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Original article

Monitoring of load, fatigue, infections, well-being, and recovery in young footballers during training and competition

Monitoramento da carga, fadiga, infecções, bem-estar e recuperação em jovens futebolistas durante treinamentos e competição

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ABSTRACT

Objective: The study sought to verify if there is a difference between training period and competition in load, mood, fatigue, infections, well-being, and recovery. **Methods:** Twenty male soccer players (17.79 ± 1.23 years old; 72 ± 9.50 kg; height 1.80 ± 0.08 m) were monitored during the pre-competitive week (PCO) and competition (COM). The instruments used were the Profile of Mood States (POMS), the Wisconsin Upper Respiratory Symptom Survey (WURSS), general well-being, and the Total Quality of Recovery scale (TQR). The Internal Training Load (ITL) was monitored by the subjective effort perception. **Results:** There was a significant difference for POMS-TMDSCORE (P = 0.001), fatigue (P = 0.001) and CV% recovery (P = 0.001) of the COM vs. PCO condition. The severity of WURSS was greater in PCO vs. COM (P = 0.011). For PCO, there was a correlation between CV% recovery (r = 0.61) and fatigue (r = 0.62). In COM, there was a correlation between ITL and CV% recovery (r = 0.94), weekly recovery (r = -0.84), fatigue (r = 0.57), TMDS-CORE (r = 0.48). **Conclusion:** We concluded that although the ITL is lower in COM, mood, fatigue, and weekly variation of recovery are greater when compared to PCO. Besides, regardless of the period, there is a relationship between the ITL and monitoring methods.

Keywords: monitoring; competition; soccer.

RESUMO

Objetivo: O estudo buscou verificar se existe diferença entre período de treinamentos e competição na carga, humor, fadiga, infecções, bem-estar e recuperação. **Métodos:** Vinte futebolistas homens (17,79 ± 1,23 anos; 72 ± 9,50 kg; altura 1,80 ± 0,08 m), foram monitorados durante a semana pré-competitiva (PCO) e competição (COM). Foram utilizados os instrumentos *Profile of Mood States* (POMS); *Wisconsin Upper Respiratory Symptom Survey* (WURSS); bem-estar geral e qualidade total de recuperação (QTR). A carga interna de treinamento (CIT) foi monitorada pela percepção subjetiva de esforço. **Resultados:** Houve diferença significativa para POMS-PTHESCORE (P = 0,001), fadiga (P = 0,001) e recuperação CV% (P = 0,001) da condição COM vs. PCO. A severidade do WURSS foi maior em PCO vs. COM (P = 0,011). Para PCO houve correlação da recuperação CV% r = 0.61) e fadiga (r = 0.62). Em COM, houve correlação da CIT com CV% de recuperação (r = 0,94), recuperação semanal (r = -0,84), fadiga (r = 0,57) PTHESCORE (r = 0,48). **Conclusão:** Conclui-se que apesar da CIT ser menor em COM, o humor, a fadiga e variação semanal da recuperação são maiores quando comparados a PCO. Além disto, independente do período, há relação da CIT e métodos de monitoramento.

Palavras-chave: monitoramento; competição; futebol.

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Introduction

Stress can be physiologically characterized as a reduced recovery from neuroendocrine reactions and the autonomic nervous system dominance [1]. Therefore, changes in the physiological state. During the training process, the external training load results in physiological changes [2]. The physiological changes accompanying can be controlled by the athletes' training loads monitoring, being crucial to understand the training process and to identify possible adaptations, assessing fatigue and recovery status to minimize non-functional overload risks, injury, and disease [3].

Subjective measures are options for the monitoring routine of athletes, with low cost, consistent, sensitive, and easy to implement, compared to objectives measures [4]. These measures make it possible to verify the relationship of responsiveness load besides being validated in the literature as psychological indicators [4-6]. In this way, questionnaires and diaries have been used to determine such effects on the athletes' behavioral responses, being recommended as a common practice to investigate the recovery state and well-being through the scales of Total Quality of Recovery (TQR) and Well-Being [7,8].

