

The Effects of Caffeine on Sleep Patterns Among Adolescents

Lauren Margolis

Peabody College, Vanderbilt University

This review of literature examines whether there is a causal relationship between caffeine consumption and sleep patterns among adolescents. Literature suggests that there is a cause and effect relationship between caffeine intake and cognitive performance in adults. Researchers also found that among the adult population, consuming caffeine before sleep resulted in increased sleep onset time, reduced total sleep time, and poorer sleep quality. Specifically, adolescents ingest the majority of their total caffeine intake through caffeinated sodas. Studies have shown that adolescents consume more caffeine later in the week, which correlates with shorter total sleep time and decreased sleep quality. Thus, in review of the literature, it was determined that caffeine negatively affects sleep habits among adults, but further research should be conducted in order to conclude whether this relationship holds true among adolescents.

Introduction

It is no surprise that more and more people are turning to caffeine in order to keep up with all the daily responsibilities demanded of them. Accordingly, there are many sources of caffeine available to people today: coffee, tea, sodas, and even candies. The overbearing presence of coffee establishments such as Starbucks and Dunkin' Donuts are enough to illustrate that society has become dependent on caffeinated beverages. Caffeine is a known stimulant that people utilize to increase alertness and wakefulness (James, 1998). Moreover, caffeine has been shown to improve functional and cognitive performance (Smith, Maben, & Brockman, 1993; Sun, Zhang, He, Liu, & Miao, 2007).

As previously stated, caffeine can be beneficial for some cognitive functions; however, there are some depressing effects that result from consuming caffeine as well. Thus it is essential to consider both the positive and negative effects of this substance. Although research has not shown that caffeine has any significant causal relationship with mood (Smith et al., 1993), several studies have found that the intake of caffeine before bed delays sleep onset time, decreases total sleep time, and reduces sleep quality (Goldstein, 1963; James, 1998; Smith et al., 1993; Wright, Badia, Myers, Plenzler, & Hakel, 1996). Further research should be conducted in order to reveal whether these effects on sleep cause negative consequences for performance and behavior.

Despite research that has indicated sleep-related problems from caffeine consumption

(Goldstein, 1963; James, 1998; Smith et al., 1993; Wright et al., 1996), the total caffeine intake among adolescents is increasing (Bernstein, Carroll, Thuras, Cosgrove, & Roth, 2002; Pollak & Bright, 2003). Specifically defined, adolescents include children between 13 and 19 years-old and during this time they undergo significant mental and physical development ("Adolescence," 2008). Therefore it is vital that this group receives sufficient sleep to develop normally. Bernstein et al. (2002) noted in their study of 36 subjects, ranging in age from 13 to 17 years, that 22.2% of the sample met the criteria for caffeine dependence. Pollak and Bright (2003) study concluded that adolescents consume most of their total caffeine intake through sodas and increase their ingestion as the week progresses. This may suggest that adolescents depend on caffeine to remain alert when they start to feel the effects of sleep deprivation due to long school day hours.

Although research demonstrates that caffeine causes sleep problems in adults, few studies have specifically concluded causality between caffeine and sleep patterns among adolescents. Thus, the results of studies that sampled adults may not be generalized to the population of adolescents. Moreover, the studies that have conducted their research with adolescents used self-reported measurements (Orbeta, Overpeck, Ramcharran, Kogan, & Ledsky, 2006; Pollak & Bright, 2003). Because the reliability of self-reports is questionable, the validity of these results should also be considered with caution. Researchers should utilize other methodologies, such as an ex post facto study, to draw causality.

Review of Literature

Caffeine Effects

Caffeine is a known stimulant that affects behavior and performance, and so has been a topic of interest for many researchers (Goldstein, 1963; James, 1998; Smith et al., 1993; Sun et al., 2007). In a study of 10 healthy male volunteers aged 18-20, Sun et al. (2007) gave subjects one of five treatments: no substance, caffeine pill, placebo pill, two caffeine pills, or a caffeine and placebo pill. They then asked them to complete vigilance and cognitive performance tests as quickly and accurately as possible, including the Letter Cancellation Task, Stroop Test, and Continuous Addition Test. The researchers found that those subjects who received two caffeine pills or a caffeine and placebo pill performed better on these tests than when under the other treatments. This demonstrates that caffeine has more beneficial effects on performance than no caffeine or low doses of caffeine. Furthermore, the research suggests that the expectation of caffeine also improves performance. However, a major limitation in this study is that practice may be a confounding variable, meaning that increased performance could be attributed to the fact that subjects completed the tests several times before receiving the caffeine treatment.

