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Monitoring training loads in an elite sprint swimmer: a case report

Monitoramento das cargas de treinamento em nadador de velocidade de elite: relato de caso

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Abstract – This study explored the relationship between weekly internal training loads (ITL) and the perceived recovery and performance of an elite sprint swimmer over a 10-week periodized training plan, integrating hormonal and immune responses. ITL, perceived recovery, salivary cortisol, salivary testosterone, and SIgA concentrations were quantified. Repeated-sprint ability swim tests were conducted in weeks 1 and 5. The results revealed that as ITL increased, perceived recovery scores decreased (r = -0.61). Higher ITL in the initial weeks (1, 2, and 3; ~4000 AU) correlated with elevated salivary cortisol concentrations (Δ% = baseline to week 3 = +65%) and a decreased Testosterone:Cortisol ratio (Δ%=baseline-to-week 3=-46.3%). A decline in SIgA concentration (164.6 mg·L^{-1}, Δ% baseline-to-week 7=-34.5%) following a preparatory competition preceded the onset of an upper respiratory tract infection (URTI). Repeated sprint ability increased by 6.2% (week 1 to 5), and the 10-week training plan resulted in a faster 50-m freestyle time (week 1 = 22.52 s vs. target competition = 21.84 s, Δ% = -3.0%). In conclusion, the study found that performance improvement occurred after the 10-week periodized training plan, with weekly ITL correlating with recovery status and immuno-endocrine responses. Detection of decreased SIgA post-competition preceded URTI occurrence.

Key words: Sports training; Endocrine system; Swimming.

Resumo – *Este estudo explorou a relação entre as cargas internas de treinamento semanais (ITL) e a percepção de recuperação e desempenho de um nadador de velocidade de elite ao longo de um plano de treinamento periodizado de 10 semanas, integrando respostas hormonais e imunológicas. Foram quantificados ITL, percepção de recuperação, cortisol salivar, testosterona salivar e concentrações de SIgA. Testes de habilidade de natação em sprints repetidos foram realizados nas semanas 1 e 5. Os resultados revelaram que, à medida que o ITL aumentava, os escores de recuperação percebida diminuíam (r = -0,61). Maior ITL nas semanas iniciais (1, 2 e 3; ~4000 UA) correlacionou-se com concentrações elevadas de cortisol salivar (Δ% = linha de base até a semana 3 = +65%) e uma diminuição da relação Testosterona:Cortisol (Δ% = linha de base até a semana 3 = -46,3%). Um declínio na concentração de SIgA (164,6 mg·L^{-1}, Δ% linha de base até a semana 7 = -34,5%) após uma competição preparatória precedeu o início de uma infecção do trato respiratório superior (ITRS). A capacidade de sprints repetidos aumentou 6,2% (semana 1 a 5), e o plano de treinamento de 10 semanas resultou em um tempo de estilo livre de 50 metros mais rápido (semana 1 = 22,52 s vs. competição-alvo = 21,84 s, Δ% = -3,0%). Em conclusão, o estudo demonstrou que houve melhora do desempenho após o plano de treinamento de 10 semanas, com ITL semanal correlacionando-se com o estado de recuperação e respostas imunoendócrinas. A detecção de diminuição de SIgA pós-competição antecedeu a ocorrência de ITRS.*

Palavras-chave: *Treinamento esportivo; Sistema endócrino; Natação.*

INTRODUCTION

Appropriate periodization of training load (TL) and recovery activities are critical to optimizing athletic performance[1]. Quantifying the TL properly allows the monitoring of the efficiency of the training periodization[2]. Indeed, research shows that the training-induced psychophysiological stress imposed on the athlete, the internal training load (ITL), determines the real stimulus resulting in training adaptation[2,3]. A common method for quantifying the ITL is the session rating of perceived exertion (s-RPE method)[4-6] which requires the athletes to rate their perceived intensity of the entire training session using the perceived exertion category ratio scale (CR10-scale)[4]. The product of the score indicated in the CR-10 scale and the duration (volume) of a given training session is referred to as ITL.

The session-RPE method has been shown to be a valid and reliable method to quantify the ITL in swimmers[7,8] as well as a useful tool for quantifying ITL in competitive swimmers[9,10]. Indeed, monitoring ITL, along with other perceptual and physiological markers, and performance assessment, is essential to evaluate individual responses to a given training plan[11]. It is widely accepted that a multidimensional and integrated approach to training monitoring provides insightful data that can be used to assist coaches' decision-making about future training and the athlete readiness to perform[12,13].

