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Original Article

Regular sleep quality and psychological state correlate in collegiate competitive springboard divers

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Abstract:
Problem Statement: Mental health issues in athletes are gaining increasing attention, and proper sleep is an important factor for healthy mental health and improved athletic performance. **Objectives:** To explore the association between psychological evaluations regarding sports competitions and sleep quality in collegiate springboard divers. Methods: A cross-sectional study design was launched with 26 collegiate springboard diving athletes who answered a State-Trait Anxiety Inventory for evaluating anxiety as well as Diagnostic Inventory of Psychological-Competitive Ability for Athletes, a self-administered psychological questionnaire specific to competitive athletes. Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI), and the correlation between psychological and sleep variables were assessed as well. Additionally, the psychological variables were compared between poor and normal sleep quality groups. **Results:** On psychological evaluation, PSQI scores showed significant negative correlations with results for self-control ($\rho = -0.670$, $p < 0.001$), ability to relax ($\rho = -0.508$, $p < 0.001$), and concentration ($\rho = -0.589$, $p < 0.001$). Significantly higher scores for self-control ($p < 0.001$), ability to relax ($p = 0.004$), and concentration ($p = 0.001$) were obtained in the normal sleep group compared to the poor sleep group. **Conclusions:** Our results suggest that sleep quality and duration are significantly related to psychological variables that reflect the domain of mental stability and concentration, especially the item of self-control. Additionally, the level of trait anxiety was considerably associated with poor sleep quality. Adequate sleep is essential to ameliorate the sense of self-control and vice versa. Considering that psychological testing is not practical because of its complexity as well as the attitude of athletes, sleep assessment can act as a convenient substitute for their psychological evaluation.
Key Words: **Sleep, Athlete, Springboard divers, Self-control, Concentration, Mental stability**

Introduction

Competitive springboard diving has been part of the Olympic Games for over a century. It is a highly competitive, cognitively complex sport, involving strength, agility, balance, timing, courage, and quickness (Huber, 2015; Rubin, 1999). Competitive diving is also a sport of moments, requiring the mental factors extreme focus, patience, flexibility, and attention to detail. Consequently, once divers reach an advanced skill level, their performance largely depends on their mental preparedness and emotional control (Oberhausen, 1984).

Elite divers are generally in their early twenties, regardless of gender, when psychological problems first occur. According to a report from the British Association, many divers begin to struggle with the more difficult skills at this age and lose their motivation, leading them to drop out from competition (Foley et al., 2005). Regardless of exposure to substantial psychological stress, research based on the psychological characteristics focusing on competitive springboard divers has been scarce. A previous study demonstrated the use of self-efficacy resources in diving athletes, emphasizing the effects of social influence and emotion on their self-efficacy (Pattinson et al., 2017). Despite the need to develop an evaluation to provide effective psychological support, insufficient work has been conducted in this area, relative to the amount of clinical intervention directed toward physical injuries (Jones, 2017).

The intense mental and physical demands on a high-level athlete, which are of an intensity that goes beyond the imagination of an average person, may cause serious mental health problems (Hughes & Leavey, 2012). Moreover, the peak competitive years for athletes tend to overlap with the peak age for the risk of the onset of mental disorders (Gulliver et al., 2012). Even collegiate athletes confront a wide array of stressors, ranging from the pressure of increased public scrutiny through social media, restricted support networks due to relocation, and potential for a career-ending injury (Egan, 2019; Rice et al., 2016). Psychological evaluation for athletes is warranted for the proper conditioning of the mind and body, improvements of performance, and prevention of mental disorders that require treatment.

Sleep is essential activity to athletic performance and recovery from training and competition (Watson, 2017). Sleep has also been documented to have a beneficial effect on performance in high-level athletes in a range of sports, such as basketball, tennis, and endurance cycling (Mah et al., 2011; Roberts et al., 2019;

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Schwartz & Simon, 2015). Sleep also plays an essential role both in mood and emotional regulation and in prophylaxis against mental disorders. Better sleep quality predicts emotional well-being and positive affect (Sin et al., 2017; Wang & Boros, 2019), whereas poor sleep quality and insufficient sleep duration increase negative affect (Latif et al., 2019; Sin et al., 2020). Poor sleep quality also appears to affect self-control capacity, including emotion regulation (Palmer & Alfano, 2017). Sleep deprivation is also one of the critical factors in the risk for developing mental disorders, including mood and anxiety disorders. A large-scale cohort study demonstrated that reduced quantity of sleep increases the risk for major depression, which in turn increases the risk for decreased sleep (Roberts & Duong, 2014). Sleep is a fundamental substate for mental health even in younger, well-trained athletes.

