Journal of Health, Population and Nutrition

RESEARCH

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Factors associated with caffeine intake among undergraduates: a cross-sectional study from Palestine

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Abstract

Background Caffeine is one of the world's most frequently consumed central nervous system stimulants. Moderate caffeine intake has beneficial health effects, while increased caffeine intake may have harmful effects in the human body. Existing literature indicated that undergraduates consume caffeine excessively. Till this date, little is known about the consumption pattern of caffeine among Palestinian undergraduates. Therefore, the current study aimed to estimate the percentage of caffeine consumption among Palestinian undergraduates, to assess their caffeine daily intake, and to identify factors associated with unsafe caffeine consumption.

Methods A cross-sectional study was conducted in Palestine between March and May 2022. Undergraduates were recruited by random sampling after a personal invitation. Undergraduates aged between 18 and 25 were included in the study, while those who were taking medications, had medical conditions affecting the data collection process, and had incomplete responses were excluded from the study. Caffeine consumption was assessed using a semi-quantitative food frequency questionnaire (FFQ) developed by the research team. The content validity of the FFQ was done by three reviewers. Also, a questionnaire was used to collect data related to sociodemographic characteristics, medical history, lifestyle habits, sleeping quality, physical activity, and psychological status. Data were analyzed through the descriptive statistics and inferential statistics (Chi-square test, Mann-Whitney test, and Kruskal-Wallis H test).

Results The final analysis included 486 undergraduates with a mean age of 20.1 ± 1.48 years. The majority of the undergraduates were female (65.0%) and single (89.5%). The sample was distributed almost equally between the first (26.3%), second (23.0%), third (22.8%), and fourth (18.7%) academic years, and only 44 undergraduates (9.1%) were in their fifth year. The vast majority of university students (96.5%) consumed caffeinated products, with coffee ranking first place. Nearly half of the participants (32.7%) exceeded the safe levels of caffeine consumption. Males, smokers, poor physical activity, higher Sleep Hygiene Index (SHI) scores, and greater anxiety, stress, and depression scores had significantly higher rates of unsafe caffeine intake than their peers ($p < 0.05$). The total caffeine consumption was significantly associated with gender, low household income, smoking status, physical activity level, SHI score, as well as anxiety ($p < 0.05$).

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Conclusion Caffeine consumption in the studied sample was significantly high and exceeded the safe levels. The current study revealed that unsafe caffeine consumption was more common among males, smokers, and physically active individuals. Caffeine intake was also linked to poor-quality sleep and higher psychological concerns. Therefore, educational programs are recommended to increase awareness of the adverse effects of high caffeine intake.

Keywords Caffeine consumption, University students, Psychological status, Association, Cross sectional study

Introduction

Caffeine is one of the world's most frequently consumed central nervous system stimulants, mostly consumed from natural sources such as coffee, tea, energy drinks, fizzy drinks, and chocolate, but it can also be found in appetite suppressants, weight loss products, painkillers, and cold medicines [1]. Coffee and tea are the most commonly consumed stimulants that are culturally acceptable worldwide, with approximately 80% of all adults all over the world reported to consume caffeine in their habitual diet [2]. In the last decade, the total caffeine consumption has rapidly increased due to population growth [3].

The popularity of caffeine has increased due to several subjective benefits, including mood improvement, delayed onset of sleep, increased alertness and attention, and improved work performance [4]. In addition, athletes frequently consume caffeine-containing substances to enhance their physical performance [5].

The health consequences of caffeine are mostly influenced by the administered dosage. Numerous studies showed that moderate intake of caffeine has a protective effect against diabetes, coronary heart disease, stroke, neurodegenerative diseases, cancer, and inflammatory diseases [6]. A recent meta-analysis by Kim Y et al. also found that consuming moderate doses of caffeine (e.g., 2–4 cups/day) reduces the risk of all-cause and cause-specific mortality [7].

However, high intake of caffeine has harmful effects on the human body and is associated with tachycardia, tremors, agitation, headaches, and restlessness [8]. In addition, consuming large amounts of caffeine can result in poor sleeping quality and quantity [9]. In a recent review, it was found that the prevalence of poorer sleep quality was more prevalent among individuals who consume caffeine-containing beverages [10]. Interestingly, Ramakrishnan and his colleagues developed a mathematical model to predict sleep reaction time in compliance with caffeine dosage [11], and some evidence has suggested that caffeine intake may increase the odds of psychological disorders. However, findings in this regard are not confirmed yet [12]. For instance, a study in Korea found an inverse relationship between caffeine consumption and lifetime depression [13], while other studies concluded that there is no association between caffeine consumption and mental health disorders [14]. Nevertheless, more studies have pointed out that caffeine consumption increases the risk of anxiety and depression [15], as well as psychological distress [16].

Regardless of the negative consequences associated with caffeine intake, most consumers ignore them, which encouraged organizations to set recommendations about the maximum limit of caffeine intake. According to the European Food Safety Authority (EFSA), the maximum limit of caffeine intake is up to 400 mg a day, which is equivalent to 3 mg/kg body weight. Generally, this dose is not associated with adverse effects in a healthy adult population [17].

Numerous studies have shown that university students consume caffeine excessively, and therefore, they are more exposed to its' harmful effects [18]. In Pakistan, for instance, caffeine intake has been reported among 75.5% of university students [19], while another study conducted among Bahrani university students concluded that 98% of participants ingested caffeine regularly [16]. Similarly, a high proportion of medical students (98.4%) in Jordan consume caffeinated products [20]. Indeed, it was found that the university lifestyle suits consuming higher levels of caffeine in contrast to the rest of the population [21]. For instance, consuming high doses of caffeine is more common among college students attempting to lose weight or having disordered eating behaviors [4]. Furthermore, high caffeine intake by university students is linked to poor sleep quality [22]. A study by Jun et al. found that high school students who consumed greater amounts of caffeine had a shorter sleep duration than others [23]. Another study indicated that consuming 200 mg of caffeine in the morning significantly influences total sleep time as well as sleep efficiency [24].

According to many studies, undergraduates have higher rates of psychological disorders (e.g., stress, anxiety, depression) compared to the general population in both developed and developing countries [25, 26]. In a systematic review of 24 studies, it was reported that university students represent 30.6% of the global prevalence of depression [25]. Another study conducted in Palestine showed that 23.1% of medical students had moderate to severe depression and 46.8% had moderate to severe anxiety [27]. Such high rates of psychological disorders among undergraduates can be attributed to several factors, including social factors, biological factors, academic factors, and lifestyle habits [28].

Previous research has not yet evaluated the percentage of caffeine consumption among Palestinian undergraduates. So, the aim of this study is to estimate the level of daily caffeine consumption among university students in Palestine; to identify the percentage of students who exceed the recommended level of caffeine intake among university students in Palestine; and to explore the sociodemographic, nutritional, lifestyle, and psychological factors associated with high caffeine consumption among university students in Palestine.

