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■ RESEARCH ARTICLE

Caffeine Consumption and Sleep in Adolescent Student Athletes

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ABSTRACT: The present study aims to understand the relationship between the quantity and quality of sleep and caffeine consumption in to understand further conditions that optimize student-athletes' sports and academic performance. We found an inverse relationship between the hours of sports played and sleep quality, a positive relationship between sleep quantity and sleep quality, and that as caffeine consumption increases, sleep quality decreases. The results partially supported our hypothesis and suggested that student-athletes should be cautious of the relationships between caffeine consumption and sleep to further optimize their sports and academic performance. We strongly encourage student-athletes to prioritize sleep during the sports season. Not only does sleep further improve and maximize athletic performances, but sleep also reduces the chances of getting injuries moving forward.[5]

KEYWORDS: Biomedical and Health Sciences; Nutrition and Natural Products; Sports Performance; Sleep; Caffeine.

■ Introduction

Caffeine, sleep quality, and quantity are critical elements that profoundly impact an athlete's overall performance.[1] Because of this, athletes must manage these behavioral factors to prioritize their psychological and physiological well-being. Student-athletes, full-time students participating in competitive sports sponsored by their educational institution, may find managing their caffeine consumption and sleep even more challenging as they must simultaneously balance their academics and athletic performance. Additionally, since student-athletes are under prolonged periods of heightened stress due to the competitive nature of athletics, this ultimately leads to rising concurrent mental and physical health issues.[2] Mental and physical health concerns, such as fatigue and continuous stress, or lifestyle habits, including late bedtime, early wakeup time, part-time jobs, etc., often stimulate student-athletes' sleep disorders.[3] By understanding the relationship between factors that impact athletic performance, student-athletes may protect themselves from unnecessary stress and optimize their athletic and academic perfor-mance.

Sleep is vital in cognitive and bodily functions and contributes to physical and mental homeostasis. Human motor cognitive coordinated tasks largely depend on the sleep-wake rhythm, also known as the circadian rhythm. Athletes follow this rhythm while awake, exercising during the day, sleeping, and recovering at night. Because of this, athletic and physical performance largely depends on the quality and quantity of sleep.[4] Research has shown that improved sleep quantity and quality are often associated with improved performance and competition success. In addition, sleep decreases risk factors for injury or illness.[5] While sleep should be prioritized, many student-athletes face numerous obstacles that prevent them from getting the recommended quantity of sleep. Training, academic demands, high-stress levels, and other factors may decrease sleep quantity and quality. Many student-athletes may consume caffeine to compensate for this reduced sleep quality and quantity and improve their athletic performance despite sleep deprivation.

Caffeine, a naturally occurring stimulant commonly found in coffee and tea, increases the activity of the central nervous system, resulting in enhanced energy levels. As a result, caffeine may benefit athletes in cognitive and physical sports performance, especially under conditions of sleep deprivation.[6] Recent findings have demonstrated that benefits from caffeine can be seen in various sports, including endurance, stop-and-go, high intensity, strength, and power events.[7] However, caffeine also has a profound disruptive effect on sleep. Specifically, it is associated with alterations in habitual sleep durations, which is defined as [(weekday sleep duration) + (weekend sleep duration)]/7.[8] Not only that, caffeine is often associated with daytime sleepiness and disturbed sleep despite being commonly used to promote alertness and wakefulness.[9] To understand the underlying potential long-term consequences of caffeine's effects on sleep, fur-ther research is needed.

The present study aims to understand the relationship between the quantity and quality of sleep and caffeine consumption in student-athletes to understand further conditions that optimize student-athletes' sports and academic performance. We hypothesize that a general trend of higher levels of caffeine intake relates to an increase in poorer sleep quantity and quality in student-athletes.

■ Methods

Data collection took place from April to May 2023. Participants included high school student-athletes (N= 21) who were 15-18 years old with an average age of 16. Participants were recruit-ed from Chiang Mai International School in Chiang Mai, Thailand. The inclusion criteria for participants were to require active engagement in a school team sport, which was

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defined as playing a team sport offered at school when the survey was conducted. Only one participant who completed the study did not meet these criteria. Volleyball, Futsal, and Badminton were the only sports offered this season. Consequently, volleyball athletes were prioritized in the search for participants that satisfied the requirements; all subjects were on the school volleyball teams (Junior Varsity [Grade 9/10] or Varsity level [Grade 11/12]) except for one. Participants were given written and verbal descriptions of the experiment, and all voluntarily agreed to participate in this study before completing the survey.

