SLEEP RESPONSES OF YOUNG SWIMMERS TO TRAINING LOAD AND RECOVERY DURING TAPERING

RESPOSTAS DO SONO ÀS CARGAS DE TREINAMENTO E RECUPERAÇÃO EM JOVENS NADADORES DURANTE O POLIMENTO

RESPUESTAS DEL SUEÑO A LAS CARGAS DE ENTRENAMIENTO Y RECUPERACIÓN EN JÓVENES NADADORES DURANTE EL TAPERING

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ABSTRACT

Introduction: Tapering is a decisive phase in planning a young swimmer's preparation for competition. During this period, not only training loads, but also recovery, which includes sleep quality, must be constantly monitored. Objective: This study aims to investigate sleep behavior as a variable directly influenced by training load during the tapering phase of training for young swimmers. Methods: A polysomnography test was performed at the beginning of the tapering phase, as a baseline for sleep variables. In each daily training session, the overload and recovery variables were measured. The internal training load was evaluated in the PSE session and the external load by quantifying the training. The recovery variables were divided into the recovery variable, assessed using the TQR questionnaire, and sleep variables, which included sleepiness, scored using the Karolinska scale, and sleep behavior, using an actigraph and a sleep diary. Conclusion: It is concluded that there is no significant influence between training loads and sleep variables. However, a strong association was observed between TST and EL (External load), in the irregular sleep group. ***Level of evidence III, Study of behavior.***

Keywords: Athletes; Actigraphy; Adolescents; Athletic performance.

RESUMO

Introdução: A etapa de polimento é uma fase decisiva no planejamento da preparação de um jovem nadador para a competição. Durante esse período, não somente as cargas de treinamento, mas também a recuperação, que inclui a qualidade do sono, devem ser constantemente monitoradas. Objetivos: Este estudo objetiva investigar o comportamento do sono como variável diretamente influenciada pela carga de treinamento durante a fase de polimento do treinamento de jovens nadadores. Métodos: O exame de polissonografia foi realizado no início da fase de polimento, como base para as variáveis do sono. Em cada sessão diária de treinamento foram medidas as variáveis de sobrecarga e de recuperação. A carga interna de treinamento foi avaliada pela sessão de PSE e a carga externa, pela quantificação do treinamento. As variáveis de recuperação foram divididas em variável de recuperação, com o questionário QTR e variáveis de sono, que incluíram sonolência pela escala de Karolinska e comportamento do sono com actígrafo e diário de sono. Conclusões: Conclui-se que não há influência significativa entre as cargas de treinamento e as variáveis do sono. Entretanto, foi observada forte associação entre TTS e CE no grupo sono irregular. ***Nível de evidência III, Estudo de comportamento.***

Descritores: *Atletas; Actigrafia; Adolescentes; Desempenho esportivo.*

RESUMEN

Introducción: El tapering es una fase decisiva en la planificación de la preparación de un joven nadador para la competición. Durante este período, deben monitorearse constantemente no sólo las cargas de entrenamiento, sino también la recuperación, que incluye la calidad del sueño. Objetivo: Este estudio tiene como objetivo investigar el comportamiento del sueño como variable directamente influenciada por la carga de entrenamiento durante la fase de tapering del entrenamiento de jóvenes nadadores. Métodos: Se realizó una polisomnografía al inicio de la fase de tapering como base de las variables del sueño. En cada sesión diaria de entrenamiento se midieron las variables de sobrecarga y recuperación. La carga interna de entrenamiento fue evaluada por la sesión de PSE y la carga externa mediante cuantificación del entrenamiento. Las variables de recuperación se dividieron variables de recuperación, con el cuestionario QTR y variables de sueño, que incluían somnolencia mediante la escala de Karolinska y comportamiento del sueño con un actígrafo y diario de sueño. Conclusiones: Se concluyó que no existe una influencia significativa entre las cargas de entrenamiento y las variables del sueño. Sin embargo, se observó una fuerte asociación entre TTS y el CE, en el grupo de sueño irregular. ***Nivel de evidencia III, Estudio de comportamiento.***

Descriptores: *Atletas; Actigrafía; Adolescentes; Rendimiento deportivo.*

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INTRODUCTION

Sports training proposes adaptations resulting from the level of stress that the body imposes, determined by the quality, quantity and organization of variables involved, such as volume and intensity, in addition to considering the individual characteristics of responses to training loads.[1]