Methodology

Study design, settings, and population

This cross-sectional observational study was conducted among a representative sample of undergraduates who were enrolled at Palestine Polytechnic University (PPU) in Hebron City, Palestine. PPU is one of the major universities in the West Bank, situated in the southern area of Palestine. As of 2023, the student population exceeded 7000 students. Recruitment of Palestine Polytechnic University students represents the study population ideally due to the homogeneity of the Palestinian community lifestyle habits, ethnicity, and culture. Furthermore, the university offers all major disciplines (medicine and health sciences, applied and basic sciences, engineering and natural sciences, as well as human sciences), which assure a representative sample.

Sample size calculation and sampling method

Undergraduates were recruited by random sampling after a personal invitation from the research team. The data was collected via a paper questionnaire. Five hundred and fifty students were invited by personal face-to-face invitations; 520 students accepted to participate and signed the consent forms, providing a 94.5% response rate. The sample size was calculated by using G Power software for a known population, with an alpha of 0.05 (two-sided) and 80% power. Previous research reported that the prevalence of high caffeine intake was 18% [22]. The expected difference in the prevalence is considered 10%. A minimum of 200 participants were required to assess the prevalence of high caffeine intake. To assess the association between caffeine intake and other variables, the Chi-square statistical test was selected. The calculated sample was 450 individuals. Considering dropouts, the minimum required sample size was raised to 500 participants.

Undergraduates aged between 18 and 25 years who agreed to participate in the study and signed the consent form were included in the study, while undergraduates who were taking medications, had medical conditions that may affect the data collection process (e.g., those undergoing chemotherapy or radiotherapy, and those with inflammatory bowel disease (IBD)), refused to participate in the study, and had incomplete responses were excluded from the study.

Data collection and research tool

Data collection was performed via face-to-face interview using a pre-tested six-part questionnaire, as follows: (1) sociodemographic information; (2) nutritional status; (3) medical history; (4) lifestyle habits; (5) caffeine consumption; and (6) psychological status. A team of four trained researchers collects the data within a period of three months, starting from March to May 2022. All undergraduates at PPU were sent a personal invitation in order to participate in the study, and they were informed about the study design, objectives, and the type of data that would be collected, with affirmation of the optional participation.

Sociodemographic characteristics

Sociodemographic-related data was obtained from each undergraduate, including gender, age, marital status, place of residence, monthly income, and academic level too.

Nutritional status

Undergraduates self-reported their weight (kg) and height (m). Body mass index (BMI) was calculated by dividing weight by height squared (kg/m^2) and categorized into four weight categories according to the World Health Organization (WHO) cut-off points [29]. Undergraduates were also asked whether they were following a diet plan or not.

Medical history

Undergraduates' medical history was assessed by three self-reported questions as follows: (1) whether they suffer from chronic diseases; if yes (name the disease and the duration of suffering from it); (2) whether they undergo a previous surgery; if yes (when?); and (3) whether they use medicines on a regular basis; if yes (name the medicine and the purpose of its use).

Lifestyle habits

This section focused mainly on smoking, physical activity level, and sleeping quality. Smoking-related data includes smoking status (smoker, former smoker, or nonsmoker), type of smoking (cigarettes or shisha), smoking frequency per day, and whether smoking increases caffeine intake; if the answer was yes, the most consumed caffeinated products are listed ascendingly.

Undergraduates' physical activity level was assessed using the short version of the International Physical Activity Questionnaire (SF-IPAQ) [International Physical Activity Questionnaire]. According to the IPAQ scoring protocol, the metabolic equivalent, minutes per week

(MET.min/week), was calculated for each of walking, moderate-, and vigorous-intensity activities. A score of ≤ 3 MET indicates a low level of physical activity; a score of 3–6 MET indicates a moderate level of physical activity; and a score of ≥ 6 MET indicates a high level of physical activity [30].

The sleeping quality of the study participants was assessed using the Arabic version of the validated and reliable Sleep Hygiene Index (SHI) [31]. The SHI is a 13-item index that evaluates the presence of behaviors thought to comprise sleep hygiene. A 5-point Likert scale was used for the rating of each item, which ranges from 0 (never) to 4 (always). The total score ranges from 0 to 52, with an increasing score indicating poor sleep hygiene [32]. A cut-off score of 16 was found to be appropriate for categorizing students with poor sleep quality, considering a sensitivity of 77% and a specificity of 47.5% [33]. Moreover, the Arabic SHI has presented a moderate internal reliability, with a Cronbach's alpha of 0.589 [31].

Caffeine consumption

In this part, students were asked if they consume caffeine, when they usually consume caffeine, where they usually consume caffeine, what is their most consumed source of caffeine, if they consider themselves to be caffeine addicted, and if they have tachycardia or anxiety.

Caffeine consumption was estimated using a semi-quantitative food frequency questionnaire (FFQ) that contains questions related to caffeinated product consumption, frequency, and serving size [16]. The research team developed an Arabic language FFQ based on previous literature that used FFQ to assess caffeine consumption across various populations [21, 22, 24], while considering factors like the types of the consumed caffeinated drinks and reporting the manner of consumption. Furthermore, the frequency and format of the questions were based on a validated general FFQ among Palestinians. For content validity, the final FFQ was sent to three experts in dietary assessment. The test-retest reliability was evaluated by involving 22 participants to complete the FFQ at both baseline and two weeks later. However, to provide an accurate quantitative estimation of the consumed beverages, the study team used visual references for cups and glasses often locally utilized for coffee and tea consumption. The caffeine-containing products include Arabic and Turkish coffee, espresso, Americano coffee, Nescafé, cappuccino, green tea, black tea, soft drinks (Coca-Cola), energy drinks (XL, Red Bull, hype), soda drinks, cacao, dark chocolate, and milk chocolate. To calculate the average daily intake of caffeine, reference values were recruited from the United States Department of Agriculture (USDA) [34] and the caffeinated products websites. The caffeine intake of the study participants was classified as safe if it was less than or equal to 400 mg per day, since the habitual consumption of caffeine up to 400 mg per day does not pose any safety risks for non-pregnant adults [17].

Psychological status

The psychological status was measured using the validated Arabic version of the Depression Anxiety Stress Scales (DASS) [35]. The short form of DASS is a self-report tool designed to assess psychological distress over the past week. It is composed of 21 items representing the following psychological states: depression, anxiety, and stress. Undergraduates were asked to evaluate their experience with each item during the previous week using a 4-point combined frequency/intensity scale. The scale ranges from 0 (did not apply to me at all) to 3 (applied to me very much or most of the time). Scores for depression, anxiety, and stress were calculated by summing the scores for the relevant items. The severity of each psychological state is classified into five levels: "normal," "mild," "moderate," "severe," or "extremely severe [36].