Although the importance of sleep has been strongly advocated, poor sleep hygiene is often observed among collegiate athletes. Sleep disturbance is particularly prevalent in collegiate athletes, with poor sleep quality, insufficient sleep, and daytime sleepiness that is commonly observed as they are expected to balance their training with their academic achievements (Mah et al., 2018; Monma et al., 2018). Social, physical and phycological environments of collegiate athletes are less conducive to help them obtain restorative sleep. Moreover, their academic and athletic schedules tend to be irregular due to travel, practice and game schedules, different meal schedules, mandatory team meetings, or other factors, all of which can disrupt the regular sleep–wake cycle (Kroshus et al., 2019). Admitted that sleep hygiene of collegiate athletes appears to be inappropriate, there are considerable concerns not only about their performance but also about their mental health issues. Taken together, it is highly important to elucidate the relationship between sleep propensities and psychological valuables specific to collegiate athletes.

Along with psychological factors, strength, and technical skill, sleep propensity is related to proper recovery and has a significant influence on athletic performance. Previous studies have identified a correlation between vigor and sleep variables in wheelchair basketball players (Tsunoda et al., 2017). A successful link between psychological evaluation and assessment has the potential to enable effective support for athletes. Although previous studies have postulated the importance of adequate sleep for physical and psychological performance, so far, insufficient evidence on the relationship between sleep and psychological variables in athletes has been produced. Exploring the relationships between sleep and psychological correlates in competitive sports could provide a suitable strategy for supporting highly trained athletes.

This study explored subjective sleep assessments and psychological variables using self-administered psychological questionnaires. We used the State-Trait Anxiety Inventory (STAI) to evaluate degrees of state and trait anxiety and the Diagnostic Inventory of Psychological-Competitive Ability for Athletes (DIPCA.3), which was developed to evaluate psychological states in sports competitors, to extract the psychological characteristics exclusive to athletes. The components of the DIPCA.3 include competitive ability, mental stability and concentration, confidence, and strategic ability, all of which are relevant to sports performance. We sought to identify which psychological factors are most associated with sleep propensity, specifically in relation to collegiate competitive springboard divers.

Material & methods

Study Design

A cross-sectional study design was adopted, using survey distributed through direct contact at the October 2020 Japanese Inter-Collegiate Swimming Championships, the highest level of swimming competition for college students in the country. The survey implementer (MI) visited the teams and invited the athletes to participate. Ultimately, students from 16 university teams participated in the survey. The participants were informed of the aim of the study and gave their written consent to participate.

Participants

Overall, 26 highly trained, elite collegiate aquatics diving athletes (10 male and 16 female; mean ± standard deviation (SD) age: 20.0 ± 1.0 years old) voluntarily enrolled in the survey, completing a questionnaire to investigate three areas: sleep habits, psychological athletic performance, and anxiety characteristics. The participants were in their first to fourth year of college. Of the 26 participants, 19 had more than 10 years of diving experience. The sole exclusion criterion was not having provided consent for the survey. None were treated for any kind of mental or sleep disorders.

Ethics Approval

The research protocols were given post-approval by the Institutional Human Research Ethics Committee (IRB #2021-097), and they conformed to the principles outlined in the Declaration of Helsinki. Because there were no participants under the age of 18, the study was conducted without parent or guardian consent but only with the consent of the participants. The study was entirely conducted in accordance with the relevant guidelines and regulations, and informed consent was obtained for all participants.

Sleep Assessment

The Pittsburgh Sleep Quality Index (PSQI) was used for subjective sleep evaluation. The PSQI is a validated instrument used to measure sleep quality and patterns; it contains seven components each assessed with a self-rated item (Buysse et al., 1989): subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, use of sleep medication, and daytime dysfunction, within the past month.

