

Caffeine

Effects on sleep and academic performance in college students

Caffeine can have a powerful effect on individuals. This article looks at the effect of caffeine on sleep and academic performance in college students, as well as types of caffeine consumed, how much caffeine is consumed, reasons students consume caffeine, sleep quality, and academic performance outcomes.

Olivia Bonanni, RN BSN, Department of Nursing, The College of New Jersey, USA

Mallory Mullen, RN BSN, Department of Nursing, The College of New Jersey, USA

Taylor Falcon, RN BSN, Department of Nursing, The College of New Jersey, USA

Humphrey Huang, RN BSN, Department of Nursing, The College of New Jersey, USA

Allison Lowry, RN BSN, Department of Nursing, The College of New Jersey, USA

Dr Tracy Perron, professor, Department of Nursing, The College of New Jersey, USA

The scope and purpose of this article is to examine the current literature on caffeine, specifically caffeine consumption and alternatives. Caffeine has been shown to have effects on various life factors in college students (17–24-year-olds), such as sleep and academic performances, which will be investigated through literature (Alsharif et al, 2018; Bucher et al, 2019; Alfawaz et al, 2020; Eduviere et al, 2021; Wang and Biro, 2021).

Types of caffeine consumed

Caffeine is consumed worldwide by college students in many different forms

(Alsharif et al, 2018; Jahrami, et al, 2020; Mahoney et al, 2019; Eduviere et al, 2021; Zahra et al, 2021). Caffeine is considered a psychoactive substance, which may be found naturally or artificially, as synthetic coffee is commonly added to food and beverages to increase the level of stimulants (Jahrami, et al, 2020; Eduviere et al, 2021; Zahra et al, 2021). The most common source of caffeine is identified as coffee, as it is often readily available to individuals (Alsharif et al, 2018; Mahoney et al, 2019; Jahrami et al, 2020). Other major sources of caffeine consumed specifically by college students include, tea (black and green), chocolate, carbonated soft drinks, energy drinks, cocoa, and

medications or dietary supplements (Alsharif et al, 2018; Kepershoek et al, 2018; Mahoney et al, 2019; Jahrami, et al, 2020; Eduviere et al, 2021; Zahra et al, 2021). Energy drinks have recently become a more popular category of caffeinated beverages for college students, particularly males (Alsharif et al, 2018; Mahoney et al, 2019). Each type of caffeinated drink has varying levels of caffeine concentration; for example, coffee contains around 85 mg of caffeine per cup, whereas tea contains 30 mg per cup, cola contains 18 mg per cup, and energy drinks contain 80 mg per cup (Kepershoek et al, 2018). In a sample of 1 248 college students in five United States' universities, 72% consumed coffee,

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61.4% consumed tea, 68.8% consumed soda, 36.4% consumed energy drinks, and 12.2 % consumed other forms of caffeine (Mahoney et al, 2019). Although some studies differed in their defined four major sources alternating between chocolate, soft drinks, and energy drinks, constants in all were coffee and tea (Alsharif et al, 2018; Jahrami et al, 2018; 2020; Kepershoek et al, 2018; Mahoney et al, 2019; Eduviere et al, 2021; Zahra et al, 2021). Caffeine can be found in a copious amount of food, beverages, and supplements, which provides easy access for college students and increases their risk of being affected by caffeine (Alsharif et al, 2018; Kepershoek et al, 2018; Mahoney et al, 2019; Jahrami, et al, 2020; Eduviere et al, 2021; Zahra et al, 2021).

How much caffeine is consumed

It has been estimated that over 80% of

the world population consumes caffeine (Alsharif et al, 2018). It is the most commonly used central nervous system stimulant and psychoactive substance worldwide (Kepershoek et al, 2018; Jahrami et al, 2020). In college students specifically, consumption is 92% (Mahoney et al, 2019; Zahra et al, 2021). Mahoney et al (2019) found the average daily consumption of caffeine for all college students was 159 mg per day; for those who frequently consume caffeine, the average intake of caffeine was 173 mg each day. Two studies in the middle-East found caffeine is also often abused by college students (Alsharif et al, 2018; Jahrami et al, 2020), with one fifth of students frequently consuming over the advised 400 mg of caffeine a day (Jahrami et al, 2020). Amounts of caffeine exceeding 400 mg often result in negative effects on college students pertaining to physiological and psychological detriments (Jahrami et al, 2020; Zahra et al, 2021).