Data analysis

The data was analyzed using the statistical package for the social sciences, SPSS version 21. Data cleaning was performed to remove incomplete responses or invalid data. Outliers were identified using the Z score approach, where data points with a z-score over a threshold of 3 were considered outliers and therefore eliminated. Descriptive statistics (mean ± SD) were used to describe continuous variables, and categorical variables were expressed as counts and percentages (n, %). Normality of continuous variables was checked via the Shapiro-Wilk Test, which showed that the data were not normally distributed. Accordingly, the Kruskal-Wallis H test and Mann-Whitney U test were employed for continuous variables and different groups. A Chi-Square test was used for categorical variables to compare between different groups. Pearson's correlation coefficient (r) was also used to investigate the association between caffeine intake and continuous variables, including age, BMI, scores of SHI, depression, anxiety, and stress. The level of significance was set at $p < 0.05$.

Results

Undergraduates' sociodemographic characteristics

A total of 520 undergraduates were informed about this study, and 497 of them met the inclusion criteria and gave their consent to participate in the study. Ten participants were eliminated due to being identified as outliers according to their caffeine consumption. A total of 486 undergraduates were included in the final analysis, with a mean age of 20.1 ± 1.48 [18–25] years old and one questionnaire being excluded due to missing data, as shown

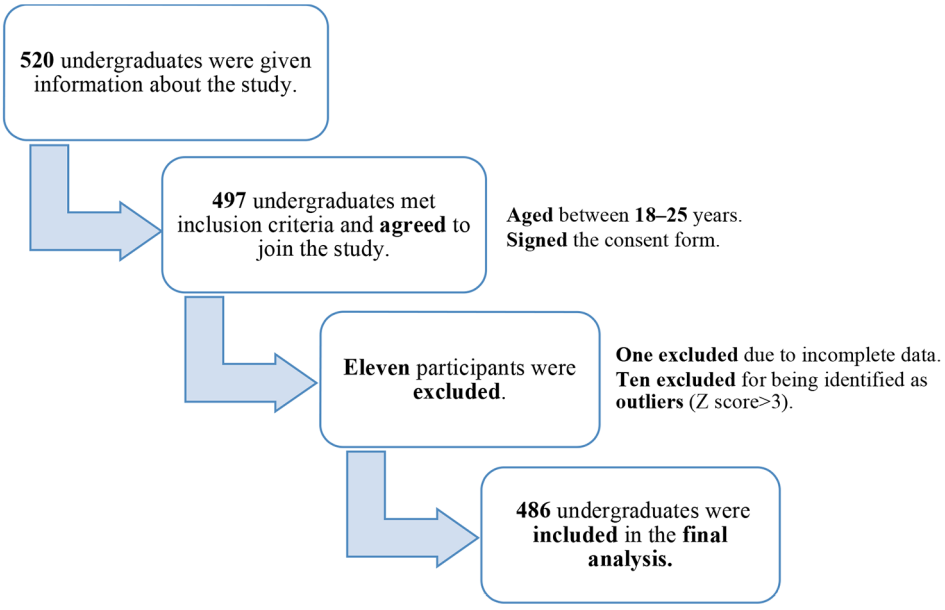

Fig. 1 Undergraduates' recruitment steps

Table 1 Sociodemographic characteristics according to undergraduates' gender, presented in number (N) and percentage (%)

Variables		Males (*N* = 170)		Females (*N* = 316)		Total (*N* = 486)		P-value
		N	%	N	%	N	%	
Marital status	Single	162	95.3	273	86.4	435	89.5	0.002*
	Married	8	4.7	43	13.6	51	10.5	
Academic year	1st	39	22.9	89	28.2	128	26.3	< 0.001*
	2nd	41	24.1	71	22.5	112	23.0	
	3rd	30	17.6	81	25.6	111	22.8	
	4th	28	16.5	63	19.9	91	18.7	
	5th	32	18.8	12	3.8	44	9.1	
Living area	City	107	62.9	226	71.5	333	68.5	0.052
	Camp/village	63	37.1	90	28.5	153	31.5	
Living status	With family	132	77.6	271	85.8	403	82.9	< 0.001*
	With spouse	13	7.6	33	10.4	46	9.5	
	Student housing	25	14.7	12	3.8	37	7.6	
Monthly income	< 1500 NIS[1]	9	5.3	7	2.2	16	3.3	0.187
	1500–5000 NIS	83	48.8	163	51.6	246	50.6	
	> 5000 NIS	78	45.9	146	46.2	224	46.1	

Significant at *: $p < 0.05$ using Pearson Chi-square test. [1]: New Israeli Shekel currency

in Fig. 1. Sociodemographic characteristics of the study participants are shown in Table 1.

Medical history & lifestyle habits of undergraduates

Regarding medical history, the vast majority of study participants stated that they don't have chronic diseases (95.7%), don't take medicines on a regular basis (94%), are not following any dietary regimen (88.5%), and never have any surgical procedure (78.6%). According to lifestyle characteristics, 129 (26.5%) undergraduates were smokers. Among them, 52.9% reported that smoking increases caffeine consumption. Furthermore, the analysis of IPAQ reveals that 11.5% of students are classified as sedentary individuals, 29.2% are moderately active individuals, and 59.3% are very active individuals, as presented in Table 2.

Undergraduates' sleeping quality

The mean SHI score was 22.58 ± 6.77 [3–48], with the majority (81.7%) representing poor sleeping quality; 34.3% of them were males and 65.7% were females (Fig. 2).

Table 2 Medical history and lifestyle characteristics according to undergraduates gender

Variables		Total (*N* = 486)		Males (*N* = 170)		Females (*N* = 316)		*P*-value
		N	%	*N*	%	*N*	%	
Medical history								
Chronic disease	Yes	21	4.3	44	25.9	60	19	0.003*
	No	265	95.7	126	74.1	256	81	
Medication	Yes	29	6	13	7.6	16	5.1	0.172
	No	457	94	157	92.4	300	94.9	
Following a diet	Yes	56	11.5	29	17.1	27	8.5	0.005*
	No	430	88.5	141	82.9	289	91.5	
Surgery	Yes	104	21.4	44	25.9	60	19	0.050
	No	382	78.6	126	74.1	256	81	
Lifestyle habits								
Smoking	Non-smoker	340	70	87	51.2	42	13.3	< 0.001*
	Smoker	129	26.5	74	43.5	266	84.2	
	Former smoker	17	3.5	9	5.3	8	2.5	
Type of smoking	Cigarette	49	34	46	48.4	3	6.1	< 0.001*
	Pipe (shisha)	56	38.9	21	22.1	35	71.4	
	Both	39	27.1	28	29.5	11	22.4	
Does smoking increase caffeine consumption?	Yes	73	52.9	57	61.3	16	35.6	0.001*
	Sometimes	41	29.7	18	19.4	23	51.1	
	No	24	17.4	18	19.4	6	13.3	
Physical activity level	Low/sedentary	288	59.3	33	19.4	23	7.3	< 0.001*
	Moderate	142	29.2	72	42.4	70	22.2	
	High	56	11.5	65	38.2	223	70.6	

