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Original Article

Anxiety Severity as a Correlate of Perceived Cardiac Autonomic Symptoms in Female Medical Students Who Consume Energy Drinks and Tea: A Cross-Sectional Study from Sialkot, Pakistan

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ABSTRACT

Background: Anxiety can produce palpitations, chest discomfort, dizziness, and breathlessness that overlap with symptoms attributed to caffeinated beverages, potentially complicating interpretation of stimulant-related symptom reports. Objective: To determine whether anxiety severity was independently associated with a high burden of self-reported cardiac autonomic symptoms among female medical students after accounting for energy drink consumption, tea intake, and other measured covariates. Methods: This analytical cross-sectional study included 274 female medical students from three medical colleges in Sialkot, Pakistan. Anxiety was assessed using the GAD-7. High cardiac autonomic symptom burden was defined using self-reported palpitations, chest discomfort, dizziness, and dyspnoea. Associations were examined using bivariate tests and multivariable logistic regression. The primary complete-case model included 175 participants, and a sensitivity analysis included 243. Results: At least mild anxiety was present in 187 participants (68.2%). Ninety-one (33.2%) met the high symptom-burden threshold. Mean GAD-7 scores were 11.26 ± 5.89 versus 7.30 ± 5.72 in participants with high versus lower symptom burden, respectively (mean difference 3.96, 95% CI 2.49–5.43; p<0.001). GAD-7 remained associated with high symptom burden in the primary model (aOR 1.18 per point, 95% CI 1.10–1.26; p<0.001) and sensitivity analysis (aOR 1.13, 95% CI 1.07–1.19; p<0.001). Conclusion: Anxiety severity was independently associated with self-reported cardiac autonomic symptom burden in this population, although the cross-sectional design does not establish causal direction. Keywords: Anxiety; GAD-7; Caffeine; Palpitations; Somatic symptoms; Cross-sectional studies; Medical students; Pakistan.

INTRODUCTION

Anxiety is common among medical students and may manifest through both psychological and somatic symptoms, including palpitations, chest tightness, dizziness, and breathlessness. These symptoms overlap substantially with complaints frequently reported after consumption of caffeine-containing beverages and energy drinks, creating an

important challenge when interpreting stimulant-related cardiovascular symptoms in young adults. Previous research among medical students has documented the consumption of energy drinks and associated adverse effects, including cardiovascular and neuropsychiatric symptoms (1). A recent systematic review further demonstrated that energy drink consumption can produce measurable changes in cardiovascular parameters, including heart rate, blood pressure, and corrected QT interval, supporting the biological plausibility of stimulant-related cardiac symptoms (2). However, objective physiological changes do not necessarily explain the subjective symptoms reported by individual consumers, particularly when anxiety is also present.

The relationship between caffeine exposure and anxiety is complex. Experimental evidence indicates that caffeine can provoke anxiety and panic symptoms, particularly among individuals with panic disorder. A systematic review and meta-analysis of placebo-controlled caffeine-challenge studies found substantially greater susceptibility to caffeine-induced panic attacks among patients with panic disorder than among healthy controls, together with a marked increase in subjective anxiety (3). These effects are biologically plausible because caffeine acts primarily through antagonism of adenosine A1 and A2A receptors, mechanisms involved in alertness and physiological arousal (4). At the same time, anxiety itself is highly prevalent among medical students; pooled international evidence suggests that approximately one-third experience clinically relevant anxiety symptoms during medical training (5). Consequently, in observational studies of stimulant-related symptoms, failure to measure anxiety directly may make it difficult to determine whether reported palpitations, dizziness, chest discomfort, or breathlessness are primarily associated with stimulant exposure, anxiety-related somatic symptom perception, or both.

This issue may be particularly relevant in Pakistan, where medical students commonly consume multiple caffeinated products, including energy drinks and tea. Commercial information has reported approximately 72 mg of caffeine per 250 mL serving of Sting energy drink (6), while energy drink use has also been documented among Pakistani medical students (7). However, locally measured caffeine concentrations may differ substantially from labelled or commercially reported values. A laboratory analysis of energy drinks available in Lahore found variation between measured and labelled caffeine concentrations, including a considerably lower measured concentration for Sting than the commonly cited commercial estimate (8). Such variability makes precise estimation of actual caffeine exposure difficult when consumption is assessed using self-reported frequency rather than measured caffeine dose. It also strengthens the need to distinguish stimulant exposure from other factors that may influence symptom reporting.