The approach of psychological questionnaires and the analysis of disease incidence (respiratory tract infection) demonstrate a relationship with physical stress and state of recovery [9,10]. Studies have used these approaches combined with the Rating of Perceived Exertion (RPE) of the training session, a measure that is understood as a marker of psychophysiological load and that has been reported as a good alternative for measuring intensity during exercise and can act as a "global" measure of training stress, in addition to providing important information for adjusting loads in training sessions [7,11].

In this sense, an important point in the monitoring process is the Internal Training Load ratio (ITL) accumulated during training sessions and weeks of competitions. There is already evidence that the game in the competition by itself creates a larger modification scenario of physiological homeostasis when compared to training since it is the moment of the athletes' maximum performance [7,12]. However, in soccer, it is not clear whether a competitive microcycle (CM) of high-level will promote greater changes in mood, recovery, upper respiratory tract infections (URTI), and fatigue compared to a pre-competitive microcycle (PCM) with higher ITL in training. The Copa São Paulo de Futebol Júnior is the most important competition in the South American continent in the Federação Paulista de Futebol (FPF) category. The information from the present study could be used to design effective training strategies that can improve performance and reduce the injury risk in this competition.

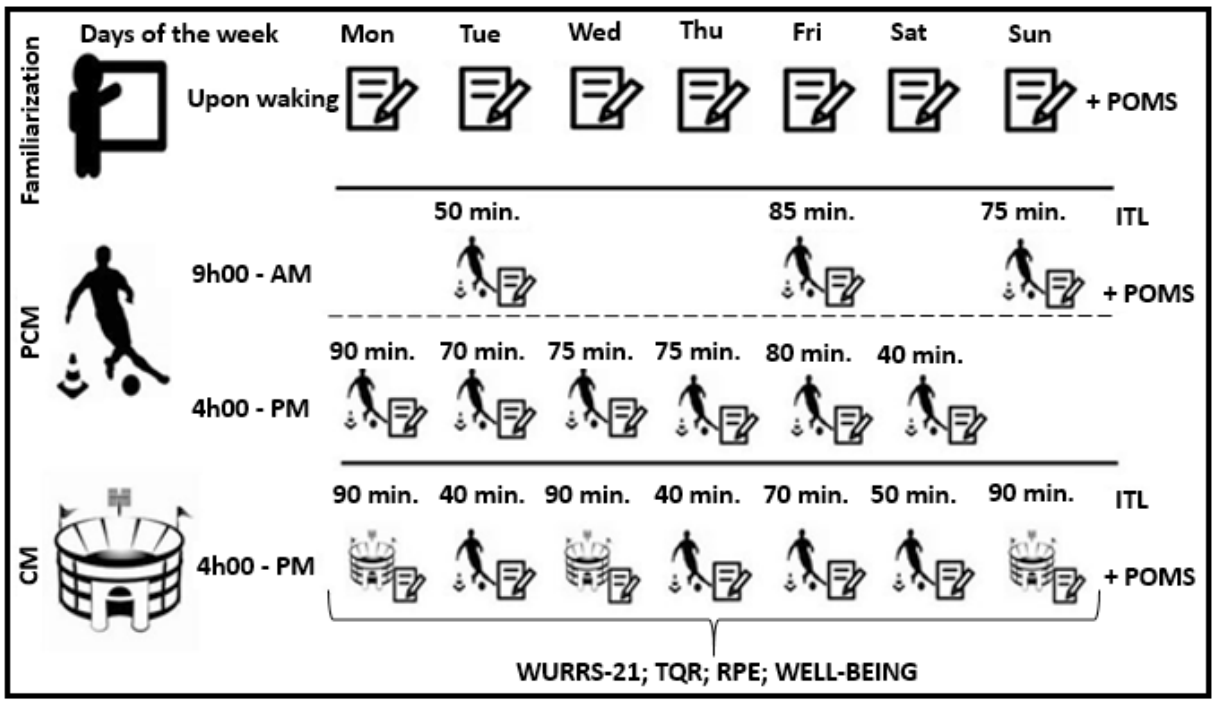
Therefore, the present study sought to verify whether there is a difference between a pre-competitive and competitive microcycle in load, mood, fatigue, infections, well-being, and recovery in young soccer players. Thus, the hypotheses of the present study are: 1) weekly ITL values and subjective methods of load monitoring measured during the training and competition week will be significantly related; 2)

