Nature and Science of Sleep

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SHORT REPORT

Associations of Training and Academic Stress with Sleep in Dual-Career Collegiate Badminton Athletes: A Preliminary Study

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Introduction: Poor sleep negatively impacts cognitive and physical functioning and affects athletic and academic achievement. "Dual-career" athletes emphasize the pursuit of academic excellence along with athletic performance.

Purpose: The study aimed to assess sleep characteristics and sleep quality in dual-career collegiate badminton athletes. Furthermore, the study explored associations between training and academic stress and sleep, providing a theoretical basis for better training and sleep programs for dual-career athletes.

Participants and Methods: In this study, 15 dual-career collegiate badminton athletes were recruited, and 12 subjects (male n = 8, female n = 4, mean age 20.3 ± 1.7) completed the questionnaire. Repeated measurements were taken monthly in the spring semester from March to August 2021. The questionnaire assessed sleep quality and daytime sleepiness by the Pittsburgh Sleep Quality Index (PSQI) and Epworth Sleepiness Score (ESS). Moreover, we collected average training, study time per week, and monthly sports competitions and academic tests to quantify participants' training and academic stress.

Results: An average of 36.1% of dual-career athletes reported poor sleep and 25.0% had excessive daytime sleepiness. Overall, a significant positive correlation existed between PSQI scores and weekly study hours ($r = 0.308$, $p = 0.009$). Significant positive correlations were found between the four stressors and PSQI (August: $r = 0.868$, $p < 0.001$; July: $r = 0.573$, $p = 0.026$) or ESS scores (March: $r = -0.678$, $p = 0.015$; August: $r = 0.598$, $p = 0.040$) for specific months. Hierarchical linear modeling (HLM) analysis identified that lower study and training hours predict better sleep quality.

Conclusion: Dual-career collegiate badminton athletes had a higher prevalence of poor sleep and daytime sleepiness, and daytime sleepiness did not result in better sleep quality; study and training hours had the greatest effect on the sleep quality of dual-career collegiate badminton athletes.

Keywords: training stress, academic stress, dual-career collegiate athletes, sleep quality, subjective evaluation

Introduction

Sleep is key in daily activities, physiology, cognitive function, and physical recovery.[1] Previous studies have shown that sleep deprivation negatively affects cognitive function, learning and memory, reaction time and mood.[2–5] Inadequate sleep duration has also been shown to affect metabolic and endocrine functions.[6–8] It also increases physical exertion during exercise, impairing endurance and strength performance.[9–11]

The sleep health of athletes is of increasing concern. Sleep quality and duration are vital for high performance athletes to achieve enhanced physical recovery and competitive performance during training or competition.[12–15] In previous studies, collegiate athletes were unable to obtain satisfactory sleep duration and quality.[16–18] Therefore, athletes can improve sleep quality by balancing sleep time and training load.[19] It has been shown that higher education can adversely

Received: 22 August 2023
Accepted: 18 December 2023
Published: 24 January 2024

affect sleep in college students.[20] Furthermore, a correlation between sleep problems and poor academic achievement has been found in collegiate athletes.[21] Previous studies have shown that insufficient sleep impairs memory, cognitive function and adversely affects learning ability.[10,22,23] The integration of sport and education has recently received a great deal of attention internationally.[24,25] Although the athletic training and educational stages of student-athletes are highly overlapping,[26] more and more athletes are seeking a "Dual Career" approach to their overall development, ie, pursuing athletic performance and academic success simultaneously. Moreover, solutions to problems related to the integration of sport and education are being explored all over the world.[27–30] In summary, sleep is an important consideration for dual-career athletes attempting to pursue high-performance levels in academics and training.

Poor sleep quality among dual-career college athletes has been widely recorded in Europe and the United States.[16,18] However, research on the relationship between sleep health and academic and athletic performance among "dual-career" collegiate badminton athletes is relatively scarce.[31] Therefore, this study aimed to assess sleep characteristics of dual-career collegiate badminton athletes and investigate the prevalence of poor sleep, as well as the stressors impacting sleep quality. Furthermore, the study explored the associations between training and academic stress and sleep quality of the athletes to provide a basis for coaches and teachers to formulate more favorable training and academic strategies scientifically.