The 7-item Generalized Anxiety Disorder scale (GAD-7) provides a brief and validated method for quantifying anxiety symptom severity and is therefore suitable for examining anxiety as a continuous exposure in observational research (9). Importantly, the association between caffeine and subjectively experienced anxiety is not necessarily linear at commonly consumed doses. In a randomized placebo-controlled crossover trial, administration of 150 mg of caffeine to individuals with low habitual caffeine intake did not significantly increase subjective anxiety in either participants with panic disorder or health controls, despite measurable changes in physiological arousal and avoidance behavior (10). This divergence between subjective symptoms and physiological responses highlights the limitations of attributing self-reported cardiac or autonomic complaints solely to caffeine or energy drink consumption.

Despite evidence linking stimulant exposure with cardiovascular effects and anxiety with somatic symptom expression, the relative contribution of anxiety severity to perceived cardiac and autonomic symptoms has not been adequately separated from stimulant-consumption patterns in comparable medical-student populations. In particular, observational studies that assess energy drink or tea intake without simultaneously accounting for anxiety may risk attributing symptoms to stimulant exposure that are partly associated with anxiety or heightened symptom perception. Therefore, the present study aimed to determine whether anxiety severity, measured using the GAD-7, was independently associated with a high burden of self-reported cardiac autonomic symptoms among female medical students in Sialkot, Pakistan, after adjustment for energy drink frequency, tea intake, and other relevant covariates.

MATERIAL AND METHODS

This analytical cross-sectional study was conducted among female medical students enrolled at three medical colleges in Sialkot District, Punjab, Pakistan: Islam Medical & Dental College, Sialkot Medical College, and Khawaja

Muhammad Safdar Medical College. Data were collected from 1 July to 10 September 2026. The study was designed to examine whether anxiety severity was independently associated with a high burden of self-reported cardiac autonomic symptoms after accounting for energy drink consumption, tea intake, and other potentially relevant covariates. Female medical students aged 18–30 years who were enrolled at one of the participating institutions were eligible for inclusion. Students with a known history of cardiovascular disease, pregnancy or lactation, current use of medication with a strong influence on heart rate or the QT interval, or a self-reported chronic illness capable of independently producing palpitations were excluded.

The sample size was calculated using Cochran's formula for prevalence estimation as part of the parent study. An anticipated stimulant-use prevalence of 65%, a 5% margin of error, and a 95% confidence level produced an initial sample size of 350. Because the eligible source population comprised 1,243 female students across the three participating colleges, finite population correction was applied, yielding a required sample of 273, which was rounded to 274 participants. This sample-size calculation was intended for prevalence estimation in the parent study rather than specifically for the multivariable analysis of the association between anxiety and cardiac autonomic symptoms. No separate statistical power calculation was performed for the regression analysis.

The source population was stratified according to institution, and the target sample of 274 participants was allocated proportionally according to each college's share of the eligible female-student population. Within each institutional stratum, students were selected by simple random sampling from available enrolment rosters. A total of 504 female students were randomly selected and approached for participation. Of these, 230 declined participation or did not complete the questionnaire, resulting in 274 completed responses and an overall response rate of 54.4%. The final sample comprised 117 students from Islam Medical & Dental College, 81 from Sialkot Medical College, and 76 from Khawaja Muhammad Safdar Medical College. Written informed consent was obtained from all participants before enrolment.

Data were collected face-to-face by trained female data collectors using a structured, pilot-tested questionnaire administered in a private setting. The questionnaire was available in English or Urdu, and interviews lasted approximately 12–15 minutes. Anxiety severity was assessed using the 7-item Generalized Anxiety Disorder scale (GAD-7), a validated self-report instrument that evaluates the frequency of anxiety symptoms during the preceding two weeks (9). Each item is scored from 0 to 3, producing a total score ranging from 0 to 21. Scores were categorized as minimal anxiety (0–4), mild anxiety (5–9), moderate anxiety (10–14), and severe anxiety (15–21). For the primary multivariable analysis, the total GAD-7 score was analyzed as a continuous variable, with the adjusted association expressed per one-point increase in the score.

