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Sleep Quality in CrossFit: A Cross-Sectional Study

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Abstract

Objective Based on the relationship between sleep and sports performance, the present study aimed to evaluate sleep quality and excessive daytime sleepiness among adult CrossFit (CrossFit, LLC, Santa Cruz, CA, USA) practitioners and to verify possible associations with intestinal health.

Methods This cross-sectional study involved males and females aged $\geq$ 18 years who had been regularly practicing CrossFit for at least 3 months. This survey used an online questionnaire addressing demographic and socioeconomic data, disease history, dietary characteristics, and questions regarding CrossFit. To assess intestinal health, the ROME IV Consensus Criteria and Bristol Scale were used. The Pittsburgh International Sleep Quality Index (PSQI-BR) and Epworth Sleepiness Scale were used to assess sleep quality.

Results A total of 1,090 people (73.3% females) with a mean age of 31.2 $\pm$ 7.5 years were included. Considering the diagnosis of constipation, 36.9% of the patients were classified as constipated, especially females when compared with males ($p < 0.001$). On the sleepiness scale, 22.4% of the volunteers showed excessive daytime sleepiness, which was also observed more frequently among females ($p = 0.013$). In the PSQI-BR, 47.4% of participants were classified as having poor sleep quality (poor sleepers). The overall PSQI-BR score was 5.81 $\pm$ 2.85, with no difference between males and females ($p = 0.360$). There was a positive correlation between the PSQI-BR global score and a diagnosis of constipation and excessive daytime sleepiness. There was a negative correlation between the stool type on the Bristol scale and the PSQI-BR global score.

Conclusion The present study demonstrated that sleep quality was poor among CrossFit users, especially females, which can compromise their training performance.

Keywords
- sleep
- sleep quality
- high-intensity interval training
- disorders of excessive somnolence

Introduction

CrossFit (CrossFit, LLC, Santa Cruz, CA, USA) was founded in 1996 by the gymnast Greg Glassman, who presented a training proposal in which the main objective was to vary the exercises, using the whole body, in a shorter activity time, with high-intensity and high-volume repetition exercises.[1] CrossFit training improves physical abilities, including aerobic capacity, strength, muscular endurance, speed, coordination, agility, and balance.[2,3] The exercises proposed in training are functional

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exercises, Olympic weightlifting, gymnastic movements, and aerobic conditioning, which can be practiced at a high intensity.[1,3]

It is understood that diet and training alone are inadequate for improving sports performance. The importance of sleep for athletes and physical activity practitioners is being increasingly discussed in the literature.[4,5] Training creates an environment of stress, and sleep plays a fundamental role in athletes' recovery. The importance of quality sleep for sports performance goes beyond recovery, as it also plays a fundamental role in the athlete's psychophysiological state. It is helpful in physical recovery and directly improves cognition, mood, reaction time, and decisions.[5–7]

Hormones are also released during sleep, such as growth hormone (GH), which is secreted during the slow-wave phase of sleep.[8] In addition to being crucial for growth, GH participates in an important axis called GH/IGF-1, which stimulates cell growth, reduces fat percentage through mobilization and oxidation of fat, and increases energy expenditure.[8,9]

Sleep deprivation in athletes can affect performance in different ways, as it affects central fatigue, neuromuscular responses, cognitive control, and the subjective perception of exertion.[4] These effects lead to early muscle fatigue, which may impair performance in physical training, increase the subjective perception of exertion, impact execution and load on training and reaction time of activities, reduce cognitive capacity, and affect attention and quick decision-making capacity in athletes.[4,5,10]

Postexercise recovery is critical for all athletes and physically active individuals.[4] An imbalance between training stress and physical recovery can compromise performance in subsequent training sessions. Muscle fatigue and delayed-onset muscle soreness impair sleep.[11] Furthermore, sleep deprivation is associated with increased catabolic hormones and decreased anabolic hormones, impaired muscle protein synthesis, and impaired training adaptations and recovery.[12] The importance of improving sleep quality among athletes is increasingly being discussed, and efforts are being made to spread awareness regarding the importance of adopting sleep hygiene strategies.[4,12]

An important aspect of sleep quality is gut health. It is known that there is communication between the intestine and the brain, known as the gut-brain axis. Changes in this communication and alterations in the microbiota composition have been observed in diseases such as depression, anxiety, and insomnia, among others, and may be associated with poor sleep quality.[13,14] A gut with dysbiosis can produce free radicals and inflammatory cytokines, impairing the quality of sleep. Likewise, fragmented sleep and sleep deprivation are associated with the development of dysbiosis, which can happen due to activation of the hypothalamic-pituitary-adrenal axis.[15] And when training and exercise variables are included, this association between sleep and gut health needs to be carefully evaluated, since higher intensity exercises can promote changes in the microbiota, which can impact sports performance.[16]

Even in non-athletic, physically active individuals, improving sleep quality is important because of the role of sleep in performance, recovery, and quality of life.[4,9,11] Therefore, the present study aimed to evaluate sleep quality and excessive daytime sleepiness in adult CrossFit practitioners and verify possible associations with intestinal health.