Materials and Methods

Study Procedure and Participants

15 dual-career collegiate badminton athletes were recruited for the study; 3 athletes dropped out due to cessation of training, graduation, or other personal factors, and finally 12 subjects (males n = 8, females n = 4, age: 20.25 ± 4.66 years) completed the 6-month pilot study. Subjects had a sports rating of national level 2 and above (master sportsman n = 2, level 1 athlete n = 7, level 2 athlete n = 3), years of participation in athletic training (11.04 ± 2.49 years). All participants can be classified as highly trained athletes according to the criteria framework outlined by McKay et al.[32] Under the dual pressure of academics and training, participants maintained badminton-specific training 3–5 times per week for about 1.5 hours each time. They did not report any previously or currently diagnosed clinical sleep problems or any major injuries or illnesses that impacted the athletes' training or competitions throughout the study. All participants completed an online questionnaire monthly from March 1, 2021 to August 30, 2021. Due to the applied nature of this study, participants were asked to maintain their daily sleep habits and to sleep in their dormitory throughout the trial to reflect a relative realistic environment. Informed consent was obtained from all subjects after explaining the purpose, procedures, and possible risks of the study. This study complies with the Declaration of Helsinki, and the ethical approval was obtained from the Ethic Committee of Wuhan Sports University (2003096).

Questionnaires and Measurements

The online questionnaire contained basic information about age, height, body mass, body mass index (BMI), athletic level, and years of training (Table 1). In addition, Pittsburgh Sleep Quality Index (PSQI), Epworth Sleepiness Score (ESS), and additional quantitative data were also collected in the questionnaire to describe the academic and training stressors they were experiencing.

Academic stress was quantified using the number of academic tests completed per week in the previous month and the hours spent in class and on self-study. These factors have been identified as common sources of stress for college students in the Undergraduate Stress Questionnaire.[33] In addition, to assess training stress, all subjects provided the average weekly training time (including all forms of training in the badminton gym, strength room, and track and field) as well as the number of competitions completed within the previous month as markers of training stress.[18] The reliability of the participant's recall of the questionnaire data was ensured by communicating and confirming the training stress data provided by the athletes with their coaches. All data were kept confidential and anonymized.

The online questionnaire also included 2 validated tools to assess sleep quality and daytime sleepiness. The Chinese version of PSQI and ESS used in the study have been validated with good reliability and validity.[34–36]The PSQI evaluated sleep duration, sleep onset latency, subjective sleep symptoms, sleep medications, and disturbances.[37] The PSQI measures symptoms of sleep disorders over 1 month and is categorized into 7 subscale scores; these are combined

Table 1 Subjects' Basic Characteristics

Characteristics	Mean (SD)		*P*
	Male (n = 8)	Female (n = 4)	
Age (years)	20.50 (1.93)	19.75 (0.96)	0.49
Height (m)	1.80 (0.06)	1.68 (0.06)	0.12
Body mass (kg)	73.88 (21.97)	60.25 (2.36)	0.26
BMI	22.70 (5.34)	21.43 (0.97)	0.66
Training years	10.69 (2.94)	11.75 (1.26)	0.51

Abbreviation: SD, Standard Deviation.

to create an overall PSQI scores. Overall PSQI scores range from 0 to 21, with higher scores indicating poorer sleep quality. A score of 5 on the PSQI scale was used as a threshold to distinguish poor sleep from good sleep.[38] The degree of daytime sleepiness was assessed using the ESS.[39] The ESS assesses sleep propensity on a scale of 0–3 in eight standardized daily situations. Scores range from 0 to 24, with higher scores reflecting deeper sleepiness and scores of 10 or higher indicating clinically elevated levels of daytime sleepiness.

Statistical Analyses

Sample size estimation was performed a priori with a type I error of 0.05 and a power of 80%. Power calculation for sample size was carried out using G*Power Software (Version 3.1.9.2, Universität Düsseldorf, Düsseldorf, Germany). The required number of subjects to be enrolled was found to be 10 in the group.