Significant at *: $p < 0.05$ using Pearson Chi-square test

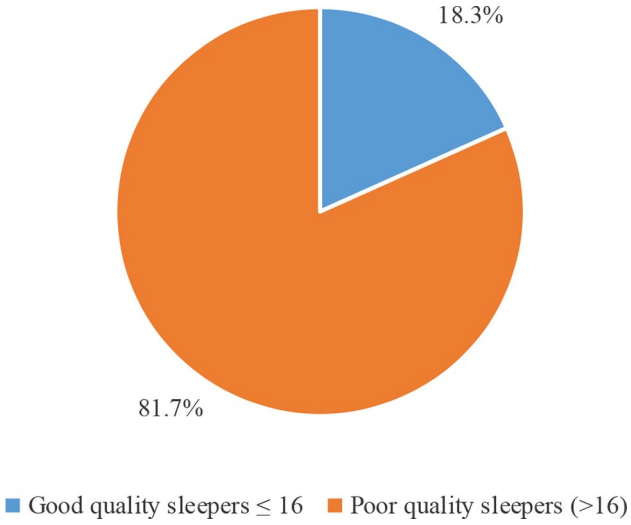

Fig. 2 Undergraduates' sleeping quality presented in percentages

Psychological status of undergraduates

According to DASS21 scores for psychological well-being, 21.2% of participants indicated severe or extremely severe levels of stress, 45.2% indicated severe or extremely severe levels of anxiety, and 24.5% indicated severe or extremely severe levels of depression, as illustrated in Fig. 3.

Undergraduates' caffeine consumption patterns

Table 3 provides information about caffeine consumption among study participants. Caffeine intake was reported by the majority of undergraduates (96.5%). Caffeine was mostly consumed after eating a meal and upon waking up by 41.9% and 44.4%, respectively. Caffeine was mostly consumed at home (47.6%), and coffee was the most consumed source of caffeine (48%), followed by tea (27.2%), energy drinks (9.3%), soft drinks (8.2%), cacao (6.3), and carbonated beverages (1.1%). Most undergraduates described themselves as being addicted to caffeine (41.1%), with a minority of participants (23.3%) believing that caffeine is a weight loss stimulant. Moreover, more than half of the studied participants self-reported having anxiety (56.4%), and 29.8% are having tachycardia.

Figure 4 illustrates that 32.7% of undergraduates consumed more than 400 mg of caffeine per day and presents the differences of unsafe caffeine intake based on gender, smoking status, and sleeping quality, whereas males, smokers, and undergraduates with poor sleeping quality were exceeding the safe level of caffeine intake compared to their counterparts. The average consumption of caffeine was 406.0 ± 546.4 (0–5729.3) mg/day. Their average frequency of daily caffeine intake was 7.4 ± 3.9 times.

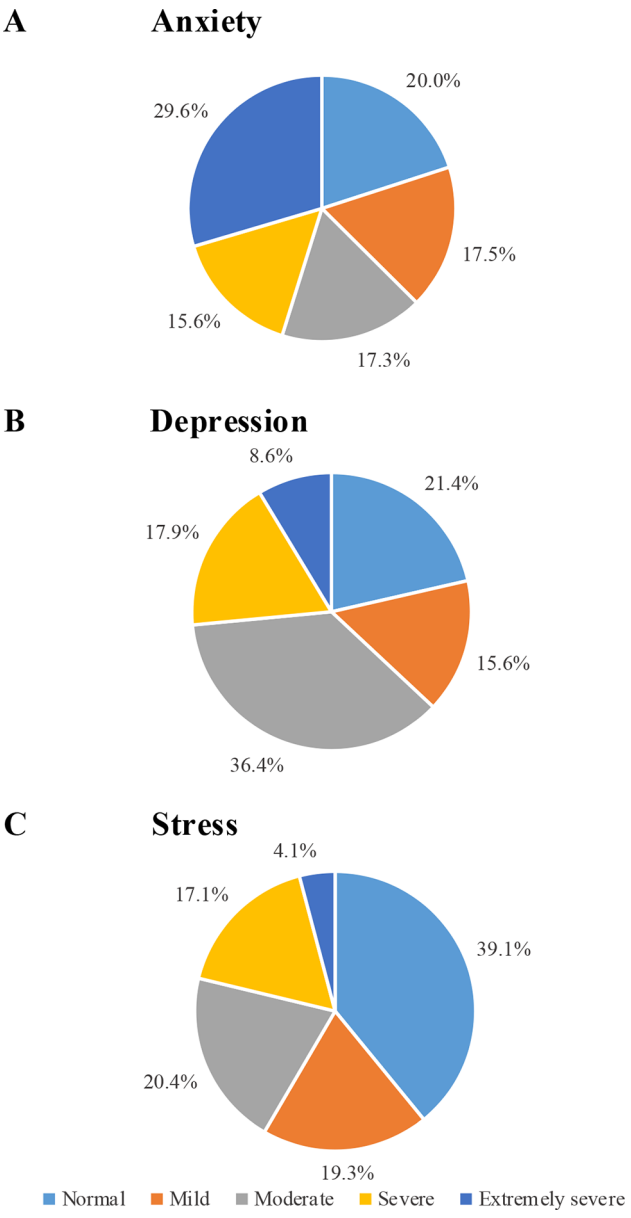

Fig. 3 Classifications of undergraduates into normal, mild, moderate, severe, or extremely severe levels of anxiety (**A**), depression (**B**), and stress (**C**), according to DASS21

Factors associated with caffeine consumption

Table 4 shows that unsafe consumption of caffeine (>400 mg/day) was more common among males ($p < 0.001$, effect size = 0.18), older age ($p = 0.016$, 95% CI: 0.035–0.045), smokers ($p < 0.001$, effect size = 0.26), physically active individuals ($p = 0.002$, effect size = 0.17), and poor-quality sleepers ($p = 0.047$, effect size = 0.09). Moreover, undergraduates who exceeded the safe limits set by EFSA had significantly higher SHI scores ($p = 0.002$, 95% CI: 0.05–0.09), and higher anxiety ($p = 0.006$, 95% CI: 0.01–0.03,), depression ($p = 0.037$, 95% CI: 0.053–0.061), and stress scores ($p = 0.016$, 95% CI: 0.01–0.021) in comparison to their counterparts. In addition, the percentage of undergraduates who agreed that smoking increases caffeine intake was significantly higher among unsafe consumers (61.6%) versus safe consumers (38.4%) (Table 4).

Table 5 demonstrates the quantitative comparison of caffeine intake according to study variables. The results revealed that male students ($p < 0.001$, 95% CI: 0.01–0.02) and students with household monthly income < 1500 NIS ($p = 0.025$, 95% CI: 0.02–0.026) are consuming more caffeine compared to the other groups. Moreover, caffeine consumption is higher among smokers in comparison to their counterparts (non-smokers and former smokers) ($p < 0.001$, 95% CI: 0.01–0.019). Students with high physical activity ($p < 0.001$, 95% CI: 0.01–0.02), and those with extremely severe anxiety have the highest amount of caffeine consumption ($p = 0.006$, 95% CI: 0.06–0.07). Furthermore, poor-quality sleepers had significantly higher consumption of caffeine compared to good-quality sleepers ($p = 0.019$, 95% CI: 0.01–0.015).

