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Caffeine: Effects on Women, Academic Performance, and Well-Being

Introduction

College students report utilizing caffeine-containing beverages such as coffee, tea, or energy drinks to mitigate the effects of poor sleep, to boost academic performance, for taste, and the social aspect.[1,2,3,7] It is reported that students do not begin consuming caffeine regularly (mostly via coffee and tea) until they enter college.[7,18] However, there are notable health implications associated with excessive caffeine use that may negatively impact academic performance, rather than improve it.

Sex, race, hormone status, and individual tolerance can influence the effects of caffeine in the body. Studies have shown that women react differently to caffeine than men due to hormonal shifts that occur with aging, oral contraceptive use, and race. However, current research including female participants is limited. This review aims to present current research findings on the effects of caffeine on women, while also highlighting the effects of caffeine on academic performance in the collegiate setting.

Background

Caffeine is the most widely used psychoactive drug in the world.[1,3] When caffeine is consumed, it is quickly absorbed by the intestines. Peak caffeine plasma levels are achieved within 15 minutes to 2 hours after consumption, with effects occasionally lingering up to 10 hours.[3,4,5,6,8,10] Caffeine mimics the feeling of alertness by binding to adenosine receptors in the brain. When caffeine is not present, adenosine binds normally, which triggers feelings of fatigue.[6,9,10] After caffeine consumption, and in addition to alertness, many people report feelings of motivation, confidence, energy, and general well-being, which may contribute to caffeine's reported addictive qualities.[4] However, once the body becomes used to a consistent intake of caffeine, it takes higher doses to achieve the same effects, which can have negative consequences such as increases in anxiety, depression, irritability, jitters, and difficulty sleeping.[1,2,7] If caffeine intake is decreased abruptly in order to avoid these effects, withdrawal symptoms such as headaches, mood swings, and fatigue can occur.[1,3,5] In addition, caffeine consumption has been associated with a decreased threshold for coping with and handling stress, which can negatively affect all aspects of life.[1] The FDA recognizes caffeine as safe if consumed under 400 mg per day, or the equivalent of 4-5 cups of coffee.[11,12] Nonetheless, this amount may still affect people differently as some are more sensitive to caffeine than others.[4,17]

Caffeine and Women

The current body of literature focuses primarily on the effects of caffeine in male participants highlighting a critical gap when it comes to understanding the effects of caffeine in women. This may be because caffeine metabolism has been found to be altered by female hormones (particularly estrogen), oral contraceptive use, and pre or post-menopausal status.[24,25,27,28,29] Liver enzyme CYP1A2 is responsible for breaking down toxins and drugs, like caffeine, as well as playing a role in estrogen metabolism.[24,29] Since this enzyme must be shared between both processes, caffeine metabolism/clearance from the body is variable among women.[24,27]

Tworoger and Gertig et al. evaluated the Nurse's Health Study (cohort study established in 1976) which included 121,701 women. The participants were given the same questionnaire in 2-year increments until 2004. The questionnaire included questions about caffeine intake, disease diagnoses, and general lifestyle factors. Interestingly, ovarian cancer cases were found to be less common in those who consumed greater amounts of caffeine, no matter the source.[25] Additionally, increased caffeine intake was positively

correlated with estrogen levels in premenopausal women, and negatively correlated with estrogen levels in postmenopausal women.[25] Lucero and Harlow et al. also confirmed this finding in their cross-sectional study of 498 premenopausal women, observing that caffeine (from coffee in particular), increased estrogen levels more so than caffeine found in tea.[23] Schliep and Schisterman et al. conducted a study including race as another parameter. The study participants were from a cohort of 259 premenopausal women of different races and ethnicities, followed by the Biocycle study conducted in 2005-2007. The study evaluated how caffeine in coffee, soda, and black and green tea are related to serum concentrations of hormones, and whether those associations differ by race. Blood samples were collected 8 times over the course of 2 menstrual cycles. Analyses showed that higher caffeine intakes were associated with decreased estrogen concentration among white women, while having the opposite effect on Asian and African American women.[24] Asian women also reached peak caffeine levels earlier than white women.[24] These findings highlight the inconsistency of caffeine's effects among individuals of varying racial and ethnic backgrounds.