in the condition with the highest ITL, these monitoring parameters will be more sensitive and related; 3) the presence of games in the competitive microcycle will induce higher psychobiological stress than the pre-competitive microcycle, exclusively from training.

Methods

Experimental design

An observational study was carried out over 2 microcycles to monitor mood, upper respiratory tract infection, well-being, recovery, and internal training load. The monitoring process was carried out every day using questionnaires and scales within the general control process. The analysis was performed after the first week of the familiarization period; the second week was defined as pre-competitive microcycle (PCM) and the third week as competitive microcycle (CM). The PCM week consisted of 7 days and 9 training sessions (totaling 640 minutes), with 2 sessions in the morning (beginning at 9:00 am) and 7 sessions in the afternoon (beginning at 4:00 pm). The CM week consisted of 7 days and 7 sessions (totaling 470 minutes), with 4 training sessions and 3 official games in the afternoon (beginning at 4:00 pm and games at 2:00 pm and 4:00 pm) (Figure 1). All training sessions were prescribed by the technical team of the analyzed team, and both microcycles had technical-tactical characteristics.



PCM = Pre-competitive microcycle; CM = Competitive microcycle; POMS = Profile of Mood States questionnaire; ITL = Internal training load; WURRS-21 = Severity of symptoms of upper respiratory tract infection; TQR = Recovery questionnaire; RPE = rating of perception exertion
Figure 1 – Study experimental design

The athletes were instructed on the procedures that would be performed during the research and clarified doubts related to the questionnaire items and scales. The mood state questionnaire was carried out at the end of each microcycle in the afternoon (6 pm). The respiratory tract infection questionnaires and well-being and recovery scales were applied every day at the same time in the morning when they woke up. The ITL of athletes was monitored through the RPE multiplied by the training session time.

Participants

Twenty young male soccer players (17.79 ± 1.23 years old; 72 ± 9.50 kg; height 1.80 ± 0.08 m, BMI = 22.12 ± 2.00 kg/m²; and 11.04 ± 1 Fat%) belonging to an under-20 team that participated in the main national competition of the category in Brazil. They were monitored for 2 weeks, classified as the last PCM and the first CM. The following criteria were determined for the inclusion of players in the data analysis: 1) 3 years of practice in the sport having played in official competitions of the Federação Paulista de Futebol (FPF) in the last 3 years and 2) having at least 3 years of experience in systematic training in soccer (frequency of 5 to 6 weekly sessions). Subjects who had muscle, joint, bone, and ligament injuries in the month before the study were excluded from the study. The study was approved by the Research Ethics Committee of the local institution (Nº 1.765.430). After its approval, subjects of legal age and responsible for minors signed an informed consent form, as well as the minors were informed through a consent form. This approach was necessary since the subjects of this research were aged between 16 and 20 years old.

Profile of Mood States questionnaire (POMS)

Participants were asked to answer how they felt in the past week, including the assessment day. Replies were established as confidential to reduce the possibility of false answers [14] or external influences. The athletes were instructed to record a self-assessment on 65 items using a 5-Point Likert Scale (0 to 4), with 0 – Not at all, 1 - A little, 2 - Moderately, 3 – Quite a lot, and 4 - Extremely. The results generated 6 items related to the mood state: tension, depression, anger, vigor, fatigue, and confusion. The sum of these 6 items represents total mood disturbance (TMDSCORE) except for the vigor scale score. The items fatigue and TMDSCORE were used as estimates of the subjects' recovery status, that is, less fatigue and TMDSCORE was interpreted as better recovery status. On the other hand, higher fatigue and TMDSCORE were interpreted as worse recovery status [15].