The relationship between frequency of caffeine intake and continuous variables (e.g., age, BMI, SHI score, depression score, anxiety score, stress score, and caffeine intake) was studied using Pearson's correlation coefficient (Table 6). Figure 5 presents scatter plot that show the correlation between daily caffeine intake and SHI, depression, anxiety, and stress scores. A positive correlation was observed, suggesting that higher intake of caffeine is associated with higher levels of poor sleeping quality ($p = 0.002$), depression ($p = 0.002$), anxiety ($p < 0.001$), and stress ($p = 0.013$) among undergraduates.

Discussion

To the best of our knowledge, previous research has not studied caffeine consumption among Palestinian undergraduates. Therefore, this study aimed to evaluate the level of daily caffeine consumption among university students in Palestine. Furthermore, the study aimed to investigate the percentage of students who exceed the recommended level of caffeine intake as well as to determine whether sociodemographic, nutritional, lifestyle, and psychological factors are associated with high caffeine consumption among Palestinian undergraduates.

About 96.5% of students reported regular daily caffeine consumption, with the majority consuming coffee, tea, and soft drinks. This percentage was very similar to studies performed in university students from the USA [4], Bahrain [16], and Egypt [37]. Furthermore, the total daily caffeine intake was also similar to a former study performed in Alexandria University students (406 mg/day in the current study versus 396 in the former study) [37]. Among caffeine consumers, 32.7% of participants in the current study exceeded the safe level set by EFSA of 400 mg/day [17]. This proportion is lower compared

Table 3 Caffeine consumption-related data

Variables		Total (*N* = 486)		Males (*N* = 170)		Females (*N* = 316)		X^2 (W)	P-value
		N	%	N	%	N	%		
Caffeine consumption status	Yes	469	96.5	166	97.6	303	95.9	0.97 (0.03)	0.231
	No	17	3.5	4	2.4	13	4.1		
Time of caffeine consumption	Upon waking up	199	41.9	81	48.5	118	38.3	5.2 (0.1)	0.045*
	Before eating	65	13.7	16	9.6	49	15.9		
	After eating	211	44.4	70	41.9	141	45.8		
Place where caffeine is mostly consumed	Home	226	47.6	58	34.7	168	54.5	38.8 (0.27)	< 0.001*
	Workplace	40	8.4	28	16.8	12	3.9		
	University	180	37.9	64	38.3	116	37.7		
	Public places	29	6.1	17	10.2	12	3.9		
Does caffeine reduce body weight?	Yes	111	23.3	52	31.1	59	19	10.9 (0.16)	0.002*
	No	366	76.7	115	68.9	251	81		
The most consumed source of caffeine	Coffee	228	48	85	50.9	143	46.4	36.9 (0.29)	< 0.001*
	Tea	129	27.2	23	13.8	106	34.4		
	Soft drinks	39	8.2	22	13.2	17	5.5		
	Energy drinks	44	9.3	27	16.2	17	5.5		
	Cacao	30	6.3	9	5.4	21	6.8		
	Carbonated beverages	5	1.1	1	0.6	4	1.3		
Addicted to caffeine (self-reported)[1]	Yes	196	41.1	78	46.7	118	38.1	4.3 (0.11)	0.042*
	No	281	58.9	89	53.3	192	61.9		
Having tachycardia (self-reported)	Yes	142	29.8	48	28.7	94	30.3	0.83 (0.04)	0.401
	No	335	70.2	119	71.3	216	69.7		
Having anxiety (self-reported)	Yes	269	56.4	92	55.1	177	57.1	0.64 (0.08)	0.372
	No	208	43.6	75	44.9	133	42.9		

Significant at *: $p < 0.05$ using the Pearson Chi-square test. X^2 (W): Chi-square and effect size. [1]: self-reported according to participants thoughts about themselves

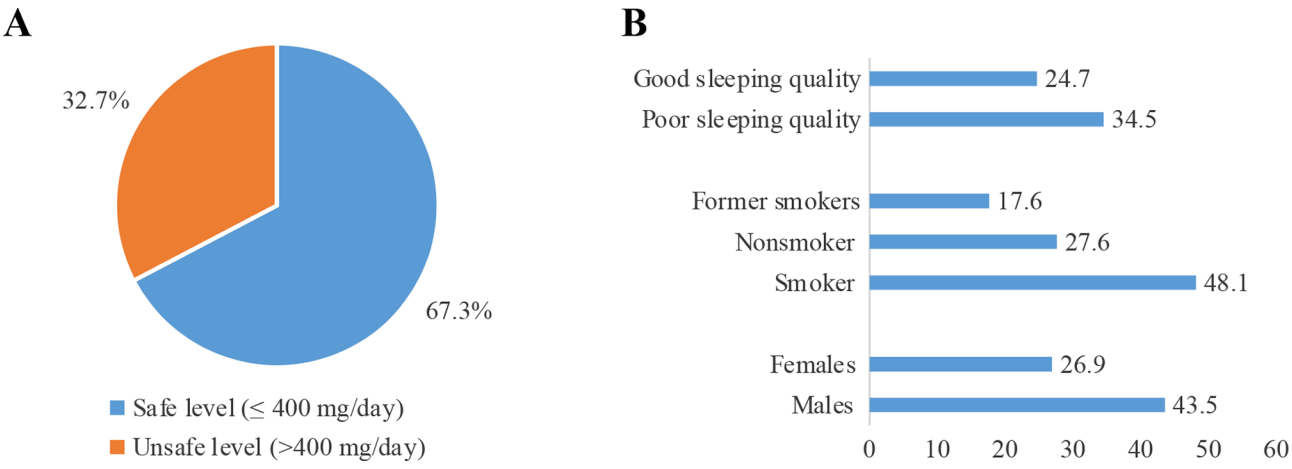

Fig. 4 Daily caffeine intake in relation to the safety level set by EFSA (**A**). Differences in unsafe caffeine intake based on gender, smoking status, and sleeping quality presented in percentage (**B**)

to university students in Egypt (69.4%) [37]. In line with the findings of previous studies [17, 18, 38], our study indicated that coffee was the most commonly consumed source of caffeine by students, followed by tea.

Based on our analysis, caffeine consumption patterns differentiate according to gender. For instance, our findings showed that males consume more caffeine upon walking up, drink more coffee, believe that caffeine is a weight loss stimulant, and perceive themselves as being addicted to caffeine in comparison to females. This is in line with a previous study, which revealed that young males drank coffee more than young females [38]. In addition, our findings indicated that a greater percentage of females reported that they consume caffeine more frequently in their home than men.

