PSYCHOMETRIC PROPERTIES OF THE PITTSBURGH SLEEP QUALITY INDEX IN ATHLETES

PROPIEDADES PSICOMÉTRICAS DEL ÍNIDICE DE CALIDAD DE SUEÑO DE PITTSBURGH EN DEPORTISTAS

Favela-Ramírez, CA[1ACDF]; Castro-Robles, AI[2BCD]; Bojórquez-Díaz, CI[3BCE]; Chan-Barocio, NL[4BC]

[1] Instituto Tecnológico de Sonora, México, carlos.favela@itson.edu.mx
[2] Instituto Tecnológico de Sonora, México, alejandra.castro@itson.edu.mx
[3] Instituto Tecnológico de Sonora, México, cecilia.bojorquez@itson.edu.mx
[4] Instituto Tecnológico de Sonora, México, nadia.chan@itson.edu.mx

Responsabilities.
[A] Research design; [B] Data collector; [C] Editor of the paper; [D] Statistical processing; [E] Financial support; [F] Idea original y coordinador de toda la investigación.

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Correspondence:
Carlos Artemio Favela Ramírez. carlos.favela@itson.edu.mx

ABSTRACT

The Pittsburgh Sleep Quality Index (PSQI) is a widely used instrument in clinical and non-clinical populations for the evaluation of sleep quality. The purpose of this work was to determine the factorial structure and internal consistency of the ICSP in university athletes from southern Sonora, Mexico, for the evaluation of the psychometric properties of the instrument. A non-experimental cross-sectional study was carried out with 98 university athletes, 39 women (38.2%), in a range of 17 to 25 years. The internal consistency and homogeneity of the instrument were evaluated, as well as the exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). Reliability results indicated a Cronbach's α of 0.79 after eliminating the components of sleep medication use and habitual sleep efficiency. The EFA identified a two-factor model and the AFC a one-dimensional model. It is concluded that the sleep quality in this sample of athletes is better explained by a unidimensional model of five components.

KEY WORDS: sleep quality, sport, validity and reliability.

RESUMEN

El índice de calidad de sueño de Pittsburgh (ICSP) es un instrumento ampliamente utilizado en poblaciones clínicas y no clínicas para la evaluación de la calidad de sueño. El objetivo de este trabajo fue determinar la estructura factorial y consistencia interna del ICSP en deportistas universitarios del sur de Sonora México para la evaluación de las propiedades psicométricas del instrumento. Se realizó un estudio transversal no experimental con 98 deportistas universitarios, 39 mujeres (38,2%), en un rango de 17 a 25 años. Se evaluó la consistencia interna y homogeneidad del instrumento, así como los análisis factorial exploratorio (AFE) y confirmatorio (AFC). Los resultados de confiabilidad indicaron un α de Cronbach de 0,79 eliminando los componentes de uso de medicamentos para dormir y eficiencia habitual del sueño. El AFE identificó un modelo de dos factores y el AFC un modelo unidimensional. Se concluye que la calidad de sueño en esta muestra de deportistas se explica mejor mediante un modelo unidimensional de cinco componentes.

PALABRAS CLAVE: calidad del sueño, deporte, validez y confiabilidad.

INTRODUCTION

Sleep has been recognized as an essential factor for improved performance, enhanced recovery and well-being of athletes (1). Sleep monitoring is carried out through various methods such as polysomnography (considered the gold standard), actigraphy, commercial sleep technology, phone applications, sleep diaries and sleep questionnaires (2). In determining which of these methods is most appropriate, variables such as human and financial resources, potential sleep problems, and the need for expertise and speed with which results are obtained are generally taken into account (3). Regardless of the method used to assess sleep, it has been widely documented that athletes have a high prevalence of poor sleep quality characterized by symptoms of insomnia, prolonged sleep latencies, increased sleep fragmentation, non-restorative sleep and excessive daytime fatigue (1,4-11). Given the large amount of evidence reported on the effects of sleep on performance variables, mood, cognitive function, memory, learning, metabolism, disease, and injury, it is not surprising that its assessment in athletes has become very popular in recent years (2,12).