Stimulant exposure was assessed using self-reported consumption frequency. Energy drink intake was categorized as non-consumption, 1–2 cans per week, 3–4 cans per week, or at least 5 cans per week. Background tea consumption was categorized as non-consumption, 1 cup per day, 2–3 cups per day, or at least 4 cups per day. Cardiac and autonomic symptoms experienced during the preceding 30 days were assessed using a self-reported symptom checklist comprising four core symptoms: palpitations, chest discomfort, dizziness, and dyspnoea occurring on mild exertion or at rest. Each symptom was recorded on a four-level frequency scale of Never, Rarely, Sometimes, or Often. The primary outcome was a high burden of self-reported cardiac autonomic symptoms, operationally defined as reporting at least two of the four symptoms at a frequency of Sometimes or Often, or reporting any single symptom at a frequency of Often. This operational threshold was used to identify clustering of frequently perceived symptoms and did not represent a clinical diagnosis.

Potential confounding variables included energy drink consumption frequency, tea intake, age group, self-reported anemia, sleep deprivation, physical activity, current oral contraceptive use, and socioeconomic status. Age was categorized as 18–19, 20–22, 23–25, or ≥26 years. Anemia was defined as self-reported physician-diagnosed anemia within the preceding 12 months. Sleep deprivation was defined as sleeping for fewer than 6 hours per night on most nights. Physical activity was categorized as sedentary/light, moderate, or vigorous according to the reported frequency and intensity of weekly exercise. Current oral contraceptive use was recorded as yes, no, or undisclosed. Socioeconomic status was assessed using parental education and household income and categorized into tertiles. Anemia was retained as an analytical covariate rather than an exclusion criterion because the screening exclusion criterion applied to chronic illnesses considered independently capable of producing palpitations.

Descriptive statistics were used to characterize the study population and principal study variables. Categorical variables were summarized as frequencies and percentages, whereas continuous variables were summarized using mean ± standard deviation or median and interquartile range, as appropriate to the available distributional information. The unadjusted association between anxiety and high cardiac autonomic symptom burden was examined using an independent-samples t-test for the continuous GAD-7 score and the chi-square test for GAD-7 severity categories. Additional bivariate comparisons were performed for selected covariates. Seven bivariate statistical comparisons were conducted without adjustment for multiple testing; consequently, p-values close to the conventional significance threshold were interpreted as exploratory. All tests were two-tailed, and a p-value <0.05 was considered statistically significant.

The primary adjusted analysis used multivariable binary logistic regression to estimate the independent association between GAD-7 total score and high cardiac autonomic symptom burden. GAD-7 score was entered as a continuous predictor and the model adjusted for energy drink consumption frequency, tea intake, age group, anemia, sleep deprivation, physical activity, oral contraceptive use, and socioeconomic status. Adjusted odds ratios (aORs) with 95% confidence intervals were reported. Model performance and fit were assessed using the area under the receiver operating characteristic curve, classification accuracy at a predicted-probability threshold of 0.50, the no-information rate, McFadden pseudo-R^2, and the likelihood-ratio test.

The primary regression was conducted using complete cases for the variables included in the fully adjusted model. Missing data were most prominent for physical activity, which was unavailable for 75 participants (27.4%), and oral contraceptive disclosure, which was unavailable for 24 participants (8.8%). Undisclosed oral contraceptive use was retained as a separate analytical category rather than being treated as exposed or unexposed; however, missingness in other covariates resulted in further case loss. The complete-case primary model therefore included 175 of the 274 participants. To evaluate whether the principal GAD-7 association persisted in a larger analytical sample, a post-hoc sensitivity analysis was performed after removing physical activity and oral contraceptive use from the covariate set. This sensitivity model retained energy drink consumption, tea intake, age group, anemia, sleep deprivation, and socioeconomic status and included 243 participants. The remaining 31 participants were excluded because of missing information on tea intake (n=12), age group (n=7), sleep deprivation (n=6), anemia status (n=4), or socioeconomic status (n=2). Because the sensitivity model differed from the primary model in both sample size and adjustment set, its estimates were treated as a complementary assessment rather than as directly interchangeable with the primary model.

