Effects of Caffeine Consumption on Exam Performance Throughout University Students

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KEYWORDS
Universities, caffeine, Students, performance.

ABSTRACT
Background: caffeine can be found in many types of food and beverages such as coffee beans, chocolates, and tea. Caffeine consumption could be used for different reasons. For example, healthcare providers use caffeine to reduce fatigue and cope with demanding workloads. The aim of this study is to estimate the effect of caffeine consumption on exam performance among universities students. Methodology: The study used a cross-sectional design. Students at The Hashemite University in Zarqa-Jordan from both sexes were eligible to participate by completing an electronic questionnaire. Results: A total of 145 participants participated in the study, 113 (80.7%) participants reported a usual drinking of 1-2 coffee cups per day. Most of participants (48.6%) reported that the usually sleep >7 hours when they do not drink coffee. While most of participants (40%) reported 5-7 hours of sleep when they drink coffee. Conclusion: We concluded that caffeine intake decreases the amount of sleeping hours by 2 or more hours during night for students and this effect on their concentration, but on the other hand the student's feels more energy after drinking caffeine and this helps them to feel more awake.

1. Introduction

Caffeine is considered one of the most consumed central nervous system and moods stimulant worldwide (Ludwig et al., 2014)[1]. In addition, caffeine can be found in many types of food and beverages such as coffee beans, chocolates, and tea(Mitchell et al., 2014) [2]. For example, every cup of coffee contains more than 90% caffeine substance, and the effect of caffeine could last from one hour to 3-4 hours (Winston et al., 2005)[3]. Caffeine consumption could be used for different reasons. For example, healthcare providers use caffeine to reduce fatigue and cope with demanding workloads(Franke et al., 2015)[4]. However, athletes reported that caffeine could enhance their physical performance (Desbrow & Leveritt, 2007)[5]. In addition, several studies found that caffeine could be used to enhance energy, social participation, or even for the taste of caffeine (Turton et al., 2016)[6]. Based on the literature, consuming caffeine could be beneficial to human health. Many studies found that caffeine has effects on psychomotor and central nervous system performance (Smith, 2002)[7]. Consumption caffeine was found to decrease the risk of developing or preventing some types of cancer and neurodegenerative diseases such as Alzheimer's disease (Arab, 2010; Ross et al., 2000)[8,9] However, consuming high dosages of caffeine beverages could lead to adverse effects on human health such as headache, sleep disorders, anxiety, tachycardia, and high blood pressure (Temple et al., 2017)[10]. Also, caffeine could lead to physical dependency, which may cause a decreasing in human performance during withdrawal stage (O'Callaghan et al., 2018)[11].

During university journeys, students face several types of challenges and stress, especially during tests and exams. Consequently, students put all extra effort to achieve their target during exams, and these extra efforts require concentration and hard work beyond their physical and mental threshold. These stressful situations may lead to physiological and cognitive responses within the students' body which also may lead to neuropsychiatric problems such as anxiety and depression (Hope & Henderson, 2014)[12]. Therefore, many students using caffeinated products as one of the coping strategies to deal with their stress, which they believe it could increase attention, improve their achievement, and improve their memory (Hameleers et al., 2000)[13]. Despite extensive studies addressing the effects using caffeinated beverages on the cognitive and physiological performance level, few studies have been conducted to investigate the potential effects of caffeine intake on students' performance during exams. Therefore, the purpose of this study was to examine the relationship between caffeine intake and academic performance among students.

2. Materials and Methods

Study design

The study used a cross-sectional design. Students at The Hashemite University in Zarqa-Jordan from both sexes were eligible to participate by completing an electronic questionnaire.

Questionnaire development

After reviewing relevant literature, investigators developed a pilot questionnaire to be tested on a small group of students to check for face and content validity. The pilot participants' feedback was taken into consideration, and a final modified version of the questionnaire was developed in an online format through (Google Forms), to be shared with the university students. A hyperlink to the electronic questionnaire was shared with prospective participants through official electronic platforms related to the Hashemite University students. The questionnaire included 16 closed-ended items, divided into 2 main sections: section 1: Basic demographic and academic performance information (5 questions), and section 2: Sleep and caffeine consumption personal information (11 questions). The questionnaire was in Arabic language and required about 10 minutes to complete.The study was evaluated and approved by the Institutional Review Board (IRB) of the Hashemite University.

Statistical analysis:

SPSS version 26 (SPSS Inc.) was used for data analysis. Descriptive analysis was utilized to describe our results. A chi-square test was used to investigate correlations between caffeine intake and demographics and GPA. p values less than 0.05 were considered statistically significant.

3. Results

Demographic data

A total of 145 participants participated in the study, after removal invalid responses we got only 140 responses, 103 (73.6%) females and 37 (26.4%) males. Most of the students were in their 4th studying year (55.7%); 87.31% were in the age range 18 through 22. Participants' GPAs were categorized into four categories: 1-1.9, 2-2.9, and 3-4, and below 1. We found that 57.9% of students were within the 3-4 GPA category (see table 1).