The severity of symptoms of Upper Respiratory Tract Infection (URTI) through WURSS-21

The questionnaire includes 1 global question, 10 questions based on symptoms, 9 questions of functional impairment/quality of life, and 1 question of global change. Through a 7-Point Likert scale, the severity of each symptom was evaluated,

being 1 (very mild), 3 (mild), 5 (moderate), and 7 (severe). When the athletes did not present symptoms, the recorded scores were 0. The questionnaires were filled in every day as soon as they wake up. This questionnaire validity has been demonstrated to verify the severity of URTI symptoms [16].

General Well-Being questionnaire

The questionnaire was applied to assess fatigue, sleep quality, general muscle pain, stress levels, and mood using a five-point scale (scores from 1 to 5) [17]. The athletes' general well-being state was determined by adding the 5 evaluated criteria and then calculating the group's weekly average.

Total quality of recovery (TQR)

It was used to monitor the athletes' subjective recovery. When they woke up, they were asked: "How do you feel about your recovery?". A TQR scale (model) was presented, whose replies were rated from 0 to 10 [18]. The TQR score was calculated as the average of daily values for a week. An index of variation in recovery in weeks was also obtained by the coefficient variation (TQRCV%).

Internal training load (ITL

The magnitude of the ITL was obtained by multiplying the reported RPE (CR-10 scale) by the duration of the training session (minutes), represented in arbitrary units [19]. The RPE was registered after all training sessions and games through the question "How was the intensity of your training session?" 180 individual sessions (total athletes x observed sessions) were observed during the PCM and 140 sessions during the CM, totaling 320 individual sessions. The training session's RPE was obtained after 30 minutes of the training session or finished game to reflect the entire training session's global evaluation. Each player answered the question individually, without the contact or influence of other players.

Statistical analysis

The data normality was verified by the Shapiro-Wilk test. Only the symptom severity variable of WURSS-21 was not normal. For this reason, the data for this variable was transformed into a natural logarithm to approximate the Gaussian distribution. This procedure brought normality to this variable. In descriptive statistics, mean, standard deviation, and 95% confidence interval (95% CI) were used. For comparison between conditions, an independent t-test (PCM vs CM) was used. Cohen effect size (ES) between groups was calculated using the formula: d = (average PCM condition - average CM condition)/combined standard deviation. Values of d < 0.2, 0.2-0.6, 0.6-1.2, 1.2-2.0, 2.0-4.0 and > 4.0 were considered trivial, small, moderate, large, very large and extremely large, respectively [20]. The relationship between variables was calculated using Pearson's linear correlation. Besides, the confidence interval (95% CI) of the associations between the variables was calculated. The criteria adop-

ted for the interpretation of the correlation magnitudes were (r): ≤ 0.1, trivial; > 0.1-0.3, small; > 0.3-0.5, moderate; > 0.5-0.7, large; > 0.7-0.9, very large and > 0.9-1.0, almost perfect [21]. When the 95% CI confidence limits were violated, the magnitude of the correlation was considered "unclear"; otherwise, the magnitude was considered the actual observed [21]. The level of significance adopted for the inferential tests was P < 0.5. The analysis was performed using SPSS software version 22.0 (*IBM Corp., Armonk, NY, USA*).

Results

There was a significant difference for TMDSCORE (P = 0.001, ES = 1.82 [large]), Fatigue (P = 0.001, ES = 1.49 [large]) and CV% recovery (P = 0.001, ES = 0.93 [moderate]) of the CM vs PCM condition. The severity of URTI variable was higher in the PCM condition when compared to CM (P = 0.011, ES = 0.89 [moderate]) (Table I).