Materials and Methods

Study Design

This cross-sectional study was conducted through online interviews with CrossFit practitioners to evaluate sleep quality in this population between February and April 2022. This study was approved by the Ethics Committee of the institution (#5.180.521, CAAE 53658421.4.0000.5105). All participants signed an informed consent form after receiving explanations regarding the research objectives and methods.

Participants

This study involved convenience sampling, and all those who agreed to participate were analyzed according to the inclusion and exclusion criteria. Individuals who had been practicing CrossFit for at least 3 months, aged between 18 and 60 years of both sexes, and who signed the informed consent form were selected. Individuals who did not complete the survey questionnaire or did not fit the study age group were excluded from the study.

Data Collection

Participants answered an online questionnaire with demographic and anthropometric data, disease history, dietary intake, and data regarding gut health. The volunteers were asked about their current weight and height, and their body mass index (BMI) was calculated as proposed by the World Health Organization (WHO).[17] In this study, BMI was categorized as underweight, normal weight (eutrophic), overweight, and obese (all obesity categories together) for the classification of nutritional status, according to the classification proposed by the WHO.[17]

Regarding CrossFit training, the volunteers were asked about the weekly training frequency, duration of each training session, how long they had been training, whether they participated in competitions, and their goals with training. Additionally, they were asked about their participation in any other physical activity tasks in addition to CrossFit.

Gut health was assessed using the ROME IV consensus criteria and the Bristol scale. According to the authors,[18,19] the ROME IV consensus allows the diagnosis of constipation and should be used alongside the Bristol scale for interpretation. The ROMA IV criteria[19] represent a standardized and internationally accepted questionnaire to diagnose functional constipation and are based on six symptoms: less than three evacuations per week, straining to evacuate, presence of hard or lumpy stools, sensation of incomplete evacuation, sensation of anorectal obstruction or blockage, and need of manual maneuvers to facilitate defecations. Those individuals who present two or more of these symptoms in at least one quarter

of the evacuations, reported in the last 3 to 6 months, are considered constipated.[19] The Bristol scale[18] classifies stools in types 1 to 7, based on the shape, consistency, and appearance of the stool. By using the visual scale, the volunteer can identify which number their stools fall under. Lower values on the scale are associated with constipation and higher values with diarrhea.[18,19] Volunteers were also asked how they rated their gut function as well as the highest number of consecutive days without bowel movements.

Sleep quality was assessed using the validated international questionnaire Pittsburgh scale, or Pittsburgh Sleep Quality Index (PSQI-BR), which involves sleep-related questions and allows the classification of individuals as having good or poor sleep quality.[20] It assesses sleep quality over a 1-month time interval, and it can be easily understood and answered. Individuals with a global score > 5 are classified as poor sleepers, and those with a global score ≤ 5 are classified as good sleepers.[20] Additionally, the Epworth Sleepiness Scale, also validated in Portuguese for use in Brazilians, was used to assess excessive daytime sleepiness.[21] It is a self-administered questionnaire that assesses the probability of falling asleep in eight situations involving daily activities, such as sitting and reading; watching TV; sitting, inactive in a public place; as a passenger in a car for an hour without a break; lying down to rest in the afternoon when circumstances permit; sitting and talking to someone; sitting quietly after a lunch without alcohol; and in a car, while stopped for a few minutes in traffic. The overall score ranges from 0 to 24, with scores above 10 suggesting the diagnosis of excessive daytime sleepiness. The higher the global score on this questionnaire, the greater the daytime sleepiness.[21]

Statistical Analysis

The database was created using Microsoft Excel (Microsoft Corp., Redmond, WA, USA) and analyzed using the IBM SPSS Statistics for Windows, version 19.0 (IBM Corp., Armonk, N.Y., USA). The Shapiro-Wilk test was used to assess normality. Qualitative (categorical) variables are described using absolute and relative frequencies (percentages). Quantitative variables with a normal distribution are presented as means and standard deviations. Quantitative variables with normal distribution were compared using the Student t-test for independent samples. Categorical variables were compared using the Pearson Chi-square or Fisher exact test. A Pearson correlation analysis was also performed to verify the associations between sleep quality and other research variables. Results with a significance level of 95% (p-value ≤ 0.05) were considered statistically significant.