Among college student consumers, males appear to consume more caffeine than females overall (Mahoney et al, 2019; Eduviere et al, 2021; Zahra et al, 2021). Different amounts of caffeine are consumed depending on the type of caffeine and gender of students (Mahoney et al, 2019). Males reported consuming 120.3 mg of caffeine a day from coffee and females reported an intake of 110 mg. As for tea, males consumed 60.9 mg/day and females consumed 50.1 mg/day (Mahoney et al, 2019). There is often consumption of caffeine from energy drinks as well, which totalled to 53.2 mg/day in males and 30 mg/day in females (Mahoney et al, 2019). Lastly, caffeine consumption in soda each day averaged 38.3 mg for males and 36 for females (Mahoney et al, 2019). Consuming these amounts of caffeine would require 150 ml of coffee for 40–180 mg, 150 ml of tea for 24–50 mg, and 180 ml of soda for 15–29 mg (Zahra et al, 2021). Caffeine is

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also consumed in chocolate which provides 1–36 mg of caffeine per 28 grams of chocolate (Zahra et al, 2021). AlSharif et al's (2018) study found that 51.5% of students consumed 4 or more cups of caffeine a day, which is considered excessive intake. Overall, college students can easily access and consume caffeine in many different forms every day (Eduviere et al, 2021; Mahoney et al, 2019; Zahra et al, 2021).

Reasons students consume caffeine

In addition to the many different types of caffeine, there are also many reasons students may consume caffeine. Caffeine is commonly known for its ability to make a person more awake and increase energy (Bucher et al, 2019; Zahra et al, 2021). Studies have shown that many college students consume caffeine to increase wakefulness, overcome fatigue, cope with stress, and overall improve their cognitive performance (AlSharif et al, 2018; Bucher et al, 2019; Mahoney et al, 2019). Students reported they will use caffeine during times of increased stress, such as exams, to try and improve their ability to concentrate (Devi et al, 2018; Bucher et al, 2019; Alfawaz et al, 2020). In addition, students will use caffeine to delay sleep onset, leaving more time for studying and again hoping to improve academic performance (Kepershoek et al, 2018; Jahrami et al, 2020; Eduviere et al, 2021). Zahra et al (2021) found that 83.4% of college students reported that caffeine makes them more alert, while 80.6% reported that it makes them more energetic.

The consumption of caffeine can also be based on the social aspect of it, with places like coffee shops becoming increasingly popular hang-out spots for college students in the US, for example. The social aspect and taste of caffeine has been shown to be a major factor when college students were asked about the reason they continue to drink caffeine (Bucher et al, 2019; Mahoney et al, 2019). One study in particular, which looked at different sources of caffeine and reasons for consumption, found that 39% of students consumed caffeine strictly for the social aspect (Mahoney et al, 2019). In addition, students have admitted to the use of caffeine as an appetite suppressant, as it is perceived to decrease their level of hunger (Zahra et al, 2021).

All of this caffeine consumption leads to dependence as studies have found that

college students also consume caffeine simply because of the withdrawal they experience without having it (Mahoney et al, 2019; Zahra et al, 2021). Another reason included the perception that caffeine enhances physical performance (Zahra et al, 2021). Zahra et al (2021) discovered that 66.4% of consumers in their study would use caffeine because it enhances workouts, 56.5% said that they exercise longer with caffeine, and 73.1% said it improves athletic performance. No matter the type, it is clear that caffeine is consumed by students for a variety of reasons (Bucher et al, 2019; Mahoney et al, 2019; Zahra et al, 2021).

Effect on sleep quality and daytime sleepiness

College students who consume caffeine have poorer sleep quality (AlSharif et al, 2018; Kepershoek et al, 2018; Bucher et al, 2019; Jahrami et al, 2020; Eduviere et al, 2021; Wang and Biro, 2021). After consumption of caffeine, students experience sleep disruption and fewer hours of sleep (AlSharif et al, 2018; Kepershoek et al, 2018; Bucher et al, 2019; Jahrami et al, 2020; Eduviere et al, 2021; Wang and Biro, 2021). Students experience specific sleep problems due to caffeine consumption, such as insomnia, and restlessness (Jahrami et al, 2020; Wang and Biro, 2021). Caffeine also delays the onset of sleep, which is actually a commonly cited reason for its intake (Kepershoek et al, 2018; Jahrami et al, 2020; Eduviere et al, 2021). College students struggle with both falling and staying asleep while consuming caffeine (Kepershoek et al, 2018; Bucher et al, 2019; Mahoney et al, 2019; Jahrami et al, 2020). Students reported waking up frequently throughout the night as a result of caffeine (Kepershoek et al, 2018; Mahoney et al, 2019).