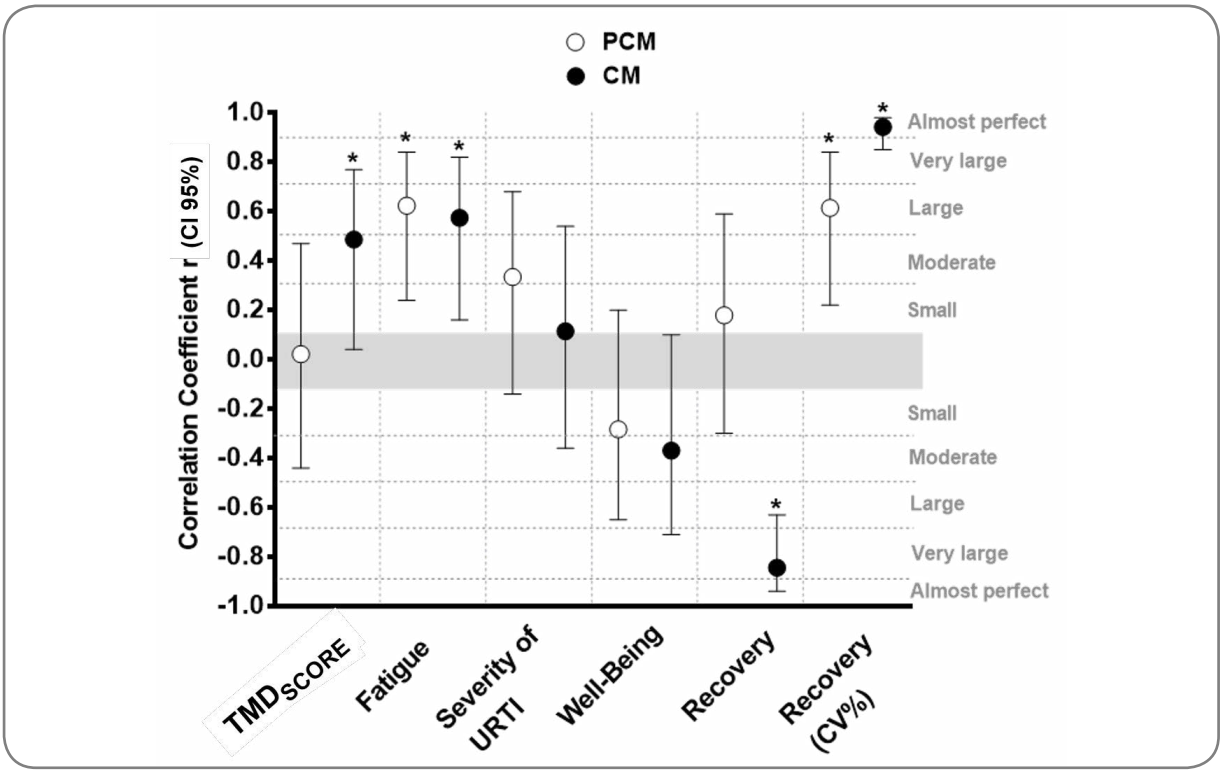
Table I - Results of the monitoring variables in the pre-competitive and competitive microcycles condition of the analyzed soccer team (mean ± SD)

Variables	PCM	CM	Average difference [CI 95%]	P Value	ES
POMS					
TMD_{SCORE} (AU)	97 ± 12	131 ± 24*	34.7 [20.7 a 48.7]	0.001	1.82
Fatigue (AU)	0.8 ± 1.1	8.2 ± 7.0*	8.1 [4.4 a 11.8]	0.001	1.49
WURSS-21					
URTI Severity (n)	3.3 ± 3.5	0.9 ± 1.4*	2.3 [1.1 a 3.5]	0.011	0.89
Well-Being					
Escore geral (UA)	19.1 ± 1.6	19.7 ± 2.3	0.7 [-0.2 a 1.6]	0.288	0.35
TQR					
Recovery (AU)	15.2 ± 1.1	15.8 ± 2.0	0.6 [-0.4 a 1.6]	0.248	0.38
Recovery (CV%)	12.8 ± 3.9	19.1 ± 8.8*	6.2 [2.5 a 9.9]	0.008	0.93
ITL					
Load (AU)	3789 ± 421	2923 ± 286*	866 [488 a 1105]	0.003	1.02