Results

Initially, the survey received 1,120 responses to the questionnaire. After excluding duplicates and analyzing the exclusion criteria, 1,090 volunteers practicing CrossFit, of both genders, were included. Among the survey participants, 799 were females (73.3%) and 291 were males (26.7%). The mean age was 31.2 ± 7.5 years, with no difference between males and females ($p = 0.111$). ►**Table 1** presents the general and anthropometric characteristics of the study participants. There was no difference in terms of alcohol consumption between the sexes. Differences in weight, height, and BMI were as expected upon comparing males and females. Smoking status was different between males and females ($p = 0.001$).

When questioned about the presence of diseases, 693 volunteers (63.6%) reported no diseases. In contrast, 311 (28.5%) reported anxiety, 66 (6.1%) depression, 57 (5.2%) joint problems, 28 (2.6%) dyslipidemia, 25 (2.3%) high blood pressure, 8 (0.7%) cardiovascular disease, and 7 (0.6%) diabetes. Regarding medication use, 715 (65.6%) reported that they did not use any medication. Furthermore, 84 (7.7%) volunteers used anxiolytics, 43 (3.9%) used antidepressants, 41 (3.8%) used anabolic steroids, 19 (1.7%) used appetite suppressants, 18 (1.7%) used antihypertensives, 17 (1.6%) used hypoglycemic agents, and 7 (0.6%) were consuming statins. Among the females, 222 (27.8%) reported the use of contraceptives.

In terms of the characteristics of the volunteers' diet, most CrossFit practitioners (49.9%) classified their diet as good but with points to improve, with no differences between males and females ($p = 0.179$). Most (83.9%) volunteers had already consulted a nutritionist, but only 54.8% were currently following the diet. Females followed diets more commonly than males (57.4% and 47.4%, respectively; $p = 0.003$).

When asked about the use of supplements, 764 volunteers (70.1%) said they currently consumed some supplements; in contrast, 326 (29.9%) did not use these products. Among males, 210 (72.2%) said they currently consumed a supplement. Among females, 554 (69.3%) said they used a supplement, with no differences between sexes regarding its use ($p = 0.367$). The most commonly consumed supplements were whey protein (52.3%), creatine (51.6%), glutamine (24.4%), preworkouts (18.9%), vitamin D (18.2%), and omega 3 (17.1%).

Regarding physical activity, ►**Table 2** presents the details of the volunteers' CrossFit training. When asked if they participated in any other physical activity besides CrossFit, 562 (51.6%) participants answered yes. Among the activities performed in addition to CrossFit, 251 (23%) said they practiced bodybuilding, 223 (20.5%) practiced running, 120 (11%) participated in team sports such as volleyball or soccer, 100 (9.2%) rode bicycles, 47 (4.3%) performed swimming, 43 (3.9%) participated in fight sports, and 14 (1.3%) played tennis.

On the Epworth Sleepiness Scale (ESS-BR), of the total sample, 244 (22.4%) volunteers showed excessive daytime sleepiness. Females had a higher prevalence of excessive daytime sleepiness than males practicing CrossFit (24.3% and 17.2%, $p = 0.013$). The ESS-BR global score was 6.6 ± 3.8, with no statistical difference between males and females (6.3 ± 3.3 and 6.7 ± 3.9, respectively, $p = 0.102$).

In the analysis of sleep quality using the PSQI-BR, 517 volunteers (47.4%) were classified as having poor sleep quality. ►**Table 3** presents the scores by domain and an overall score of the PSQI-BR questionnaire. A comparison

Table 1 General and anthropometric characteristics of CrossFit practitioners.