All data are considered continuous variables and expressed as mean ± standard deviation. First, we used the independent samples *t*-test to compare genders to verify the randomization of sample data selection. Second, we categorized sleep quality profiles PSQI and ESS monthly to explore the prevalence of poor sleep quality and daytime sleepiness (overall PSQI scores ≥5 or ESS score ≥10). Third, this study investigated the relationship between sleep quality and daytime sleepiness and the stressors associated with sleep quality. We performed Spearman Correlation Analysis on the complete data first, and considering the month's effect on the data, we further analyzed the data separately for each month. Finally, given the repeated-measures design, we used Hierarchical Linear Modelling (HLM) for quantitative studies and significance tests between variables to determine which factors best-predicted sleep quality. All analyses were conducted by IBM SPSS 26 for Windows. Significance levels were all set at $p< 0.05$.

Results

Quality of Sleep at Night and Daytime Sleepiness

The mean bedtime for the cohort was 23:52 (±49 min), wake-up time was 07:53 (±56 min), and sleep duration was 7 h 15 min (±61 min). On average, 36.1% of athletes reported poor sleep (overall PSQI scores ≥ 5) and 25% reported excessive daytime sleepiness (ESS score ≥ 10) over the 6 months (Table 2).

There was some fluctuation in cohort's sleep across seasons. Monthly mean bedtimes were earliest in March and August, with the most early awakenings occurring in March; the most extended mean sleep duration in the cohort occurred in July, and the shortest was in March (Figure 1). Besides, the overall PSQI scores was 3.78 (±2.39), with the highest mean in April and the lowest in March and July. The percentage of poor sleep quality was similar to the PSQI scores, with the highest in April and August and the lowest in July. The ESS of the cohort was 7.15 (±5.48), with the highest mean in April and the lowest in June. The highest prevalence of daytime sleepiness was in April and the lowest in June (Table 2 and Figure 1).

Relationship Between PSQI Scores and Daytime Sleepiness, Academic Stress and Training Stress

Figure 2 showed the trends of training and academic stress in 6 months. Overall, there was a significant positive correlation between PSQI scores and weekly study time ($r = 0.308$, $p = 0.009$) (Figure S1). For each month, we found

Table 2 Sleep Quality and Daytime Sleepiness Over 6 Months

Month	Bedtime (Time ± min)	Wake-Up Time (Time ± min)	Sleep Duration (Hours ± Hours)	Overall PSQI Score (Mean ± SD)	ESS Score (Mean ± SD)	Overall PSQI Scores ≥ 5 (%)	ESS Score ≥ 10 (%)
March	23:45 (47)	07:37 (66)	6.83 (1.09)	3.08 (2.64)	7.83 (5.04)	33.33	25.00
April	00:02 (53)	07:50 (70)	7.17 (1.60)	4.33 (2.67)	7.92 (6.22)	50.00	33.33
May	23:55 (28)	07:56 (30)	7.29 (0.86)	3.58 (1.68)	6.58 (5.82)	25.00	25.00
June	23:53 (52)	07:54 (56)	7.13 (0.86)	3.83 (1.95)	5.42 (6.52)	33.33	16.67
July	23:55 (50)	08:15 (67)	7.63 (0.68)	3.58 (2.43)	7.50 (4.15)	16.67	25.00
August	23:45 (67)	07:50 (43)	7.46 (0.69)	4.25 (3.02)	7.67 (5.58)	58.33	25.00

Abbreviations: PSQI, Pittsburgh Sleep Quality Index; SD, Standard Deviation; ESS, Epworth Sleepiness Score.

that overall PSQI scores significantly correlated with the average study time per week in August ($r = 0.868$, $p < 0.001$) (Figure S2), also significantly correlated with the average training time per week in July ($r = 0.573$, $p = 0.026$) (Figure 3). However, the PSQI scores did not suggest a significant association with the number of academic tests and the number of sports competitions in any of the months; ESS scores had a significant positive correlation with the number of academic tests in March ($r = -0.678$, $p = 0.015$) (Figure S3), and the number of sports competitions in August also significantly correlated with ESS scores ($r = 0.598$, $p = 0.040$) (Figure S4). In addition, overall PSQI scores and ESS scores were not significantly correlated in complete study period or any month ($p > 0.05$).