Derived from this need, one of the most accessible methods for coaches and sports professionals are sleep questionnaires and sleep diaries (13). These methods are mostly subjective and provide moderate approximations of actual sleep quality; however, they have the advantage that they are inexpensive, can be applied at home for long periods of time due to their ease of administration and high patient compliance, do not require supervision, and contain useful complementary information on sleep habits (13,14). Because of the diagnostic importance of rating scale questionnaires, it is essential that they present quality assurance through psychometric confirmation of their dimensions, i.e., whether the questionnaire items are all correlated and representative of factors affecting sleep quality (15).

One of the most widely used questionnaires is the Pittsburgh Sleep Quality Index (PSQI). The PSQI is an instrument used for the diagnosis of sleep quality and sleep disorders both in clinical populations and in other research protocols for various populations (14) and has been accepted as the standard instrument for sleep measurement with more than 2,272 citations listed in Pubmed alone (16). In sport it has been used in numerous investigations with adolescent, youth, and college student athletes (17,18), as well as in team and individual sports (19,20). However, it is required to identify in depth to what extent the components contribute to high PSQI scores in this population (3). In this sense, the dimensionality of the PSQI has been much debated because, since its creation, several studies have been carried out analyzing its factorial structure, arriving at models made up of one, two or three factors according to the characteristics of the sample studied and methodological differences (15,16). These discrepancies between studies can lead to an inadequate representation of the behavioral history and sleep experience of the person being evaluated (15).

On the other hand, PSQI has been validated and made reliable in its Spanish version in countries such as Spain, Colombia, Peru and Mexico (21-24). However, these validations have been applied only in the general population or in those with some disease and not in athletes. Another factor to take into account is that athletes may show different sleep patterns and habits compared to the non-athlete population, probably due to high levels of stress and anxiety caused by the physiological and psychological demands to which they are subjected (2,26). Similarly, it is mentioned that athletes may be more sensitive when reporting their sleep results because they have a constant evaluation of other variables day after day (27). Therefore, the aim of this study was to determine the factorial structure and internal consistency of the ICSP in a sample of university athletes from southern Sonora, Mexico, in order to evaluate the psychometric properties of the instrument.

MATERIAL AND METHODS

Study design and participants

It is a cross-sectional, non-experimental study conducted between May and August 2021 with a sample of 98 university athletes of which 39 were women (38.2%), in a range of 17 to 25 years who trained within individual and team sports representative of the university and who had at least one year of experience at that level. The sample was selected non-probabilistically by convenience and permission was requested from the branch head coaches and the technical-methodological area of the department of sports and health of the institution. The exclusion criterion was set as exclusion criteria for athletes diagnosed with chronic insomnia or psychological disorders. The protocol of this research was approved by the ethics committee of the Instituto Tecnológico de Sonora (ITSON); prior to the evaluation, the informed consent report was obtained in accordance with the Helsinki declaration in writing from all participants and they were informed of the objectives of the research. The questionnaire was provided through the Google Forms application and explained in detail in an online session to clarify any doubts. The anonymity of their responses was strictly preserved.

Measuring instruments

Pittsburgh Sleep Quality Index

The PSQI consists of 19 self-assessed questions and five secondary questions to be answered by bed or roommates. The latter questions are only used for clinical information. The scores from the 19 self-assessed questions are summed in a nonlinear fashion to yield seven components including subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, sleep medication use, and daytime dysfunction. These components are measured variables and should not be confused with the term component/factor (latent variable) used in factor analysis (28). Component scores are grouped into subscales ranging from 0 to 3, where 3 indicates the most sleep dysfunction. The sum of the seven component scores results in an overall subjective sleep quality score (ranging from 0 to 21), which is a measure of sleep health during the 1-month period immediately preceding the time of assessment. Higher overall scores represent worse subjective sleep quality. To distinguish good sleepers from poor sleepers, the ICSP global score cutoff point >5 is used with a sensitivity of 89.6% and a specificity of 86.5% (28). Those with a value ≤5 were classified as good sleepers because it has been evidenced in previous studies of college students this classification is consistent (29). A previously published Mexican Spanish version of the ICSP was used for the present study (23). The reliability of the Mexican version of the ICSP was carried out in a sample of adult population with a psychiatric disorder and control subjects with no psychopathology. In that study, factor analysis produced two factors (sleep quality per se and sleep duration) that explained 63.2 % of the variance and a Cronbach's reliability coefficient of α=0.78.