The participants rated the quality of their sleep in response to the items from "very good" to "very bad," in a numerical range of 0–3 points. The seven component scores were added to produce a global score ranging 0–21 points. The item concerning the use of sleep medication was excluded from the analysis because no participant was taking such medication.

Psychological Assessment

DIPCA.3

The DIPCA.3 was used to evaluate the psychology of each participant. The DIPCA.3 is a self-evaluation questionnaire developed to evaluate athletes' psychological state in sports competition, specifically focusing on competitive athletes (Ichiba et al., 2020; Kosaka et al., 2016; Tokunaga, 1999; Tokunaga, 2004). The DIPCA.3 consists of 52 items in total, including 4 "lie scale" items that establish the reliability of the answers. If the lie scale score is 12 or less, then the reliability is poor. The participants were asked to respond to each question on a five-point scale ranging from "It is always the case" (5) to "It is almost never the case" (1). There were 12 categories of items: patience, aggressiveness, volition for self-realization, volition for winning, self-control, ability to relax, concentration, confidence, decision, predictive ability, judgment, and cooperation. Each category is evaluated with a full score of 20 points, up to a maximum possible score of 240 points. The items patience, aggressiveness, volition for self-realization, and volition for winning were grouped into a single element called volition for self-competition. The items self-control, ability to relax, and concentration were grouped into the element mental stability and concentration; confidence and decision into the element confidence; and predictive ability and judgment into the element strategic abilities. Cooperation constituted an element in itself.

STAI

The STAI is a widely used measure of state and trait anxiety levels (Spielberger et al., 1983). Its items are grouped into two scales: the anxiety state (STAI-1), where anxiety is conceived as a particular experience and a feeling of insecurity or helplessness, such as regarding the perception of damage that can lead to worry or escape and avoidance, and the anxiety trait (STAI-2), where anxiety is assumed as the tendency to perceive stressful situations as dangerous and threatening and to respond to such situations with a different intensity. The STAI has been used to evaluate features of anxiety in the context of sports (Horikawa & Yagi, 2012). This instrument incorporates four rating scales, ranging from 0 (nothing) to 3 (very much). STAI-1 and STAI-2 include 20 items assessed on a four-point Likert scale, with scores ranging 20–80.

Statistical Analysis

All data are expressed as means and SDs, unless otherwise specified. A Shapiro–Wilk test indicated that the data were not normally distributed. Spearman's rank correlation was used to examine the relationship between sleep components and psychological indices. For the PSQI score, the participants were divided into two groups: those with a score of less than 5 (normal sleep) and those with a score of 5 or more (poor sleep). The psychological scores were compared between the groups using the Mann–Whitney U test. All statistical analyses were conducted using IBM SPSS Statistics version 27 (IBM Corp., Armonk, NY, USA). The level of significance was set to $p < 0.05$.

Results

Table 1 describes the sleep component scores in the PSQI and the actual values that could be quantified. Table 2 shows the scores for psychological variables evaluated using DIPCA.3 and STAI.

Table 1. Component scores and on the PSQI and absolute values

Variable measured	PSQI score	Value (SD)
Subjective sleep quality	1.2 (0.9)	
Sleep latency	1.3 (1.1)	
Sleep duration (h)	0.8 (1.0)	7.0 (1.2)
Habitual sleep efficiency (%)	0.2 (0.4)	93.9 (8.1)
Sleep disturbances	0.7 (0.5)	
Sleeping medication	0	
Daytime dysfunction	1.0 (0.8)	
Total score (range: 0–21)	5.8 (3.1)	

Abbreviations: PSQI, Pittsburgh Sleep Quality Index
Minimum score = 0 (better), maximum score = 3 (worse)
The total PSQI score is indicated by the sum of the seven items listed, ranging from 0 to 21.
Values are shown as means (standard deviations), unless specified.

