Caffeine Consumption and Sleep in Adolescent Student Athletes

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Introduction

Caffeine, sleep quality, and quantity, are critical elements that profoundly impact an athletes overall performance (Lo et al., 2017). 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 concomitant mental and physical health issues (Wilson & Pritchard, 2005). 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 stimulates sleep disorder in student-athletes (Monma et al., 2018). By understanding the relationship between factors that impact athletic performance, student-athletes may protect themselves from unnecessary stress and optimize their athletic and academic performance.

Sleep plays a vital role in cognitive and bodily functions and contributes to physical and mental homeostasis. Human motor cognitive coordinated tasks are largely dependent on the sleep-wake rhythm, also known as the circadian rhythm. Athletes follow this rhythm as well as they are awake and exercising during the day and sleeping and recovering at night. Because of this, athletic and physical performance are largely dependent on the quality and quantity of sleep (Davenne, 2007). Research has shown that improved sleep quantity and quality are often associated with improved performance and competition successes. In addition, sleep decreases risk factors for injury or illness (Watson, 2017). 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 levels of stress and other factors may decrease sleep quantity and quality. To compensate for this decreased sleep quality and quantity, and improve their athletic performance despite the sleep deprivation, many student-athletes may consume caffeine.

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 provide benefits to athletes in cognitive, physical sport performance especially under conditions of sleep deprivation (Guest et al., 2021). Recent findings have demonstrated that benefits from caffeine can be seen in a variety of sports including: endurance, stop-and-go, high intensity, strength and power events (Burke, 2008). 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 (Hwangbo et al., 2016). Not only that, caffeine is often associated with day-time sleepiness and

disturbed sleep despite being commonly used to promote alertness and wakefulness (Roehrs & Roth, 2008). To understand the underlying potential long-term consequences of caffeine's effects on sleep, further research is needed.

The aim of the present study is to understand the relationship between the quantity and quality of sleep, and caffeine consumption in student-athletes to further understand conditions that optimize student-athletes' sport 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 years old. Participants were recruited from Chiang Mai International School, located in Chiang Mai, Thailand. Inclusion criteria for participants were to require active engagement in a school team sport, as defined as, playing a team sport that is offered at school during the time the survey was conducted. Only one participant who completed the survey 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/or 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 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 completed the survey, responses from Google Forms were transferred into Google Sheets. The raw data directly transferred from the 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 was used to measure the sleep quality of the subjects (Moghaddam et al., 2011). The questionnaire contained 10 main questions, some with sub questions, in order to determine the sleep quality. The PSQI score is the sum of seven component scores; each component scored between 0 to 3, 3 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, ranging 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 the course of 5 days. participants were asked how many 8 oz servings of caffeinated drinks (green tea, black tea, brewed Coffee, carbonated drinks, energy drinks, instant coffee) and shots of espresso (1 oz serving size), were consumed. Participants completed the questionnaire retrospectively recalling their consumed caffeinated drinks over the past 5 days. Then, average caffeine consumed was calculated using data from Mayo clinic in mg/8 oz except for espresso, which is measured in mg/1 oz (Mayo Clinic, 2022).

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 of the results, the Pearson correlation coefficient associated 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 $\pm$ standard deviation.

Results

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

Table 1. Participants' Demographics

Demographic Information	Mean $\pm$ Standard Deviation
Age, year	16 $\pm$ 0.8
Sports Played Per week, hours	6.1$\pm$ 2.25
Sport, n (%) Volleyball Football* Basketball* Futsal Badminton Cross Country*	 20 (100) 12 (60) 12 (60) 9 (45) 3 (15) 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 sleep quality and sleep quantity of the participants, 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 score because one of the attributes of sleep quality is sleep duration (Nelson et al., 2022). Thus, we did a control analysis to confirm that this trend was replicated in our dataset as a way of assessing reliability of the sleep data.

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)**.