Quantitative Analysis of the Effect of Training and Academic Stress on Sleep Quality

Based on our repeated-measures data, the hierarchical linear modeling analysis identified a null model first, with a −2 log likelihood of 328.94. In addition, we calculated an intragroup correlation coefficient (ICC = 0.4805), suggesting that 48.05% of the total variance in the PSQI was attributable to the different participants and that multilevel modeling analyses should be conducted. After modeling possible combinations of the four stressors (weekly training time, weekly study time, sports competitions, and academic tests), it was found that weekly study time and training time best predicted the PSQI scores, which represents the quality of sleep. The model is as follows:

$$PSQI_{ij}=\gamma_{00}+\gamma_{10}Study\_Hours+\gamma_{20}Training\_Hours+\mu_{0j}+\varepsilon_{ij}$$

$PSQI_{ij}$ represents the PSQI scores at month j for individual i in the study; γ_{00} is the mean total intercept for all individuals; γ_{10} is the regression coefficient for weekly study hours in the fixed effects ($\gamma_{10} = 0.059$, SE = 0.216, $p = 0.008 < 0.05$); and γ_{20} is the fixed effect regression coefficient for weekly training hours ($\gamma_{20} = 0.108$, SE = 0.051, $p = 0.$

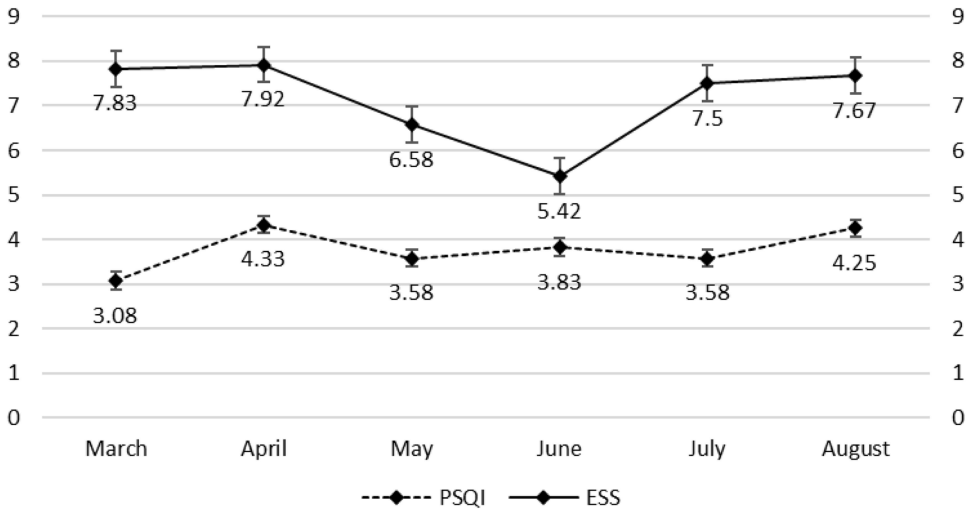

Figure 1 Changes of mean overall PSQI scores and ESS scores in 6 months.