Table 2. Psychological competitive abilities measured on the DIPCA.3 and STAI

DIPCA		
Factor synthesis	Scales	Scoring
Volition for self-competition	Patience	14.7 (3.2)
	Aggressiveness	15.4 (2.7)
	Volition for self-realization	17.3 (2.2)
	Volition for winning	12.0 (2.9)
Mental stability and concentration	Self-control	13.8 (3.9)
	Ability to relax	12.2 (4.1)
	Concentration	14.8 (3.4)
Confidence	Confidence	12.5 (4.3)
	Decision	13.0 (3.4)
Strategic abilities	Predictive ability	12.5 (3.3)
	Judgment	13.0 (2.9)
Cooperation	Cooperation	14.4 (4.4)
STAI		
	STAI-1 (state)	37.6 (8.1)
	STAI-2 (trait)	42.5 (10.0)

Abbreviations: DIPCA, Diagnostic Inventory of Psychological-Competitive Ability for Athletes; STAI, State-Trait Anxiety Inventory, Values are shown as means (standard deviations), unless specified.

Correlation Analysis

Rank correlation analysis (Table 3) shows that lower PSQI scores, which indicate poorer sleep quality, were inversely associated with self-control ($\rho = -0.670$, $p < 0.001$), ability to relax ($\rho = -0.508$, $p < 0.001$), and concentration ($\rho = -0.589$, $p < 0.001$), suggesting a correlation between poor sleep quality and mental stability. Subjective sleep quality was negatively correlated with self-control ($\rho = -0.577$, $p = 0.002$). Sleep duration revealed negative correlations with volition for winning ($\rho = -0.568$, $p = 0.002$), self-control ($\rho = -0.457$, $p = 0.019$), and concentration ($\rho = -0.482$, $p < 0.013$), which are reliant to volition for competition and mental stability. Habitual sleep efficiency showed no significant correlation with any psychological variable. Sleep disturbance showed significant negative correlations with self-control ($\rho = -0.518$, $p = 0.007$), ability to relax ($\rho = -0.540$, $p = 0.004$), and concentration ($\rho = -0.530$, $p = 0.005$). Daytime dysfunction showed significant negative correlations with self-control ($\rho = -0.492$, $p = 0.011$) and decision ($\rho = -0.473$, $p = 0.015$), which is associated with mental stability and confidence.

The STAI-1 and STAI-2 scores showed no significant correlations with sleep, suggesting no direct relationship between anxiety characteristics and sleep quality.

Table 3. Rank correlations between sleep items and psychological variables of springboard divers

								Total PSQI s
	Psychological variables	Subjective sleep quality						
DIPCA	Patience	−0.065						
	Aggressiveness	0.064						
	Volition for self-realization	−0.067						
	Volition for winning	−0.039						
	Self-control	−0.577†						
	Ability to relax	−0.292						
	Concentration	−0.337						
	Confidence	0.078						
	Decision	−0.178						
	Predictive ability	−0.142						
	Judgment	−0.215						
	Cooperation	−0.061						
STAI	STAI-1 (state)							
	STAI-2 (trait)							

Abbreviations: DIPCA, Diagnostic Inventory of Psychological−Competitive Ability for Athletes; STAI, State−Trait Anxiety Inventory, The sleep medication item was excluded because no participants took medication for sleep. †$p < 0.005$ **$p < 0.01$ *$p < 0.05$

Comparison of Groups According to Sleep Quality

Table 4 shows variables in a comparison between the two sleep quality groups as represented by global PSQI score. The score for self-control was significantly higher in the normal sleep group relative to the poor sleep group ($U = 12.5$, $p < 0.001$). There were significant higher scores for ability to relax ($U = 28.0$, $p = 0.004$) and concentration ($U = 23.0$, $p = 0.001$) in the normal sleep group relative to the poor sleep group, suggesting a relationship between poor sleep quality and mental stability. In addition, significantly higher scores for decision ($U = 36.5$, $p = 0.015$), predictive ability ($U = 37.0$, $p = 0.018$), and judgment ($U = 39.0$, $p = 0.024$) were found in the normal sleep group than in the poor sleep group, implying that poorer sleep has relevance for strategic ability and confidence.

The poor sleep group showed a significantly higher score of STAI-2 than the normal sleep group ($U = 42.0$, $p = 0.036$), implying that sleep quality is associated with anxiety traits.