Statistical analysis

Sample characteristics are presented as counts and proportions for categorical variables, mean and deviation for quantitative variables with normal distribution. For non-normally distributed variables evaluated by the Shapiro-Wilk test, median and interquartile range (IQR) are shown. The PSQI component scores (0-3) are ordinal categories; therefore, the median and the 75th and 25th percentile IQR are appropriate for reporting measures of central tendency and dispersion (30). Internal consistency and homogeneity were assessed using Cronbach's alpha and the correlations of the seven components using Spearman's index. To further assess internal consistency, corrected item-total correlations and Cronbach's alpha coefficients were evaluated if the component item was removed. The factor structures of the questionnaire were evaluated by exploratory factor analysis (EFA) using the principal component analysis (PCA) extraction method and varimax rotation with Kaiser normalization because the skewness value on more than one item was greater than 1(31). To assess the adequacy of the EFA we used Bartlett's test of sphericity and the Kaiser-Meyer-

Olkin (KMO) measure of sampling adequacy. We used the sedimentation plot presenting the initial eigenvalues associated with each factor to determine the latent factors assuming that values > 1 were significant and held for rotation. Rotated loadings of sleep components >0.40 were considered dominant and as a defining element for each specific factor, whereas items with factor loadings ≥0.40 on more than one factor were considered cross-loadings and were not considered as part of the structure. Using the a priori criterion, manual extraction of a single factor was also performed to evaluate the original factor structure of the questionnaire (32).

Confirmatory factor analysis (CFA) was performed to examine whether the model extracted in the EFA could be further confirmed. We used maximum likelihood estimation to estimate the parameters and considered several indices of model fit to assess the adequacy of the models: the chi-square test ($\chi 2$) and its relation to the degree of freedom ($\chi 2/df$), the Root Mean Squared Error of Approximation (RMSEA), the Standardized Root Mean Squared Residual (SRMR), the Comparative Fit index (CFI), and the Goodness of Fit Index (GFI). The following criteria were taken to consider adequate model fit: low $\chi 2$ values and significance >0.05; $\chi 2/df$ values < 2; RMSEA values ≤ 0.06; SRMR values ≤ 0.08; CFI close to 1 (CFI ≥ 0.95 indicates good fit); GFI values ≥ 0.95 (25). Statistical analyses were performed using the IBM SPSS program (version 24) where the EFA was carried out and the JASP program (version 0.16.3) where the CFA was performed. The level of statistical significance was established at $p<0.05$ and all tests were bilateral.

RESULTS

Table 1 provides the descriptive statistics and the correlation matrix between the PSQI components. The overall PSQI score had a mean of 7.23 ± 3.60, identifying 68.3% of athletes with poor sleep quality with PSQI values >5. The mean of the components was in the range of 0.43-1.80; the components with the highest scores were sleep latency (1.80 ± 0.90), subjective sleep quality (1.26 ± 0.87) and daytime dysfunction (1.18 ±0.84). The lowest scores were sleep duration (0.98 ± 0.86), habitual sleep efficiency (0.47 ± 0.62) and use of sleep medications (0.43 ± 0.90). Correlation coefficients were low among a large number of components and ranged from 0.04 to 0.57; the lowest correlation was between habitual sleep efficiency and sleep disturbances and the highest correlation was observed between subjective sleep quality and sleep latency. Only the sleep efficiency component did not present significant correlations ($p<0.05$).

Table 1. Descriptive statistics of the PSQI and correlations between components.

PSQI components	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1. Subjective sleep quality	1						
2. Sleep latency	0.57**	1					
3. Sleep duration	0.46**	0.22*	1				
4. Habitual sleep efficiency	0.34**	0.21*	0.49**	1			
5. Sleep disturbances	0.49**	0.46**	0.39**	0.04	1		
6. Use of sleep medications	0.16	0.22*	0.87	-0.20*	0.26**	1	
7. Daytime dysfunction	0.56**	0.44**	0.39**	0.19	0.39**	0.29**	1
Mean (SD)	1.26 (0.87)	1.80 (0.90)	0.98 (0.86)	0.47 (0.62)	1.07 (0.43)	0.43 (0.90)	1.18 (0.84)
Median (IQR)	1 (1,2)	2 (1,3)	1 (0,2)	0 (0,1)	1 (1,1)	0 (0,0)	1 (1,2)

Pittsburgh Sleep Quality Index (PSQI), standard deviation (SD), interquartile range (IQR). ** Correlation is significant at the 0.01 level (bilateral). * Correlation is significant at the 0.05 level (bilateral).