The monitoring of training loads is based on the manipulation of stimuli through the external load, in which coaches stipulate parameters of volume and intensity, which are modulated by the total duration of training, duration of stimulus intervals and recovery in the session, as well as, number of sets, repetitions and weights.[2] The intensity of the load planned by the coach and the intensity perceived by the athletes (internal load) is the object of study by several researchers. Monitoring training loads is extremely important, since stimuli incompatible with the athlete's physical capacity can trigger negative and/or null adaptations.[3]

Regardless of the type of period chosen by the technical committee, in swimming the stimuli are planned and distributed in generally annual macrocycles and the polishing step is carried out two to three weeks before the target competition.[4,5,6] At this stage, in addition to maximizing physical capabilities, the recovery of motor, tactical, psychic and emotional actions (stress control, anxiety and motivation) must be carefully monitored, with the knowledge that restful sleep is also part of this recovery strategy.[5]

Psychophysiological recovery is an essential element in the physical preparation of athletes, as recovery sessions must be included in the planning and periodization during the season.[7] Halson[8] found that sleep is the most effective recovery strategy for athletes in competition. Biological changes affect the sleep pattern during puberty, with a decrease in total sleep time (TST), which accentuates evening characteristics in adolescents.[9]

Changes in sleep during adolescence are common and are due to the maturing process of the nervous system, promoted by biological rhythmicity, leading to a time delay in the central nervous system, specifically in the circadian pattern of the sleep/wake cycle.[10,11,12] In this phase, insomnia or Sleep Delay Syndrome[13] it is the most common disorder among teenagers, which corresponds to a reduction in total sleep time to an average of less than 7 hours per night, when what is indicated for this age group is 9 to 9.5 hours of sleep per night.[14,15] When a teenager is an athlete and their daily training volume is high, this daily average of sleep can be even lower, reflecting on the athlete's performance the following day.[16,17] Thus, the aim of the present study was to analyze the effects and relationships between training loads and sleep behavior in young swimmers during the polishing phase.

MATERIALS AND METHODS

Cross-sectional study and quantitative approach. The sample consisted of 15 swimming athletes (male n=5 and female n=10), age 13.4±0.51 years, weight 54.2±7.8 kg, height 163.2±7.5 cm and BMI 20.2±2.0%, representatives of two clubs in the city of Recife, affiliated to the Brazilian Confederation of Aquatic Sports – CBDA. The sample was selected for convenience and adherence, the participants should have at least one year of swimming training and a minimum load of 12 hours of weekly training. Participants and their guardians were informed of the risks and procedures of the research, signing their respective terms of acceptance, with a study approved by the Ethics Committee, nº 3.366.677/2019.

Data were collected over the three weeks (21 days) before the target competition, in the polishing phase of the macrocycle. Anthropometric data (body mass, height, BMI, trunk-cephalic height and spread), biological maturation,[18] as well as polysomnography data were collected on the first day of the polishing phase.

Sleep behavior was assessed using polysomnography, performed in the first week, actigraph and sleep diary, performed throughout the polishing process. Polysomnography was performed at the athlete's residence, between 9 pm and 7 am, serving as the baseline for this study, providing information about sleep efficiency (SE), total sleep time (TST), sleep latency (SL) and number of awakenings after sleep onset (AAS). After the analysis of SE, the athletes were classified in normal sleep (SE>85%), according to the American Academy of Sleep Medicine (AASM) guidelines;[19] regular sleep (SE>85%) and irregular sleep (SE<85%). The same variables were evaluated over the three weeks of polishing using the actigraph and the sleep diary. Data on the sleep-virgil cycle were collected using an actigraph (ActiGraph GT3X), placed on the non-dominant wrist of each athlete[17], with data analyzed using the Actilife software. The sleep diary was applied to the athlete's awakening, complementing the actigraph analyses.[20]

Training loads were recorded over the three weeks of polishing. The external load was provided daily by the technician, taking into account the session volume in meters and the intensity, through the speed and volume swam in each training zone, a method proposed by Maglischo et al.,[21] adapted in this study by Nogueira.[16] The Subjective Effort Perception (SEP) monitored the internal load through the SEP-session.[2,3,22] The calculation was composed of the product between the training intensity, obtained through the SEP session and the total time of the session in minutes, presenting the value in arbitrary units (AU).[5,21]