PCM = Pre-Competitive Microcycle condition; CM = Competitive Microcycle condition; TMDSCORE = Total Mood Disorder score; URTI = Upper Respiratory Tract Infections; CV% = percentage of coefficient variation; AU = arbitrary units; ES = Effect Size; *Significant difference between conditions (P < 0.05)

Figure 2 shows the correlations between ITL in the PCM and CM conditions with the variables analyzed in the study. An almost perfect positive correlation was found between recovery CV% and ITL (r = 0.94, 95% CI 0.85 to 0.98, P = 0.0001), a very large negative in weekly recovery (r = -0.84, 95% CI -0.63 to -0.94, P = 0.0001), large positive for fatigue (r = 0.57, 95% CI 0.16 to 0.82, P = 0.010) and moderate positive for TMDSCORE (r = 0.48, 95% CI 0.04 to 0.77, P = 0.034) in the CM condition. For the PCM

condition, a large positive correlation was found between recovery CV% and ITL (r = 0.61, 95% CI 0.22 to 0.84, P = 0.0001) and a large positive for fatigue (r = 0.62, 95% CI 0.24 to 0.84, P = 0.004).



The gray area represents trivial correlation values (see methods). * = p <0.05
Figure 2 - Correlation coefficient (with 95% confidence interval) between internal training load (ITL) during the pre-competition condition (PCM - white circles) and competition (CM - black circles) with the POMS variables (TMDSCORE and Fatigue), WURSS-21 (Severity of URTI), well-being and recovery (average and CV%)

Discussion

The main finding of the present study suggests that although the internal training load is lower in the competitive condition, the mood, fatigue, and weekly variation of recovery are greater when compared to the pre-competitive condition. In exception, the severity of upper respiratory tract infections was higher in the pre--competitive condition, positively due to the greater ITL accumulated in this period. Also, it was demonstrated that fatigue and weekly variation in recovery are related to the internal load accumulated in both conditions. However, there is only in the competitive condition a relationship between the internal training load of the players and the mood disturbance and the average weekly recovery.

The present study's results showed higher TMDSCORE and fatigue values for the CM when compared to the PCM suggesting that the athletes' psychophysiological disturbance is higher in the presence of competition, even with the ITL in PCM higher than the CM. These findings presented similar results with the studies by Rohlfs *et al.* [12], who through the BRUMS tool (adapted version of POMS) highlighted mood

changes in pre-game and game situations for depression ($p < 0.001$), anger ($p < 0.003$), vigor ($p < 0.000$), and fatigue ($P < 0.000$) in professional soccers, which in our data can be justified by the requirement level of this competition. Fatigue can be explained by the intensity of the game, representing a state of tiredness and a low level of energy higher in the CM compared to PCM [8,10,22,23].

The data from the present study showed higher severity of URTI in PCM when compared to CM, unlike Freitas *et al.* [24], who did not present a significant difference between the weeks of higher and lower ITL ($p > 0.05$) but larger reports were presented of symptoms of URTI in the period of higher ITL compared to a tapering (of 11 athletes, all reported at least 1 symptom in the first period, and 6 symptom records were verified in the second), demonstrating a trend similar to our results. However, the higher URTI severity in the PCM seems to be justified by other factors such as nutritional, environmental, and immunosuppression mechanisms; as mentioned by Gleeson [25], factors that were not investigated in the present study.