Table 1: Demographics Data

	n (%)
Participants	140 (100%)
Female	103 (73.6%)
Male	37 (26.4%)
Academic college year	
1st	10 (7.70%)
2nd	16 (11.2%)
3rd	33 (23.1%)
4th	78 (55.7%)
5th	3 (2.10%)
GPA	
<1	17 (12.10%)
1-1.9	2 (1.4%)
2-2.9	40 (28.6%)
3-4	81 (57.9%)
Age groups	
18-22	122 (87.1%)
23-27	16 (11.4%)
28-31	2 (1.40%)
Abbreviations: GPA, grade point average; P, Probability value	

Sleep hours with vs without drinking caffeine

113 (80.7%) participants reported a usual drinking of 1-2 coffee cups per day. Most of participants (48.6%) reported that the usually sleep >7 hours when they do not drink coffee. While most of participants (40%) reported 5-7 hours of sleep when they drink coffee (see table 2).

The effect of caffeine on daily performance

Most participants (72.9%) reported that caffeine increase concentration during the day, while (60%) of participants reported an increase in energy after drinking caffeine. Most of our participants (89%) reported that caffeine helps them to feel more awake (see table 2).

Symptoms related to caffeine drinking

Most of participants reported symptoms of headache (19.7%) after an overdose of caffeine, while only (9.2%) of participants reported anxiety and insomnia, and (5.3%) reported hunger feeling and (3.9 %) reported colic pain (see table 2).

Caffeine amount during exams period

We found that most of participants (69.3%) did drink more caffeine during exams period, while 38 participants (27.1%) reported no increase in caffeine drinking during exams period.

Most participants (55%) reported that there is no relationship between their exams' performance and caffeine intake. Furthermore, only (30%) of participants reported that caffeine has a negative impact on exams' performance (see table 2).

Table 2: Caffeine amount, Sleep hours with vs without drinking caffeine

	n (%)
Number of caffeine cups per day	
None-1	4 (2.9%)
1-2	113 (80.7%)
3-4	18 (12.9%)
>4	18 (12.9%)
Sleep hours without caffeine intake	
< 2 hours	10 (7.1%)
2-4 hours	10 (7.1%)
hours	52 (37.1%)
>7hours	68 (48.6%)
Sleep hours without caffeine intake	
< 2 hours	17 (12.8%)
hours	39 (27.9%)
5-7 hours	56 (40.1%)
>7hours	27 (19.3%)
The effect of caffeine on daily performance	
Concentration	
Yes	102 (72.9%)
No	38 (27.1%)
Energy	
Yes	85 (60.7%)
No	55 (39.3%)
Awake	
Yes	89 (63.6%)
No	51 (36.4%)
Symptoms after an overdose of caffeine	
Increased heart rate	22 (15.8%)
Headache	27 (19.7%)
Dizziness	11 (7.9%)
Gastric acidity	11 (7.9%)
Poor visual acuity	4 (2.6%)
Anxiety	13 (9.2%)
Insomnia	13 (9.2%)
Hunger	8 (5.6%)
Satiety	2 (1.3%)
Colic pain	5 (3.9%)
Mixed symptoms	24 (17.1%)
Increased caffeine amount during exams period	
Yes	102 (69.3%)
No	38 (27.1%)
The relationship between caffeine intake and exams performance	
Yes	63 (45%)
No	77 (55.0%)
The negative impact of caffeine intake on exams performance	
Yes	42 (30.0%)
No	98 (70.0%)

Association between caffeine intake and demographics and GPA

The number of daily caffeine cups was not significantly associated with GPA. Gender was significantly associated with the number of caffeine intake (see table 3).

Table 3: Association between caffeine intake and demographics and GPA

	Cups number None-1 n (%)	Cups number 1-2 n (%)	Cups number 3-4 n (%)	Cups number >4 n (%)	P-value
Gender Female Male	 2 (1.4%) 2 (1.4%)	 85 (61%) 28 (20%)	 14 (10%) 4 (2.8%)	 2 (1.4%) 3 (2.14%)	 <0.00*
Academic college year 1st 2nd 3rd 4th 5th	 0 (0.0%) 1 (0.07%) 1 (0.07%) 2 (1.4%) 0 (0.0%)	 9 (6.4%) 13 (9.3%) 27 (19.3%) 62 (44.3%) 2 (1.4%)	 0 (0.0%) 2 (1.4%) 3 (2.14%) 12 (8.6%) 1 (0.07%)	 1 (0.07%) 0 (0.0%) 2 (1.4%) 2 (1.4%) 0 (0.0%)	 .865
GPA <1 1-1.9 2-2.9 3-4	 1 (0.07%) 0 (0.0%) 2 (1.4%) 1 (0.07%)	 13 (9.3%) 2 (1.4%) 28 (20%) 70 (50%)	 2 (1.4%) 0 (0.0%) 8 (5.7%) 8 (5.7%)	 1 (0.07%) 2 (1.4%) 2 (1.4%) 2 (1.4%)	 .713
Age groups 18-22 23-27 28-31	 3 (2.14%) 1 (0.07%) 0 (0.0%)	 99 (71%) 12 (8.6%) 2 (1.4%)	 16 (11.4%) 2 (1.4%) 0 (0.0%)	 4 (2.8%) 1 (0.07%) 0 (0.0%)	 .951