Providing an adequate balance between stress (training and competition load, other life demands) and recovery is essential for athletes to achieve high-level performance, especially when peaking for competition[1,14,15]. However, highly trained swimmers experience highly variable TLs and recovery-stress responses, making it challenging for scientist and coaches to optimize the training process[10]. The high variability in TLs and inter-individual response to training reinforces the importance of monitoring elite swimmers in an individual basis. Thus, the aim of this study was to investigate the relationships between the weekly ITL and the responses of markers of perceived recovery and performance, integrated with hormonal and immune responses of an elite sprint swimmer, during a 10-week periodized training plan.

METHODS

Experimental design

The present cross-sectional study describes a 10-week period of periodized training responses for an elite Brazilian sprint swimmer (gold medal in the 50-m and bronze medal in the 100-m freestyle competition in Beijing 2008 Summer Olympics and bronze medal in the 50-m freestyle competition the London 2012 Summer Olympics, 50-m and 100-m freestyle world records). The study was conducted during a periodization for the most important Brazilian national competition of the 2015 season (Maria Lenk Trophy 2015). The elite swimmer was monitored during periodized training plan, comprising of 55 training sessions and 2 official competitions (preparatory and target competition, week 6 and post week 10, respectively). All procedures received University's Ethics Committee approval (CAAE 02313512.5.0000.5391).

Procedures

Training plan

The 10-week periodized training program started with a progressive loading period (weeks 1 to 3), followed by a 1-week taper (exponential tapering - week 4). The second loading period implemented with reduced TL (as compared to weeks 1 to 3) for 3 weeks (weeks 5, 6 and 7), followed by a 3-week tapering phase (progressive tapering - weeks 8, 9 and 10). The training included dry-land and specific swimming training sessions, which aimed to develop maximum strength (12 sessions) and power (21 sessions). In addition, swim sessions classified as sprinting (20 sessions) and anaerobic tolerance (13 sessions) were also implemented. The sprint training volume was determined within each session to ensure optimum performance, whereby if a significant decrement of performance was detected, the training session was interrupted.

- Maximum Strength Training Sessions. Each session consisted of 3-4 sets of 1-6 RM for the bench press, seated row, military press, back squat, and dead lift. The rest interval between sets was 2 to 5 min.
- Power Training Sessions. Each session consisted of 2-4 sets of 6-10 multiple-jumps and 2-4 sets of 4-8 drop jumps (40 to 60 cm), 2-4 sets of 6-10 medicine ball throws and 2-4 sets of 2-6 reps of Olympic lifts. The rest interval between sets and exercise was 2 to 5 min. Some training sessions were implemented following a complex training approach, involving the integration of strength training and plyometrics in order to improve explosive power.
- Swim Sprint Training Sessions. Sessions consisted of all-out sprints (15 to 50-m). The rest interval between sprints was 2 to 6 min.
- Swim Anaerobic Tolerance Training Sessions. Sessions consisted of all-out sprints (35 to 100-m). The rest interval between sprints was 1 to 6 min, passive and active recovery (pace corresponding to 40-60% of the best 100-m individual velocity).

ITL

ITL was calculated using the session rating of perceived exertion (s-RPE) method[4]. The scores of the CR10 scale were registered according to the method guidelines[6]. A training load score was calculated by multiplying the s-RPE (CR-10 scale) score by the duration of training (in minutes). Data from all sessions were combined to provide the overall training load score for each day (ITL_{DAILY}) or week (ITL_{WEEKLY}) of training.

Total Quality Recovery

Total Quality Recovery (TQR) was used to monitor the athlete perceived recovery[14]. Before the start of each training session, the elite swimmer answered the question "How do you feel about your recovery?", using the 6-20 TQR scale[12]. The weekly average TQR (TQR_{WEEKLY}) score for elite swimmer was calculated as the average of the daily scores from a given week. The TQR was also assessed on days off.

8 x 25 meters sprint test

To monitor swim sprint performance and blood lactate response, a 25-m sprint test (8 x 25m with 60 s rest) were performed in week 1 and 5. A drop of blood from earlobe was collected to determine lactate concentration among the sprints 2, 4, 6 and 8 and recovery after the last 25-m sprint (3, 5, 10, 15 and 20 minutes). The blood was analyzed by YSI Sport 1500 (YSI, USA). Fatigue index (FI) was calculated by the formula FI = [(best sprint – worse sprint/ best sprint) x 100].