Table 4 Undergraduates' characteristics according to their caffeine daily intake in relation to the safety level set by EFSA

Variables		Total caffeine intake (mg/day)		(95%CI)/ X^2 (W)	*P*-value
		≤ 400 mg/day (*N* = 327)	> 400 mg/day (*N* = 159)		
		Mean ± SD/ *N* (%)			
Sociodemographic characteristics					
Age (years)		20 ± 1.4	20.4 ± 1.6	(0.035–0.045)[a]	0.016*
Gender	Male	96 (56.5)	74 (43.5)	13.8 (0.18)[b]	< 0.001*
	Female	231 (73.1)	85 (26.9)		
Marital status	Single	295 (67.8)	140 (32.2)	0.53 (0.03)[b]	0.280
	Married	32 (62.7)	19 (37.3)		
Academic year	1st	89 (69.5)	39 (30.5)	2.33 (0.071)[b]	0.674
	2nd	75 (67)	37 (33)		
	3rd	78 (70.3)	33 (29.7)		
	4th	59 (64.8)	32 (35.2)		
	5th	26 (59.1)	18 (40.9)		
Living area	City	288 (68.5)	105 (31.5)	0.67 (0.04)[b]	0.236
	Camp/village	99 (64.7)	54 (35.3)		
Living status	With family	273 (67.7)	130 (32.3)	0.43 (0.03)[b]	0.812
	With spouse	29 (63)	17 (37)		
	Student housing	25 (67.6)	12 (32.4)		
Monthly income	< 1500 NIS[1]	11 (68.8)	5 (31.2)	2.88 (0.08)[b]	0.236
	1500–5000 NIS	174 (70.7)	72 (29.3)		
	> 5000 NIS	142 (63.4)	82 (36.6)		
BMI categories	Underweight	19 (63.3)	11 (36.7)	0.81 (0.04)[b]	0.977
	Normal weight	233 (67.5)	112 (32.5)		
	Overweight	61 (69.3)	27 (30.7)		
	Obesity	14 (60.9)	9 (39.1)		
BMI (kg/m^2)		23.1 ± 4.1	23.1 ± 3.6	(0.54–0.56)[a]	0.91
Medical history					
Chronic disease	Yes	11 (52.4)	10 (47.6)	2.3 (0.07)[b]	0.107
	No	316 (68)	149 (32)		
Medication	Yes	20 (69)	9 (31)		0.510
	No	307 (67.2)	150 (32.8)		
Following a diet	Yes	39 (69.6)	17 (30.4)	0.16 (0.02)[b]	0.407
	No	288 (67)	142 (33)		
Surgery	Yes	70 (67.3)	34 (32.7)	0.11 (0.01)[b]	0.548
	No	257 (67.3)	125 (32.7)		
Lifestyle habits					
Smoking	Non-smoker	246 (72.4)	94 (27.6)	19.5 (0.26)[b]	< 0.001*
	Smoker	67 (51.9)	62 (48.1)		
	Former smoker	14 (82.4)	3 (17.6)		
Type of smoking	Cigarette	25 (51)	24 (49)	5.6 (0.19)[b]	0.077
	Pipe (shisha)	37 (66.1)	19 (33.9)		
	Both	17 (43.6)	22 (56.4)		
Does smoking increase caffeine consumption?	Yes	28 (38.4)	45 (61.6)	16.1 (0.33)[b]	< 0.001*
	Sometimes	25 (61)	16 (39)		
	No	20 (83.3)	4 (16.7)		
Physical activity level	Low/sedentary	212 (73.6)	76 (26.4)	12.8 (0.17)[b]	0.002*
	Moderate	83 (58.5)	59 (41.5)		
	High	32 (57.1)	24 (42.9)		
SHI categories	Good sleeping quality	67 (75.3)	22 (24.7)	3.16 (0.09)[b]	0.047*
	Poor sleeping quality	260 (65.5)	137 (34.5)		
SHI score		21.9 ± 6.4	23.9 ± 7.3	(0.05–0.09)[a]	0.002*
Psychological status					

Table 4 (continued)

Variables		Total caffeine intake (mg/day)		(95%CI)/ X^2 (W)	*P*-value
		≤ 400 mg/day (*N* = 327)	> 400 mg/day (*N* = 159)		
		Mean ± SD/ *N* (%)			
Depression	Normal	80 (76.9)	24 (23.1)	8.4 (0.14)[b]	0.077
	Mild	53 (69.7)	23 (30.3)		
	Moderate	108 (61)	69 (39)		
	Severe	60 (69)	27 (31)		
	Extremely severe	26 (61.9)	16 (38.1)		
Anxiety	Normal	77 (79.4)	20 (20.6)	10.5 (0.15)[b]	0.032*
	Mild	60 (70.6)	25 (29.4)		
	Moderate	55 (65.5)	29 (34.5)		
	Severe	46 (60.5)	30 (39.5)		
	Extremely severe	89 (61.8)	55 (38.2)		
Stress	Normal	136 (71.6)	54 (28.4)	4.2 (0.1)[b]	0.376
	Mild	63 (67)	31 (33)		
	Moderate	66 (66.7)	33 (33.3)		
	Severe	49 (59)	34 (41)		
	Extremely severe	13 (65)	7 (35)		
Depression score		7.8 ± 4.0	8.6 ± 4.1	(0.053–0.061)[a]	0.037*
Anxiety score		7.0 ± 4.3	8.1 ± 4.0	(0.01–0.03)[a]	0.006*
Stress score		8.7 ± 4.2	9.7 ± 4.1	(0.01–0.021)[a]	0.016*

Significant at *: $p < 0.05$ according to Pearson chi-square test for categorical variables and the Mann-Whitney test for continuous variables. SHI: Sleep Hygiene Index. X^2 (W): Chi-square and effect size. [a] (95% CI), [b] X2 (W). [1]: New Israeli Shekel currency

This study also found that the percentage of safe-level consumers was significantly higher among males. Our findings are in agreement with the findings reported in previous studies [11, 39], which reported higher caffeine consumption among males. However, in contravention of our findings, former studies found that female students had higher daily caffeine intake compared to male students, which is attributed to female predominancy in the study population [4] and a higher level of stress among females [40]. However, findings from our study revealed that nearly half of smokers were male students and were more likely to exceed the safe levels of caffeine while smoking, which is well-documented in previous literature [4, 39]. However, smoking increases the rate of caffeine metabolism by inducing the cytochrome P450 1A2 (CYP1A2) enzyme [41]; therefore, smokers may need to consume caffeine more than non-smokers to experience identical effects. In addition, behavioral factors may contribute to the relationship between caffeine consumption and smoking [4]. These findings highlight the need for educational interventions, campaigns, and university policies by implementing guidelines that raise awareness about the risks and health implications of caffeine overconsumption among high-risk groups, particularly males and smokers. Moreover, this targeted intervention could provide healthier alternatives other than caffeine for stress coping strategies like a balanced diet and exercise, along with regular monitoring for their caffeine intake.

Our findings indicated a significant difference in the consumption of caffeine-containing products according to physical activity level. It revealed that physically active individuals consumed higher levels of caffeine compared to lowered physically active or sedentary individuals. This could be explained by the fact that caffeine enhances performance by reducing fatigue, heightening mental alertness and attention, as well as improving physical endurance [42].