The previously mentioned studies excluded women taking oral contraceptives, but studies focusing on those who do, discovered that exogenous hormones can slow caffeine clearance and metabolism in the body.[4,16, 27-29] Tian and Natesan et al. compared caffeine clearance rates in a pharmacokinetic study of 12 men and 12 women who consumed 1-3 cups of coffee per day. Overall, blood samples showed increased clearance rates in men compared with women when the oral contraceptive users were included, but no significant difference in clearance rate when oral contraceptive users were excluded.[29] Abernethy and Todd et al., also found that caffeine elimination was extended in premenopausal women who were taking oral contraceptives with no other medications for at least 3 months prior to the blood draw. This case-control study included a total of 18 premenopausal women, 9 of those taking oral contraceptives, and the other 9 not taking any medications.[28] Similarly, Pollock and Wylie et al., also found a lower clearance rate of caffeine in postmenopausal women taken therapeutic estrogen in their cross-sectional study.

Caffeine and Academic Performance

Caffeine consumption in moderate doses (3-6 mg/kg body weight) is associated with improved ***exercise*** performance, reduced mental fatigue, improved concentration, and alertness.[3,10,13,14,15,18] However, caffeine may not be the best option for boosting grade point average (GPA) or ***academic*** performance. Most studies with student participants were focused on caffeine in the form of energy drinks. However, most energy drinks fall into the category of supplements and are thus not regulated by the FDA with the same scrutiny as drugs are.[19] Therefore, the caffeine content listed on the container may not be accurate.[19] In addition, energy drinks typically contain a significant amount of added sugar, which can contribute to perceptions of increased energy for short periods of time.[15,19]

Trunzo and Samter et al., conducted a cross-sectional study including 486 undergraduate students (187 male, 293 female), investigating the correlation between energy drinks, social problem solving, and academic performance. The parameters in the initial survey given to participants included energy drink usage, non-energy drink caffeine consumption, and drug use. Social problem-solving skills were measured using a short questionnaire (SPSI-R), consisting of a list of problems and how the participant would respond to them, and self-reported GPA was used as a measure for academic performance. Results suggested that energy drink use had a negative correlation with both social problem solving skills and GPA.[1] However, caffeine from other sources did not show a significant correlation with GPA.[1] Additionally, social problem solving skills were significantly correlated with energy drink usage, showing those with higher scores for social problem solving were those who also consumed fewer energy drinks.[1] It was concluded that consistent energy drink usage may be a factor in decreased academic performance

(GPA) because the students with poor academic performance and social problem solving skills were using more energy drinks than those who have better social problem solving skills and academic performance.[1]

Sleep Quality

Excessive caffeine consumption can disturb sleep quality and duration, which may lead to impaired concentration, increased fatigue, and drowsiness, which in turn limits academic performance. Faris and Jahrami et al., looked at how sleep quality differed between those who use energy drinks versus those who do not. This cross-sectional study included 919 randomly selected participants (237 male and 682 females). Analyses showed that 41% of participants reported the regular use of energy drinks, and 34.3% of those reported disrupted sleep.[20] Multiple studies have shown that insufficient sleep negatively alters the immune system, nervous system, mood, and academic performance, therefore increased consumption of high caffeine containing energy drinks can contribute to poor academic performance.[19,20,22]

Conclusions

Women should be aware of how hormone status and oral contraceptive use can alter how caffeine affects their body to make informed decisions about caffeine intake. If women are aiming to consume caffeine as a cognitive aid rather than only for the taste or as a part of social gatherings, it may be beneficial to consider the possible side effects of anxiousness, irritability, and sleep alterations that may last longer than expected. Another consideration could be made about caffeine's effect on hormones, rather than hormone's effect on caffeine in the body, in that diminished sleep quality and increased perception of stress could alter hormone status, thus leading to other health implications.

Overall, caffeine can enhance alertness and concentration, but not so much memory or the ability to perform more complex and brain-exhausting tasks. In other words, caffeine can aid in task completion, but this would not necessarily translate to a higher grade, i.e. better performance. Because caffeine affects people differently, it is difficult to make generalizations about its beneficial or negative effects. However, what is known, is that adequate sleep and a varied diet of proteins, complex carbohydrates, and unsaturated fats provide sustained energy throughout the day,[21] so that stimulants like caffeine are not relied upon and potentially cause negative side effects that impede academic performance even more.

Resources for Further Exploration

To learn more about caffeine and its safety, visit:

- energydrinkinformation.com
- The 2020-2025 dietary guidelines for Americans
- United States Olympic Committee Caffeine Factsheet
- UC Davis Energy Drink Factsheet
- USADA article "5 things to know about energy drinks"

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