Characteristics	TOTAL (n = 1,090)	WOMEN (n = 799)	MEN (n = 291)	*P*-value[#]
Age (years)				
Mean ± SD	31.2 ± 7.5	31.0 ± 7.6	31.8 ± 7.3	0.111
Height (m)				
Mean ± SD	1.67 ± 0.09	1.63 ± 0.06	1.77 ± 0.07	< **0.001**
Weight (kg)				
Mean ± SD	71.5 ± 14.1	66.5 ± 10.9	85.1 ± 12.8	< **0.001**
BMI (kg/m^2)				
Mean ± SD	25.6 ± 3.8	25.0 ± 3.6	27.2 ± 3.6	< **0.001**
BMI categories – n (%)				< **0.001**
Low weight (BMI < 18.5 kg/m^2)	7 (0.7%)	6 (0.7%)	1 (0.3%)	
Normal weight (18.5 ≤ BMI < 25.0 kg/m^2)	539 (49.4%)	461 (57.7%)	78 (26.8%)	
Excess of weight (25.0 ≤ BMI < 30.0 kg/m^2)	420 (38.5%)	258 (32.3%)	162 (55.7%)	
Obesity (BMI ≥ 30.0 kg/m^2)	124 (11.4%)	74 (9.3%)	50 (17.2%)	
Smoking – n (%)				**0.001**
Yes	58 (5.3%)	34 (4.3%)	24 (8.2%)	
No	961 (88.2%)	722 (90.3%)	239 (82.2%)	
Yes, in the past, but not actually	71 (6.5%)	43 (5.4%)	28 (9.6%)	
Alcohol beverage consumption – n (%)				0.114
Yes	662 (60.7%)	474 (59.3%)	188 (64.6%)	
No	428 (39.3%)	325 (40.7%)	103 (35.4%)	

Abbreviations: BMI, body mass index; kg, kilogram; m, meter; SD, standard deviation.
[#]Student t-test for independent samples and Pearson Chi-square or Fisher exact test for categorical samples.

between males and females revealed a statistically significant difference only in sleep duration and daytime dysfunction domains. Female practitioners of CrossFit had better sleep duration than males ($p < 0.001$), while males had fewer dysfunctions throughout the day ($p < 0.001$). However, there was no significant difference in the global score between males and females ($p = 0.360$).

►**Table 4** presents the categorization of volunteers in each domain of the PSQI-BR, with the total prevalence comparing males and females. Differences between the groups confirm the findings in ►**Table 3**, as there was a significant difference between males and females in the domains of sleep duration and daytime disorders, especially in the difficulty of maintaining enthusiasm to perform usual activities. However, regarding the categorization of volunteers into good and bad sleep quality according to the global score, there was no significant difference between males and females ($p = 0.678$).

Participants were also assessed for bowel function and health. When asked about bowel function, 74.1% reported adequate daily functioning, 23.1% said they went for more than one day without a bowel movement, and 2.8% had liquid stools several times throughout the day. There was a statistically significant difference in the categorization between males and females ($p < 0.001$), in which the prevalence of adequate bowel function was higher among males (91.1% vs. 68%), and trapped bowel was more common among females (29.2% vs. 6.2%).

When asked about the highest number of consecutive days without a bowel movement, 798 (73.2%) said they had gone 2 days or less, 192 (17.6%) from 2 to 4 days without defecation, 77 (7.1%) between 4 days and 1 week, 19 (1.7%) between 1 and 2 weeks, and 4 (0.4%) for more than 2 weeks. The number of days without defecation was greater among females than among males ($p < 0.001$).

Based on the ROME IV criteria, 402 volunteers (36.9%) were classified as having constipation. This diagnosis rate was higher among females than males who practiced CrossFit (43.8% vs. 17.9%, $p < 0.001$). There was a significant difference between the types of stools ($p < 0.001$), with a higher prevalence of types 1 and 2 among females than among males, which corroborates the higher diagnosis of constipation already described above (►**Table 5**).

In the correlation analysis, the PSQI-BR global score did not correlate with age, sex, weight, and BMI among all CrossFit practitioners. However, there was a positive correlation between the sleepiness scale ($r = 0.100$, $p = 0.001$) and all PSQI-BR domains (►**Figure 1**). Sleep quality, according to the PSQI-BR global score, also showed a positive correlation with the volunteers' classification of bowel function ($r = 0.121$, $p < 0.001$), with the highest number of days without a bowel movement ($r = 0.110$, $p < 0.001$), and the sum of ROMA IV criteria for constipation ($r = 0.201$, $p < 0.001$). A negative correlation was observed between the PSQI-BR global score and stool type on the Bristol scale

Table 2 CrossFit training characteristics of volunteers.