Our results also indicated that higher caffeine intake was associated with depression and anxiety. In parallel with these findings, a previous study found that caffeine consumption is correlated to depressive symptoms and higher anxiety levels in college students [15]. Another study by Jahrami and his colleagues found that consuming large amounts of caffeine increases the risk of anxiety symptoms in university students [16]. However, several studies had conflicting results, which suggest that caffeine intake may confer protection against depression. For example, caffeine consumption was inversely associated with depression symptoms in a sample of Korean adults [13]. In a Japanese population as well, habitual caffeine intake reduced the prevalence of depression by 39% [43]. Nevertheless, scientific evidence indicated that caffeine suppresses adenosine receptors in the central nervous system, predominantly in the amygdala, hippocampus, and prefrontal cortex, which may explain the correlation underlying mood disorders (e.g., anxiety, depression) and caffeine intake [44].

Table 5 Undergraduates' characteristics according to total caffeine intake

Variables		Total caffeine intake (mg/day), Mean ± SD	*P*-value (95%CI)
Sociodemographic characteristics			
Gender	Male	435.9 ± 371.8	< 0.001* (0.01–0.02)
	Female	290.8 ± 301.5	
Marital status	Single	338.4 ± 328.2	0.855 (0.85–0.87)
	Married	368.2 ± 388.3	
Academic year	1st	345.6 ± 329.9	0.261
	2nd	350.6 ± 369.2	
	3rd	301.9 ± 312.3	
	4th	355.5 ± 329.6	
	5th	369.1 ± 327.8	
Living area	City	337.2 ± 337.4	0.422 (0.41–0.52)
	Camp/village	350.9 ± 329.5	
Living status during studying years	With family	335 ± 329.7	0.261 (0.62–0.78)
	With spouse	393.1 ± 395.2	
	Student housing	348.7 ± 310	
Monthly income	< 1500 NIS[1]	380.4 ± 382.7	0.025* (0.02–0.026)
	1500–5000 NIS	318.3 ± 337.8	
	> 5000 NIS	364.3 ± 327.3	
BMI categories	Underweight	354.5 ± 302.7	0.700 (0.69–0.73)
	Normal weight	335.2 ± 336.4	
	Overweight	343.8 ± 331.3	
	Obesity	411.2 ± 373.3	
Medical history			
Chronic disease	Yes	409.2 ± 334.9	0.259 (0.25–0.27)
	No	338.5 ± 334.7	
Medication	Yes	310.4 ± 266.2	0.879 (0.87–0.88)
	No	343.5 ± 338.7	
Following a diet	Yes	357.6 ± 380.4	0.998 (0.97–0.99)
	No	339.5 ± 328.7	
Surgery	Yes	333.6 ± 332.6	0.741 (0.73–0.75)
	No	343.7 ± 335.6	
Lifestyle habits			
Smoking status	Non-smoker	288.3 ± 287.5	< 0.001* (0.01–0.019)
	Smoker	489.5 ± 402.7	
	Former smoker	283.3 ± 326.6	
Type of smoking	Cigarette	512.4 ± 421.6	0.015* (0.01–0.02)
	Pipe (shisha)	375.6 ± 377.1	
	Both	546.5 ± 392.2	
Does smoking increase caffeine consumption?	Yes	553 ± 396.2	0.001* (0.001–0.003)
	Sometimes	487.6 ± 440.7	
	No	269.4 ± 267.7	
Physical activity level	Low/sedentary	291.3 ± 293.8	< 0.001* (0.01–0.02)
	Moderate	389.6 ± 326.7	
	High	478.2 ± 474.9	
SHI categories	Good sleeping quality	282.1 ± 295.6	0.019* (0.01–0.015)
	Poor sleeping quality	354.9 ± 341.7	
Psychological status			
Depression	Normal	264.6 ± 276.5	0.087 (0.06–0.07)
	Mild	336.6 ± 368.9	
	Moderate	356.4 ± 298.2	
	Severe	383.3 ± 411.9	
	Extremely severe	391.9 ± 351.8	

Table 5 (continued)

Variables		Total caffeine intake (mg/day), Mean ± SD	*P*-value (95%CI)
Anxiety	Normal	261.4 ± 259.8	0.006* (0.06–0.07)
	Mild	309.3 ± 350.2	
	Moderate	344.1 ± 361.9	
	Severe	378.6 ± 347.9	
	Extremely severe	393.6 ± 338.4	
Stress	Normal	310.3 ± 329.6	0.171 (0.112–0.121)
	Mild	345.7 ± 320.6	
	Moderate	339.9 ± 330.4	
	Severe	395.8 ± 358.2	
	Extremely severe	402.4 ± 363	
Caffeine intakes	≤ 400 mg/day (safe level)	151.9 ± 105.5	< 0.001* (0.01–0.02)
	> 400 mg/day (unsafe level)	731.5 ± 305.7	

Significant at *: $p < 0.05$ using Kruskal-Wallis H test. ** $p < 0.05$ using Mann-Whitney U test. [1]: New Israeli Shekel currency

Table 6 Correlation between caffeine intake and continuous variables

Variable	Caffeine intake (mg/day)	*P*-value
	Correlation Coefficient	
Age	0.056	0.214
BMI	0.054	0.238
SHI score	0.138**	0.002
Depression score	0.139**	0.002
Anxiety score	0.158**	< 0.001
Stress score	0.113*	0.013

*Correlation is significant at the level 0.05, ** correlation is significant at the level 0.01. BMI: body Mass Index; SHI: Sleep Hygiene Index

In this study, we also observed that consumption of caffeinated beverages is associated with poor sleep quality. In agreement with this observation, several studies have found that sleep quality is correlated with caffeine consumption [39]. Caffeine could alter the sleep-awake cycle, resulting in sleep disturbances [45]. It is worth noting that sleep quality may be affected by other factors like stress, electronic media, fast food consumption, etc [39].

Interestingly, the association between caffeine consumption and mental health could be mediated by sleep disturbances. It is worth noting in this context that the confidence intervals in our findings indicated the strength and precision of the association between higher levels of caffeine intake and higher levels of poor sleeping quality, depression, anxiety, and stress among our study participants. Each of which reinforces the effect of caffeine on mental health. In addition, evidence has documented the correlations between sleep quality and depression, anxiety [46], and stress [47]. Lemma and his colleagues noted that depression was strongly associated with poor sleep quality among university students in Ethiopia [48]. Another study found that higher levels of depression and/or anxiety symptoms are linked to poor sleep quality in college students [49].