Statistical analyses were performed using Python with the pandas, SciPy, and statsmodels packages. The study was reported according to the STROBE framework for cross-sectional observational studies. Ethical approval was obtained from the Institutional Ethics Review Committee of Islam Medical & Dental College, Sialkot (IRB-2026-087; 28 June 2026).

Administrative permission to approach students was obtained from Sialkot Medical College (SMC/Admin/2026-138; 25 June 2026) and Khawaja Muhammad Safdar Medical College (KMMC/Academics/2026-045; 26 June 2026). All participants provided written informed consent before participation, and the study was conducted in accordance with the Declaration of Helsinki. Participants with a GAD-7 score ≥15, corresponding to severe anxiety symptoms, were advised to consult a physician for further clinical assessment and support.

RESULTS

A total of 274 female medical students were included in the analysis. The mean GAD-7 score was 8.61 ± 6.06, with a median of 8 (IQR 3–14). Overall, 87 participants (31.8%) had minimal anxiety, 73 (26.6%) had mild anxiety, 60 (21.9%) had moderate anxiety, and 54 (19.7%) had severe anxiety. Accordingly, 187 participants (68.2%) had at least mild anxiety symptoms, defined as a GAD-7 score of 5 or greater (Table 1).

Ninety-one participants (33.2%) met the predefined threshold for a high burden of cardiac autonomic symptoms. Mean GAD-7 scores were greater among participants with a high symptom burden than among those with a lower symptom burden (11.26 ± 5.89 vs 7.30 ± 5.72). The mean between-group difference was 3.96 points (95% CI 2.49–5.43; t=5.30, p<0.001), with a standardized mean difference of Hedges' g=0.68. GAD-7 severity category was also associated with symptom-burden status (χ^2=30.28, df=3, p<0.001) (Table 2).

Table 1. Distribution of Anxiety Severity and GAD-7 Scores Among Participants (N = 274)

GAD-7 measure	n (%) / Summary value
Minimal anxiety, 0–4	87 (31.8)
Mild anxiety, 5–9	73 (26.6)
Moderate anxiety, 10–14	60 (21.9)
Severe anxiety, 15–21	54 (19.7)
At least mild anxiety, ≥5	187 (68.2)
GAD-7 total score, mean ± SD	8.61 ± 6.06
GAD-7 total score, median (IQR)	8 (3–14)

Abbreviations: GAD-7, 7-item Generalized Anxiety Disorder scale; IQR, interquartile range; SD, standard deviation.

Table 2. Association Between GAD-7 Anxiety Severity and High Cardiac Autonomic Symptom Burden

GAD-7 measure	High symptom burden (n = 91)	Lower symptom burden (n = 183)	Effect estimate	95% CI	Test statistic	p-value
GAD-7 total score, mean ± SD	11.26 ± 5.89	7.30 ± 5.72	3.96	2.49–5.43	5.30	<0.001
Standardized mean difference, Hedges' g	—	—	0.68	—	—	—
GAD-7 severity category	—	—	—	—	30.28	<0.001

Abbreviations: CI, confidence interval; GAD-7, 7-item Generalized Anxiety Disorder scale; SD, standard deviation. The continuous GAD-7 comparison used an independent-samples t-test. The categorical GAD-7 association used a chi-square test with 3 degrees of freedom. Hedges' g was calculated from the reported group sizes, means, and standard deviations.

Table 3. Multivariable Logistic Regression for High Cardiac Autonomic Symptom Burden: Primary Complete-Case Model (n = 175)

Predictor	aOR	95% CI	p-value
GAD-7 score, per 1-point increase	1.18	1.10–1.26	<0.001
Energy drinks, 1–2 cans/week vs none	2.62	0.94–7.35	0.067
Energy drinks, 3–4 cans/week vs none	3.09	1.02–9.31	0.046
Energy drinks, ≥5 cans/week vs none	7.37	1.89–28.82	0.004
Oral contraceptive use, yes vs no	8.32	1.17–59.21	0.034
Oral contraceptive use, undisclosed vs no	0.61	0.11–3.36	0.574
Sleep deprivation, yes vs no	2.02	0.90–4.51	0.088
Tea intake, per category increase	1.26	0.70–2.26	0.444
Anemia, yes vs no	0.98	0.32–2.94	0.965
Physical activity, per category increase	1.10	0.63–1.93	0.733
Age 18–19 vs 20–22 years	1.73	0.52–5.80	0.376
Age 23–25 vs 20–22 years	0.83	0.32–2.13	0.694
Age ≥26 vs 20–22 years	0.24	0.03–2.06	0.193
Socioeconomic status, per category increase	0.73	0.47–1.14	0.172