Characteristics	TOTAL (n = 1,090)	WOMEN (n = 799)	MEN (n = 291)	*P*-value[#]
How many days a week do you practice CrossFit? – n (%)				0.845
1–2 days	35 (3.2%)	26 (3.3%)	9 (3.1%)	
3–4 days	351 (32.2%)	261 (32.7%)	90 (30.9%)	
5 or more days	704 (64.6%)	512 (64.0%)	192 (66.0%)	
How many hours a day does your CrossFit training last? – n (%)				**0.036**
< 1 h/day	380 (34.9%)	275 (34.4%)	105 (36.1%)	
1–2 h/day	671 (61.6%)	502 (62.8%)	169 (58.1%)	
> 2 h/day	39 (3.5%)	22 (2.8%)	17 (5.8%)	
How long have you been training CrossFit? – n (%)				**<0.001**
3–6 months	182 (16.7%)	141 (17.6%)	41 (14.1%)	
6–12 months	236 (21.7%)	189 (23.7%)	47 (16.2%)	
1–2 years	248 (22.7%)	188 (23.5%)	60 (20.6%)	
> 2 years	424 (38.9%)	281 (35.2%)	143 (49.1%)	
Do you participate in CrossFit competitions? – n (%)				**< 0.001**
Yes	362 (33.2%)	235 (29.4%)	127 (43.6%)	
No	728 (66.8%)	564 (70.6%)	164 (56.4%)	
Category in CrossFit – n (%)				**< 0.001**
RX	190 (17.4%)	89 (11.2%)	101 (34.7%)	
Scale	586 (53.8%)	450 (56.3%)	136 (46.8%)	
Elite	29 (2.7%)	21 (2.6%)	8 (2.7%)	
Beginner	285 (26.1%)	239 (29.9%)	46 (15.8%)	
Purpose when practicing CrossFit (multiple responses) – n (%)				**0.046**
Hypertrophy	343 (31.5%)	247 (30.9%)	96 (33.0%)	
Weight loss	491 (45.0%)	382 (47.8%)	109 (37.5%)	
Health	856 (78.5%)	635 (79.5%)	221 (75.9%)	
Aesthetics	491 (45.0%)	361 (45.2%)	130 (44.7%)	
Performance in competitions	263 (24.1%)	160 (20.0%)	103 (35.4%)	

[#]Pearson Chi-square or Fisher exact test for categorical samples.

Table 3 Global Score and by domain on the Pittsburgh Sleep Quality Index (PSQI-BR).

Domain	TOTAL (n = 1,090) Mean ± SD	WOMEN (n = 799) Mean ± SD	MEN (n = 291) Mean ± SD	*P*-value[#]
Subjective sleep quality	1.01 ± 0.70	1.00 ± 0.71	1.03 ± 0.67	0.620
Sleep latency	1.14 ± 0.96	1.17 ± 0.96	1.05 ± 0.96	0.079
Sleep duration	0.89 ± 0.67	0.84 ± 0.66	1.02 ± 0.67	**< 0.001**
Usual sleep efficiency	0.34 ± 0.68	0.35 ± 0.68	0.34 ± 0.68	0.852
Sleep disorders	1.20 ± 0.49	1.21 ± 0.50	1.17 ± 0.47	0.229
Sleeping medication	0.27 ± 0.75	0.28 ± 0.76	0.25 ± 0.70	0.551
Daytime dysfunction	0.96 ± 0.67	1.01 ± 0.68	0.82 ± 0.63	**< 0.001**
GLOBAL SCORE	**5.81 ± 2.85**	**5.86 ± 2.90**	**5.68 ± 2.73**	0.360

Abbreviation: SD, standard deviation.
[#]Student t-test for independent samples.

Table 4 Domain categorization on the Pittsburgh Sleep Quality Index (PSQI-BR).