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 decrease in sleep quantity r(20) = -0.515, p = 0.02 (**Figure 3)**. The negative relationship between the two factors revealed that the duration of sport exercise also affected the quantity of sleep the individual was getting, not just the caffeine consumption. Student-athletes who devote a significant amount of time for sports are at the risk of losing quality sleep time. See Figure 3 for correlation graph.

Figure 1. Average Caffeine per day vs Sleep Quality

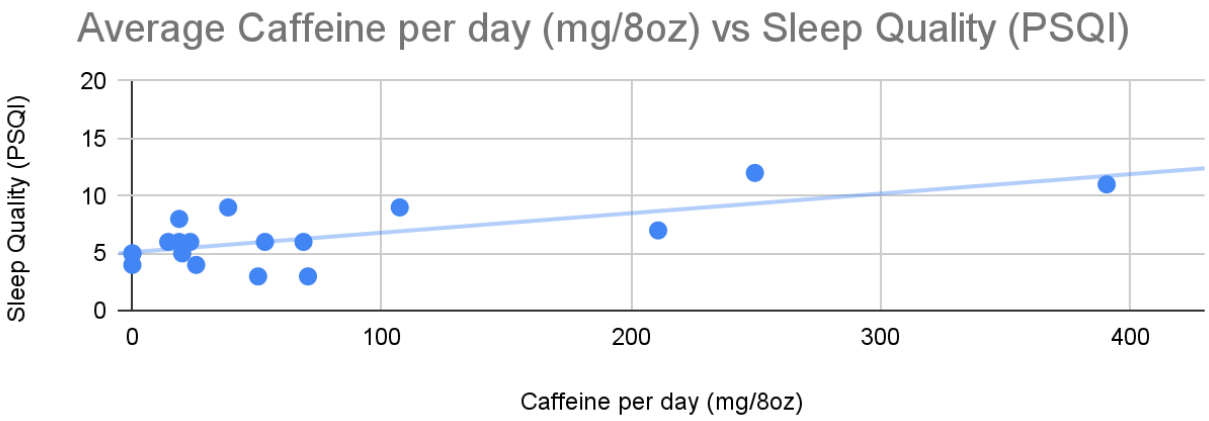


Figure 2. Average Caffeine per day vs Sleep Quantity

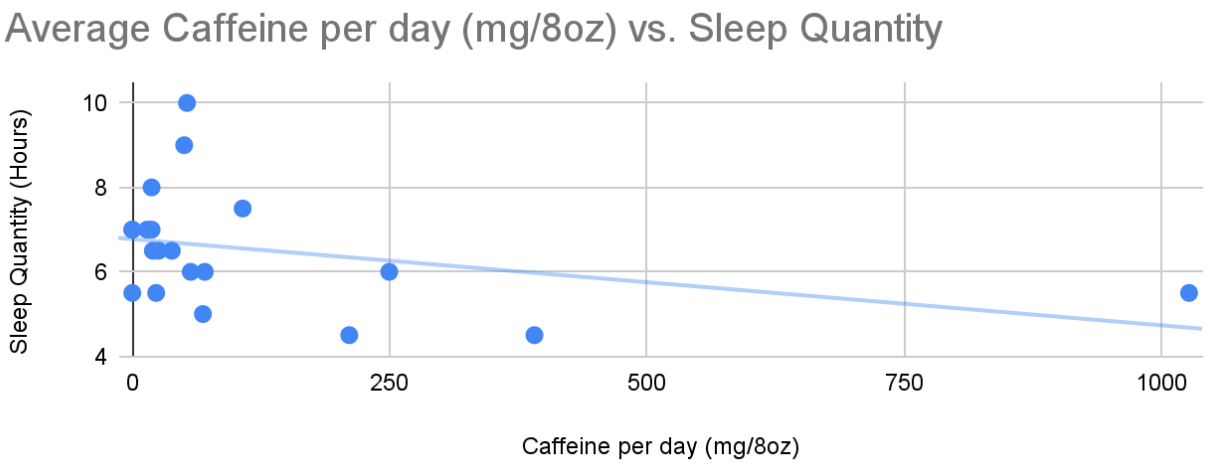
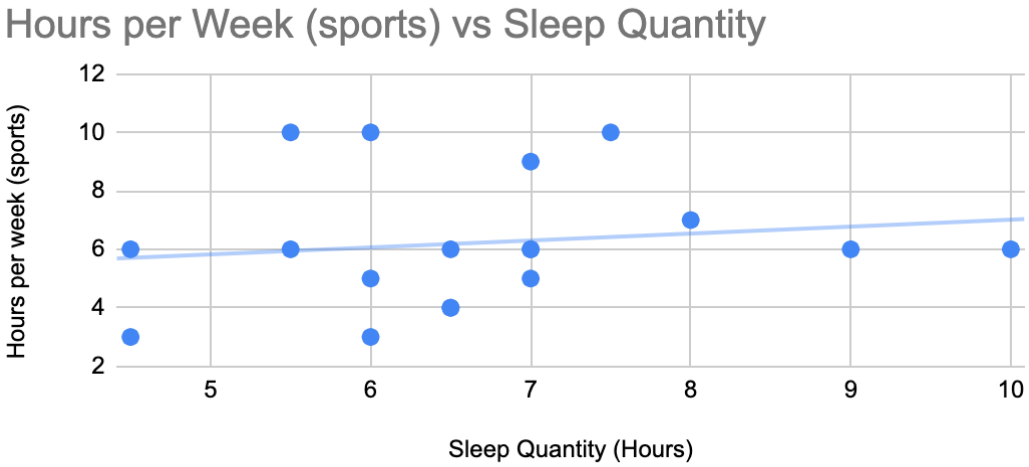