This study has several limitations. First, being a cross-sectional design study has limited the possibility to derive a cause-and-effect relationship between variables. Second, some data were collected using the self-reporting methods, making it prone to recall bias, including inaccuracies, overestimation, or underestimation of caffeine consumption, resulting in reduced precision of the association between caffeine intake and the studied variables. Third, the lack of the findings generalization since the sample was recruited from one university only. Fourth, most of our sample were females because they are more concerned about their health compared to males, therefore, under-representation of males in this study could be a limitation. Accordingly, future studies should be done on a larger sample size from different Palestinian universities and include postgraduate students. Moreover, further research should employ longitudinal study designs and combine self-reported methods with objective measurements of caffeine intake, such as the use of biomarkers to evaluate caffeine levels in blood, urine, or saliva. Additionally, technology might be involved to provide more reliable data, like smartphone applications. However, it is recommended to consider that sleep quality can be influenced by several factors other than caffeine, including electronic media, noise, artificial light, and stress. So, future studies could enhance and contribute to practical interventions to reduce caffeine intake by examining lifestyle factors related to caffeine consumption, including dietary intake and screen time, as well as the influence of academic stress and exploring coping mechanisms. Nonetheless, our study is the first of its kind to estimate the level of caffeine consumption among university students in Palestine and its' associated factors. Another strength of the current study is the use of semi-quantitative FFQ to assess caffeine intake, which examined the quantity and frequency of caffeine in various sources.

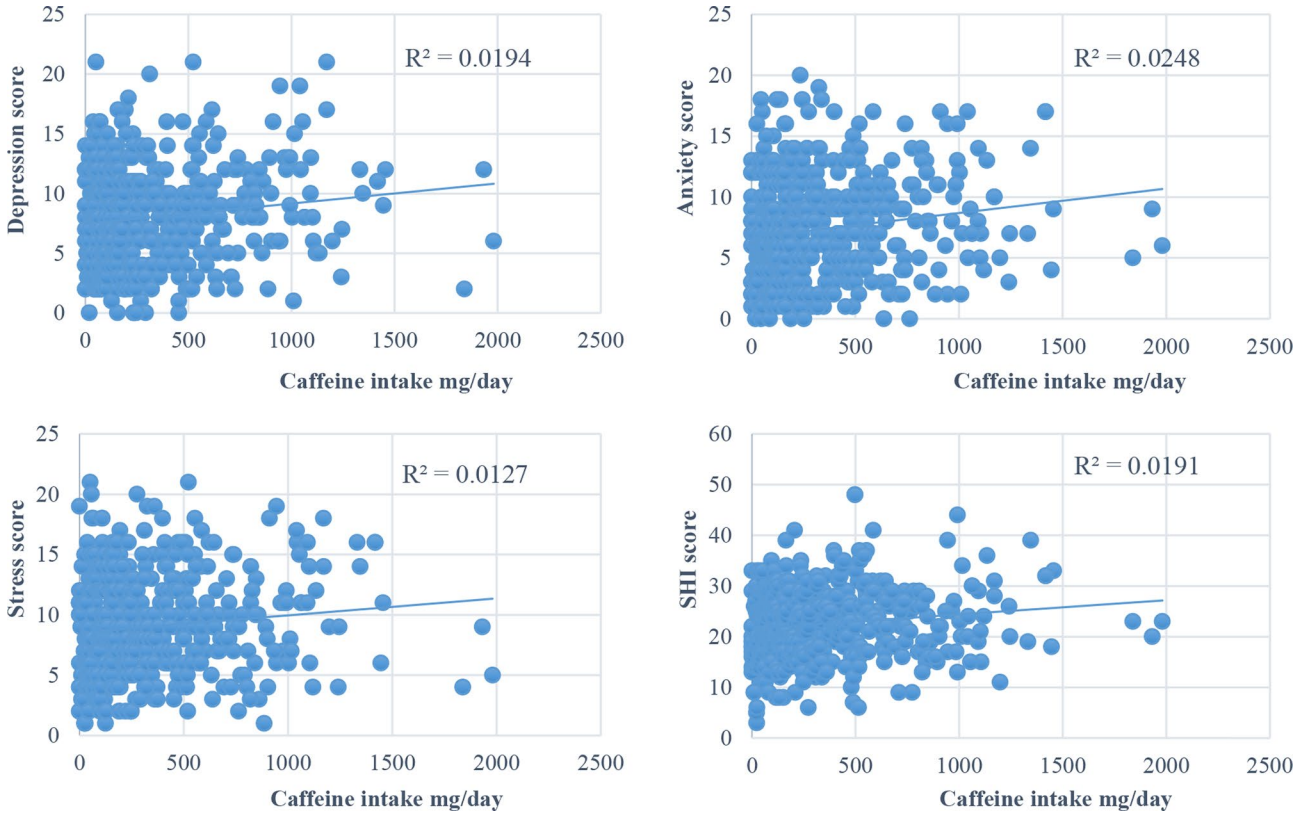

Fig. 5 The correlation (R^2) between daily caffeine intake and SHI, depression, anxiety, and stress scores

Conclusion

To conclude, caffeine consumption in the studied sample was very high and exceeded the safe levels, with coffee being the most consumed source of caffeine. The current study revealed that unsafe caffeine consumption was more common among males, smokers, and physically active individuals. Caffeine intake was also linked to poor sleep quality, stress, depression, and anxiety. Therefore, universities should implement nutrition educational programs to increase awareness of the adverse effects of high caffeine intake. Moreover, it is urgent to educate undergraduates on the different sources of caffeine, such as tea, chocolate, soft drinks, etc. Additional studies are warranted to determine whether educational campaigns may assist in reducing caffeine consumption.

Abbreviations

EFSA	European Food Safety Authority
PPU	Palestine Polytechnic University
IBD	Inflammatory Bowel Diseases
BMI	Body Mass Index
WHO	World Health Organization
SF-IPAQ	International Physical Activity Questionnaire short form
SHI	Sleep Hygiene Index
FFQ	Food frequency Questionnaire
USDA	United States Department of Agriculture
DASS	Depression Anxiety Stress Scale

Acknowledgements

The authors would like to acknowledge the students who participated in the study and agreed to join the study.

Author contributions

The authors have contributed to the manuscript as follows: MB: the principal investigator optimized the study proposal and protocol, supervised the data analysis, and edited the final manuscript file. MH, SZ participated in the study manuscript writing, MD, SA, SD , FA draft the proposal, applied for IRB, data collection, and data entry and primary analysis. All the authors read and approved the final manuscript.

Funding

None.

Data availability

Data is available upon reasonable request from the coresponding author.

Declarations

Ethical approval

The research protocols were in accordance with the Declaration of Helsinki and reported in line with the STROBE checklist for reporting cross-sectional studies. The study protocol was approved by the Deanship of Scientific Research Ethical Committee at Palestine Polytechnic University (approval code: KA/41/2022). Informed written was also collected from all undergraduates before data collection. All the collected data were saved secretly, allowing only the principal investigators and the study analyst to evaluate and conduct the proper statistical analysis. Note that participant names were not saved to avoid violating participants confidentiality. After this study was finished, the data were saved by the principal investigators correctly which may benefit any future similar or related studies.

Consent for publication

Not applicable.

Competing interests
The authors declare no competing interests.

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Received: 1 April 2024 / Accepted: 14 December 2024
Published online: 06 February 2025

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