Components	TOTAL (n = 1090)	WOMEN (n = 799)	MEN (n = 291)	*P*-value[#]
Domain 1: Subjective sleep quality – n (%)				0.538
Very good	238 (21.8%)	181 (22.7%)	57 (19.6%)	
Good	625 (57.3%)	452 (56.6%)	173 (59.5%)	
Bad	205 (18.8%)	148 (18.5%)	57 (19.6%)	
Very bad	22 (2.1%)	18 (2.2%)	4 (1.3%)	
Domain 2: Sleep latency – Minutes to fall asleep – n (%)				0.182
≤ 15 minutes	572 (52.5%)	404 (50.6%)	168 (57.7%)	
16-30 minutes	356 (32.7%)	271 (33.9%)	85 (29.2%)	
31-60 minutes	59 (5.4%)	47 (5.9%)	12 (4.2%)	
> 60 minutes	103 (9.4%)	77 (9.6%)	26 (8.9%)	
Domain 2: Sleep latency – Took > 30 min to fall asleep – n (%)				0.288
Not once in the last month	371 (34.1%)	259 (32.4%)	112 (38.5%)	
Less than once a week	328 (30.1%)	247 (30.9%)	81 (27.8%)	
Once or twice a week	251 (23.0%)	186 (23.3%)	65 (22.3%)	
Three or more times a week	140 (12.8%)	107 (13.4%)	33 (11.4%)	
Domain 3: Sleep duration – n (%)				**< 0.001**
> 7 hours	281 (25.8%)	231 (28.9%)	50 (17.2%)	
6-7 hours	679 (62.2%)	481 (60.2%)	198 (68.0%)	
5-6 hours	101 (9.3%)	71 (8.9%)	30 (10.3%)	
< 5 hours	29 (2.7%)	16 (2.0%)	13 (4.5%)	
Domain 4: Usual sleep efficiency – n (%)				0.595
> 85%	823 (75.5%)	602 (75.3%)	221 (75.9%)	
75–84%	180 (16.5%)	131 (16.4%)	49 (16.8%)	
65–74%	67 (6.1%)	53 (6.6%)	14 (4.8%)	
< 65%	20 (1.9%)	13 (1.7%)	7 (2.5%)	
Domain 5: Sleep disorders – n (%)				0.362
Not once in the last month	39 (3.6%)	27 (3.4%)	12 (4.1%)	
Less than once a week	803 (73.7%)	585 (73.2%)	218 (74.9%)	
Once or twice a week	241 (22.1%)	180 (22.5%)	61 (21.0%)	
Three or more times a week	7 (0.6%)	7 (0.9%)	0	
Domain 6: Sleep medication – n (%)				0.835
Not once in the last month	936 (85.9%)	685 (85.7%)	251 (86.3%)	
Less than once a week	69 (6.3%)	49 (6.1%)	20 (6.9%)	
Once or twice a week	30 (2.8%)	22 (2.8%)	8 (2.7%)	
Three or more times a week	55 (5.0%)	43 (5.4%)	12 (4.1%)	
Domain 7: Daytime dysfunction – Difficulty staying awake – n (%)				0.555
Not once in the last month	756 (69.4%)	550 (68.8%)	206 (70.8%)	
Less than once a week	245 (22.5%)	178 (22.3%)	67 (23.0%)	
Once or twice a week	70 (6.4%)	56 (7.0%)	14 (4.8%)	
Three or more times a week	19 (1.7%)	15 (1.9%)	4 (1.4%)	

(*Continued*)

Table 4 (*Continued*)

Components	TOTAL (n = 1090)	WOMEN (n = 799)	MEN (n = 291)	*P*-value[#]
Domain 7: Daytime dysfunction – Problem maintaining enthusiasm in usual activities – n (%)				**< 0.001**
No problem	296 (27.2%)	191 (23.9%)	105 (36.1%)	
Just a small problem	548 (50.3%)	414 (51.8%)	134 (46.0%)	
A certain problem	194 (17.7%)	147 (18.4%)	47 (16.2%)	
A very big problem	52 (4.8%)	47 (5.9%)	5 (1.7%)	
GLOBAL SCORE				0.678
Good sleepers (good sleep quality)	573 (52.6%)	417 (52.2%)	156 (53.6%)	
Poor sleepers (poor sleep quality)	517 (47.4%)	382 (47.8%)	135 (46.4%)	

[#]Pearson Chi-square or Fisher exact test for categorical samples.

Table 5 Prevalence of types of stools between men and women, according to the Bristol Scale.

	TOTAL (n = 1,090) n (%)	WOMEN (n = 799) n (%)	MEN (n = 291) n (%)	*P*-value[#]
Stool type				**< 0.001**
Type 1	27 (2.5%)	26 (3.3%)	1 (0.3%)	
Type 2	163 (15.0%)	135 (16.9%)	28 (9.6%)	
Type 3	453 (41.6%)	333 (41.7%)	120 (41.2%)	
Type 4	308 (28.3%)	200 (25.0%)	108 (37.1%)	
Type 5	89 (8.2%)	67 (8.3%)	22 (7.7%)	
Type 6	48 (4.4%)	36 (4.5%)	12 (4.1%)	
Type 7	2 (0.2%)	2 (0.3%)	0	

[#]Pearson Chi-square or Fisher exact test for categorical samples.