Abbreviations: aOR, adjusted odds ratio; CI, confidence interval; GAD-7, 7-item Generalized Anxiety Disorder scale. The model adjusted simultaneously for GAD-7 score, energy drink frequency, tea intake, age group, anemia, sleep deprivation, physical activity, oral contraceptive use, and socioeconomic status. Model AUC = 0.79 (95% CI 0.71–0.87); McFadden pseudo-R^2 = 0.280; likelihood-ratio test p<0.001; classification accuracy at a probability threshold of 0.50 = 78.9%.

Table 4. Sensitivity Multivariable Logistic Regression for High Cardiac Autonomic Symptom Burden (n = 243)

Predictor	aOR	95% CI	p-value
GAD-7 score, per 1-point increase	1.13	1.07–1.19	<0.001
Energy drinks, 1–2 cans/week vs none	2.18	0.99–4.81	0.053
Energy drinks, 3–4 cans/week vs none	4.22	1.77–10.06	0.001
Energy drinks, ≥5 cans/week vs none	7.25	2.52–20.89	<0.001
Anemia, yes vs no	2.25	1.06–4.80	0.036
Sleep deprivation, yes vs no	2.12	1.12–4.02	0.021
Tea intake, per category increase	1.47	0.93–2.33	0.097
Age 18–19 vs 20–22 years	1.13	0.43–3.00	0.800
Age 23–25 vs 20–22 years	0.98	0.48–2.01	0.951
Age ≥26 vs 20–22 years	0.30	0.06–1.56	0.152
Socioeconomic status, per category increase	0.88	0.63–1.22	0.442

Abbreviations: aOR, adjusted odds ratio; CI, confidence interval; GAD-7, 7-item Generalized Anxiety Disorder scale. The sensitivity model excluded physical activity and oral contraceptive use from the adjustment set and adjusted for GAD-7 score, energy drink frequency, tea intake, age group, anemia, sleep deprivation, and socioeconomic status. McFadden pseudo-R^2 = 0.196; likelihood-ratio test p<0.001.

In the primary complete-case multivariable logistic regression model involving 175 participants, higher GAD-7 scores remained independently associated with high cardiac autonomic symptom burden after adjustment for energy drink consumption, tea intake, age, anemia, sleep deprivation, physical activity, oral contraceptive use, and socioeconomic status. Each one-point increase in GAD-7 score was associated with an 18% increase in the adjusted odds of high symptom burden (aOR 1.18, 95% CI 1.10–1.26; p<0.001). On the fitted multiplicative odds scale, a five-point difference in GAD-7 score corresponded to approximately 2.29-fold adjusted odds of high symptom burden.

Energy drink consumption also showed increasing adjusted odds across the reported exposure categories. Compared with non-consumers, the aOR was 2.62 (95% CI 0.94–7.35; p=0.067) for 1–2 cans/week, 3.09 (95% CI 1.02–9.31; p=0.046) for 3–4 cans/week, and 7.37 (95% CI 1.89–28.82; p=0.004) for ≥5 cans/week. Oral contraceptive use was associated with an aOR of 8.32, although the estimate was imprecise (95% CI 1.17–59.21; p=0.034). Sleep deprivation showed an aOR of 2.02 (95% CI 0.90–4.51; p=0.088), whereas tea intake, anemia, physical activity, age group, and socioeconomic status were not independently associated with the outcome in the primary model. Model discrimination was AUC=0.79 (95% CI 0.71–0.87), with a McFadden pseudo-R^2 of 0.280 and an overall likelihood-ratio test p<0.001 (Table 3).

