Training load, stress tolerance and upper respiratory tract infection in basketball players

Carga interna, tolerância ao estresse e infecções do trato respiratório superior em atletas de basquetebol

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Abstract – The present study aimed to investigate the effect of external training load manipulation on internal training load (ITL), stress tolerance (ST) and upper respiratory tract infection (URTI) severity in basketball players during a 19-week macrocycle. The macrocycle was divided into three distinct phases: preparatory phase (P1) and two competitive phases (P2 and P3). The Daily Analysis of Life Demands for Athletes questionnaire (DALDA), for assessment of sources and symptoms of stress, and the Wisconsin Upper Respiratory Symptom Survey (WURSS-21), for evaluation of URTI severity, were used on a weekly basis. The ITL was assessed by Rating of Perceived Exertion (session RPE). There was a decrease in ITL at P3 when compared to P1 and P2 (p < 0.05). A decrease in "better than normal" responses in DALDA for both sources and symptoms of stress was observed at P2 and P3 when compared to P1 (p < 0.05). There was also a significant increase in URTI severity. In addition, significant relationships between ST and URTI were shown at P3, suggesting that stress tolerance may modulate URTI severity. In summary, ETL manipulation induced changes in ITL. However, unlike the initial hypothesis, a decrease in ITL during the competitive period was followed by a decrease in stress tolerance and an increase in URTI severity. Furthermore, the magnitude of stress seems to provoke an increase in URTI severity.

Key words: Immunity; Monitoring; Sport; Stress; Training.

Resumo – *O objetivo do estudo foi avaliar o efeito da manipulação das cargas externas sobre a dinâmica da carga interna de treinamento (CIT), a tolerância ao estresse (TE) e a severidade de episódios de infecção do trato respiratório superior (ITRS) em atletas de basquetebol, durante um macrociclo de 19 semanas, dividido em uma etapa preparatória (E1) e duas etapas de competição (E2 e E3). Os instrumentos Wisconsin Upper Respiratory Symptom Survey (WURSS-21) para o monitoramento das ITRS e o Daily Analysis of Life Demands for Athletes' (DALDA; TE) foram preenchidos semanalmente. A CIT foi aferida a partir da percepção subjetiva de esforço da sessão (PSE da sessão). Foi detectada queda da CIT na E3, quando comparadas às etapas E1 e E2 (p < 0,05), e decréscimo no número de respostas "melhor que o normal" na parte A (fontes de estresse) e na parte B (sintomas de estresse) do DALDA, em E2 e E3, comparado com E1 (p < 0,05). Na última etapa (E3), houve incremento da severidade de ITRS (p < 0,05). Adicionalmente, correlações significantes entre TE e ITRS foram verificadas, sugerindo que a tolerância ao estresse pode modular a severidade de ITRS. Em conclusão, a manipulação da CET provocou alterações na CIT. Entretanto, ao contrário da hipótese inicial, a redução da CIT no período competitivo foi acompanhada por redução da tolerância ao estresse e aumento da severidade da ITRS. Além disso, a magnitude do estresse parece induzir o aumento da severidade de ITRS.*

Palavras-chave: *Esporte; Estresse; Imunidade; Monitoramento; Treinamento.*

INTRODUCTION

Sports training is a systematic activity that aims to promote morpho-functional adaptations responsible for increased athletic performance[1,2]. In recent years, many theoretical models have been proposed in order to explain the complex sports training process[2-4]. Among these models, the one proposed by Impellizzeri et al.[5] has guided numerous training monitoring approaches in team sports. The authors suggest that training-induced adaptations are due to the level of stress imposed on the body (internal training load - ITL), which will be largely determined by external training load (ETL) (content of the prescribed training). External load is related to the training quality (intensity), quantity (volume) and periodization (organization).

