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ИССЛЕДОВАНИЕ ВЛИЯНИЯ ПОТРЕБЛЕНИЯ КОФЕИНА НА ЧАСТОТУ СЕРДЕЧНЫХ СОКРАЩЕНИЙ И ДРУГИЕ ФИЗИОЛОГИЧЕСКИЕ РЕАКЦИИ У СТУДЕНТОВ МЕДИЦИНСКОГО УНИВЕРСИТЕТА

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INVESTIGATING THE EFFECTS OF CAFFEINE INTAKE ON HEART RATE AND PHYSIOLOGICAL RESPONSES AMONG UNIVERSITY STUDENTS

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Резюме. Целью настоящего исследования явился анализ взаимосвязи между потреблением кофеина и его влиянием на частоту сердечных сокращений и другие физиологические реакции у студентов медицинского университета. В ходе работы оценивался уровень потребления кофеина во время сессии и сопоставлялся с показателями частоты сердечных сокращений. Полученные данные свидетельствуют о том, что кофеин может влиять на академическую успеваемость студентов.

Ключевые слова: кофеин, сердечно-сосудистая система, частота сердечных сокращений, когнитивная деятельность, аденозин, диуретик, толерантность, скорость метаболизма, энергетические напитки, отказ от употребления.

Resume. Explore the relationship between caffeine intake and its effects on heart rate and other physiological responses among university students. By measuring students' caffeine consumption levels during certain period (examination time) and correlating this data with heart rate, the study seeks to provide insights into how caffeine impacts heart rate and other physiological factors.

Keywords: caffeine, Cardiovascular, Heart Rate, Cognitive Performance, Adenosine, Diuretic, Tolerance, Metabolic Rate, Energy Drinks, Withdrawal.

Relevance. Caffeine is one of the most widely consumed psychoactive substances among college students, often used for its stimulant properties to improve focus and reduce fatigue during stressful exam periods. Understanding how caffeine affects heart rate and other physiological responses is important for evaluating its potential benefits and risks. This research is relevant to health professionals, educators, and students, as it may inform guidelines for safe caffeine consumption and enhance strategies for managing stress and academic performance.

Goal: examine the varying levels of caffeine intake and changes in heart rate and other physiological responses among university students during exam periods.

Tasks:

1. Conduct a comprehensive review of existing studies on caffeine's effects on heart rate and physiological responses.

2. Recruit a diverse sample of university students, ensuring a balanced representation of different demographics.

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3. Develop a questionnaire to assess participants' usual caffeine intake (types of drinks, quantities).

4. Interpret the findings in the context of existing literature, discussing the implications for student health, academic performance, and caffeine consumption guidelines.

Material and methods. A survey was conducted among 50 medical students aged 18 to 25, different gender and faculties; to gather information about their Caffeine intake and the difference of their heart rate and other physiological changes on their body. We took up to 200 mg per day as low intake, 200-400 mg per day as medium intake and over 400 mg per day as high level intake (data given by the US Food and Drug Administration (FDA)) according their source of caffeine such as coffee, Tea, Energy drinks, Tablets, etc. Heart Rate was measured manually by using stopwatch, smart watch and fitness tracker. More than 50 articles from PubMed, Google Scholar and UpToDate databases have been analyzed.

Results and their discussion. Caffeine is a widely used central nervous system stimulant with numerous pharmacological and physiological effects, including cardiovascular, respiratory, renal, and smooth muscle effects, mood, memory, alertness, and physical and cognitive performance. Caffeine is rapidly and completely absorbed in humans, with 99 percent being absorbed within 45 minutes of ingestion. Caffeine action is believed to occur through various mechanisms, including antagonism of adenosine receptors, inhibition of phosphodiesterase, release of calcium from intracellular stores, and antagonism of benzodiazepine receptors.

In this survey 32 Students are Daily Coffee Consumers (up to 200 mg per day as low intake) in the morning. The difference between their resting heart rate and 30- 45 minutes after the caffeine consumption was 5-12 bpm. In a statistical analysis using a paired t-test, we aimed to determine whether caffeine intake significantly increases heart rate. The data consisted of resting heart rates (ranging from 70 to 75 bpm) and heart rates after caffeine consumption (ranging from 80 to 87 bpm). We calculated the differences between the two sets of heart rates, which yielded an average increase of approximately 8.63 bpm. The standard deviation of these differences was found to be around 2.99 bpm. Subsequently, we computed the t-statistic, resulting in a remarkably high value of about 16.30, with 31 degrees of freedom. This t-statistic corresponds to an extremely low p-value (much less than 0.001), leading us to reject the null hypothesis. Therefore, we conclude that caffeine intake has a statistically significant effect on increasing heart rate.

From 50 students 26 students consume 1 to 2 bottles of energy drink that contain caffeine (200 – 400 mg per day as medium intake) in the night during exam periods. In comparing resting heart rates before and after caffeine intake, a paired t-test was conducted to assess the effect of caffeine on heart rates. The mean of the differences in heart rates was calculated to be approximately 17.08 beats per minute. With a standard deviation of 1.35, the t-statistic was computed to be approximately 36.16. With degrees of freedom equal to 25, the resulting p-value was extremely small, indicating a statistically significant difference. Thus, we reject the null hypothesis and conclude that caffeine intake significantly increases heart rate.

Only 10 students take caffeine tablets (over 400 mg per day as high level intake) for improve the cognitive function during exams. The difference of increased heart rate was 20-

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28 bpm. In a paired t-test comparing resting heart rates before and after caffeine intake, the analysis revealed a significant increase in heart rate following caffeine consumption. The mean difference in heart rates was calculated to be 24.5 beats per minute, with a standard deviation of approximately 3.13. The resulting t-statistic was 24.75, and the degrees of freedom for the test were 9. The p-value was found to be less than 0.001, indicating that the increase in heart rate due to caffeine intake is statistically significant. Thus, we reject the null hypothesis, concluding that caffeine intake significantly enhances heart rate.