Salivary hormones and Immunoglobulin A

Immediately after awakening (7:00AM), saliva sampling was conducted in the baseline and in the last day of the training weeks (1 to 10). Unstimulated saliva was collected into sterile 15-ml centrifuge tubes over a 5-minute period. The saliva samples were frozen and stored at -80°C until assay. Salivary testosterone, salivary cortisol, and SIgA were each determined in duplicate using an enzyme-linked immunosorbent assay (Salimetrics©, USA) according to the manufacturer's instructions. The testosterone-to-cortisol ratio was calculated from these data.

Statistical analyses

The data are presented as mean ± SD. Normality was verified using the Shapiro-Wilk test. The relationship between variables was determined through Pearson's correlation and confidence interval (95% CI) was calculated. The following criteria were adopted to interpret the magnitude of the correlation (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 (Hopkins et al., 2009). If the 95% CI overlapped, small positive and negative values for the magnitude were deemed unclear (Hopkins et al., 2009).

RESULTS

The increase in ITL was associated with a *large* decrease in the TQR scores over the 10 weeks (r = -0.611). Weeks with greater ITL (weeks 1, 2 and 3; ~4000 AU) (Figure 1A, 1B), presented higher salivary cortisol concentration (Δ% - baseline to week 3 = +65%) and lower T:C ratio (Δ% - baseline to week 3 = -46.3%). During the tapering period, a decrease in the ITL_{WEEKLY} was accompanied by an improvement of perceived recovery (TQR score), a reduction of salivary cortisol concentration and an increment in the T:C ratio. After the preparatory competition, there was a decrease in SIgA concentration (164.6 $mg \cdot L^{-1}$, Δ% baseline to week 7 = -34.5%). This decrease preceded the occurrence of an upper respiratory tract infection (URTI). The clinical diagnosis was provided by a Medical Doctor.