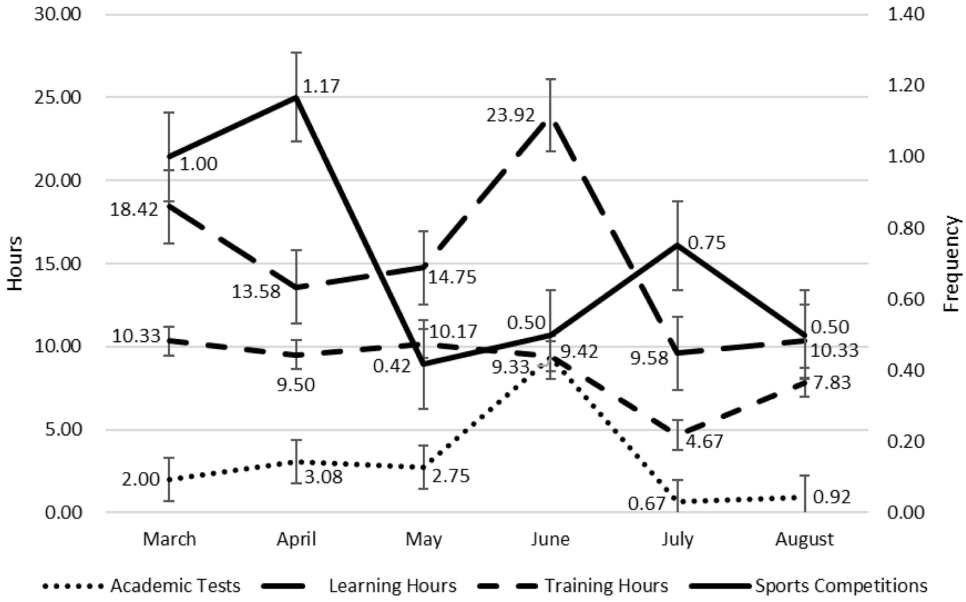

Figure 2 Change trends of academic and training stress in 6 months.

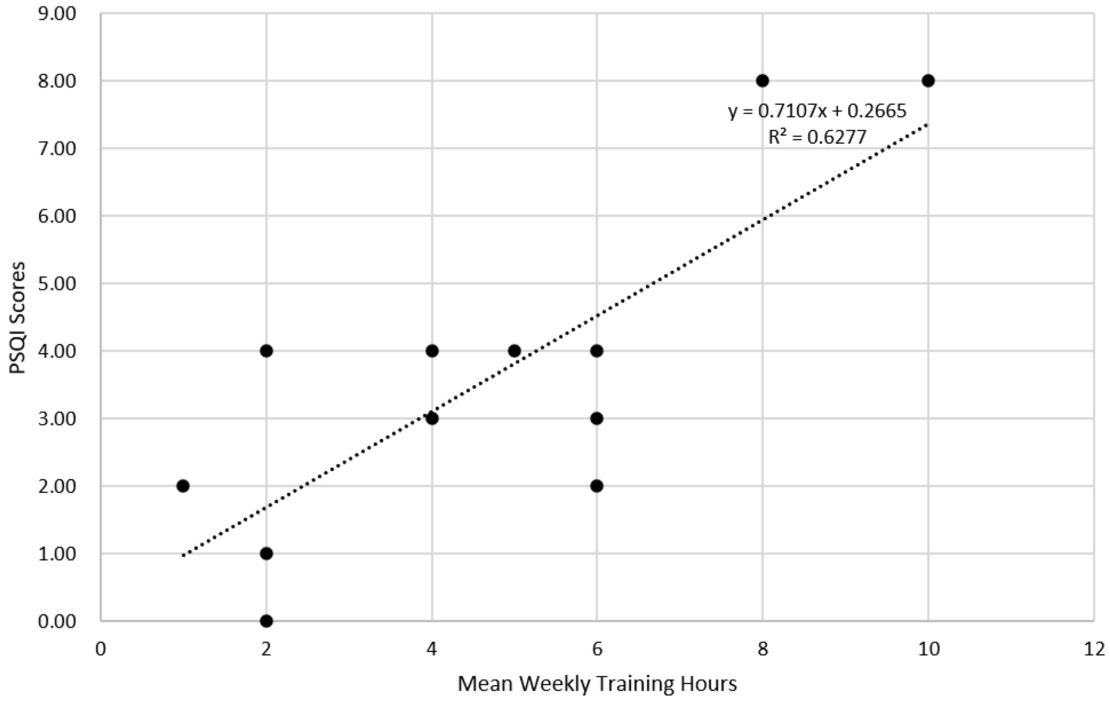

Figure 3 Scatterplot of average weekly training time and PSQI scores for July.