The sensitivity analysis included 243 participants after physical activity and oral contraceptive use were removed from the adjustment set. The association between anxiety severity and high cardiac autonomic symptom burden remained evident, with an aOR of 1.13 per one-point increase in GAD-7 score (95% CI 1.07–1.19; p<0.001). Compared with non-consumers, energy drink intake of 3–4 cans/week was associated with an aOR of 4.22 (95% CI 1.77–10.06; p=0.001), while intake of ≥5 cans/week was associated with an aOR of 7.25 (95% CI 2.52–20.89; p<0.001). The estimate for 1–2 cans/week was 2.18 (95% CI 0.99–4.81; p=0.053).

In the sensitivity model, self-reported anemia was associated with higher adjusted odds of high symptom burden (aOR 2.25, 95% CI 1.06–4.80; p=0.036), as was sleep deprivation (aOR 2.12, 95% CI 1.12–4.02; p=0.021). Tea intake showed an aOR of 1.47 per category increase (95% CI 0.93–2.33; p=0.097), while age group and socioeconomic status were not associated with the outcome. The sensitivity model had a McFadden pseudo-R^2 of 0.196 and an overall likelihood-ratio test p<0.001 (Table 4).

DISCUSSION

Anxiety severity was independently associated with a high burden of self-reported cardiac autonomic symptoms among female medical students, even after adjustment for energy drink consumption, tea intake, and other measured covariates. The direction of this association was maintained in both the complete-case primary model and the larger sensitivity analysis, although the two models differed in sample size and covariate structure and therefore should not be considered directly interchangeable. These findings suggest that anxiety is an important correlate of perceived cardiac and autonomic symptoms in this population and should be considered when interpreting symptom reports attributed to stimulant consumption.

The observed association is biologically and clinically plausible in the context of existing evidence on caffeine, anxiety, and autonomic arousal. Experimental studies have shown that caffeine can provoke anxiety and panic symptoms, particularly in individuals with panic disorder, with a systematic review and meta-analysis demonstrating markedly greater susceptibility to caffeine-induced panic attacks among affected patients than among healthy controls (3). However, evidence at more moderate doses is less consistent. In a randomized placebo-controlled crossover trial, 150 mg of caffeine did not significantly increase subjective anxiety in participants with panic disorder or healthy controls with low habitual caffeine intake, despite measurable changes in physiological arousal and avoidance behavior (10). This distinction is important because the present study relied on self-reported symptoms rather than objective cardiovascular measurements. The findings therefore support the possibility that anxiety severity and perceived cardiac symptoms may overlap substantially without implying that either anxiety or stimulant intake alone explains the reported symptom burden.

Several mechanisms may contribute to this relationship. Caffeine and other stimulant exposures may enhance sympathetic arousal and increase awareness of palpitations, dizziness, or chest discomfort, particularly in individuals who are already anxiety-prone. Conversely, students experiencing anxiety or academic fatigue may consume caffeinated products for alertness or perceived mood and performance benefits, creating a pattern in which anxiety and stimulant exposure coexist without a clearly identifiable temporal sequence. Previous research among university students has shown that caffeine use may be motivated by alertness, fatigue reduction, and related functional reasons, while patterns of consumption may also coexist with poorer sleep and other behavioural factors (15). A further explanation is heightened interoceptive attention or symptom amplification. Individuals with greater anxiety may be more likely to notice, interpret, and report bodily sensations such as palpitations or dyspnoea, even when the underlying physiological change is modest. Evidence from research on somatic symptom and illness-anxiety conditions supports the role of altered interoceptive processing and symptom-perception bias in the interpretation of bodily sensations (16).

The findings for selected covariates also warrant cautious interpretation. In the primary model, the estimate for oral contraceptive use was large but imprecise, with a very wide confidence interval, indicating substantial statistical uncertainty. Hormonal contraceptive use has been examined in relation to cardiovascular risk and physiological effects in women, but the small number of exposed participants in the present analysis prevents reliable interpretation of this association (11). Anemia and sleep deprivation were not independently associated with the outcome in the smaller complete-case model but were associated with higher adjusted odds of high symptom burden in the sensitivity analysis. Iron-deficiency anemia can produce symptoms such as palpitations, fatigue, and exertional breathlessness through reduced oxygen-carrying capacity and compensatory cardiovascular responses (12). Short sleep duration and sleep deprivation have also been associated with adverse cardiovascular outcomes and alterations in autonomic regulation, including heart-rate variability (13,14). Nevertheless, because the primary and sensitivity models differed in both sample size and covariate adjustment, the change in statistical significance for these variables cannot be attributed solely to increased statistical power.