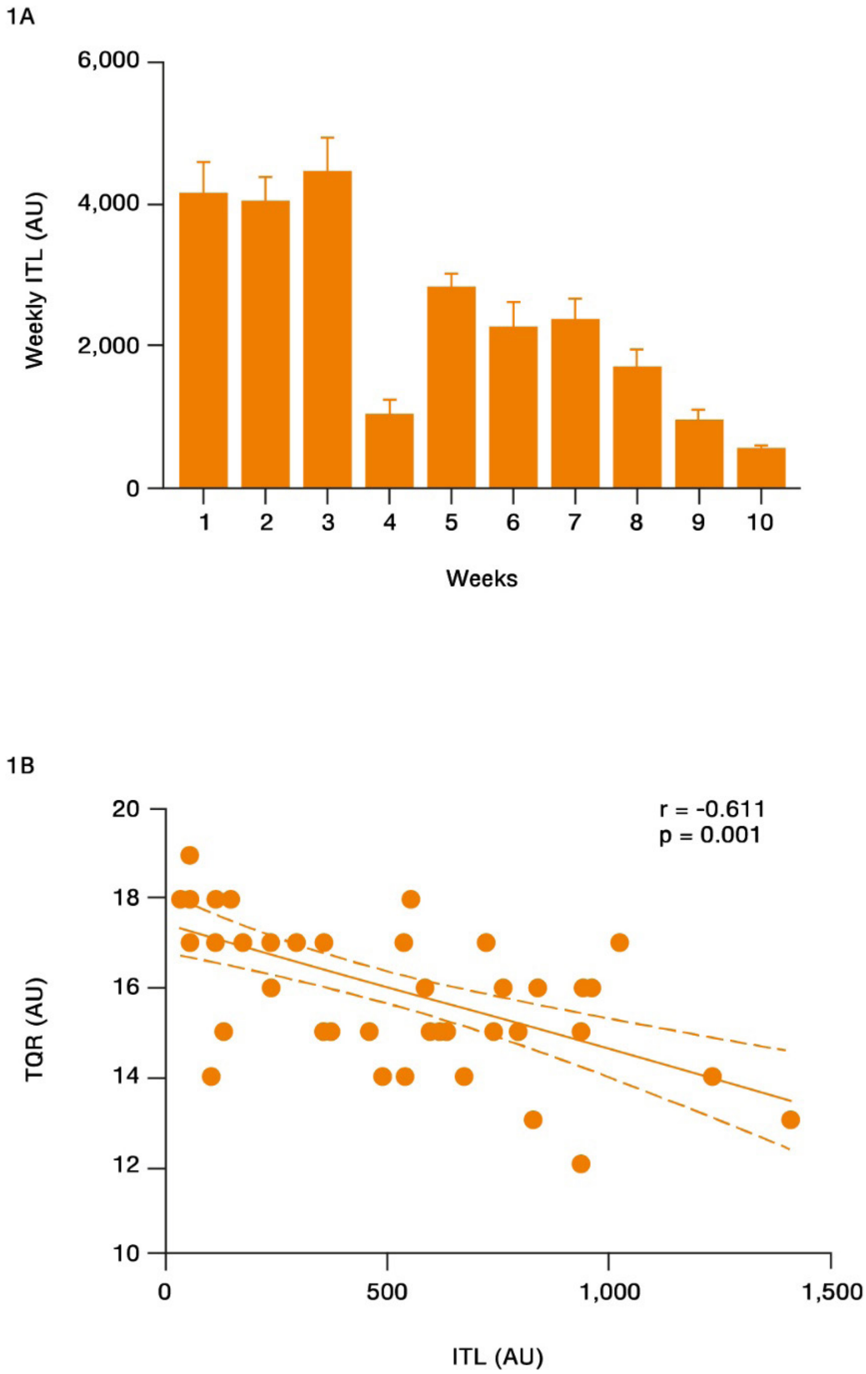

Figure 1. Mean (SD) of weekly internal training loads (ITL) over a 10-week period (1A) and the relationship of the daily ITL and the daily total quality recovery score (TQR) during the same period (n=55) (1B).

A significant correlation between ITL and TQR (r = -0.611, 95% CI = -0.40 to -0.76, p = 0.001; Figure 1B) was observed. Salivary cortisol was positively correlated with ITL_{WEEKLY} (r = 0.55, 95% CI = 0.25 to 0.85) and negatively correlated to TQR_{WEEKLY} (r = -0.49, 95% CI = -0.16 to -0.82). It was observed a correlation between the T:C ratio and the ITL_{WEEKLY} (r = -0.60, 95% CI = -0.29 to -0.91), and between the T:C ratio and the TQR_{WEEKLY} (r = 0.56, 95% CI = 0.18 to 0.94). Finally, salivary testosterone was negatively correlated with ITL_{WEEKLY} (r = -0.49, 95% CI = -0.16 to -0.82) and positively correlated with TQR_{WEEKLY} (r = 0.40, 95% CI = -0.40 to -0.76) (Figure 2).

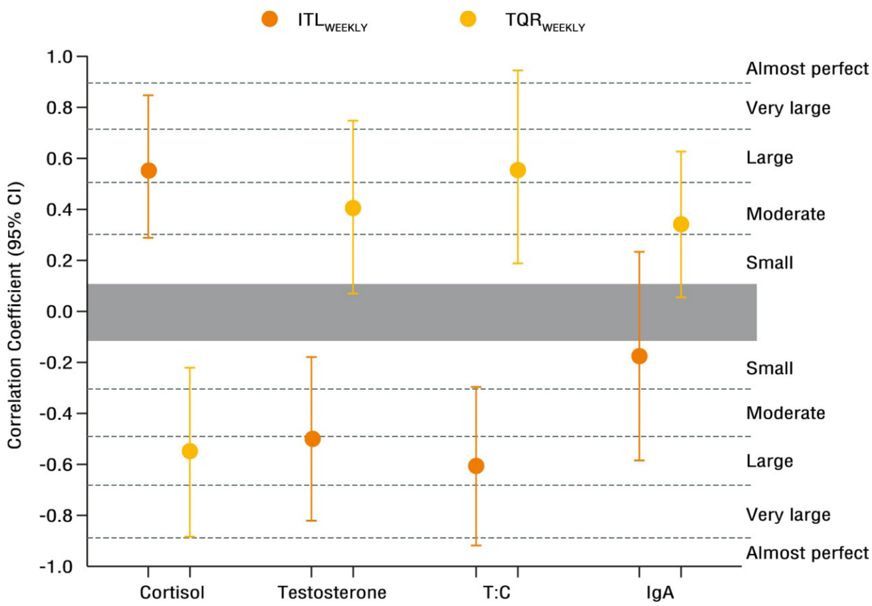

Figure 2. Correlations between salivary cortisol, salivary testosterone, testosterone:cortisol ratio, and salivary immunoglobulineA (IgA), and the weekly internal training loads (ITL) and weekly total quality recovery (TQR).

The 25-m sprint test performance times improved 6.2% from week 1 to 5, with concomitant decrease in blood lactate concentration (Figure 3). Moreover, the 10-week training plan was effective to improve the 50-m freestyle performance time: 22.52 s, 22.15 s (Δ% = -1.6%), 22.07 s (Δ% = -2.0%) and 21.84 s (Δ% = -3.0%) in the first competition simulation (week 1), the second competition simulation (week 5), the preparatory competition (week 7) and the target competition (post week 10), respectively. The average time for 8 sprints of 25 m was 11.49 s in week 1 and 10.78 s in week 5 (Δ% = -6.2%) (Figure 3A). Fatigue index (FI) was lower in week 5 (2.0%) compared to week 1 (6.1%). Blood lactate concentration showed a decrease in week 5 when compared to week 1 in sprint 4 (Δ% = -23.3%), 6 (Δ% = -33.9%), 8 (Δ% = -19.3%) and all recovery time-points (3 to 20 minute, Δ% = -13.2% to -44.8%) (Figure 3B).