038 < 0.05); μ_{0j} is the random deviation of group means about the grand intercept of the PSQI for study subject j; ε_{ij} denotes the difference between the measures within study subject j. The −2 log likelihood value of the model was 319.22, and the likelihood ratio test (LR test) showed a significant improvement in the fit of the model compared to the null model ($Chi^2 = 9.72$, df = 2, P = 0.008 < 0.05). Moreover, the −2 log likelihood values of the model were higher than that of the model when combinations of other stressors were used as predictor variables, indicating a better fit of our model.

Discussion

This study aimed to assess sleep characteristics in dual-career collegiate badminton athletes under different training and academic stresses to understand the incidence of poor sleep. In addition, the study attempted to identify potential stressors that may affect sleep quality. The results of the study showed that the prevalence of poor sleep quality and daytime sleepiness was relatively high, but they were not strongly correlated in this group; training and academic stress were associated with sleep quality to some extent, where the average weekly study hours and the weekly training hours were better predictors of sleep quality in the athletes.

In this study, 36.1% of the athletes had an overall PSQI score of 5 or higher, indicating poor sleep quality in this cohort. In comparison, Astridge et al found that 42% of 22 "dual career" swimmers had PSQI scores greater than or equal to 5.[18] In the study of Mah et al 42.4% of 628 college athletes had PSQI scores greater than or equal to 5, with a mean score of 5.4 ± 2.5 for the entire sample.[16] These results suggest that poorer sleep quality is prevalent in the college athlete population. An official American Thoracic Society statement suggests that most adults need 7–9 hours of sleep.[40] In our study, athletes slept an average of 7 hours and 15 minutes (±61 minutes), which reaches the lowest adult recommended time but falls far short of the recommended 8.3 or even 9 h in athletes.[41,42] Recent studies have shown that adolescent athletes do not achieve the recommended amount of sleep and have poorer sleep quality under the pressure of training and academics.[43] This suggests that sleep problems in this group may be long-established and negatively impact academic performance, athletic performance, and mental health.[21,44–47]

In addition, factors such as sleep hygiene and seasonal variation have a non-negligible impact on sleep. It has been shown in previous studies that maintaining the athletes' original sleep condition without standardizing the intervention is a common treatment.[48] Such an approach provides higher ecological validity to the trial while keeping daily sleep habits and sleeping in dormitories in our study.[49] The effects of seasonal changes on sleep have been widely discussed, but previous studies are inconsistent about the effects. Some studies with adults and children have shown that spring is significantly associated with shorter sleep duration, while summer is significantly associated with delayed sleep onset.[50–52] However, Mirja et al argued that season was not significantly associated with mean nighttime sleep duration, which is similar to our results.[52,53] At the same time, dual-career athletes also differ from elite athletes in terms of training-season sleep variation, and dual-career athletes appear to have little seasonally induced variability in sleep.[54] Therefore, seasonal variations in sleep for dual-career athletes are expected to be further elucidated in future studies. COVID-19 as a social stressor also posed a psychological burden on dual-career athletes.[55] A study has shown that decreased daily training during COVID-19 worsens sleep quality.[56] Fortunately, during the period of this study, there was no strict lockdown, and all teaching and training activities proceeded as normal on campus in Changsha, Hunan Province. However, all national competitions were canceled during this period, which reduced the impact of the travel time of the competition on the results. Therefore, the psychological burden of COVID-19 for dual-career athletes in the study may be obscure, and it would be interesting to repeat the study in the future at a time out of the COVID-19 period.