Table 4. Comparison of psychological variables on the DIPCA.3 and STAI between normal and poor sleep quality

Scales			U	Z	p
Patience			53.0	−1.543	0.134
Aggressiveness			53.0	−1.543	0.134
Volition for self-rea			59.5	−1.212	0.237
Volition for winning			75.0	−0.394	0.721
Self-control			12.5	−3.655	<0.001
Ability to relax			28.0	−2.840	0.004
Concentration			23.0	−3.109	0.001
Confidence			71.0	−0.601	0.574
Decision			36.5	−2.406	0.015
Predictive ability			37.0	−2.379	0.018
Judgment			39.0	−2.279	0.024
Cooperation			72.0	−0.547	0.610
STAI-1 (state)			48.0	−1.793	0.077
STAI-2 (trait)			42.0	−2.107	0.036

Abbreviations: DIPCA, Diagnostic Inventory of Psychological-Competitive Ability for Athletes; STAI, State-Trait Anxiety Inventory; PSQI, Pittsburgh Sleep Quality Index

Discussion

In this study, we examined the association between sleep quality and psychological variables in collegiate diving athletes. The most significant finding of this study related to the psychological components of mental stability and concentration, composed of self-control, ability to relax, and concentration, was significantly correlated with sleep quality. In addition, the participants with poor sleep quality showed significantly lower scores related to the variables for mental stability and concentration relative to those who had appropriate sleep. These results suggest that sleep is a key factor in regulating mental stability and concentration, which plays crucial role in athletic performance. To the best of our knowledge, this is the first study to investigate the relationship between sleep and psychological factors in athletes.

We used the DIPCA.3 and STAI to assess the psychological variables associated sleep quality in competitive springboard divers. Although a considerable number of psychological evaluations are available for athletes, such as the Social and Athletic Readjustment Rating Scale (Bramwell et al., 1975), the DIPCA.3 was chosen for the detailed psychological evaluation because it categorizes and evaluates psychological factors specific to athletes, enabling researchers to understand the psychological strengths and weaknesses of athletes. Past reports have suggested that the DIPCA.3 shows higher scores for talented athletes with higher self-assessment scores for mentality and the demonstration of talents during actual competitions (Tokunaga, 1999). The STAI was used as a measure of anxiety because competitive diving requires intense concentration, underlying a high affinity for anxiety (Rubin, 1999).

The components of mental stability and concentration, including self-control, ability to relax, and concentration, are subject to sleep quality, especially the variables of sleep disturbance and duration in the PSQI. Psychological variables are not affected by sleep latency or habitual sleep efficiency, probably because of the lack of significant differences in sleep efficiency or latency among the participants. However, the score for sleep duration and the extent of sleep disturbance varied among the participants, resulting in significant correlations. Among the psychological correlates, self-control showed robust significant correlations with subjective sleep quality, sleep duration, sleep disturbance, and daytime dysfunction. Self-control is a crucial component of successful psychological functioning, as it alters the individual's response when presented with conflicting desires (Pilcher et al., 2015). Self-control is also considered a limited resource in the self-control strength model, implementing mental stability (Tice et al., 2007). Past reports demonstrated that positive affect compensates for

the depletion of self-control, facilitating behaviors that are preferable to self-control (Shmueli & Prochaska, 2012). A growing corpus of evidence has demonstrated that athletes are less persistent during arduous physical exercise, are less likely to follow their exercise regimens, and tend to perform worse under pressure when their self-control strength is depleted (Englert, 2017). Self-control is beneficial for both physical and psychological health, predicting successful outcomes in association with achievements and accomplishment (Choi et al., 2018). However, there has been no research on self-control skills in competitive springboard diving athletes, probably because of a lack of interest in athletes' psychology and the necessary complexity of conducting research on players on the field.

Sleep duration had a significant effect on volition for winning, self-control, and concentration. This result conforms with previous studies that chronic sleep deprivation reduces strength in athletes (Bolin, 2019; Mah et al., 2018). Athletes are recommended to have an optimal level of sleep, of 8.5–9.5 hours (Bergeron et al., 2015; Bolin, 2019; Mah et al., 2018), suggesting that not only sleep quality but also quantity is important. Daytime dysfunction, representing daytime sleepiness, showed correlations with decision-making, which are also essential to sports performance and in developing strategy. A large body of human-based studies has yielded evidence that sleep deprivation impairs cognitive function, as represented by logical reasoning, decision-making, and executive function (Fullagar et al., 2015; Grandou et al., 2019; Killgore, 2010); however, the detrimental effects of sleep loss on decision-making are not substantial. This result suggests that springboard diving may have less of a negative impact on daytime sleepiness than other competitive sports that require strategy, such as ball games.