Drowsiness was checked using the Karolinska Scale, applied together with the SEP session, consisting of 9 points, starting with a value of 1 ("Very alert") and ending with a value of 9 ("Very sleepy, struggling with sleep, a lot of effort to stay awake").[23]

Recovery assessment was performed using the total quality of recovery scale (TQR), proposed by Barretta et al.,[24] answered 30 minutes before and 30 minutes at the end of the training session, with a scale between six to 20, where the smallest value represents the worst state of recovery and the largest the best state of recovery.[24,25]

DATA PROCESSING

Data were presented using descriptive statistics (mean and SD), using parametric tests throughout the study. Sleep quality data and indicators of sleepiness and recovery were treated using multivariate analysis of covariance (MANCOVA). Two-way repeated measures ANOVA (sleep quality x training weeks) with Geisser-Greenhouse's epsilon correction was used for sleep behavior variables obtained by the actigraph and training loads. Data were analyzed using SPSS software, version 20.0 (IBM, USA) and Prisma version 8.0 (Graphpad, USA), considering a significance level of 5% ($p<0.05$).

RESULTS

According to the TQR scale, in the first training week of the polishing period (6 sessions), the athletes were "reasonably recovered" (pre-session 14.7±0.5 and post-session 13.8±0.6); in the second week (6 sessions) they were "well recovered" in the pre-training (15.0±0.5) and "reasonably recovered" in the post-training (13.8±0.3); in the last week of the polishing phase they were "well recovered" in pre-training (15.0±0.2) and "reasonably recovered" (13.8±0.4). At no time during the polishing phase did the athletes present daytime sleepiness (3.3 ± 0.2 and 3.7 ± 0.2 for pre and 3.8 ± 0.2 and 4.1 ± 0.2 post) indicating "alert" and "neither alert nor sleepy" level, respectively, as shown in Table 1.

Figure 1 shows the mean and dispersion values for sleep and internal load variables. Through MANCOVA, it could be verified that no significant differences were observed in the pre ($Z_{(4, 48)}$=0.480; p=0.750) and post ($Z_{(4, 48)}$=0.713; p=0.587) recovery; similarly, in pre ($Z_{(4, 48)}$=0.477; p=0.753) and post ($Z_{(4, 48)}$=1.070; p=0.382) drowsiness, between the three weeks of the polishing period, demonstrating, for the analyzed sample, that there was no interaction between such indicators and the maturational stage together with the sleep quality.

Table 1. Mean values and standard deviation, minimum and maximum of the study sample, referring to sleep, training loads, recovery and drowsiness (n=15).

