods in higher and lower training load sessions performed during preseason (90% confident limits). Edward's-TL = Edwards training load; sRPE-TL = session rating of perceived exertion training load.

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effect (22). For further analysis in relationships between ITL methods (RPE- and HR-based), TRNs were divided in 2 groups: high- and low-load, based on a small standardized difference (ES) (i.e., 0.2× within-group SD) from the group average (2,6). The standardized difference or effect size (ES, 90% confidence limit [90% CL]) in the selected variables was calculated and quantitative chances of higher or lower changes 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 (22). A substantial effect was set at >75% (4,34,35). Pearson correlation coefficient was used to examine the relationships between different variables. The threshold values were small (0.1–0.2), moderate (0.3–0.4); large (0.5–0.6); very large (0.7–0.8), and extremely large (≥0.9) (22). The intraclass correlation coefficients were calculated.

Results

Players performed a total volume of 1,503.4 ± 35.0 minutes in the preseason TRNs, averaging 71.6 ± 1.7 minutes per TRN. The total volume of min in FMs per player was 540.5 ± 119.0 minutes, with an average of 87.09 ± 14.21 minutes per game.

The average value of sRPE throughout the TRNs was 5.25 ± 0.2 with a range from 2 to 9, whereas the average value of sRPE throughout the FMs (7.4 ± 0.9) was substantially greater (ES = 2.31 ± 2.45; almost certainly), with a range from 3 to 10.

The sRPE-TL and Edward's-TL of all TRNs and FMs throughout the preseason are shown in Figure 1. The overall sRPE-TL throughout the preseason was 12,712.0 ± 1,400.2 arbitrary units (AU) per player, with sRPE-TL during TRNs (8,329.8 ± 262.7 AU) being substantially higher (ES = 2.93 ± 0.44; almost certainly) than FMs (4,382.2 ± 1,253.1 AU). The average value of sRPE-TL in the TRNs (396.7 ± 12.5 AU) was substantially lower (−1.77 ± 0.47; almost certainly) than the value of the FMs (701.3 ± 160.0 AU). The Edward's-TL of the preseason was 4,864.4 ± 657.0 AU per player, with the Edward's-TL during TRNs (3,123.9 ± 427.7 AU) being substantially higher (ES = 3.01 ± 0.54; almost certainly) than that of the FMs (1,740.5 ± 382.0 AU). The average value for the Edward's-TL for the TRNs (148.8 ± 46.4 AU) was substantially lower (−2.80 ± 0.97; almost certainly) than that of the FMs (280.9 ± 40.5 AU).