Abbreviations: GPA, grade point average; P, Probability value (according to Chai-squared test); *, statistically significant difference;

4. Discussion

This study aimed to assess the relationship between caffeine intake and academic performance among undergraduate students. The effect of caffeine on sleep and daily performance was also studied using a content validated questionnaire. This study showed that more than 80% of the participants consumed at least one cup of coffee daily. There is a consensus in the literature that high percentage of student's drink coffee worldwide to deal with the academic stress (Hidiroglu et al., 2013; Malinauskas et al., 2007)[14,15].

The main objective of this study was to assess whether caffeine intake improve the academic performance among students. The results presented that there was no significant correlation between caffeine intake and academic performance. This was supported in the literature, a cross-sectional study found no significant association between drinking coffee and academic performance (Usman et al., 2015)[16]. Also, three online survey studies showed there was no significant correlation between caffeine intake and academic performance (Bindbeutel, 2016; Khan et al., 2017; Pattison et al., 2016)[17,18,19] In addition, Gabrish 2017 presented in her thesis that students who were not caffeine consumers had higher GPA comparing to coffee consumers (Pattison et al., 2016)[19]. One of the explanation why caffeine intake does not improve the academic performance is that caffeine disrupt the sleep(Gabrish, 2017; O'Callaghan et al., 2018)[11,20].

The participants in this study slept less hours after drinking coffee. The literature supports that caffeine affects the sleep quality and it leads to sleep deprivation (Gabrish, 2017; O'Callaghan et al., 2018)[11,20]. Caffeine works on the receptors A1 and A2A, which affects the brain function associated with sleep, arousal, and cognition (Clark & Landolt, 2017)[21]. Sleep deprivation has some side effects such as decreasing the cognitive and daytime function(Goel et al., 2009; Ribeiro & Sebastiao, 2010)[22,23].On the other hand, good sleep quality improves both cognitive and physical function(Bonnet & Arand, 2010; Schmid et al., 2015)[24,25]. Interestingly, some studies showed that people who feel tired during the day drink more coffee, which in turn causes sleep deprivation and affects the daily activities on the consequences days(Snel & Lorist, 2011; Thomas et al., 2000)[26,27].

Caffeine intake may cause some desirable effects among coffee consumers; the participants showed that drinking coffee improved the concentration and energy. Some studies supported that caffeine enhances the cognitive function, where it may decrease the risk of developing neurodegenerative diseases and prevent memory impairment (Cappelletti et al., 2015; Cunha & Agostinho, 2010; Eskelinen et al., 2009)[28,29,30]. Also, an RCT study presented that the intake of citicoline-caffeine improved attention cognitive function (Bruce et al., 2014)[31]. Furthermore, other studies showed improvement in attention after drinking caffeine (Bruce, 2012; Einöther & Giesbrecht, 2013)[32,33], and another study revealed that caffeine increased the concentration (Heatherley et al., 2005)[34].

Furthermore, the literature supports that caffeine increases energy, improves physical and cognitive function, decreases physical and mental fatigue (Harpaz et al., 2017)[35]. A review of meta-analysis supports the improvement in muscle endurance and strength and exercise performance after caffeine intake (Grgic et al., 2020)[36].

On the other hand, caffeine may lead to some undesirable effects. In this study, participants complained of headache, increased heart rate, anxiety and insomnia as the most common side effects of caffeine intake. This is similar to the findings in the literature, drinking high dose of coffee daily may cause headache (Jovel & Mejía, 2017)[37] A study conducted in 2014 showed that heart rate and blood pressure were increased among coffee consumers after drinking coffee (Hara et al., 2014)[38] and another study presented that high dose of coffee may increase the heart rate acceleration (Sudano et al., 2005)[39]. Lastly, there is a support that drinking more than two cups of coffee may cause anxiety(Alasmari, 2020; Richards & Smith, 2015)[40,41].

This study supports there is a misunderstanding that caffeine intake may improve the academic performance. The findings of this study and previous studies presented no significant association between caffeine intake and academic performance and it may cause undesirable side effects, which may affect the students' performance in the schools and universities.

5. Conclusions

We concluded that caffeine intake decreases the amount of sleeping hours by two or more hours during night for students and this effect on their concentration, but on the other hand the student's feels more energy after drinking caffeine and this helps them to feel more awake.

Some of them feels anxiety and insomnia when they take an overdose of caffeine. One of our findings showed that during exams period the caffeine intake increasing in comparison with the period without exam. The majority of students showed that there is no relationship between caffeine intake and exam performance.

We recommended that we have to do more studies in the future and take a large number of the students from deferent specializations to be sure more about the effect of caffeine on students' performance.

Conflicts of Interest: The authors declare no conflict of interest.

Informed Consent: All participants signed a written informed consent before the examination. Instructions, objectives, and steps of the procedure were explained for each participant.

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