There was no significant correlation between overall PSQI scores and ESS scores in the entire sample, suggesting that despite the high prevalence of poor nighttime sleep quality and excessive daytime sleepiness in our sample, there appears to be little association between them. However, despite using the same PSQI and ESS scales, Khalladi et al found a high correlation between sleep quality and daytime sleepiness in professional soccer players.[14] Possible reasons for this discrepancy are different types of sports and different university environments. The overall PSQI scores were correlated with the academic test, training time, and study time, suggesting that the above three stressors may be potential contributors to poor sleep. In contrast, in a previous experiment using a similar research design, the number of academic tests was determined to be best predicted for sleep quality.[18] In the present study, March was one of the most stressful months for training, and the number of academic tests may have significantly impacted poor sleep during more significant training stress. Furthermore, a study by Gaultney noted that sleep disorders predicted poor academic performance.[57] Similarly, in a study by Lund et al, 60% of 1125 students were categorized as having poor sleep quality, and participants overwhelmingly attributed their poor sleep to academic and emotional stress.[58] In our study, despite controlling for participants' no history of mental illness or psychotropic substance use, their mental health status deserved attention. Dual-career athletes are likely to face more serious mental health problems.[59,60] It has been observed to have

a bidirectional relationship between sleep and mental health: insufficient sleep duration, decreased sleep quality, insomnia, fatigue, and symptoms of sleep apnea are associated with increased stress, depression, and anxiety, whereas poor mood, increased anxiety levels can also lead to severe sleep dysfunction.[17,60] In summary, dual-career student-athletes appear at significant risk for poor sleep quality when training and academic stress increase. Conversely, student-athletes poor sleep quality also affects athletic performance and academic achievement.

Weekly study and training time in the sample were better predictors of sleep quality, with the latter predicting a more significant percentage of the variance in the data. It further supports the idea that academic and training stress both affect sleep in this sample, especially the training and study time. Similarly, Vedaa et al found that insomnia was associated with the risk of failing exams among 50,054 college students.[61] In addition, the average number of monthly competitions in our regression model was negatively associated with PSQI, although it was not included in the final model due to poor fit. This may be due to the fact that, within a specific range, an increase in the number of competitions is associated with greater physical and energetic exertion by the athlete, leading to faster sleep onset and a certain improvement in sleep quality, and a decrease in PSQI scores.[62] Therefore, special attention should be given to the dual-career student-athlete population to the harmonization of study and training schedules, which is critical and necessary to improve their sleep and achieve dual-career success.

There are several limitations in this study. First, we obtained the data only by subjective reports in this study, and future research could consider using objective measurements such as polysomnography and actigraphy to improve measuring accuracy. In addition, reported sleepiness and daytime sleepiness were based on sleep behaviors over the past month, so recall bias is inevitable. Third, although the PSQI and ESS are valid tools for measuring sleep characteristics, they do not effectively capture the duration and quality of daytime naps. The athletes in our study likely compensated for nighttime sleep deprivation through alternative rest. Finally, the number of subjects recruited for this study was limited, and for this reason we did not group them by gender (Table S1). The sample size should be expanded as much as possible in future studies to verify the results of this study.

Conclusion

Many dual-career collegiate badminton athletes suffer from poor sleep quality and daytime sleepiness. However, daytime sleepiness was not associated with sleep quality. At the same time, we found that athletes slept longer when stress was low, but sleep quality was not improved. When training is stressful, the number of sports competitions is closely related to sleep quality, and we found that study time and training time best-predicted sleep quality. Therefore, coaches and educators of "dual-career" athletes should consider the potential impact of this dual-career approach on sleep and scientifically and rationally formulate training and academic programs to achieve optimal training and academic performance.

Practical Applications

The present study highlights the training and academic stress associated with sleep quality among dual-career badminton athletes. They could not achieve satisfactory sleep quality while experiencing both training and academic stress. It is recommended that sleep hygiene education should be provided to dual-career athletes to make them more conscious about the role of sleep. Our preliminary findings could demonstrate that training and study time are the most predictive of sleep quality. Therefore, coaches and related educators should adequately coordinate dual-career athletes' schedules to improve their sleep and further dual-career achievements.

Acknowledgments

The research group would like to thank the participants for their time.

Funding

This research was funded by the Open Project of State Key Laboratory of Basic and Applied Aerospace Medicine (SMFA20K04), and the Fundamental Research Business Expenses of the Central Universities (PD-GCZX002, PD-GCZX006, and 2022YB019).

Disclosure

The authors report no conflicts of interest in this work.

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