Variables	Polysomnography Mean ± DP (min-max)		Mean ± DP (min-max)			Mean ± DP (min-max)					
	Regular (n=8)	Irregular (n=7)				Regular (n=8)			Irregular (n=7)		
			1ª week	2ª week	3ª week	1ª week	2ª week	3ª week	1ª week	2ª week	3ª week
Total sleep time (hours)	6.2±1.8 (2.9-8.50)	5.6±1.3 (3.88-7.6)	7.9±1.1 (5.9-8.7)	7.5±0.7 (6.2-8.2)	7.0±0.2 (6.6-7.4)	8.3±0.7 (7.4-9.1)	7.9±0.3 (7.5-8.3)	6.4±0.4 (5.8-6.8)	7.7±2.3 (3.9-9.8)	7.4±1.2 (5.7-8.8)	7.5±0.2 (7.3-7.9)
Sleep latency (minutes)	18.2±17.6 (1.50-60.0)	25.5±25.7 (0.0-73.6)	23.3±11.8 (8.9-36)	30.8±4.0 (24.0-34.7)	29.7±25.9 (6.1-73.4)	21.9±14.5 (9.2-40.2)	21.6±14.4 (7.6-41.57)	23.8±32.4 (0.0-80.7)	25.0±21.5 (6.1-58.7)	41.0±9.7 (28.0-51.7)	36.5±19.4 (13.3-63.67)
Sleep efficiency (%)	89.5±3.5 (85.8-94.9)	75.0±11.1 (51.5-84.1)	80±2.2 (77.0-82.8)	76.9±3.0 (73.6-80.9)	78.0±5.5 (69.5-83.1)	79.9±1.3 (78.0-81.2)	76.9±6.6 (68.4-86.3)	78.3±6.0 (68.2-82.6)	80.2±4.2 (73.6-85.1)	76.8±8.2 (67.5-88.5)	78.1±7.7 (68.6-85.0)
Awakenings (number)	49.5±38.7 (0.0-114.0)	24.1±24.6 (0.0-78.0)	20.3±1.1 (18.9-21.5)	18.4±1.4 (16.7-19.6)	16.5±0.7 (15.3-17.0)	21.1±1.5 (18.8-23.0)	20.2±1.7 (19.0-23.2)	17.0±1.2 (15.6-18.4)	19.1±1.7 (16.2-20.7)	16.4±2.6 (14.1-19.7)	15.9±1.1 (15.0-17.6)
Internal load (U.A)			543.0±91.2 (428.5-660.0)	552.7±57.7 (487.0-660.0)	526.2±33.2 (480.0-560.0)	577.5±115.7 (420.0-735.0)	512.7±74.1 (426.6-640.00)	514.4±44.2 (450.0-570.0)	510.0±101.1 (360.0-630.0)	614.8±116.4 (480.0-792.0)	548.0±52.0 (500.0-648.0)
External load (meters)			6027.7±2545.8 (3000.0-10077.7)	5102.7±369.1 (4577.7-5722.2)	6187.7±1245.3 (4985.8-7964.7)	5569.4±2452.1 (3000.0-10038.8)	4988.8±294.4 (4455.5-5333.3)	6284.6±1381.5 (4991.1-8088.8)	6486.1±2748.4 (3000.0-10116.6)	5216.6±475.1 (4700.0-6111.1)	6087.1±1116.0 (4980.0-7825.0)
Pre recovery			14.7±0.5 (13.6-15.2)	15.0±0.5 (14.30-15.73)	15.0±0.2 (14.8-15.5)	14.7±0.4 (14.0-15.2)	14.9±0.6 (14.1-15.6)	14.9±0.6 (14.1-15.6)	14.8±0.8 (13.3-15.6)	15.0±0.7 (14.2-16.1)	15.3±1.1 (14.1-16.6)
Post recovery			13.8±0.6 (13.0-14.94)	13.8±0.3 (13.2-14.1)	13.8±0.4 (13.1-14.2)	13.5±0.2 (13.2-13.8	13.8±0.5 (13.1-14.6)	14.0±0.4 (13.6-14.7)	14.1±1.2 (12.4-16.0)	13.9±0.6 (13.2-14.7)	13.4±0.7 (12.5-14.3)
Pre drowsiness			3.3±0.2 (3.0-3.8)	3.7±0.2 (3.4-4.0)	3.6±0.1 (3.4-3.8)	3.3±0.4 (3.0-4.1)	3.7±0.3 (3.3-4.1)	3.5±0.3 (2.7-3.8)	3.4±0.3 (2.8-4.0)	3.7±0.4 (3.2-4.4)	3.7±0.4 (3.2-4.5)
Post drowsiness			3.8±0.2 (3.6-4.1)	4.1±0.2 (3.8-4.4)	4.1±0.2 (3.8-4.3)	3.6±0.4 (3.1-4.3)	4.3±0.3 (4.0-4.8)	4.1±0.2 (3.6-4.3)	4.1±0.2 (3.8-4.3)	3.9±0.3 (3.5-4.4)	4.3±0.5 (3.4-5.0)

U.A = Arbitrary Units.

In addition, the two-way repeated measures ANOVA did not identify interactions between sleep quality and the weeks of polishing, for the internal load ($F_{(2, 11)}$=2.905; p=0.0971), or TST ($F_{(2, 39)}$=0.5735; p=0.5682), SL ($F_{(2, 39)}$=0.5345; p=0.5902), SE ($F_{(1.249, 6.867)}$=0.1526; p=0.7618) and AAS ($F_{(2, 11)}$=1,107; p=0.3648). Checking the groups separately, it was noticed that the internal load varied significantly from the first week to the weeks (2 and 3), following (week 1=2623 AU versus week 2=488.3 AU and week 3=487.5 AU) for the group regular sleep, and also for the irregular sleep group (week 1=2035 AU versus week 2=614 AU and week 3=618.4 AU; TE=1.01; "large"). Similarly, the TST (week 1=8.386 hours versus week 2=6.499 hours; TE=1.54; "large").

Table 2 presents the correlation coefficients (Pearson and partial) and their respective probability values (p value) between the sleep indicators and the internal training load. It was observed that only the TST showed significant (inverse) correlations with the internal training load, even after controlling for sleep quality.