In addition, the model proposed by Impellizzeri et al.[5] emphasizes that individual characteristics (eg.: level of fitness and genetic potential) and the individual's ability to deal with stress have large influence on ITL. Thus, the interaction between ETL and individual characteristics determines the ITL magnitude, which will ultimately be the stimulus responsible for inducing desired adaptive responses and increase of performance.

In this context, it is reasonable to assume that the training process success depends on accurate monitoring of ITL. Several parameters can be used to assess the ITL magnitude and its repercussions, such as the hormonal profile (testosterone/cortisol ratio), the concentration of metabolites (lactate and ammonia), the heart rate response and the Rating of Perceived Exertion (session RPE)[6-10].

In team sports, the interaction between external load and internal load is even more complex than in individual sports. In team sports, the training load control is usually made through external indicators, such as duration of technical and tactical training, number of jumps performed in a session, load used in weight lifting, among others[11]. However, in a team, the same ETL applied during a training session can induce different responses (ITL) on each of the athletes. Whereas the adaptive responses that result from the process of sports training depend on the physiological stress imposed on the body (ITL) by applying the ETL, on a practical perspective, ITL control during season[2] is extremely important, especially in team sports, so the training program can be adjusted individually.

A simple, valid and sensitive instrument, which is currently being used as an indicator of ITL, is the Rating of Perceived Exertion (session RPE)[12-15]. Relevant associations between ITL and other responses to the training process (episodes of infection and stress tolerance)[16-18] have been observed in recent studies conducted with athletes from different sports. In these studies, the Daily Analysis of Life Demands in Athletes questionnaire (DALDA), developed by Rushall[19] to assess stress tolerance, and the Wisconsin Upper Respiratory Symptom Survey-21 (WURSS-21)[20], developed for monitoring of upper respiratory tract infection (URTI) episodes and severity, have been widely used.

Despite the importance of controlling the training process, there is not much information available from approaches that integrate responses related to training load, level of stress and immunity. Given the importance of this issue, the aim of this study was to investigate the effect of ETL manipulation on ITL dynamics, stress tolerance and URTI episodes and severity in basketball athletes. This study raises the hypothesis that changing ETL during the macrocycle would also change ITL response, which could mediate stress tolerance and URTI severity.

METHODOLOGICAL PROCEDURES

Participants

We evaluated 20 male basketball professional athletes, members of a team that participates in an official qualifying tournament for the Paulista championship (mean and standard deviation for age, body mass and height of 22±5 years, 94±22 kg and 196±10 cm, respectively). The team reached the playoffs and qualified for the main division of the Paulista championship (A1). All athletes signed a consent form approved by the Research Ethics Committee of Escola de Educação Física e Esporte of Universidade de São Paulo, protocol Nº 2008/21.

Experimental Design

The athletes were monitored during a competitive season (first macrocycle of the season), from January to June, totaling 186 training sessions. In each training unit (day), athletes performed, on average, two training sessions. For analysis of results, the competitive season was divided into three phases: Phase 1 (P1 - preparatory period - weeks 1 to 7), Phase 2 (P2 - competitive period 1 - weeks 8 to 13) and Phase 3 (P3 - competitive period 2 - week 14 to 19). Seventeen official games were held during the investigated macrocycle (7 matches in P2 [5 wins and 2 losses] and 10 matches in P3 (4 wins and 3 losses in the second round and 2 wins and 1 loss in the first round of the playoffs). Table 1 shows examples of typical tasks performed in a microcycle for each phase.

During the entire period of the investigation, athletes lived in the team's accommodation, so they were subjected to similar environmental sources of stress. This minimized some important external factors that might interfere with the investigation.

Internal Training Load (ITL)

To determine the ITL, the session RPE method was used[12,14]. The internal load, presented in arbitrary units (AU), was quantified by calculating the ratio between the product of the session duration, in minutes, and the session RPE (CR-10 scale) score, recorded 30 minutes after the end of the training session. ITL accumulated values (weekly) were retained for analysis.

Box 1. Example of main objectives and organization of tasks in training microcycles (week) for each phase of the macrocycle.