Figure 3. Hours of sports per week vs Sleep Quantity



Discussion

The present study evaluated the relationship between sleep quality, sleep 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 that as caffeine consumption increases, the quality of sleep 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 performances in sport and academics.

The mean PSQI score, which measures sleep quality, is 4.2 globally (Park, 2020). A score higher than 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 qualities, 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 (Lo et al., 2017). In this study, an increased caffeine consumption directly leads to a decrease in sleep quality, as caffeine consumption increases sleep latency, shortening total and deep sleep time (Coffee & Health). When we apply these findings to a student-athletes perspective, negative sleep factors may lead to a decrease in academic and sports performance. 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 consumed in relation to exercise duration and intensity (Pickering & Kiely, 2018).

The stimulant, caffeine, is used to enhance performance and mitigate sleepiness (Clark & Landolt, 2017). 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 aspects such as different caffeine sensitivity, sleep environment and schedule, medications, etc. However, none of the participants used medications that assist sleeping in the past month in accordance with responses from the PSQI Questionnaire. Regardless, we weren’t able to predict the influences these aspects have in 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 potentially be susceptible and inaccurate as survey was retrospective. Objective measurements can be included, and prospective surveys can be used in future studies to increase reliability and accuracy. Sleep monitor machine would help measure sleep more accurately, thus, add further insight in sleep patterns, quality and quantity among student-athletes. Additional limitations include the small sample sizes from the surveys; this restricted the generalization of the results, and hindered the identification of trends and correlations between variables.

The findings from this study provided sufficient evidence that the quality and quantity of sleep and caffeine consumption is related. The strengths of the present study include studying adolescents, which provides insight into a larger age range population of student-athletes. The majority of existing research of student-athletes is done on young adults, limiting the generalizability of the findings. Additionally, we utilized a validated and reliable survey for collecting 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 sport season. Not only does sleep further improve and maximize athletic performances, sleep also reduces

chances of getting injuries moving forward (Watson, 2017). In addition, sleep has a restorative effect on bodily systems such as the immune and endocrine system, and also promotes recovery of the nervous system (Doherty et al., 2019). Caffeine intake can be considered as giving high-school student-athletes beneficial instead of harmful effects. 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 (Goldstein et al., 2010).

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