Complementarily, Table 3 presents the correlation coefficients and their respective probability values (p value) between the sleep indicators and the internal training load, considering distinct groups according to the sleep quality.

Figure 2 shows the correlation and regression coefficients and their respective indicators, considering only the TST as the dependent variable. It is observed that significant contributions (in the order of 59%) of the external load in the athletes' TST are verified, considering the group characterized as irregular sleep. For the purpose of statistical analysis, 15 days of actigraph records were analyzed.

DISCUSSION

The present study aimed to analyze the effects and relationships between training loads and sleep behavior in young swimmers during the polishing period. The sample was divided into two groups: regular sleep and irregular sleep. The results showed, from the polysomnography exam (baseline), that the regular sleep group reported a mean for the TTS of 6.2±1.8 hours, while the irregular group 5.6±1.3 representing that these young athletes sleep less than 6.5 hours/night. Lastella et al.[20] demonstrated that, for a population of elite athletes, the TST ranged from 6.5 to 8.5 hours/night, which allows establishing normal values. Corroborating the study by Taylor et al.,[26] which showed a decrease in TST in the polishing phase, generating an increase in the sense of vigor in athletes. Recent studies have revealed that 64% of high-performance athletes reported disturbed sleep the night before competition.[27,28]

For Taylor et al.,[26] sleep disorders in athletes are cited as a side effect of training. However, the exact nature of these disorders may vary for each athlete. Thus, interruptions during sleep can alter sleep architecture, affecting levels of alertness and recovery, as well as performance.

The use of the actigraph over three weeks showed that the irregular sleep group presented an average of 7.5 hours/night for the TST, while the regular sleep group presented average decreases of 8.3; 7.9 and 6.4 hours/week; however, these differences were not significant when compared with the studies by Conde[29] and Lastella et al.,[20] which demonstrated a mean TST of 6.5 and 6.4 hours/night, respectively, characterizing this study in the normative range.

The results show that LS had a gradual increase from the second to the third week for the athletes in the regular sleep group, while in the irregular sleep group this increase occurred from the first to the second week, coincidentally, the increase in training loads (volume) for the group regular sleep occurred at the same time, while in the irregular sleep group, the SEP session (subjective intensity) increased from the first to the second week.

In relation to SE, the mean values below were observed, as suggested by the scientific literature, both for the regular and irregular sleep groups. The higher these levels are, the better the support to increase training overload and, consequently, recovery. Other studies showed higher values for SE for the same phase (polishing).[28, 29] As for the AAS,