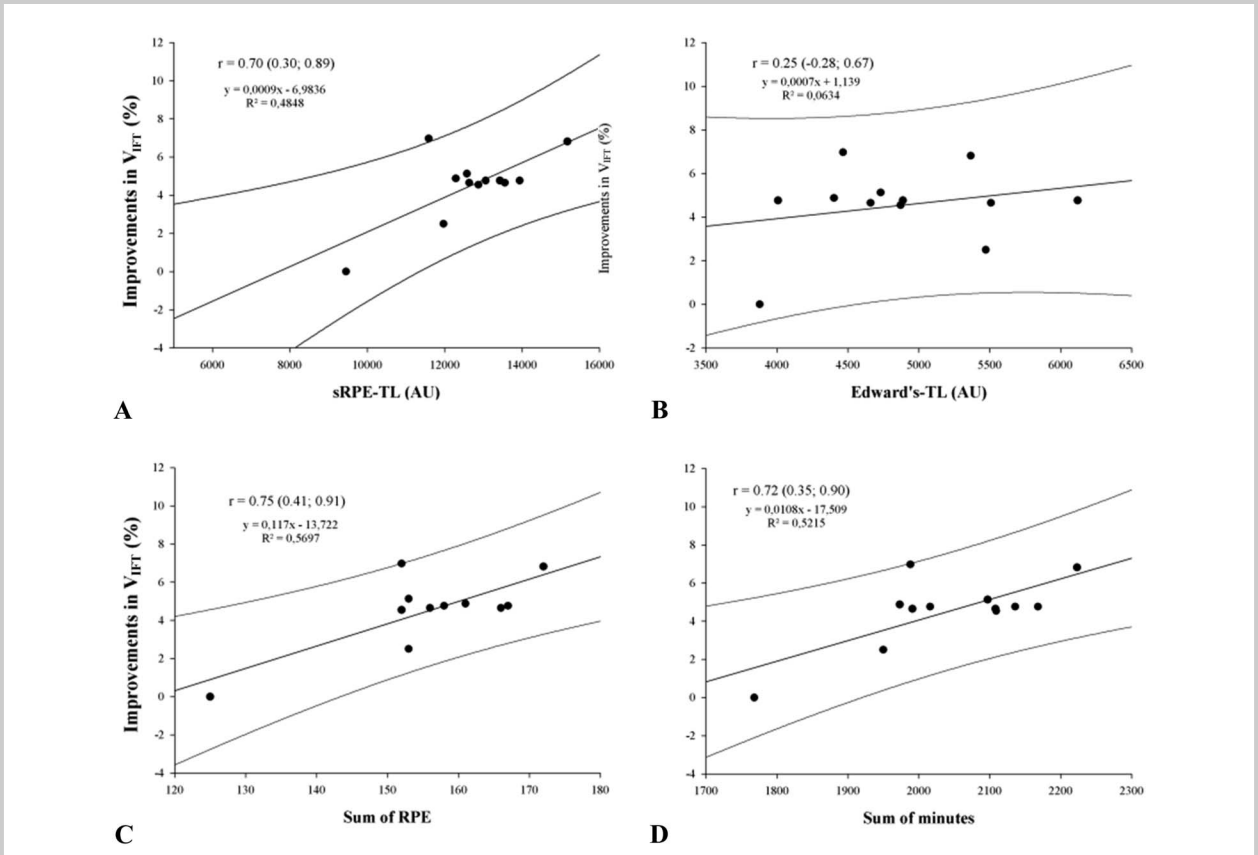

Figure 3. Within-individual correlations between different indicators of training load and changes on intermittent performance. V_{IFT}: velocity intermittent fitness test (Buchheit, 2008). Edward's-TL = Edwards training load; RPE = rating of perceived exertion; sRPE-TL = session rating of perceived exertion training load.

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Table 1. Within-individual correlations between different indicators of training load recorded during friendly matches and training sessions, and changes on intermittent performance.*†

	Edward's-TL_{res}	sRPE-TL	sRPE	Changes in V_{IFT}
Edward's-TL				
FM	0.92 (0.78–0.97)	–	–	0.66 (0.25–0.87)
TRN	0.88 (0.69–0.96)	–	–	Unclear
Min >90%				
FM	–	0.77 (0.22–0.95)	0.60 (0.03–0.88)	–
TRN	–	0.48 (0.16–0.72)	0.47 (0.14–0.71)	–
Volume (min)				
FM	–	–	0.64 (0.04–0.90)	0.68 (0.27–0.88)
TRN	–	–	0.66 (0.38–0.83)	Unclear
Sum of RPE				
FM	–	–	–	0.74 (0.38–0.90)
TRN	–	–	–	0.64 (0.21–0.87)

*Edward's-TL_{res} = Edwards training load according heart rate reserve; sRPE-TL = session rating of perceived exertion training load; V_{IFT} = velocity intermittent fitness test; Edward's-TL = Edwards training load; FM = friendly matches; TRN = training sessions; RPE = rating of perceived exertion.
†Data are presented as mean (90% confident limits).

There was an almost perfect relationship between sRPE-TL and Edward's-TL in the FMs and a very strong relationship in the TRNs (Figure 1). The relationship between the sRPE-TL and Edward's-TL in the high-load TRNs was moderate, whereas in the low-load TRNs it was large (Figure 2).

The players' V_{IFT} substantially increased (ES = 1.15 ± 0.25; almost certainly) after the preseason period (20.1 ± 0.8 vs. 21.1 ± 0.8 $km \cdot h^{-1}$, respectively). There was a strong relationship between the sRPE-TL accumulated in the preseason and improvements in V_{IFT} (Figure 3), as well as between the sum of RPE and the volume of practice (min) in the preseason with improvements in V_{IFT} (Figure 3). The volume of time (min) spent in the FMs showed a moderate relationship with the improvements of V_{IFT}, whereas there was no relationship between the volume of TRNs and intermittent performance improvements (Table 1) and neither between Edwards'-TL accumulated in the preseason and improvements in V_{IFT} (Figure 3).