Typical tasks in a training microcycle for each phase of the macrocycle		
	Mon. Wed. and Frid.	Tue. Thu. and Sat.
P1	1st session: special strength training: multiple jumps, jumps with bar (60 to 80% of 1RM), deep jumps (60-70 cm). 2nd session: technical/tactical training: low complexity and moderate intensity - simple elements, technical fundamentals, low intensity movements, game system automation (positions, movements, etc.).	1st session: special strength training: exercises with "weights" and adapted of Olympic lifting and basic lifting (pulling, squatting, yank, pitch, bench press) exercises. 2nd session: technical/tactical training: low complexity and moderate intensity - simple elements, technical fundamentals, low intensity movements, game system automation (positions, movements, etc.).
P2	1st session: jumps with bar (20 to 30% of 1RM), low volume and acceleration and speed endurance exercises - with and without change of direction - pitch and yank (adapted from Olympic lifting) *Wed: pitches/"kicks". 2nd session: technical/tactical training: emphasis on movement on the game system. *Mon: high volume and high intensity; Wed: game.	1st session: acceleration exercises, post-activation potentiation (eg.: bench press 90% of 1RM + pitches/"kicks" or passes); stabilizing exercises. 2nd session: technical/tactical training: emphasis on movement on the game system; *Tue.: technical/tactical training: preparation for the game; Thu.: day off. **Saturday, only one training session (strength, acceleration and technical/tactical training).
P3	1st session: acceleration exercises: low volume – with and without change of direction; yank; *Wed: pitches/"kicks". 2nd session: *Mon. and Fri.: technical/tactical training: emphasis on movement on the game system; *Wed.: game.	1st session: *Tue.: bodybuilding exercises (bench press and pulling), passes with and without medicine Ball and pitches/"kicks" with varied movements. 2nd session: *Tue.: preparatory technical/tactical training for the game; *Thu.: day off. **Saturday – game.

* Weeks with games on Wednesdays; **Weeks with games on Saturdays.

Questionnaire of Sources and Symptoms of Stress

The Portuguese version[21] of DALDA was used. The questionnaire was applied at the end of each week of investigation[16]. DALDA questionnaire is divided into two parts, named A and B, which represent, respectively, sources and symptoms of stress. This instrument requires the athlete to qualify each variable in both parts of the questionnaire (A and B) as being "worse than normal", "normal" or "better than normal", according to their perception of each source or symptom of stress. "Worse than normal" and "better than normal" responses for both sources and symptoms of stress were retained for analysis.

Questionnaire of Symptoms of Upper Respiratory Tract Infection (URTI)

The Portuguese version[21] of WURSS-21[20] was used. The questionnaire was applied at the end of each week of investigation. The severity of each reported symptom was rated on a 7 points "Likert" scale: 1 (very lightly), 3 (lightly), 5 (moderately) and 7 (severely). When a symptom was not present, the corresponding item on the questionnaire was filled in with 0 (zero). A general symptoms score was calculated by the sum of severity scores from the ten questions about symptoms and the nine questions about limitations, according to procedures proposed by Spence et al.[22] This score was retained for analysis and called "severity".

Statistical Analysis

Initially, we performed normality and homoscedasticity tests in order to analyze data distribution and homogeneity. ANOVA with repeated measures was used to assess differences between the three phases of the investigation (P1, P2 and P3) concerning: (a) internal training load, (b) sources of stress (Part A of DALDA questionnaire), (c) symptoms of stress (Part B of DALDA questionnaire), and (d) severity of URTI symptoms (WURSS-21 responses). Regarding the sources and symptoms of stress, "better than normal" and "worse than normal" responses were analyzed separately. The severity of symptoms was calculated by the sum of severity scores from the ten questions about symptoms and the nine questions about limitations, according to procedures proposed by Spence et al.[22] Bonferroni *post hoc* procedure was used when necessary. The correlation between the variables of interest (ITL, "better than normal" and "worse than normal" responses in DALDA and URTI severity) was analyzed using Spearman correlation. The level of significance was set at 5% ($p < 0.05$).