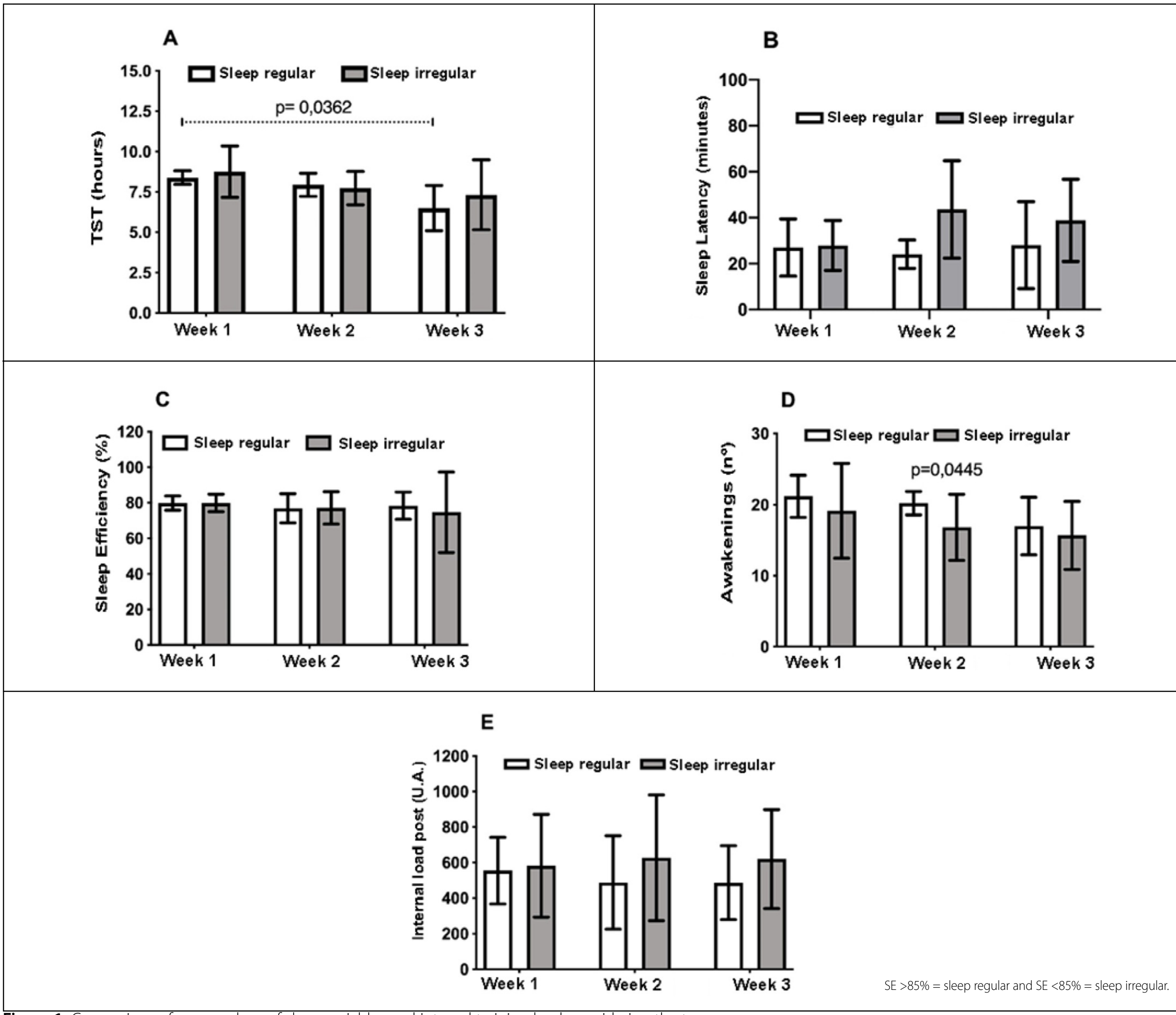


Figure 1. Comparison of mean values of sleep variables and internal training load, considering the two groups.

Table 2. Correlation coefficients between sleep indicators and training loads (n=15).

Association variables	Pearson (n=15)		Parcial[a] (n=15)	
	r	p value	r	p value
Total sleep time (hours)	-0.448	0.013	-0.448	0.015
Sleep latency (minutes)	-0.185	0.328	-0.194	0.314
Sleep efficiency (percentage)	0.086	0.653	0.086	0.659
Awakenings (number)	-0.093	0.625	-0.104	0.591
Internal training load (U.A)	0.008	0.967	0.009	0.962

[a] correlation controlled by sleep quality; U.A = Arbitrary Unit.

Table 3. Correlation coefficients between sleep indicators and training loads, considering different groups (regular sleep n=8 and irregular sleep n=7).

Association variables	Regular sleep (n=8)		Irregular sleep (n=7)	
	r	p value	r	p value
Total sleep time (hours)	-0.077	0.785	-0.769**	>0.001
Sleep latency (minutes)	-0.077	0.785	-0.229	0.411
Sleep efficiency (percentage)	0.272	0.327	0.025	0.929
Awakenings (number)	0.052	0.854	-0.284	0.305
Internal training load (U.A)	0.210	0.453	0.199	0.477