Internal consistency and homogeneity

Table 2 shows the correlations of the components with the overall PSQI score, corrected total item correlations and Cronbach's alpha. The internal homogeneity, i.e., the correlation coefficients between each component and the overall PSQI score was in the range of 0.41 to 0.81. The highest correlation was with subjective sleep quality and a poor correlation was obtained with habitual sleep efficiency. When all seven components are considered together (original one-factor model), the corrected item-total correlation was identified as ranging from 0.25 to 0.70, with habitual sleep efficiency and use of sleep medication being the lowest correlated components. The internal consistency assessment identified a Cronbach's alpha of the seven components is acceptable at 0.76. The Cronbach's alpha value is slightly increased at $\alpha=0.77$ and $\alpha=0.78$ if you remove the habitual sleep efficiency and sleep medication use component respectively. Cronbach's alpha value of $\alpha=0.79$ was also obtained considering five components (eliminating the components of habitual sleep efficiency and use of sleep medication).

Table 2. Internal consistency and homogeneity of the PSQI in college athletes.

PSQI components	Correlations of components with the overall PSQI score	Corrected item-total correlations	Cronbach's alpha if item is removed
1. Subjective sleep quality	0.81	0.70	0.68
2. Sleep latency	0.71	0.55	0.72
3. Sleep duration	0.70	0.54	0.72
4. Habitual sleep efficiency	0.41	0.25	0.77
5. Sleep disturbances	0.64	0.56	0.74
6. Use of sleep medications	0.50	0.28	0.78
7. Daytime dysfunction	0.74	0.61	0.70
Cronbach's alpha for the 7 components			0.76
Cronbach's alpha eliminating component 4 and 6			0.79

Pittsburgh Sleep Quality Index (PSQI).

Exploratory factor analysis

EFA using the principal component extraction method was used to examine the underlying construct of the PSQI. Prior to conducting the EFA, we assessed the suitability to be able to perform it. The sample size requirement was met for both tests; Bartlett's test of sphericity yielded a value of X2 = 210.219 ($p < 0.001$) and the KMO measure reached a value of 0.736. The KMO value represented a moderate degree of common variance between items (33). By comparing the eigenvalues, factor loadings and the sedimentation plot of the PSQI components, a two-factor model was extracted under the Kaiser >1 criterion (Table 3). Factor 1 was labeled "sleep quality" and was made up of the components of subjective sleep quality, sleep latency, sleep disturbances, use of sleep medications, and daytime dysfunction, which had the highest factorial weights. Factor 2 was labeled "sleep efficiency" and consisted of the components sleep duration and habitual sleep efficiency. The sleep duration component cross-loaded on both factors, but we chose to keep it in factor 2 because of its higher correlation with habitual sleep efficiency ($r = 0.49$, $p<0.01$) and its higher loading (0.62) on that factor. Factor eigenvalues of 3.1 and 1.35 cumulatively explained 63.94% of the total variance; factor 1 explained 44.58% and factor 2

19.36%. Single-factor extraction was also carried out according to the original PSQI structure. In the one-factor solution, the habitual sleep efficiency component did not reliably load within the principal component due to its absolute factor loading (0.38) and low communality (0.14), so this was excluded in the CFA.

Table 3. Factor structure matrix for the bifactorial and unifactorial solution of the PSQI.

PSQI components	**PCA**		**Communality**
Two-factor solution[a]	Factor 1	Factor 2	
1. Subjective sleep quality	0.74	0.39	0.70
2. Sleep latency	0.70	0.17	0.52
3. Sleep duration	0.48	0.62	0.64
4. Habitual sleep efficiency	0.23	0.90	0.82
5. Sleep disturbances	0.75	0.04	0.57
6. Use of sleep medications	0.66	-0.41	0.61
7. Daytime dysfunction	0.74	0.18	0.58
% variance explained (total=63.9)	44.5	19.3	
One-factor solution	Factor 1		
1. Subjective sleep quality	0.83		0.69
2. Sleep latency	0.71		0.51
3. Sleep duration	0.69		0.48
4. Habitual sleep efficiency	0.38		0.14
5. Sleep disturbances	0.71		0.51
6. Use of sleep medications	0.44		0.19
7. Daytime dysfunction	0.76		0.57
% variance explained	44.5		

Pittsburgh Sleep Quality Index (PSQI), Principal Component Analysis (PCA) extraction method.
[a] Varimax rotation method with Kaiser normalization. Components with factor loadings ≥0.40 on two factors were assumed to the principal component where they contributed the highest factor loading.