RESULTS

Figure 1 shows the ITL dynamics. A decrease in ITL was detected at P3 compared to P1 and P2. URTI severity and ST ("worse than normal" and "better than normal") for the three phases of the study are shown in Figures 2 and 3, respectively. We observed an increase in URTI severity at P3 compared to P1 and P2. "Better than normal" responses for sources and symptoms of stress showed statistically significant differences between phases ($F = 5.6$ and $F = 7.6$, respectively) (Figure 3). We also observed a decrease in the number of "better than normal" responses for sources and symptoms of stress at P2 and P3 compared to P1.
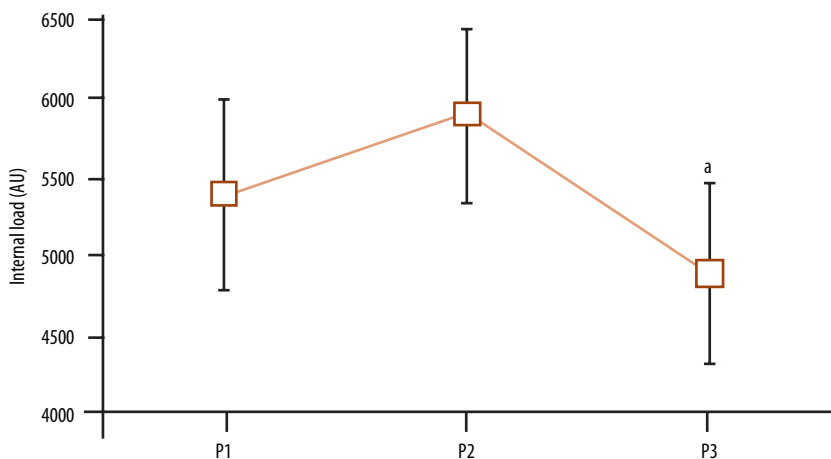

Figure 1. ITL dynamics in the phases of the study. a - different from P1 and P2.
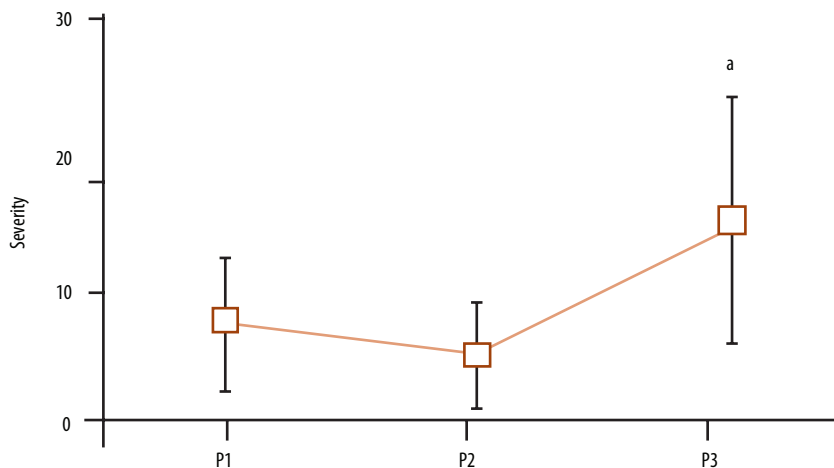
Figure 2. URTI severity in the phases of the study. a - different from P1 and P2.
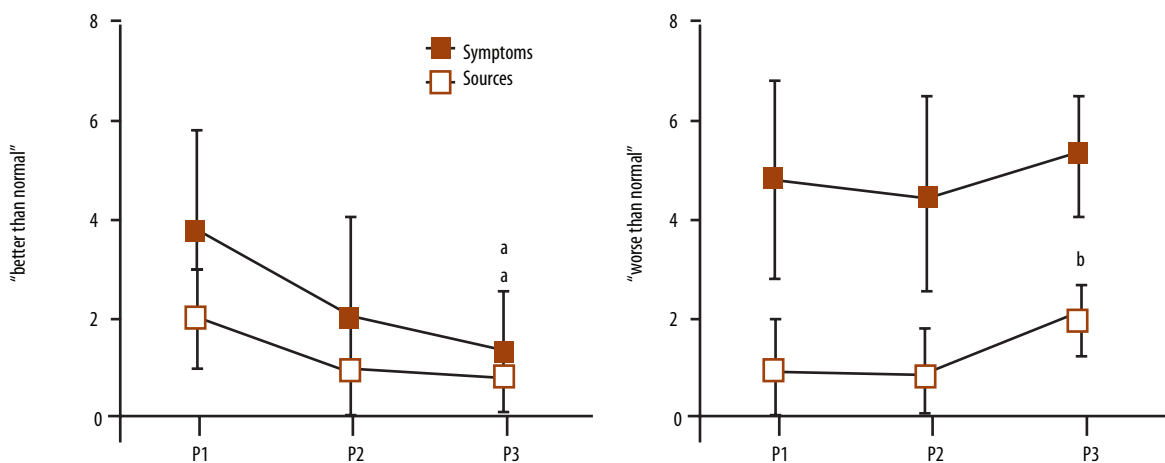

