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ASSOCIATION BETWEEN TRAINING VOLUME AND SLEEP QUALITY OF AMATEUR TRIATHLETES

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ABSTRACT

Sleep is widely recognized as a key factor for recovery and athletic performance, yet its relationship with training demands in triathletes, who sustain high training volumes across three disciplines, remains unclear. Thus, this study aimed to examine whether associations exist between sleep duration, sleep quality, and training volume in amateur triathletes. A cross-sectional design was applied, including 151 athletes (men: N = 108, 38.6 ± 8.1 years, 7.8 ± 1.8 sessions/week; women: N = 43, 39.3 ± 7.6 years, 6.5 ± 1.6 sessions/week). Participants completed two questionnaires: one on training volume during the past month, including the longest swimming, cycling, and running sessions, and another assessing sleep duration on the night before the longest training session and sleep quality via the Pittsburgh Sleep Quality Index (PSQI). Results showed that men reported higher weekly training volume (741.3 ± 987.9 km) compared to women (595.2 ± 344.2 km). Male triathletes also exhibited poorer sleep quality (PSQI score = 6.31 ± 2.4) than females (5.21 ± 2.0), although both groups indicated overall poor sleep quality. No significant correlations were observed between PSQI scores and training volumes across disciplines or total training volume in either sex. Also, sleep duration before the longest training session showed weak, non-significant correlations with session volume. In conclusion, despite high training loads and poor sleep quality, no inverse relationship was identified between training volume and sleep variables in amateur triathletes. Limitations include the cross-sectional design and reliance on self-reported measures. In practical terms, the findings highlight that sleep quality issues in triathletes may not be directly attributable to training volume, suggesting other contributing factors. This study provides original evidence addressing a gap in the literature by clarifying the lack of association between sleep and training demands in endurance athletes.

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INTRODUCTION

Triathlon is a sport consisting of swimming, cycling, and running stages, with two transitions between stages (T1 and T2) (Bentley et al., 2002). Triathlon distances range from the shortest, the super sprint, which consists of a 300 m swim, a 6.6 km bike ride, and a 1 km run; to the longest, the Ultraman, which involves a 10 km swim, a 426 km bike ride, and an 85 km run, carried out over three days (Knechtle & Nikolaidis, 2016). Given the wide range of triathlon distances, even the shortest format includes a relatively high total distance, necessitating high training volumes to maintain and/or improve athletic performance (Vleck et al., 2010). While training volume is crucial for performance in this sport, other fac-

tors, sleep quality in particular, also warrant attention (Sinisgalli et al., 2021).

Sleep quality and duration can influence sports performance in two distinct ways. When athletes achieve adequate sleep quality and duration, it promotes better recovery (Fullagar et al., 2015), helps maintain balanced strength levels, and supports body weight regulation (Gonnissen et al., 2013). Conversely, poor sleep quality combined with short sleep duration is associated with higher injury risk indicators (Charest & Grandner, 2022) and increased incidence of illness (Botonis & Toubekis, 2023; Robinson et al., 2021). It also impairs cognitive (Akazawa et al., 2019) and physical performance (Mah et al., 2018). These effects are well-documented in the endurance sports literature (Antunes et al., 2017); however, evidence linking sleep and triathlon performance remains limited.

In a study by Sinisgalli et al. (2021), inadequate sleep duration was observed in male and female amateur triathletes participating in a half Ironman race. However, this study did not explore the association between sleep duration and athletic performance. Moreover, Sinisgalli et al. (2021) faced a significant limitation in measuring sleep duration, as no specific instrument was used. Instead, sleep was categorized into duration ranges (<3 h, 4–6 h, 7–8 h, or ≥9 h per night) rather than measured as a total duration. In this context, the use of validated and reliable instruments is essential, such as the Pittsburgh Sleep Quality Index (PSQI), which assesses various sleep-related components and generates an overall classification score.

Regarding the relationship between sleep and performance in ultra-distance triathlon, Kisiolek et al (Kisiolek et al., 2022) found a negative association between sleep duration and performance, indicating that athletes with shorter sleep durations experienced reduced performance in competition. However, the literature remains unclear on whether sleep quality and duration correlate with triathlon training volume, as both adequate and inadequate sleep may affect the training process and performance in different ways.