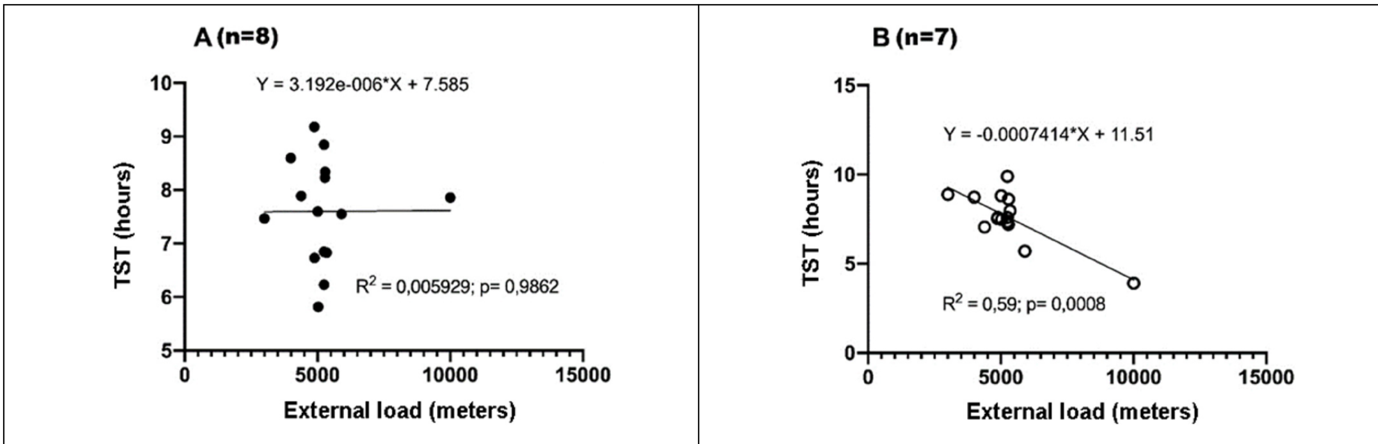
U.A= Arbitrary Unit.

they did not vary in the polishing period of three weeks for the two groups, showing a slight decrease with the proximity of the competition.

Through the analysis of the effect of the internal training load on sleep quality, it was found that there was no significant difference for the two groups studied and, according to the SEP session, the sessions were classified, on average, as "moderate" to "a little heavy" for both groups, ratings considered low in relation to the intensity prescribed by the coach. Nogueira et al.16 observed that the distribution of training loads applied to swimmers did not reach their maximum performance, due to excessive decrease in both internal and external (volume and intensity) loads, a fact confirmed through the drop in performance of athletes in competition.

When the association of sleep parameters was analyzed, the TST had a negative influence with the external training load, in the irregular sleep group, in which it presented in its average athletes in the post-pubertal maturational extract, presenting R^2=0.591, which means to say that approximately 60% of the variation in TST was explained by the training load, which comprises more than half of the sample.

Thus, it is assumed that the applied training did not promote significant improvements in the athletes' performance level, in addition to changing sleep patterns, since the distribution of loads was not made evenly so that they reached the best performance in the target competition. The results also showed that the recovery values obtained



TST= Total Sleep Time; A= regular sleep group; B= irregular sleep group.

Figure 2. Regression analysis between external training load and TST between groups of athletes.

through the TQR, presented in the pre-training "well recovered" and in the post-training an average for the descriptor "reasonably well recovered". In young swimming athletes we can say that the metabolic responses are faster compared to healthy adults. Conde[29] found that young swimmers had expressive and rapid levels of physical recovery, vigor and mood compared to sedentary youngsters, and the younger, the better physically and cognitively they present themselves.

In the analysis of daytime sleepiness, no significant differences were observed between the two moments: pre and post training, indicating average levels of "alert" in the pre-training and "neither alert nor sleepy" in the post-training. Mujika et al.[30] highlight that athletes on the eve of competitions may present high levels of anxiety, high alert behavior, psychological factors such as stress and anxiety, which were not controlled or analyzed in this study.

However, it should be considered infrequent for competitive swimmers to undergo long periods of research, leading us to assume that anxiety and stress behaviors can trigger these alert descriptors, variables that are necessary for future investigations.

The study found good applicability, practicality and ease in the adequacy of the methods of monitoring and control of the training load used, allowing its use by the technical committee, as well as, to observe the levels of recovery and sleepiness, indicators of changes in behavior of sleep.

Despite the results presented, the present study has limitations, including the reduced sample size, the expansion of the age group and a longer period of observation of the periodization. Furthermore, a psychological assessment prior to the competition could also explain some results, which could more effectively target the present findings.

CONCLUSION

It is concluded that there is no significant influence between training loads and sleep quality indicators during the polishing period in young swimming athletes. However, correlation analyzes revealed a strong association between TST and external load in the irregular sleep group. Recovery showed good recovery values in athletes during the three weeks, without significant changes. Likewise, daytime sleepiness did not report significant differences for weeks. The applicability of the instruments used was effective in monitoring loads and recovery, so that athletes express the best sports performance, without compromising sleep quality.

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All authors read and approved the final version of the manuscript. The results of the present study do not constitute endorsement by the American College of Sports Medicine. The study results are presented clearly, honestly and without fabrication, falsification or inappropriate manipulation of data.

All authors declare no potential conflict of interest related to this article

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