Figure 3. DALDA responses - "worse than normal" and "better than normal" responses for sources and symptoms of stress in the phases of the study. a - different from P1 and P2; b - different from P2

Significant correlations between analyzed variables are shown in Table 1.

Table 1. Significant correlations between analyzed variables ($p < 0.05$).

		Sources BTN		Sources WTN	Symptoms WTN	
		P2	P3	P3	P1	P3
ITL	P2	-0.69				
	P3		-0.75			
Severity	P1				0.60	
	P3			0.69		0.60

Note: ITL: internal training load; Severity: sum of severity scores from WURSS-21 responses; WTN: "worse than normal" responses; BTN: "better than normal" responses; P: phase.

DISCUSSION

The present study aimed to investigate possible alterations and associations between internal training load (ITL), stress tolerance (ST) and upper respiratory tract infection (URTI) severity in basketball athletes. Among

the findings of this study, we can highlight the decrease in ITL at P3 compared to P1 and P2, showing a lower ITL in the phase of the investigation that included 7 games of the second round and 3 games of the first round of the playoffs.

As we approached the most important phase of the macrocycle (P3), the results of the investigation suggest that the team had difficulty dealing with stressors. This was shown by an increase in "worse than normal" responses for sources of stress from P2 to P3, despite the decrease in ITL. A decrease in "better than normal" responses for sources and symptoms of stress from P1 to P2 and P3 was also observed, suggesting that the beginning of competition has a significant impact on stress tolerance.

An increase in URTI severity was observed at P3. This phase of greater URTI severity included the second round of the competition (4 wins and 3 losses) and the first round of the playoffs (2 wins and 1 loss; passing to the next phase of the tournament).

Curiously, "worse than normal" responses in DALDA for sources and symptoms of stress were not directly affected by ITL. This finding differs from results reported by Robson-Ansley, and Blannin Gleeson[16] and Achten et al.[23], which showed an increase in "worse than normal" responses for symptoms of stress after deliberate intensification of training load. These studies' duration was four weeks and 11 days, respectively. In addition, observational studies conducted with basketball athletes (with no deliberate [experimental] manipulation of training load) also revealed congruence between ITL responses and DALDA. For example, Moreira et al.[11], investigating young basketball players, members of national teams, during a preparatory phase for international tournaments (12 days of duration), found that "worse than normal" responses for symptoms of stress decrease with a decrease in ITL from the first to the second half of the training period. Similarly, the findings of Moreira et al.[18] in a 4-week study with basketball players during a competitive period showed that a decrease in ITL in the fourth week of the research provoke a decrease in "worse than normal" responses.