The athletes' well-being was similar in both conditions. However, different results were observed in professional Australian football players, Howle *et al.* [26] observed a decrease in well-being considering the baseline response concerning the presence of one game ($p = 0.02$) or two games ($p = 0.001$). The authors suggest that the answers presented in the present study are different due to the lower sensitivity of the scale since the scale presents responses from the physical and psychological aspects. The PCM showed higher responses in the physical aspect and lower responses in the psychological aspect due to the higher ITL and absence of games, so an inverse situation was observed in the CM, with lower physical responses due to the lower ITL and higher psychological responses depending on the presence of the games.

Regarding weekly recovery, results in the literature were found for competition microcycles with different numbers of games ($p = 0.295$) [27]. However, Howle *et al.* [26] showed a decrease in recovery when there was a higher number of games in the week ($p < 0.05$). In the present study, this measure seems to be influenced by both the ITL and the psychobiological stress due to the magnitude's inversion of these measures. Regarding ITL point to a difference between the microcycles, with a lower ITL in the CM, representing a reduction of approximately 22.8% about the PCM. Oliveira *et al.* [28] showed similar ITL values in competition microcycles ($p < 0.05$), however, they observed a reduction in training loads the day before and after the games aiming at the recovery of the athletes for the matches, which justifies our results in the CM (lowest ITL), which had the presence of three matches of great importance.

In order to these complementary findings, Clemente *et al.* [29] lower ITL values in a week with a greater number of games when compared to a week with a smaller number of games, and also justified this reduction in ITL by the lower training intensity one day after the game, aiming at recovery. This reason between the studies seems to be explained mainly by the games' presence, training load prescription, and recovery time since the ITL can be influenced by the external training load [2].

The moderate positive correlation between TMDSCORE and ITL for the CM suggests that the mood state behavior was more associated with the competition it-

self and seems to have generated higher psychophysiological changes in the athletes due to the games since the mood did not correlate with the ITL in PCM. Can be explained by the fact that mood disturbance varies according to different factors such as intensity, the number of games, the activity's result, and the level of motivation of the athletes according to Selmi *et al.* [23], which is believed to have reflected in the TMDSCORE changes in CM. The results showed a high positive correlation for fatigue and ITL in the 2 microcycles analyzed. Fatigue was characterized by Rohlfs *et al.* [12] through 2 different variables: physiological attribution of tiredness and the other emotional, as discouragement, which is believed to seem to respond to the internal training load accumulation of athletes in PCM and CM.

There was a correlation between CV% and ITL for both microcycles, with a high correlation for PCM and almost perfect for CM. The CV% recovery of this study seems to represent daily fluctuations perceived by athletes. Previous research has correlated lower cardiac autonomic stress through the weekly heart rate variability with a higher CV% of that same measure ($r = -0.53$) in female soccer players [30]. Thus, higher values of CV% in the week CM seem to represent higher variations of psychophysiological recovery experienced during the competition, reflecting the distribution of loads in the CM so that the athletes could play in their best state of recovery. Besides, in the PCM, minor changes in CV% were seen, suggesting that athletes were dealing better with training loads that probably did not fluctuate due to the organization of the training sessions. We adopted as a limitation of the study the lack of standardized nutrition of the athletes. However, they maintained their routines during the analyzed period. No training period was assumed other than pre-competition to check the ITL fluctuations and behavioral responses during a period of lower ITL.

Conclusion

It is concluded that the competition period presents higher psychobiological stress on mood, recovery, and fatigue in young soccer players when compared to a training period. There is a direct relationship between the accumulation of internal training load and weekly variation in recovery and fatigue regardless of the period analyzed. However, the number of respiratory tract infections is higher when a longer period of internal training load, appearing to be independent of the competition.

Conflict of interest
No conflict of interest with relevant potential.

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Author´s contributions
Conception and design of the research: Businari GB, Braz TV; **Data collection:** Businari GB; **Analyze and data interpretation:** Businari GB, Batista DR, Rosolem JM, Braz TV; **Redaction:** Businari GB, Batista DR, Braz TV; C**ritical review of the manuscript:** Braz TV, Lopes CR.

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