Mean (90% confident limits) within-individual correlations between different indicators of ITL and changes in V_{IFT} during TRNs and FMs are shown in Table 1. Strong relationships were found between Edwards'-TL and Edwards'-TL_{res} in TRNs and FMs (r = 0.88–0.92). There were very large and large relationships between the sum of RPE in FMs and TRNs, respectively, with improvements in V_{IFT} (Table 1).

Total quality recovery before playing the fifth, sixth, and seventh game was significantly higher than that of the first, second, third, and fourth games. Total quality recovery before the fourth game was significantly higher than the first, second, and third. Total quality recovery before the second and third game was significantly higher than that of first (Figure 4).

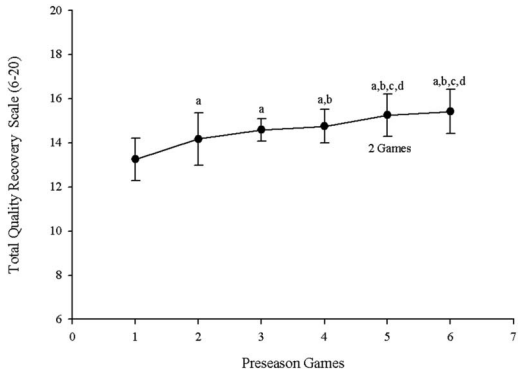

Figure 4. Evolution of "Total Quality Recovery" (27) over the friendly matches played in preseason.

Discussion

The preseason is an important training period in which players alternate conducting TRNs with playing FMs, with the aim of starting the competition period with the best possible level of fitness. The main objective of this study was to examine the effects of accumulated ITL (Edwards'-TL, Edwards'-TL_{res}, and sRPE-TL) on changes in the intermittent performance after the preseason in a professional soccer team. The results showed a large relationship between the sRPE-TL accumulated in the preseason and improvements

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in V_{IFT}. However, there were no relations between Edwards'-TL and Edwards'-TL_{res} with changes in V_{IFT}. A secondary objective of the research was to examine the relationship between various indicators of ITL during the TRNs and the FMs. The study of this relationship revealed variable magnitudes of within-individual correlations between sRPE-TL and Edwards'-TL, with extremely strong correlations for the FMs, but only moderate correlations for the high-load TRNs.

Monitoring training and match load is important for the periodization of training and assessment of the physical "dose" during training and match play (1). Previous studies failed to detect significant relationships between sRPE-TL and changes in fitness in team sports (1,8,19). Akubat et al. (1) evaluated changes in certain physiological variables (velocity at 2 $mmol \cdot L^{-1}$ [vLT] and velocity at 4 $mmol \cdot L^{-1}$ [vOBLA] in a continuous incremental test), after a 6-week period (initial phase of the competitive season) with young soccer players, and found no significant relationships between sRPE-TL and the mentioned variables. However, a recent research conducted on junior soccer players (20), reported a large correlation ($r = 0.69–0.71$) between sRPE-TL (both respiratory and muscular) and changes in aerobic fitness (Université de Montreal track test) after a 9-week period (in-season). The large relationship found could be explained by the differentiation of sRPE-TL in respiratory and muscular sRPE.

To the best of our knowledge, this is the first study demonstrating a substantial dose-response relationship between perceived TL and changes on intermittent performance in professional soccer players. In our research, the intermittent performance was assessed through a field test such as 30-15_{IFT} (9). This test has shown to be capable of assessing the effect of training on changes in the intermittent performance after a preseason (10). The high correlation between the sRPE-TL method and the changes in the intermittent performance (Figure 3), could show the validity of sRPE-TL as a measure of load (30).