The pattern observed across energy drink categories also suggests that stimulant exposure remains relevant when anxiety is considered simultaneously. Participants reporting greater energy drink consumption had higher adjusted odds of high symptom burden than non-consumers, with the largest estimates observed in the highest consumption category. However, these findings should not be interpreted as establishing a causal dose-response relationship. Energy drink exposure was measured as self-reported frequency rather than measured caffeine dose, and variation in caffeine content between products may reduce the precision of exposure classification. In addition, tea and other potential caffeine sources were not quantified in milligrams of caffeine, limiting interpretation of total stimulant exposure. The study therefore supports the importance of considering anxiety and stimulant-use patterns together rather than attributing self-reported cardiovascular-type symptoms to a single exposure.

From a clinical and public-health perspective, the findings highlight the need for cautious interpretation of palpitations, dizziness, chest discomfort, and breathlessness reported by young adult students who use caffeinated products. Such symptoms may reflect multiple overlapping influences, including stimulant exposure, anxiety, sleep deprivation, anemia, and heightened symptom perception. Screening instruments such as the GAD-7 may therefore be useful in research settings when investigators are examining self-reported stimulant-related symptoms, provided that the instrument is used as a measure of anxiety severity rather than as a diagnostic test. At the same time, clinically important cardiac symptoms should not be assumed to be anxiety-related solely on the basis of an elevated anxiety score.

Several strengths support the interpretability of this study. Participants were recruited from three medical colleges, anxiety was measured using a validated standardized instrument, and the analysis simultaneously considered stimulant exposure and multiple plausible covariates. The use of both a fully adjusted primary model and a larger sensitivity model also allowed assessment of whether the principal association remained evident under different analytical specifications. In addition, the manuscript distinguishes self-reported symptom burden from a clinical cardiac diagnosis and avoids interpreting the GAD-7 as a diagnostic instrument.

The study also has important limitations. Its cross-sectional design prevents determination of temporal sequence or causal direction between anxiety, stimulant use, and perceived cardiac autonomic symptoms. Anxiety was assessed over the preceding two weeks, whereas cardiac and autonomic symptoms were recalled over the

preceding 30 days, resulting in only partial overlap between the measurement periods. Both anxiety and the primary outcome were assessed through self-report, creating the possibility of shared-method variance, whereby participants with a greater tendency to endorse symptoms on one measure may also report more symptoms on another (17). The cardiac autonomic symptom outcome was based on a researcher-defined composite of four symptoms and was not a validated diagnostic or symptom-burden instrument, which may have introduced outcome misclassification. The primary complete-case regression included only 175 of the 274 enrolled participants because of missing covariate data, particularly for physical activity, and the possibility of bias from non-random missingness cannot be excluded. The larger sensitivity analysis reduced case loss but also changed the adjustment set, limiting direct comparison of coefficients between the two models.

The multivariable analysis was additionally constrained by the number of outcome events relative to the number of estimated parameters, which contributed to imprecision in several adjusted estimates. The oral contraceptive estimate was particularly unstable and should not be interpreted as evidence of a reliable independent association. The overall response rate of 54.4% also raises the possibility of non-response bias if students who participated differed systematically from those who declined or did not complete the questionnaire. Finally, the sample was restricted to female medical students from three colleges in a single district of Pakistan, limiting generalizability to male students, non-medical students, other age groups, and populations in different geographical or educational settings. Future observational research in comparable populations should therefore use prospective exposure assessment, more precise quantification of total caffeine intake, validated symptom instruments where available, and analytical strategies designed to minimize bias from missing data and sparse events.

CONCLUSION

Anxiety severity was independently associated with a higher burden of self-reported cardiac autonomic symptoms among female medical students after adjustment for energy drink consumption, tea intake, and other measured covariates, and the association remained evident in the larger sensitivity analysis. These findings indicate that anxiety is an important correlate of perceived cardiac and autonomic symptoms in this population and should be considered when interpreting symptom reports in studies of stimulant consumption. Because of the cross-sectional design, self-reported measurements, and limitations related to missing data and outcome measurement, the findings do not establish the direction or cause of the observed association.

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