One possible explanation for the difference between this research's results and cited studies, regarding the dynamics of "worse than normal" responses in DALDA, could be the study duration. This study was the first to investigate professional basketball athletes during a 19-week full macrocycle. We can speculate that in a prolonged investigation, that would include the competitive period, factors other than the ITL may influence stress tolerance responses. As an example, we can mention the accumulation of fatigue and emotional charge for prolonged periods, despite a decrease in ITL.

This was confirmed by the study of Nicholls et al.[24], which revealed that, during competitive season, rugby union players showed, concurrently to a large number of "worse than normal" responses, a not pleasurable and of low activation state when a circumplex model of affect was used. In other words, athletes showed a state of lethargy and fatigue, which predisposed

them to submit "worse than normal" responses in DALDA on items such as "tiredness" and "need to rest". These results clearly show that "worse than normal" responses in DALDA not merely reflect the workloads, but are also directly influenced by affective state, showing interaction between different psychophysiological constructs in the determination of stress tolerance at different moments of a competitive period.

In addition, it is important to say that one of the limitations of the cited studies was that only "worse than normal" responses in DALDA were retained for the analysis of stress tolerance. Results regarding "better than normal" responses were not presented. In this study, "better than normal" responses were more sensitive to changes in ITL. With an increase in ITL from P1 to P2, "better than normal" responses for both sources and symptoms of stress showed significant decrease. There was also a negative correlation between ITL and "better than normal" responses at all phases of the investigation, showing that the higher the ITL, the fewer the "better than normal" responses. These findings suggest that "better than normal" responses should also be used to analyze the stress tolerance dynamics in different preparatory phases.

Regarding to "better than normal" responses at P3, on a practical perspective, an increased number of these responses at this moment would be desirable, reflecting the scope of peak performance, as proposed by Rushall[19]. Contrary to expectations, there was a decrease in the number of "better than normal" responses for both sources and symptoms of stress, and an increase in URTI severity, suggesting an unfavorable scenario to achieve the maximum performance[19,25].

An increase in URTI severity from P2 to P3 could be explained, at least in part, by an increase in stress during the same period (decisive phase of the competition). This finding supports the hypothesis of an association between decreased ability to tolerate different stressors and increase in the number of URTI episodes, regardless of the stress from the training[26]. This result suggests that the widespread belief that URTI are directly associated with ITL does not necessarily confirm in a real competition, in which other sources of stress (pressure for results, disruption of routine, etc.), may have a substantial effect on the body's defenses against disease development.

This possible association was considered in other longitudinal studies in different sports. Cunniffe et al.[27], investigating athletes from rugby during 11 months, and Neville et al.[28], monitoring yachtsmen for more than 50 weeks, found that psychological stress can increase the incidence of infections in athletes. In addition, Bishop and Gleeson[29] and Nakamura et al.[30] confirmed that the number of URTI episodes tends to increase during competitive periods, corroborating the findings of the present study.

A positive correlation between "worse than normal" responses for sources and symptoms of stress (r = 0.69 and 0.60, respectively) and URTI was also observed at P3. These results corroborate the findings of Moreira

et al.[18] in a research also conducted with basketball players. The authors reported correlations between the number of URTI episodes and "worse than normal" responses for both sources (r = 0.79) and symptoms of stress (r = 0.65) in the second week of the research. These results support the existence of an association between stress and incidence of URTI, indicating the need for constant monitoring of these responses during the sports season.

CONCLUSION

ETL distribution provoked changes in ITL. However, unlike the original hypothesis, a decrease in ITL during the competitive period was followed by a decrease in stress tolerance and an increase in URTI severity. Furthermore, the magnitude of stress seems to induce an increase in URTI severity. Results indicate that the instruments used by this study can help monitoring the training process. The use of these instruments in conjunction with other indicators, such as performance tests and physiological markers, could substantially help coaches and athletes toward this direction.

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