The survey was conducted using Google Forms. Consent was given from all of the participants. Data collection took two weeks, from late April to the beginning of May 2023, just before the sports season ended. Participants were asked to evaluate their sleep quality and quantity and caffeine consumption to the best of their ability. After all participants had completed the survey, responses from Google Forms were transferred to Google Sheets. The raw data directly transmit-ted from Google Forms was then organized into processed data. The processed data included the subjects' sleep quality, measured using the metric Pittsburgh Sleep Quality Index (PSQI), sleep quantity, and average caffeine consumption per day.

The form was split into four sections: 1) inclusion and exclusion criteria, 2) basic information questions, 3) sleep quality and quantity questionnaire, and 4) caffeine intake questionnaire. The age, hours of sports activities per week, and what sports participants played were collected as part of the demographic information questions. The data from this section provided a basic idea of the range and variety of participants for this study.

Pittsburgh Sleep Quality Index (PSQI):

The Pittsburgh Sleep Quality Index measured the subjects' sleep quality.[10] The questionnaire contained main questions, some with sub-questions, to determine the sleep quality. The PSQI score is the sum of seven component scores; each component scored between 0 and 3, which indicates the worst sleep quality. The seven components quantify the subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbance, use of sleep medication, and daytime dysfunction. The Global PSQI Score is the sum of the seven component scores, rang-ing from 0 - 21. Higher scores indicate worse sleep quality.

Caffeine Intake Questionnaire:

The Caffeine Intake Questionnaire collected the participants' caffeine intake based on the caffeinated drinks consumed over five days. Participants were asked how many 8 oz servings of caffeinated beverages (green tea, black tea, brewed Coffee, carbonated beverages, energy drinks, instant coffee) and shots of espresso (1 oz serving size) were consumed. Participants completed the questionnaire retrospectively, recalling their caffeinated beverages over the past five days. Then, the average caffeine consumed was calculated using data from Mayo Clinic in mg/8 oz except for espresso, which is measured in mg/1 oz.[11]

Statistical Analysis:

Correlations were calculated for the values that were stated in the hypothesis, as well as some other exploratory values. Pearson correlation was calculated for all the results, and the Pearson correlation coefficient associated with statistical significance of $P < 0.05$ was used for all analyses. Demographic information such as hours of sports activities per week were expressed as mean standard deviation.

Results and Discussion

Results:

Twenty-one high school-aged students completed the present study's surveys. However, data was only analyzed for 20 participants as one did not meet the inclusion criteria. See Table 1 for the subject's demographics.

Table 1: Participants' Demographics

Demographic Information	Mean +/- Standard Deviation
Age, year	16 +/- 0.8
Sports Played Per week, hours	6.1+/- 2.25
Sport, n (%)	
Volleyball	20 (100)
Football*	12 (60)
Basketball*	12 (60)
Futsal	9 (45)
Badminton	3 (15)
Cross Country*	1 (5)

*Sport was not played in part of the sports season survey was conducted

The PSQI was used to measure sleep qualities and quantity scores of the subjects; a higher PSQI score indicates worse sleep quality. As a reliability check, we evaluated the participants' sleep quality and quantity and found a statistically negative correlation between the two factors, $r(20) = -0.505$, $p=0.023$. It's been extensively documented that getting less sleep results in higher PSQI scores because one of the attributes of sleep quality is sleep duration.[12] Thus, we did a control analysis to confirm that this trend was replicated in our dataset to assess the sleep data's reliability.

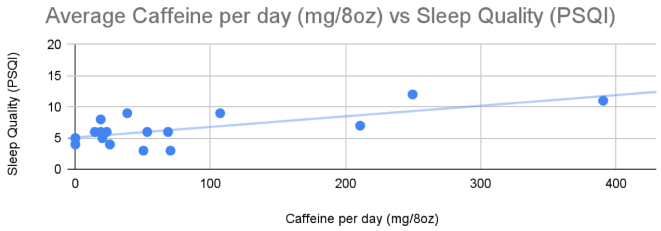

Figure 1: Inverse trend of sleep quality and caffeine consumed.

There was a significant positive correlation between sleep quality (PSQI) and average caffeine consumption per day (mg) $r(20) = 0.464$, $p = 0.04$ (Figure 1). However, there was no significant relationship between sleep quantity and average caffeine consumption per day $r(20) = -0.345$, $p = 0.136$ (Figure 2).

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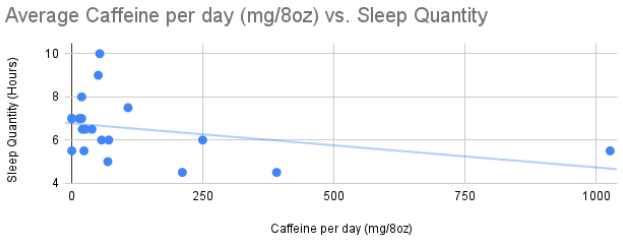

Figure 2: Inverse trend of caffeine consumed and sleep quantity.