Likewise, James (1998) reported that 36 adult habitual caffeine consumers exposed to moderate caffeine consumption 3 times daily for 6 consecutive days felt more alert after caffeine intake. On the seventh day, one group of the subjects was given a placebo instead of caffeine, which resulted in reports of feeling less alert. James' study indicates that caffeine increase vigilance, but withdrawal after habitual use has negative effects. In a previous study, Goldstein (1963) also found that 230 medical students showed less wakefulness when given caffeine if they were habitual coffee drinkers than those who rarely consumed coffee. These two studies illustrate that habitual caffeine consumers may not feel as stimulated as non-habitual users after consuming caffeine, and will feel greater withdrawal symptoms. However, these studies are limited in that they do not specifically define a habitual caffeine user.

Regarding behavior the day after consuming caffeine, Smith et al. (1993) concluded that taking caffeine before sleep had no significant influence on functional performance or mood the following day. They conducted an experiment on 48 students

at the University of Wales College in which the subjects self-reported their functional performance and mood after receiving either caffeine or placebo before bed. There was no significant difference in behavior between those who took caffeine and those who took the placebo. The researchers acknowledge that they asked the subjects to report performance or mood changes early in the day, and if they had observed them later on there may have been changes. In addition, the results were self-reported, which could yield different results than if subjects had been given a test that would better operationalize functional performance and mood.

Caffeine Use Among Adolescents

Several researchers (Bernstein et al., 2002; Lee, Mcenany, & Weekes, 1999; Morgan, Stults, & Zabik, 1982; Orbeta et al., 2006; Pollak & Bright, 2003) have found that adolescents in the United States consume the majority of their total caffeine intake through caffeinated sodas. Pollak and Bright (2003) found that soda accounted for 53.8% of caffeine consumed in their study's sample, and Bernstein et al. (2002) noted that caffeine is an ingredient in over 70% of sodas. Orbeta et al. (2006) reported that over 50% of adolescents in grades 6-10 said they never drink coffee, but 33% said they drink soda once a day or more. Moreover, consumption of these drinks by adolescents is increasing (Orbeta et al., 2006).

In the study conducted by Orbeta et al. (2006), 36 adolescents with a mean age of 15.4 years were asked to provide a dietary history that recorded the amount and sources of caffeine. They were then asked a series of questions derived from the DSM-IV substance dependence criteria, including: tolerance, withdrawal, desire and/or unsuccessful efforts to reduce limit use, and continued use despite knowledge of physical/psychological problems due to substance use. The researchers' results showed that the mean intake of caffeinate beverages was a 12 ounce can of caffeinated soda. Furthermore, 22.2% of the subjects met 3 out of the 4 criteria for caffeine dependence, and 77.8% of this group endorsed withdrawal symptoms after stopping or cutting down on caffeine. Although the findings indicate that a significant amount of this sample is caffeine-dependent, it should be noted that the sample size was relatively small and also racially homogenous (90% white), and consequently the results may not be generalized to the population of all adolescents.

Investigators who focused on the amount of

caffeine consumed throughout the week by adolescents (Pollak & Bright, 2003) concluded that the majority of 191 subjects from a public high school in Columbus, Ohio aged 12-15 years had a higher intake of caffeinated sodas as the week progressed, especially on the weekends. This increased caffeine ingestion was associated with shorter sleep duration and longer daytime sleep. The researchers suggested that adolescents may ingest more caffeine later in the week to make up for sleep deprivation due to long school-day hours. In further studies, researchers should include questionnaire about the reasons for consuming beverages containing caffeine.