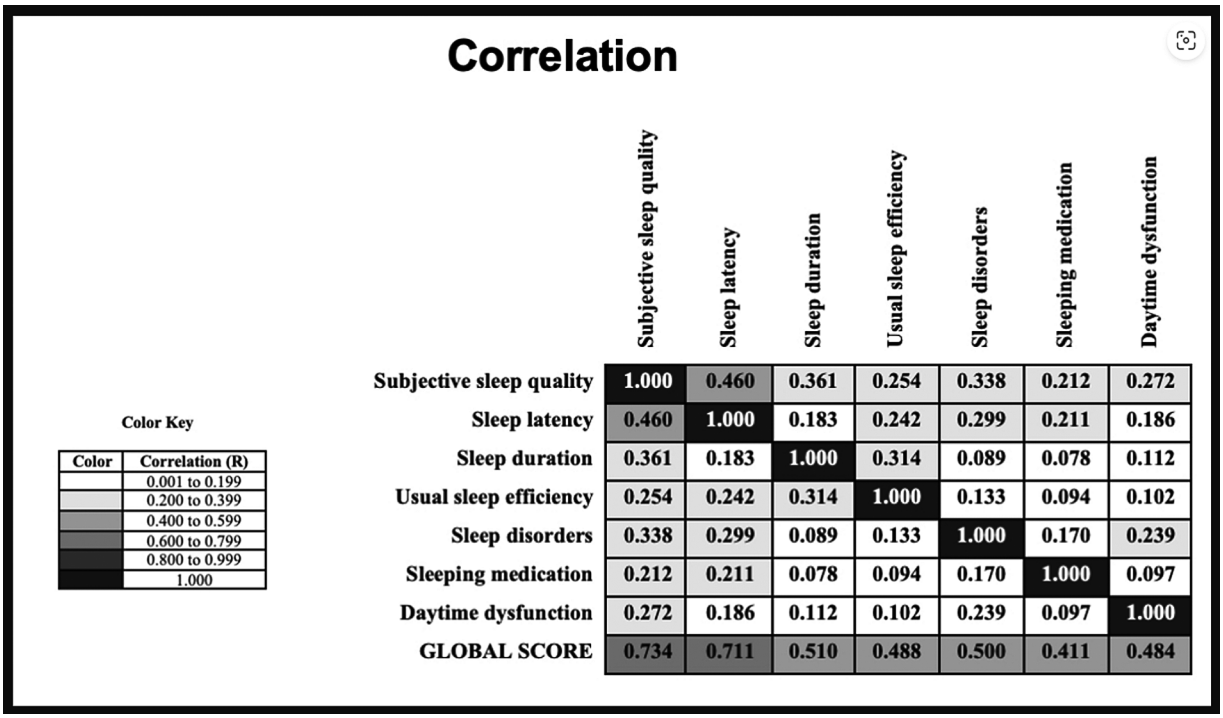

Fig. 1 Correlation coefficient between all domains and with the global score of the PSQI-BR. Pearson correlation test (r-value). All correlations were $p < 0.05$.

($r = -0.100$; $p = 0.001$). These correlations are significant but considered weak.

The PSQI-BR global score did not correlate with characteristics of CrossFit training in our volunteers, as weekly training frequency ($r = 0.008$, $p = 0.798$), duration of training in hours ($r = -0.001$, $p = 0.978$), CrossFit practice time ($r = 0.035$, $p = 0.253$), and participation in competitions ($r = 0.023$, $p = 0.449$). In the stratification by sex, there was also no correlation between the PSQI-BR global score and the CrossFit training characteristics, both for men and women ($p > 0.05$).

Discussion

In this study, we reported an average score of 5.81 ± 2.85 points on the PSQI-BR scale. Among 1,090 participants, 47.4% were classified as having poor sleep quality. Additionally, 22.4% of the participants had excessive daytime sleepiness. Women had better sleep duration than males; however, they had more daytime dysfunctions than males, mainly due to a lack of enthusiasm to perform daily activities.

Only one German study evaluated the quality of sleep in CrossFit practitioners using an online questionnaire. The results obtained in our study are slightly different in absolute terms from the results found by Klier et al.,[22] in which the authors evaluated 149 CrossFit athletes using the PSQI-BR of both sexes and demonstrated that 62% of the participants were classified as having good sleep quality while 38% had poor sleep quality. Compared with our results, most individuals slept well; however, in the results found by Klier et al.,[22] the percentage of individuals with good sleep quality was higher. This fact may be related to the number of weekly workouts and workout intensity since their study did not report these variables and only mentioned the average time of CrossFit practice.[22] Our study did not evaluate sports performance variables in CrossFit and, perhaps, a hypothesis to be better investigated in future studies is that men and women respond differently regarding the impact of training on sleep quality.