Unlike mental stability and concentration, other components such as volition for competition, confidence, strategic ability, and cooperation showed no significant correlation with sleep components or any significant difference between participants with and without normal sleep quality. In addition, neither state nor trait anxiety measured by the STAI correlated with any of the psychological ratings. These psychological factors tend to be resistant to inadequate sleep propensities. One explanation may be that sleep deprivation has less of an impact on long-term cultivated traits, such as self-actualization and self-confidence, than self-control and concentration. As for mental stability and concentration, a myriad of neuroimaging studies demonstrated that sleep deprivation deteriorates a wide array of cognitive functions (Simon et al., 2020; Vandekerckhove & Cluydts, 2010; Yoo et al., 2007), yielding increased emotional instability and decreased activity of the ventromedial prefrontal cortex, which is involved in the modulation of self-control (Hare et al., 2009).

Our findings further indicate that athletes with poorer sleep quality show higher levels of anxiety traits represented by STAI-2 than those with normal sleep. Trait anxiety refers to a stable characteristic that dictates an individual's response to a stressful situation, generating the tendency to constantly direct attention toward the source of threat (Pacheco-Unguetti et al., 2010). It is likely that trait anxiety, rather than state anxiety, which is defined as situational reactive anxiety, chronically impairs sleep quality. Previous polysomnographic study demonstrated that higher magnitudes of trait anxiety affect rapid eye movement parameters (Horváth et al., 2016), which are reliant on emotional memory processing (Schäfer et al., 2020). It is consistent with previous studies that reported that lack of self-control is substantially related to increased trait anxiety, as is disturbed inadequate sleep quality in elite athletes (Sheehan et al., 2018). Although trait anxiety is resistant to alteration, it is assumed that improved sleep may decrease the level of anxiety of athletes.

This study has several limitations. First, the survey was conducted in a small group of athletes in a particular event, which significantly mitigates the possibilities of the generalization of the results. Second, objective sleep assessment tools, such as wearable devices, are needed, as assessment using the PSQI is subjective and limited to self-perception. Recent research has explored objective sleep evaluation using wearable devices in athletes, enabling to evaluate more accurate sleep data (de Zambotti et al., 2019; Halson, 2019). Third, the DIPCA is an established inventory focusing on the psychological elements of athletes; however, it is not universal. Globally validated psychological assessments that implement factors of sleep are warranted.

Several practical applications could be derived from this study: 1) coaches should be aware that lack of sleep can impair self-control, ability to relax, and concentration in athletes, all of which are essential for optimizing athletes' preparation; 2) athletes should ensure that they develop and maintain regular sleep habits in daily life, preventing the harmful effects of lack of sleep; and 3) it is generally agreed that self-control is critical for sports performance, but restorative and appropriate sleep is important for developing self-control, and vice versa.

Conclusions

In conclusion, this study explored the association between psychological evaluation and sleep assessment in collegiate springboard diving athletes and examined the components of psychological evaluations that correlate with poor sleep quality. Our results suggest that sleep quality and duration are closely related to psychological variables reflecting the domain of mental stability and concentration, especially regarding self-control. In addition, trait anxiety level was considerably associated with poor sleep quality. Adequate sleep is essential for ameliorating a sense of self-control and vice versa. Taking into account that psychological testing is not practical due to its complexity and the athletes' attitudes, sleep assessment has the potential to be a convenient substitute for psychological evaluation for athletes. In addition, coaches should pay more attention to the sleep hygiene of the athletes in order to enhance their performance and well-being, especially in sports that

require intense concentration such as diving competitions. Further research into the broader realm of sports is warranted for elucidating the association with sleep-related assessment for athletes.

Conflicts of interest - No potential competing interest was reported by the authors.

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