Confirmatory factor analysis

The two-factor model extracted in the EFA was not admitted for the CFA because it presented negative variances. The single-factor six-component model without the habitual sleep efficiency component presented adequate fit values ($\chi 2$ = 10.86, p>0.05; $\chi 2$/df =1.20; RMSEA = 0.04; SRMR = 0.04; GFI = 0.96; CFI = 0.98). All components had appropriate standardized coefficients (0.40 to 0.82) and significant (p<0.001), with the highest value being subjective sleep quality and the lowest coefficient being the use of sleep medication. The single-factor five-component model was also run without the components of habitual sleep efficiency and use of sleep medication due to their low correlations with the other components. This model obtained adequate fit values slightly higher than the six-factor unidimensional model (χ2 = 5.83, p>0.05; χ2/df =1.16; RMSEA = 0.04; SRMR = 0.03; GFI = 0.97; CFI = 0.99). Figure 1 shows the structure of the five-component unidimensional model with its standardized coefficients. As the model shows, all components had appropriate (0.64 to 0.84) and significant (p<0.001) standardized coefficients, with the highest value being subjective sleep quality and the lowest coefficient being sleep duration.

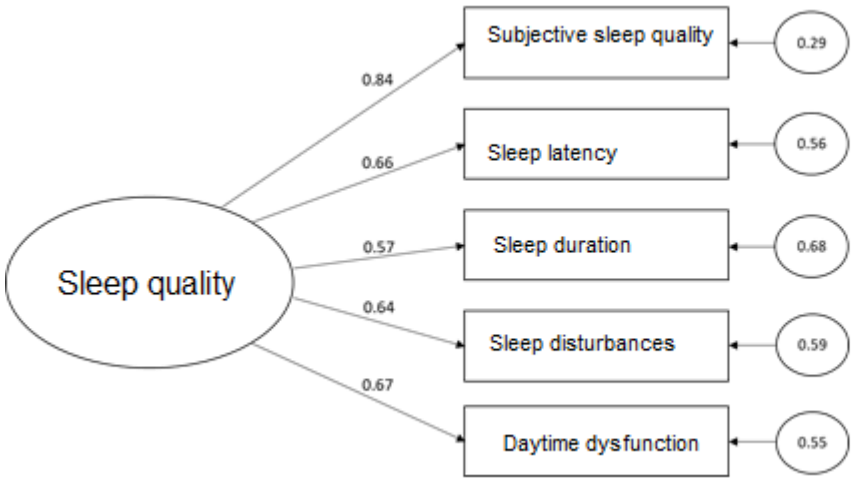

Figure 1. One-factor model of the five-component Pittsburgh sleep quality index with standardized coefficients and significant error terms p<0.001.

DISCUSSION AND CONCLUSIONS

To the best of our knowledge, this is the first study to date to examine the psychometric properties of the Spanish version of the PSQI in a sample of college athletes in Mexico. Results showed that the components of habitual sleep efficiency and use of sleep medication were not applicable to identify sleep quality and that a single-factor five-component model seemed to better capture the phenomenon of sleep quality in this sample of athletes.

The model obtained using the two-factor EFA was not satisfactorily validated in the CFA. This discrepancy between analyses is because the EFA is a data-driven approach that may lead to spurious deviations from well-known factor structures (34). Thus, a main finding of this study demonstrates that sleep quality in this sample of college athletes assessed through the PSQI can be better explained by a unidimensional five-component model consisting of subjective sleep quality, sleep latency, sleep duration, sleep disturbances, and daytime dysfunction by eliminating the components of habitual sleep efficiency and use of sleep medications. In this sense, these two eliminated factors had poor item-total and between-component correlations. Although the medication use component had an acceptable factor loading (r = 0.40) in the six-component unidimensional model, removing it still resulted in a better goodness of fit of the data with the five-component model. These findings of a unidimensional model with fewer components than in the original version are similar to those presented in a study conducted on a sample of Chinese citizens around 100 years of age where they also found the best fit with five components (eliminating the use of sleep medications and daytime dysfunction) and another study with older adults in the United States where they validated the PSQI in a unidimensional manner with only three components (subjective sleep quality, sleep latency and sleep disturbances) (34,35). These previous studies with similar results support the feasibility of simplifying the components of the PSQI in practice.