Sleep Patterns in Adolescents

Pollak & Bright (2003) reported that adolescents tend to go to bed later and sleep later on weekend nights. This is most plausibly explained by school schedules that require students to wake up early in the morning. Despite such set schedules, people in general tend to either be morning types or evening types (Wright et al., 1996). Morning types prefer to wake early and find it difficult to stay awake past their normal bedtime hour; conversely, evening types have a preference for going to sleep at a later hour and have trouble waking up in the morning. Wright et al. (1996) surveyed Italian students ranging 14-18 years in age with a modified version of the School Sleep Habits Survey, which asks several sleep related questions, including: trouble staying awake in different situations; items regarding irregular sleep habits, prolonged sleep latency, and difficulties waking up; items regarding use of caffeine, tobacco, and alcohol; and a morningness/eveningness scale. Researchers found that evening types oversleep about 1 hour more on weekend mornings than morning types, and 30 minutes less on weeknights. Additionally, 30% of evening types described themselves as poor sleepers, compared to 15% of morning types who described themselves as such. Also, evening types more frequently used caffeine-containing beverages; however the study does not conclude whether caffeine use has a causal or simply correlation relationship with evening types.

The Effects of Caffeine on Sleep Patterns

Caffeine consumption has been found to disturb sleep by reducing sleep time and sleep quality (Goldstein, 1963; James, 1998; Smith et al., 1993; Wright et al., 1996). In his experiment, Brezinova (1974) found that consuming caffeine

before bedtime decreased total average sleep time, increased sleep onset time, and increased number of wake-ups. 6 normal volunteers aged 50-63 years had their sleep habits recorded on 15 non-consecutive nights, in which for 5 nights each they received decaffeinated coffee, decaffeinated coffee with added caffeine, or no bedtime drink. Brezinova's research showed that under the caffeine condition, subjects slept an average of 2 hours less than with no drink or decaffeinated coffee. They also had a sleep onset latency on average of 66 minutes with caffeine, as compared to 18 minutes with no drink and 21 minutes with decaffeinated coffee. Finally, when taking coffee before bed, the subjects woke up on average four more times than in the other conditions. The investigator concluded that there were no significant findings between the no-drink control and decaffeinated coffee situations. Although the findings regarding caffeine and its effects on sleep patterns is important, it may not be a strong generalization to the current study because of the sample size and age of its subjects.

Even those who consume small amounts of caffeine on a daily basis are subject to feel the effects on their sleep time and quality (Smith et al., 1993; Wright et al., 1996). Consuming an average of two cups of coffee per day can cause people to take longer to fall asleep, sleep for shorter periods of time, and report poor sleep quality (Smith et al., 1993). One study in particular (Wright et al., 1996) sampled 40 healthy males aged 18-25 years who were self-reported as low to moderate caffeine-consumers and were given either a caffeine pill or placebo pill at bedtime. Researchers then sampled their melatonin levels, which is a neurobiological timekeeping system involved in the sleep-wake process. The results showed caffeine effectively suppressed melatonin levels, which prolonged sleep onset time. Moreover, it prevented a nighttime drop in body temperature, and so subjects experienced body temperature levels similar to daytime levels. The relationship between caffeine and melatonin levels may indicate causality between the two variables. Yet this study also sampled older people, which may not directly relate to the current study of sleep patterns in adolescents.

Research specifically on caffeine's effects on sleep habits of adolescents shows similar results to that on adults (Orbeta et al., 2006; Wright et al., 1996). Adolescents who are high caffeine consumers are almost twice as likely to have difficulty falling asleep than those who have a lower daily caffeine intake (Wright et al., 1996). There are also more

likely to have interrupted sleep, especially on nights when they consume more caffeine (Wright et al., 1996).