Besides poorer sleep quality, college students are also affected the next day (Jahrami et al, 2020; Eduviere et al, 2021). Many college students who consume caffeine experience excessive daytime sleepiness (Jahrami et al, 2020; Eduviere et al, 2021). These negative effects on sleep are related to altered circadian rhythms (Eduviere et al, 2021). Adenosine is our 'physiologic sleep enhancer' that helps regulate our sleep; the more adenosine the longer and deeper the sleep (Eduviere et al, 2021). Caffeine inhibits adenosine receptors, and therefore alters the

circadian rhythm to result in reduced sleep efficiency (Eduviere et al, 2021). College students will then feel increasingly fatigued and experience sleepiness in their lectures (Eduviere et al, 2021). Overall, the effect of caffeine on sleep is negative and adversely affects college students throughout the night and following days (AlSharif et al, 2018; Eduviere et al, 2021; Wang and Biro, 2021).

Academic performance outcomes

In addition to the effects of caffeine on sleep quality, caffeine intake also has negative effects on academic performance (AlSharif et al, 2018; Devi et al, 2018; Alfawaz et al, 2020; Eduviere et al, 2021). During times of high academic stress, such as exams, college students consumed greater amounts of caffeine and did so more regularly (Devi et al, 2018; Bucher et al, 2019; Alfawaz et al, 2020). The high amounts of caffeine consumption increased irritability and fatigue (Devi et al, 2018; Eduviere et al, 2021). Both of these effects of caffeine consumption negatively affect the student's ability to learn (Devi et al, 2018; Alfawaz et al, 2020). Further, the heightened caffeine intake during exam periods also increased the time it takes for students to fall asleep and reduced sleep duration (AlSharif et al, 2018; Devi et al, 2018; Kepershoek et al, 2018; Eduviere et al, 2021; Wang and Biro, 2021). The prolonged onset of sleep and subsequent fewer hours of sleep contributed to poor sleep quality and excessive daytime sleepiness (AlSharif et al, 2018; Devi et al, 2018; Kepershoek et al, 2018; Eduviere et al, 2021; Wang and Biro, 2021). In turn, excessive daytime sleepiness and poor sleep quality has been associated with poor academic achievement (AlSharif et al, 2018; Okano et al, 2019; Eduviere et al, 2021). This leads to poor performance because it affects the students' ability to concentrate during lectures (Okano et al, 2019; Eduviere et al, 2021). Furthermore, this causes students to spend more hours studying at night, which leads students to develop inconsistent sleeping schedules and have decreased sleep duration, negatively affecting their academic performance (Garmy and Ward, 2018; Okano et al, 2019; Eduviere et al, 2021).

Sleep duration is another factor that influences overall sleep quality and academic attainment (Garmy and Ward,

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2018; Okano et al, 2019; Wang and Biro, 2021). Students who had experienced sleep disturbances such as not getting enough sleep, excessive daytime sleepiness, and poor sleep maintenance had a lower cumulative GPA and poorer academic success (Alsharif et al, 2018; Eduviere et al, 2021). Sleep is a crucial component when it comes to academic achievement because sleep helps improve memory consolidation, memorisation, alertness, and cognition (Okano et al, 2019; Eduviere et al, 2021). Further, caffeine does not enhance memory and memory can be negatively affected by sleep schedule changes (Devi et al, 2018; Eduviere et al, 2021). Lack of sleep increases fatigue and sleepiness in addition to negatively affecting one's cognitive performance (Alsharif et al, 2018; Okano et al, 2019). Improving sleep quality, consistency, and duration of sleep is associated with better academic performance (Okano et al, 2019; Eduviere et al, 2021; Wang and Biro, 2021). The more sleep university students had on average contributed to better overall exam scores (Okano et al, 2019; Eduviere et al, 2021).

Alternatives to caffeine usage

Overall, evidence about caffeine supports the premise that ingesting an excessive amount of caffeine can be detrimental to their sleep schedule and subsequently their academic performance (Alsharif et al, 2018; Devi et al, 2018; Garmy and Ward, 2018; Bucher et al, 2019; Okano et al, 2019; Alfawaz et al, 2020; Eduviere et al, 2021; Wang and Biro, 2021). Therefore, ongoing research persists to discover alternatives to caffeine that are suitable for all populations (Alsharif et al, 2018). Many alternatives can be found in natural herbal remedies; there are over 60 different fruits and plants that naturally contain caffeine (Nimbhorkar et al, 2021). Wang and Biro (2021) argued that while these natural herbs may provide a more mundane and safer version of caffeine, they may also provide the benefit of being adaptogens. According to Fang et al (2020), adaptogens allow the body to better adapt to stress, as