This shows Caffeine has several cardiovascular effects, including increased heart rate due to its blockade of adenosine receptors, particularly the A1 subtype, and an increase in cyclic adenosine mono phosphate (cAMP) levels due to phosphodiesterase inhibition. This leads to an increase in heart rate, which is primarily due to increased catecholamine production, reduced vasodilation, and enhanced cardiac contractility. The heightened release of catecholamines accelerates heart rate and increases peripheral vascular resistance, contributing to higher blood pressure. Additionally, elevated cAMP levels due to phosphodiesterase inhibition enhance calcium availability in cardiac myocytes, improving myocardial contractility and contributing to increased stroke volume. The stimulatory properties of caffeine drive heart rate and contractility, but this can overshadow the relaxation of vascular smooth muscle, leading to vasodilation in some vascular beds. Therefore, while vasodilation occurs in certain contexts, the overall effect of caffeine on the cardiovascular system may still lead to an increase in systemic vascular resistance, especially in response to catecholamine release.

Not only heart rate increase, 90% of 50 students felt more attention, concentration, and overall cognitive performance. Literature data confirms our results: Caffeine acts as neuromodulator that promotes sleep and relaxation by blocking adenosine receptors, particularly the A1 and A2A subtypes. This reduces the inhibitory effects of adenosine on the nervous system, leading to increased arousal and wakefulness. Caffeine also enhances dopamine activity, a neurotransmitter involved in attention, motivation, and learning. It improves neuronal signal transmission, promoting efficient information processing and enhanced alertness, concentration. Caffeine has cognitive benefits such as improved attention and focus, memory enhancement, and faster reaction times in cognitive and motor tasks. However, it has limitations such as tolerance and sensitivity, as well as potential anxiety and sleep disruption. The optimal dose for cognitive effects is typically moderate, with medium intake (around 200-400 mg) enhancing cognition and higher doses potentially leading to adverse effects. Overall, caffeine's effects are often dose-dependent, with moderate doses potentially enhancing cognition and higher doses potentially leading to adverse effects.

50 % of students who consumed caffeine as Energy drinks and Tablets first time experienced increased urination. Caffeine inhibits adenosine receptors in the kidneys, reducing water reabsorption and increasing urine production. It also enhances renal blood flow, contributing to its diuretic effect. This increases the filtration rate of plasma, leading to more fluid being processed and excreted as urine. Additionally, caffeine stimulates the kidneys to excrete more sodium, potentially leading to an osmotic diuresis, resulting in increased urine output. Individuals who consume caffeine regularly may develop a tolerance to its diuretic effects, meaning that they may experience less pronounced increases in urine

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output compared to those who seldom consume it. In habitual users, the kidneys may adapt to the presence of caffeine, resulting in a blunted diuretic response. For those who do not consume caffeine regularly, the diuretic effect can be more significant. Such individuals may notice an increased frequency of urination shortly after consuming caffeine, particularly in higher doses. Caffeine is considered mild diuretic, with moderate consumption of 3-4 cups per day not significantly leading to dehydration. Its impact on hydration can be balanced with total fluid intake, as caffeine in beverages may offset the diuretic effect.

Also Caffeine enhances metabolic rate and physical performance, particularly in endurance sports, by increasing free fatty acid availability in the bloodstream. However, regular consumption can lead to tolerance, requiring larger doses. When abruptly stopped, withdrawal symptoms like headaches, fatigue, and mood swings may occur. Gradually reducing caffeine intake can help mitigate withdrawal effects and minimize discomfort.

Conclusions:

1. The analysis of caffeine's impact on heart rate across various consumption levels reveals a consistent and significant increase in heart rate following intake. In a study with 32 students consuming low doses of caffeine, an average increase of approximately 8.63 bpm was observed, with a high t-statistic of 16.30 and a p-value less than 0.001. Similarly, in a medium intake group of 26 students, a mean heart rate increase of 17.08 bpm was noted, yielding a t-statistic of 36.16, also with a significant p-value. For those consuming high doses, a mean difference of 24.5 bpm was calculated, resulting in a t-statistic of 24.75 and a p-value under 0.001. Collectively, these findings robustly support the conclusion that caffeine intake significantly elevates heart rate, highlighting its physiological effects on cardiovascular function during periods of increased cognitive demand, such as exams.

2. Caffeine acts as a neuromodulator that improves various aspects of cognitive function, including attention, concentration, and memory. The majority (90%) of students felt enhanced cognitive performance after caffeine intake, suggesting that moderate doses are beneficial for mental alertness and task performance.

3. A significant portion of caffeine consumers (50%) experienced increased urination upon first exposure to caffeine. This is attributed to caffeine's action on renal adenosine receptors, leading to decreased water reabsorption and increased sodium excretion, thereby enhancing urine production.

4. Regular caffeine consumption can lead to the development of tolerance, necessitating higher doses to achieve the same physiological effects (FDA). This phenomenon underscores the importance of managing caffeine intake to optimize its benefits while minimizing adverse reactions.

5. Abrupt cessation of caffeine can lead to withdrawal symptoms such as headaches, fatigue, and mood changes noted by students. Gradual tapering of caffeine intake is recommended to alleviate these symptoms, highlighting the need for awareness in individuals who regularly consume caffeine.

6. While moderate caffeine consumption may enhance physical performance and cognitive function, higher doses could lead to adverse effects such as increased heart rate and anxiety. This necessitates a careful balance in consumption to leverage caffeine's benefits while minimizing potential health risks.

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