Conclusion

Caffeine use has been found to have both positive and negative consequences on behavior and functional performance (James, 1998; Smith et al., 1993; Sun et al., 2007). Consuming caffeine leads to increased performance on vigilance and cognitive tests, and also to more alertness (James, 1998; Smith et al., 1993; Sun et al., 2007). Unfortunately, ingesting caffeine at bedtime can result in later sleep onset time, decreased total sleep time, and poorer sleep quality among adults (Goldstein, 1963; James, 1998; Smith et al., 1993; Wright et al., 1996). In addition, adults tend to wake up more frequently during the night after having caffeinated beverages before bed (Brezinova, 1974). Adolescents intake most of their total amount of caffeine through caffeinated sodas, and reported that they consume more soda toward the end of the week (Bernstein et al., 2002; Lee et al., 1999; Morgan et al., 1982; Orbeta et al., 2006; Pollak & Bright, 2003). Researchers suggested that this is because they experience sleep deprived later in the week due to long school-day hours, and consequently use caffeine to remain awake during the day (Pollak & Bright, 2003).

Although several experimental research studies have concluded that caffeine negatively affects sleeping patterns, the majority of these experiments have been conducted using a small sample of adults (Brezinova, 1975; Goldstein, 1963; James, 1998; Smith et al., 1993; Sun, et al., 2007; Wright et al., 1996). Therefore the results may not generalize to the population of adolescents. Investigators who sampled adolescents used volunteer, self-reported surveys, which may not yield reliable results (Orbeta et al., 2006; Pollak & Bright, 2003). Future research should be done using alternative research designs with adolescents in order to conclude causality between caffeine and sleep patterns among this population.

References

- Adolescence. (2008, March 29). In *Wikipedia, the free encyclopedia*. Retrieved March 30, 2008, from <http://en.wikipedia.org/wiki/Adolescent>
- Bernstein, G. A., Carroll, M. E., Thuras, P. D., Cosgrove, K. P., & Roth, M. E. (2002). Caffeine dependence in teenagers. *Drug and Alcohol Dependence*, 66, 1-6.
- Brezinova, V. (1974). Effects on caffeine on sleep: EEG study in late middle age people. *British Journal of Clinical Pharmacology*, 1, 203-208.
- Giannotti, F., Cortesi, F., Sebastiani, T., & Ottaviano, S. (2002). Circadian preference, sleep and daytime behaviour in adolescence. *Journal of Sleep Research*, 11, 191-199.
- Goldstein, A. (1963). Wakefulness caused by caffeine. *Naunyn-Schmiedeberg's Archives of Pharmacology*, 248, 269-278.
- James, J. E. (1998). Acute and chronic effects of caffeine on performance, mood, headache, and sleep. *Neuropsychobiology*, 38, 32-41.
- Lee, K. A., Mcenany, G., Weekes, D. (1999). Gender differences in sleep patterns for early adolescents. *Journal of Adolescent Health*, 24, 16-20.
- Morgan, K. J., Stults V. J., & Zabik M. E. (1982). Amount and dietary sources of caffeine and saccharin intake by individuals aged 5 to 18 years. *Regulatory Toxicology Pharmacology*, 2, 296-307.
- Orbeta, R. L., Overpeck, M. D., Ramcharan, D., Kogan, M. D., & Ledsy, R. (2006). High caffeine intake in adolescents: Associations with difficulty sleeping and feeling tired in the morning. *Journal of Adolescent Health*, 38, 451-453.
- Pollak, C. P., & Bright, D. (2003). Caffeine consumption and weekly sleep patterns in US seventh-, eighth-, and ninth-graders. *Pediatrics*, 111, 42-46.
- Smith, A. P., Maben, A., & Borekman, P. (1993). The effects of caffeine and evening meals on sleep performance, mood and cardiovascular function the following day. *Journal of Psychopharmacology*, 7, 203-206.
- Sun, Y., Zhang, Y., He, N., Liu, X., & Miao, D. (2007). Caffeine and placebo expectation: Effects on vigilance, cognitive performance, heart rate, and blood pressure during 28 hours of sleep deprivation. *Journal of Psychophysiology*, 21, 91-99.
- Wright, K. P., Jr., Badia, P., Myers, B. L., Plenzler, S. C., & Hakel, M. (1996). Caffeine and light effects on nighttime melatonin and temperature levels in sleep-deprived humans. *Brain Research*, 747, 78-84.