Compared with other studies on different sports, a study carried out by Mah et al.,[23] also examining sleep quality through the PSQI-BR, evaluated 628 athletes from 29 sports teams at Stanford University (basketball, golf, gymnastics, rowing, sailing, soccer, swimming and diving, tennis, athletics, volleyball, water polo, baseball, soccer, wrestling, hockey, and softball). They found that 42.2% (approximately 265 participants) were classified as having poor-quality sleep, more similar to our results.

Charest and Grandner analyzed the sleep quality of 317 athletes from 11 different sports activities during the 2016 Rio de Janeiro Olympic Games using the PSQI questionnaire. In addition to the studies already presented, their study showed a prevalence of $> 50\%$ for poor sleep quality after the Olympic games.[24] Their result in different sports is similar to those of our study, which demonstrated 47.4% of poor sleepers, including athletes and practitioners. Sleep quality can be impaired in both elite and amateur athletes, and the reasons for this finding need to be considered by coaches and health professionals.[4]

Most participants were classified as having good sleep quality in our study. The age of the volunteers could explain this high number since the average age of the participants was 31.2 years, an age group often comprised of individuals who combine their social life with work, physical activity, and studies. However, according to Klier et al.,[22] poor sleep can impair physical and mental performance in CrossFit practitioners regardless of age.

To improve training results or reach maximum potential, good physical condition is an inevitable requirement, along with good nutrition and good-quality sleep. Simpson et al.[25] reported a correlation between physical training load and sleep, suggesting that physical training can have an impact on the decrease in the amount of sleep. From this point of view, in our study, nearly 65% of the participants had a training load of more than 5 days a week, and 51.6% had other activity(s) in addition to CrossFit, which may be one of the underlying causes for poor sleep quality; that is, attention must be paid to sleep, to have excellent physical recovery, to avoid possible damage or injury during sports practice, and for better health.

The Epworth Sleepiness Scale is used to assess the degree of daytime sleepiness. In the present study, a significant number of the participants (22.4%) reported excessive daytime sleepiness. According to the PSQI-BR questionnaire findings, females had better sleep duration but more daytime dysfunctions. These results are confirmed when compared with the findings of the study by Otis et al.,[26] in which the group of healthy females, also classified in the present study, 53.4% claimed to have abnormal sleepiness. These results can be justified by numerous reasons, such as the training schedule, daily activities, and increased anxiety; among the general characteristics of the participants, anxiety was the most reported symptom (28.5%).

Anxiety can affect eating, which may lead to an increase or decrease in caloric intake and changes in eating behavior. Food is often used as an escape from reality, stress, and moments of pressure, a scenario that favors the consumption of processed foods mainly because of hedonic hunger.[27–29] In our study, a high prevalence of participants with anxiety (28.5%) was observed, which caught our attention, since 45.2% of the participants did not undergo nutritional monitoring, and the average age among the research participants was 31.2 years old, the age group in which an environment of stress could be favored by the need to reconcile with numerous daily activities. Therefore, there is a great possibility that the volunteers' anxiety affected their eating behavior and, consequently, influenced intestinal health, leading to increased anxiety.

Another point that deserves further discussion is the observed association between bowel function and sleep quality, even if weak. There is a link between gut health and sleep, as there exists a microbiota-intestine-brain axis, demonstrating the interference of irregular functioning of the intestine or dysbiosis compromising sleep, just as poor sleep can worsen dysbiosis.[14,15] Athletes participating in an intense training regimen may experience alterations in gut microbiota, resulting in dysbiosis, which can further reduce their sleep quality.[15,30]

This study, similar to many others, is not free of limitations, such as the use of a convenience sample or even the use of an online questionnaire. The use of self-reported weight and height values for analysis is another limitation. However, in an online survey, self-reported weight and height is only intended to characterize the sample since it is not a good, isolated parameter for physical activity practitioners. This is the first study evaluating sleep quality in Brazilian adults who practice CrossFit, a study with a large number of participants that allows us to understand aspects of sleep affected by the CrossFit regimen. These findings will allow health professionals to develop strategies to improve sleep quality in this population, resulting in better performance and health.

Conclusion

The present study demonstrated a high prevalence of poor sleep quality among CrossFit practitioners. As sleep quality can be a factor in improving CrossFit training performance, attention should be paid to sleep to improve not only performance but also physical and mental health in this population. According to the data collected, females had greater daytime dysfunction and constipation compared to males. New studies are needed to better evaluate the association between sleep and CrossFit, with special attention to differences between males and females.

Authors' Contributions

All authors contributed equally to the manuscript and read and approved the final version of the manuscript.

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Conflict of Interests

The authors have no conflict of interests to declare.

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