Thus, this study aimed to analyze whether there is an association between sleep quality in the previous month and training volume for each triathlon stage and the total triathlon volume. Additionally, it aimed to investigate whether sleep duration on the night before a long training session correlates with the total volume achieved in that session.

METHODOLOGY

Participants and Ethical Aspects

The total sample consisted of 151 trained amateur triathletes, 43 females, and 108 males. These volunteers are classified as trained amateurs because they participate in local championships, train at least three times per week, specifically identify with triathlon, have competitive goals, and are developing specific skills for triathlon (McKay et al., 2022). The athletes' characterization data are presented in Table 1. All volunteers agreed to participate in the study after being informed of the objectives and signing the informed consent form. This research was approved by the ethics committee of the State University of Campinas under opinion no. 4.749.908.

Table 1. *Mean and standard deviation of age, training experience, and training sessions per week.*

	Age	Training Experience	Training Sessions
Female	39.33 ±7.6 years	58.2 ±40.3 months	6.5 ±1.6 sessions
Male	38.59 ±8.1 years	69.4 ±74.7 months	7.8 ±1.8 sessions

Procedures

All triathletes were contacted via social networks or through coaching groups and sports teams. After agreeing to participate, the volunteers completed two questionnaires. One questionnaire collected data on training volumes in kilometers completed over the past month, as well as during the last long training session. Additionally, participants were instructed to refer to their training logs and tracking tools to improve the reliability of their responses. Data on sleep quality were collected using the PSQI-Br instrument, along with information on bedtime and wake-up time on the night before the last long training session. The instruments are described in greater detail in the following section.

Instruments

The volunteers completed a questionnaire that recorded the total volume in kilometers completed over the last month for each triathlon stage: swimming, cycling, and running. The sum of these volumes represented the total training volume for the past month. Additionally, the volunteers recorded the total volume of their last long training session and their bedtime and wake-up times on the night before this session.

Sleep quality was assessed with the Pittsburgh Sleep Quality Index (PSQI), developed by Buysse et al. (Buysse et al., 1989) and validated in Portuguese by Bertolazi et al. (Bertolazi et al., 2011), referred to as PSQI-Br. This self-reported questionnaire evaluates sleep quality over the previous 30 days through 19 items covering seven components of sleep quality: subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction. Each component generates a score that, when combined, yields the overall sleep quality classification. Scores below five indicate good sleep quality, classifying individuals as good sleepers, while scores of five or higher indicate poor sleep quality, identifying individuals as poor sleepers. The higher the total score, the worse the sleep quality. To verify instrument reliability, Cronbach's alpha coefficient was calculated (Landis & Koch, 1977), yielding a value of 0.71.

Statistical Analysis

Mean and standard deviation were used to describe the variables. The Shapiro–Wilk test was applied to assess normality. Since the data did not meet the normality assumption, Spearman's correlation was used to assess the association between the variables of interest. A significance level of $p \leq .05$ was adopted. All analyses were conducted using IBM SPSS version 23.0 statistical package.

RESULTS

Table 2 below presents data related to the volumes of long training sessions, as well as swimming, cycling, running, and total training volume. It should be noted that the standard deviations for total volume and cycling exceeded the means, indicating a large degree of variation in the analyzed population.

Table 2. *Mean and standard deviation of long training volume, swimming, cycling, running, and total volume.*

	Volume (km)				
	Long Training	**Swimming**	**Cycling**	**Running**	**Total**
Female	68.3 ±42.5	20.5 ±16.6	464.9 ±328.1	109.7 ±63	595.2 ±344.2
Male	70.9 ±44.3	20.7 ±14.2	604.7 ±962.1	115.8 ±70.2	741.3 ±987.9

Data regarding sleep quality and duration are shown in Table 3 below. The analysis of the total PSQI-Br data reveals that both male and female triathletes exhibit poor sleep quality.