In addition, large correlations were found between the amount of time spent during the preseason and the sum of RPE with improvements in the V_{IFT} ($r = 0.72–0.75$). Moderate correlations between the amount of time spent in FMs and improvements in the V_{IFT} ($r = 0.68$) were also obtained. Previous research (8,20) showed significant relationships between the amount of time spent (in training and competition) and changes in aerobic performance. The data obtained in our study confirm the importance of the volume used on changes in the intermittent performance, especially with the volume (min) in competition (FMs). Therefore, coaches should provide their players with a sufficient volume of minutes during the preseason (especially in FMs), to achieve the desired improvements in the intermittent performance.

Neither HR-based method revealed significant relationships with changes in the intermittent performance. Although HR_{res} is considered to be the best form of expressing HR for interindividual comparisons (14), our modified proposal (Edwards'-TL_{res}) did not show significant relationships. The thresholds based on arbitrary zones may have limited these relationships with changes in fitness, so other methods such as iTRIMP have been used (1,29).

Relations between sRPE-TL and Edwards'-TL were higher during the FMs ($r = 0.91$) than for the TRNs ($r = 0.80$) (Figure 1). Furthermore, when the TRNs were analyzed in terms of the magnitude of the load (high-load sessions and low-load sessions), the results on the relationships were divergent. Thus, correlations between sRPE-TL and Edwards'-TL during low-load sessions were very strong ($r = 0.74$), whereas in high-load sessions they were only moderate ($r = 0.34$) (Figure 2). A possible explanation for this disparity in relationships might be the differences in the content of the sessions, with a greater amount of high-intensity and short-duration (high neuromuscular load) exercise in the sessions with more loading (11), for which it is not possible to assess HR response (23). The almost perfect relations between the 2 methods of ITL for the FMs could be the result of the large reliance on aerobic metabolism during the competition, with HR averages for 90 minutes near the anaerobic threshold (33). These data provide great validity to sRPE-TL as a control method for ITL during competition and indicate that it can be used effectively as an alternative to HR, because its use is forbidden in official competition.

Another aspect that the study design allowed the analysis of was the relationships between sRPE and variables related to volume and intensity. Thus, the relationships between the analyzed volume marker (min) and sRPE were strong for the TRNs ($r = 0.66$) and FMs ($r = 0.64$). However, relations between the analyzed intensity marker (min >90% HR_{max}) and sRPE were moderate for the TRNs ($r = 0.47$) and strong for the FMs ($r = 0.60$). Previous research suggested that the relationship between sRPE and other measures of intensity such as HR may not be as high as previously thought (1). Although traditionally the sRPE value was considered as a marker of intensity in calculating sRPE-TL (23), the strong relationships obtained in our study between sRPE and the volume markers (min) and intensity (min >90% HR_{max}) confirm sRPE as a dependent marker of volume and intensity, and not as a "pure" measure of training intensity (11).

In a sport with so much media attention as soccer, many coaches propose high intensity TLs in the preseason to rapidly improve the fitness levels of the players and in this way achieve a high level of performance at the beginning of the competitive period (28). In our study, intermittent performance improved significantly (ES = 1.15 ± 0.25; almost certainly) after the preseason period (V_{IFT}: 20.1 ± 0.8 vs. 21.1 ± 0.8 $km \cdot h^{-1}$, respectively). In addition, daily monitoring of the levels of recovery with the TQR scale helped to confirm improvements in the levels of recovery before FMs were played throughout the preseason (Figure 4), thus confirming optimal tapering before official competition.

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Practical Applications

In soccer, the preseason is an important training period to achieve a high fitness level at the beginning of the competition period. A proper monitoring of the TLs during this period could be paramount to attempting to predict individual responses to training. The present results show that practice volume (especially in competition) and subjective measures of ITL (accumulated sRPE-TL and the sum of RPE), can explain approximately 50% of the variation on intermittent performance after the preseason, in professional soccer players. This can have a special utility at practical level, considering that during preseason FMs, some coaches tend to allocate more playing time to the theoretically starting line-up players, that to the others. Thus, coaches must clearly understand that for allowing players's potential to increase intermittent performance, it is necessary to allocate a proportionate amount of playing time in competition.

In addition, the sRPE-TL method can be a very interesting alternative to HR for quantifying ITL during the competition in professional soccer players, due the strong correlations achieve between both methods during the FM in this study. In summary, these results could show the validity of sRPE-TL as a measure of load in professional soccer players.

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