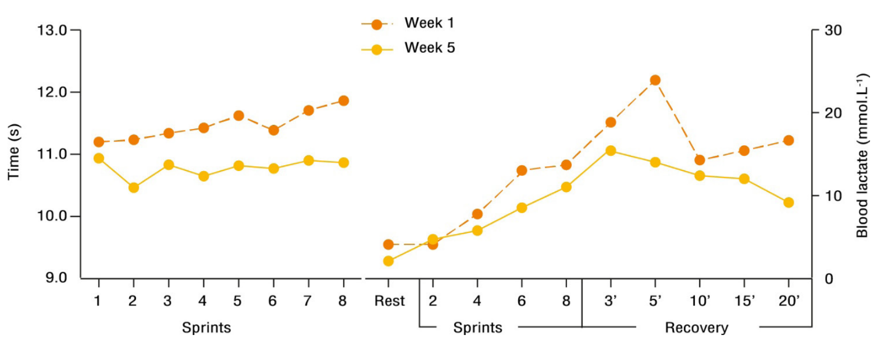

Figure 3. Performance and blood lactate concentration responses for the repeated-sprint test in week 1 and week 5 of the study.

DISCUSSION

The findings of the present case study indicate that: 1) the magnitude of ITL was negatively associated with the score of perceived recovery

(TQR score); 2) the magnitude of ITL was positively associated with salivary cortisol concentration and negatively associated with the T:C ratio; 3) There were large relationships between endocrine responses and ITL_{WEEKLY} and TQR_{WEEKLY}; 4) both the 50-m freestyle and sprint test (8x25m) performance times, and the blood lactate responses decreased during the period of the study; and 5) a decrease of SIgA preceded the occurrence of a relevant URTI after a competition.

The results of this case study confirmed the initial hypothesis that the weekly ITL, recovery status and immuno-endocrine responses measured throughout the periodization would be significantly related. These findings are in line with a recent systematic review that showed subjective measures (i.e. ITL_{WEEKLY}) were more responsive to TL than objective measures[16]. Altogether, the current results highlight the importance of an integrated approach to monitor the training process in individual athlete.

A decrement in SIgA in the week 7 after a preparatory competition (Δ% vs week 1 = -34.5%) preceded the URTI, which took the athlete off training for 2 days. Interestingly, the athlete did not show any alteration in SIgA or symptoms related to URTI during the intensified training periods, corroborating previous assumptions that elite athletes are more resistant to infections[17]. These observations fit with the S-shaped relationship suggested between TL and the risk of infections[18]. It is reasonable to speculate that the occurrence of URTI, despite the lower magnitude of ITL, could be due to the psychobiological stress induced by competition.

The present study presents rare information of an Olympic champion. This characteristic is simultaneously the strength and a limitation of the study. The reason for such a limitation relies on the fact that individuals with unique physiologic and psychological characteristics are rare in the world. Olympic champions rarely allow researchers to investigate their training and physiology let alone to publish these data. Readers should be aware that the results presented here may serve as a reference for top performers and caution should be taken when trying to generalize these results. Additionally, developing athletes may use such results as top benchmarks over their developing career.

CONCLUSION

In conclusion, the present case study shows how multidimensional, integrated training monitoring data can be used to support elite athletes to achieve their performance goals[10,17]. The present case demonstrates that simple, field-based methods that little interfere with the athlete's routine, provide insights and can be conducted over a whole season without interfering with the athlete's training and preparation.

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COMPLIANCE WITH ETHICAL STANDARDS

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Ethical approval

Ethical approval was obtained from the local Human Research Ethics Committee - 86121 and the protocol (CAAE 02313512.5.0000.5391) was written in accordance with the standards set by the Declaration of Helsinki.

Conflict of interest statement

The authors have no conflict of interests to declare.

Author Contributions

Conceived and designed the experiments: CRL, MSA, AM. Performed the experiments: CRL, MDG, DS, TVB. Analyzed the data: CRL, AM. Contributed reagents/materials/analysis tools: AM. Wrote the paper: CRL, TOB, AM, AJC, MSA.

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