Table 3. *Mean and standard deviation of bedtime, time taken to sleep, wake-up time, hours of sleep per night, PSQI-Br total scores and duration of sleep before long training.*

	PSQI 1	PSQI 2	PSQI 3	PSQI 4	PSQI-Br	Duration of sleep before long training
	Bedtime	Time taken to sleep	Wake-up time	Hours of sleep per night	Total scores	
Female	22.3 ±0.8 hrs	14.5 ±11.6 min	5.1 ±0.86 hrs	6.5 ±1 hrs	5.21 ±2	7.13 ±1.2 hrs
Male	22.2 ±2.2 hrs	20.3 ±14.7 min	5.59 ±1.2 hrs	6.4 ±0.9 hrs	6.31 ±2.4	7.10 ±1.3 hrs

The Spearman correlation between sleep duration the night before a long training session and the volume of that training session showed the following results: for females, r = .18 and p = .9; for males, r = -.09 and p = .3. These results indicate weak, non-significant correlations.

The correlations between swimming, cycling, running, and total volume and the overall PSQI-Br score were not significant, as shown in Table 4.

Table 4. *Spearman correlation coefficient, between PSQI-Br, with swimming, cycling, running and total volumes.*

		Swimming Volume	Cycling Volume	Running Volume	Total Volume
PSQI-Br	Female	-.13	-.14	-.11	-.16
	Male	-.17	-.12	-.22	-.16

DISCUSSION

The aim of this study was to analyze whether there is an association between sleep quality and duration, and training volume, in trained male and female amateur triathletes. The results showed that both groups had poor sleep quality and inadequate sleep duration the night before longer training sessions. However, no correlation was found between sleep quality and duration and training volumes.

In triathlon, regardless of race distance, the typical pattern is that swimming involves the shortest distances, cycling the longest, and running intermediate distances (Millet & Vleck, 2000). This distribution helps explain the training volumes found among the triathletes in this study. Another factor that may account for the high training volumes, particularly in cycling and total volume, is that higher total training volumes yield more specific adaptations for triathlon (Cejuela & Sellés-Pérez, 2022). Additionally, training volumes are strong predictors of performance in long-distance events (Knechtle & Nikolaidis, 2016).

Both male and female groups demonstrated poor sleep quality, a pattern observed at all athlete levels (Swinbourne et al., 2016) and in both sexes (Carter et al., 2020). Poor sleep quality is a risk factor for illness and impaired recovery after training, particularly for amateur athletes (Simpson et al., 2017), and it negatively impacts sports performance (Malhotra, 2017).

Sleep duration on the night before long training sessions was under 7 hours and 30 minutes for both groups, which can negatively affect endurance performance (Antunes et al., 2017; Roberts et al., 2019; Souissi et

al., 2020). Evidence suggests that even amateur triathletes would benefit from sleeping 8 hours or more (Roberts et al., 2019; Sargent et al., 2021), especially before high-volume training sessions. Therefore, implementing sleep hygiene protocols could be a practical, low-cost approach to improving sleep quality and duration in these athletes (Fullagar et al., 2015; Knufinke et al., 2018).

No correlation was found between sleep quality and duration and the measured training volumes. However, considering the PSQI-Br total score, the average sleep duration over the last month, and the sleep duration the night before the long training session, we observe a pattern similar to that described by Sargent, Halson, and Roach (Sargent et al., 2021), where athletes wake up earlier to start training, consequently reducing sleep duration to accommodate higher training volumes.

The high injury rate in triathlon (Kienstra et al., 2021) and the association of these injuries with high training volumes (Kienstra et al., 2017) suggest that poor sleep quality and inadequate sleep duration before long training sessions should be considered risk factors for injuries. The literature suggests a link between poor sleep quality, insufficient sleep duration, and an increased risk of injury (de Sousa Nogueira Freitas et al., 2020; Grier et al., 2020; Haraldsdottir et al., 2021).

The primary limitations of this study include an imbalance between male and female participants, which prevented statistical comparisons between the sexes, and the use of indirect sleep assessments (questionnaires and diaries), which are limited relative to direct measures (such as polysomnography and actigraphy).

In conclusion, no correlation was found between sleep quality and duration, and training volume in male and female triathletes. Both poor sleep quality and inadequate sleep duration were observed on the night before long training sessions. These sleep indicators, along with the high training volumes common in triathlon, may pose health risks to athletes and are directly linked to reduced physical performance. Implementing educational initiatives to encourage adherence to sleep hygiene protocols may effectively improve sleep quality and duration among triathletes.

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Conflict of Interests

The authors have no conflicts of interest to declare.

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