Further exploratory analyses revealed a statistically significant negative relationship between hours of sports played per week and sleep quantity. An increased amount of sports played per week was associated with decreased sleep quantity $r(20) = -0.515$, $p = 0.02$ (Figure 3). The negative relationship between the two factors revealed that the duration of sports exercise also affected the quantity of sleep the individual was getting, not just the caffeine consumption. Student-athletes who devote significant time to sports risk losing quality sleep time. See Figure 3 for the correlation graph.

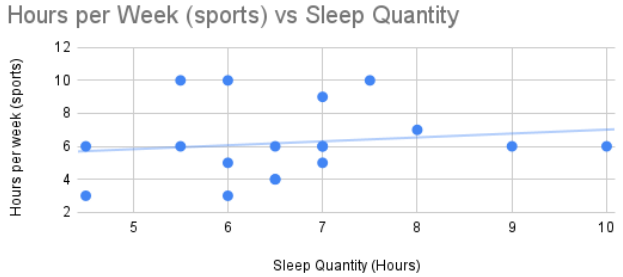

Figure 3: Hours of sports per week vs. Sleep Quantity.

Discussion

The present study evaluated the relationship between sleep quality, quantity, and caffeine consumption. We found an inverse relationship between the hours of sports played and sleep quantity, a positive relationship between sleep quantity and sleep quality, and an inverse relationship as caffeine consumption increases and sleep quality decreases. The results supported our hypothesis of an inverse relationship between the level of caffeine consumption and sleep quality and quantity in student-athletes. Along with previously conducted research,[5,6] our findings suggest that student-athletes should be cautious of the relationships between caffeine consumption and sleep to optimize their performance in sports and academics further.

The mean PSQI score, which measures sleep quality, is 4.2 globally.[13] A score above 5 indicates poor sleep quality relative to clinical measures. In our study, the mean score of respondents was 6.75, indicating the participants were experiencing poor sleep quality, presuming factors like "caffeine consumption" and "nervousness and anxiety due to academics and sports" affected sleep quality in this study. The inverse relationship between caffeine consumption and sleep quality supported our hypothesis. As found in Lo's study, food and drinks containing caffeine affected the sleep quality of student-athletes.[1] In this study, increased caffeine consumption directly leads to decreased sleep quality, as caffeine consumption increases sleep latency, shortening total and deep sleep time.[3] Negative sleep factors may decrease academic and sports performance when we apply these findings to a student-athlete perspective. Students should prioritize and protect their sleep quality by being aware of the volume of caffeine consumed, as well as the time in which it is finished in relation to exercise duration and intensity.[15]

The stimulant caffeine is used to enhance performance and mitigate sleepiness.[16] We hypothesized a negative correlation between sleep quantity and caffeine consumption. However, the effects of increased caffeine consumption were not directly correlated to a decrease in sleep quantity in this study. Although a negative trend was found between caffeine consumption and sleep quantity, this correlation was not statistically significant. Potential reasons for this may relate to different caffeine sensitivity, sleep environment, and schedule, medications such as sleeping aides and recreational drugs, etc. However, the participants had yet to use medicines that assist sleeping in the past month to responses from the PSQI Questionnaire. Regardless, we couldn't predict the influence of these aspects on sleep quantity in this study.

Further research is needed to clarify the relationship between caffeine consumption and sleep quantity. Average caffeine consumption and sleep quantity data may be susceptible and inaccurate as the survey was retrospective. Objective measurements can be included, and prospective surveys can be used in future studies to increase reliability and accuracy. Sleep monitor machines would help measure sleep more accurately, thus adding further insight into sleep patterns, quality, and quantity among student-athletes. Additional limitations include the small sample sizes from the surveys, which restricted the generalization of the results and hindered the identification of trends and correlations between variables, and the lack of reference to the time of caffeine consumption, which may potentially affect results.

The findings from this study provided sufficient evidence that the quality and quantity of sleep and caffeine consumption are related. The strengths of the present study include studying adolescents, which provides insight into a larger age range population of student-athletes. Most existing research on student-athletes is done on young adults, limiting the generalizability of the findings. Additionally, we utilized a validated and reliable survey to collect sleep quantity and quality data. This increases our confidence in the reliability of the data collected and the accuracy of the self-report data included.

Conclusion

We strongly encourage student-athletes to prioritize sleep during the sports season. Not only does sleep further improve and maximize athletic performances, but sleep also reduces the chances of getting injuries moving forward.[5] Sleep has a restorative effect on bodily systems such as the immune and endocrine systems and promotes nervous system recovery.[17] Caffeine intake can be considered if beneficial instead of harmful effects are given to high school student-athletes. Low to moderate amounts of caffeine (3-6 mg/kg) can be consumed prior to training or competitions to enhance physical, mental, and cognitive performance and not disrupt and lower sleep quantity and quality.[18]

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