well as provide the body with energy and restore it back to equilibrium (Fang et al, 2020). As a result, this helps the body create resistance to stressors and adapt better (Fang et al, 2020). One study suggests that potentially safe and effective replacements of caffeine could be ginkgo biloba and kudzu (Nimbhorkar et al, 2021). Ginkgo biloba has been sold in the United States since the 1960s and is very popular in Chinese culture, due to its caffeine content, digestive properties, and antioxidant effects (Fang et al, 2020; Nimbhorkar et al, 2021). Kudzu or *Pueraria tuberosa* is rich in antioxidants and increases alertness (Fang et al, 2020; Nimbhorkar et al, 2021). Some herbal remedies may provide effective replacements for common sources of caffeine, such as energy drinks (Nimbhorkar et al, 2021); however, it is important to note that some herbal remedies may interact with medication and that correct dosage is important.

Another alternative to caffeine use is exercise. Cardiovascular exercise such as running, high-intensity interval training, jumping jacks, burpees, or anything that increases heart rate is proven to have multiple positive effects on alertness (Dolezal et al, 2017). These exercises have been shown to wake one up, stimulate the nervous system, enhance memory storage and retrieval of memories, and speed up the overall mental process (Dolezal et al, 2017). Not only does exercise keep the body stimulated and alert, but those who engage in high levels of physical activity have been found to have a longer and better quality of sleep (Dolezal et al, 2017; Wang and Biro, 2021). Cardiovascular exercise keeps the body system awake and alert, and promotes better sleep at night, in turn allowing an individual to have a more restful night, awakening refreshed with more energy (Wang and Biro, 2021).

Alternatives to better academic performance

College students can improve their academic performance by focusing on improving their sleep habits rather

than relying on caffeine. Students who experience a shorter duration of sleep at night struggle with less enjoyment in school and decreased academic achievement (Garmy and Ward, 2018; Okano et al, 2019). Therefore, it is important for students to gain an adequate amount of sleep each night to improve learning (Okano et al, 2019; Eduviere et al, 2021; Wang and Biro, 2021). In addition to the negative effect on sleep due to caffeine, students who participate in high screen time experience an increase in insomnia as well as an increase in sleep-wake disturbances (Garmy and Ward, 2018; Jahrami et al, 2020; Wang and Biro, 2021). Therefore, decreasing caffeine and reducing screen time before bed promote better sleep and allow students to get the recommended amount of sleep required to fight daytime fatigue (Garmy and Ward, 2018; Wang and Biro, 2021).

Another way to decrease sleep distributions is the timing of daytime activities, such as when caffeine is ingested and when exercise is done. Studies have shown that individuals who ingest caffeine several hours before trying to fall asleep have increased difficulties falling asleep and staying asleep (Alsharif et al, 2018; Kepershoek et al, 2018; Bucher et al, 2019; Eduviere et al, 2021). In order to not disrupt sleep cycles students should consume caffeine, if needed, earlier in the day (Kepershoek et al, 2018; Eduviere et al, 2021). Findings also show that exercise done within 2 hours of bedtime leads to lack of REM sleep and disruptions of the sleep-wake cycle (Dolezal et al, 2017; Wang and Biro, 2021). However, exercise can improve memory and enhance mental processes to increase academic performance (Dolezal et al, 2017). Students can benefit from exercising in the morning and early afternoon in order to give themselves the energy to carry themselves throughout the day while simultaneously not disrupting their sleep (Wang and Biro, 2021).

Conclusions

In today's society, caffeine is an extremely

prominent substance (Kerpershoek et al, 2018; Jahrami et al, 2020). Specifically within the daily lives of college students, caffeine is something that has an extremely important role, and can affect various aspects of their own individual experiences. As stated, multiple studies have shown common themes regarding just how many lifestyle factors can be adversely affected by caffeine consumption, especially sleep and academic performance (Alsharif et al, 2018; Bucher et al, 2019; Eduviere et al, 2021; Wang and Biro, 2021). There are effective alternatives to caffeine usage and improvement of academic attainment, such as cardiovascular exercise and herbal alternatives (Dolezal et al, 2017; Fang et al, 2021; Nimbhorkar et al, 2021; Wang and Biro, 2021). These alternatives would benefit from more in-depth study.

Overall, caffeine has been found to have negative associations with sleep and academic performance (Alsharif et al, 2018; Bucher et al, 2019; Eduviere et al, 2021; Wang and Biro, 2021). More studies should also be done to further explore these negative effects, as well as other potential alternatives, in order to help college students in the future. **CHHE**

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