In our study, sleep efficiency values were not correlated with the components and global PSQI score. This component denominated habitual sleep efficiency refers to the time spent sleeping divided by the time spent in bed. The lack of correlation of habitual sleep efficiency with the other components may be due to the lower amount of time spent in bed by athletes and the overestimated perception of longer sleep duration (5,26). It has also been pointed out that since the low value and a narrow distribution range may lead to a low statistical correlation with other variables (36). Furthermore, in athletes, one of the biggest challenges is the difficulty in falling asleep due to their thoughts about competitions. In relation to this, a study concluded that sleep efficiency does not seem to be related to physical performance in college tae kwon do athletes, so perhaps the evaluation of this component is not so relevant (37). In the same order of ideas, component 6, called use of sleep medication, also did not present adequate correlations with the components and the global score of the PSQI. These results are consistent with those presented in Chinese university students (36) where this component was eliminated from the generated models because the factor loadings turned out to be very low and the mean score was close to zero. It has been mentioned that the report of sleep medication use is not an accurate barometer of sleep deprivation, because the use of sleep medication assesses how patients may cope with sleep problems and does not measure it directly (38). In this sense, it was found in the present study that 24.6% of the sample reported having used sleep medication at least once a week. These data are higher than those presented in a report by the National Collegiate Athletes Association of the United States in 2014, where it was identified that an average of 10.3% of college students in various sports used some type of sleep medication (39).

Another finding of the study was that the PSQI questionnaire in its Spanish version applied to this sample of athletes showed an acceptable internal consistency (Cronbach's alpha) considering the seven components (α=0.76) and increased slightly (α=0.79) if the component of habitual sleep efficiency and use of sleep medication were eliminated. These values are very similar to those obtained in the Spanish version applied to Mexican psychiatric patients (α=0.78) and the original version (α=0.83), however, in these studies they used the global score of the seven components as the unit (23,28).

On the other hand, it is important to highlight that 68.32% of the athletes in this study were considered poor sleepers with a mean PSQI score of 7.23 ± 3.60. Our results are similar to those found in a sample of 138 university students and athletes from England where a mean PSQI value of 6.89 ± 3.03 was identified, with 65% of the sample rated as poor sleepers (40). In contrast to these results, another study with a sample of 628 college athletes from the United States identified that they had a mean PSQI score of 5.38 ± 2.45 and only 42.4% of athletes rated as poor sleepers (18). However, in both studies, these values were considered by the authors to be negative. This prevalence of sleep disorder in college athletes is mainly related to lifestyle habits such as going to bed late, getting up early, part-time night work and use of smartphones/cell phones after lights out; psychological disorders; competition activities, morning workouts, the time of the season when evaluated and competition-related stressors (8,18,41). Therefore, management to improve sleep quality by minimizing environmental factors and daily behaviors is recommended.

In light of these results, it is concluded that the single-factor model composed of five components of the PSQI presents adequate psychometric properties and is valid to identify the phenomenon of sleep quality in college athletes from southern Sonora, Mexico.

LIMITATIONS AND FUTURE DIRECTIONS

The present study had several limitations. Firstly, the limited sample of evaluated athletes is considered, so that the results are not generalizable to the entire athlete population. Similarly, the lack of validation by the test-retest procedure or by means of convergent-discriminant validity is also considered. Objective sleep measurements (e.g., actigraphy or polysomnography) were also not included to evaluate their association with the measures obtained through the questionnaire. In addition, this study was cross-sectional, so it does not provide information on the persistence of sleep quality over time and how it affects different periods of training and/or competition. Future research is needed to add quantitative instruments for measuring sleep and to contrast them with subjective questionnaires and correlate them with physical-sports performance tests.

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