Libyan Med J. 2026;18(8):455-459
https://doi.org/10.69667/lmj.26801

Libyan Medical Journal

https://lmj.ly/index.php/ojs/index eISSN: 3107-0426

Original article

The Relationship between Academic Stress and Selected Physiological Parameters among Undergraduate Medical Students at Tobruk Medical University, Libya

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Keywords:
Academic Stress, Blood Pressure, Heart Rate, Respiratory Rate, Body Mass Index, University Students.

ABSTRACT

Academic stress is common among university students and is theorised, through activation of the sympathetic nervous system and the hypothalamic–pituitary–adrenal (HPA) axis, to influence cardiovascular and metabolic parameters [1–3]. To examine the relationship between self-reported academic stress and heart rate, respiratory rate, blood pressure, and body mass index (BMI) among university students. A cross-sectional study was conducted in 121 university students. Academic stress was scored on a continuous scale and additionally categorised into low, moderate, and high stress groups. Heart rate, respiratory rate, blood pressure, and BMI were recorded for each participant. The Shapiro–Wilk test was used to assess normality of distribution; as all variables deviated significantly from normality, Spearman's rank correlation and the Kruskal–Wallis H test were used, with Mann–Whitney U post-hoc comparisons (Bonferroni-corrected) where indicated. Academic stress score correlated significantly and negatively with both blood pressure readings ($\rho = -0.568$ and -0.474, both $p < 0.001$), and the high-stress group had significantly lower blood pressure than the low- and moderate-stress groups (all $p < 0.001$, Bonferroni-corrected). No significant associations were found between academic stress and heart rate, respiratory rate, or BMI (all $p > 0.05$). In this sample, higher self-reported academic stress was associated with lower rather than higher blood pressure, while heart rate, respiratory rate, and BMI showed no significant relationship with stress level. These findings, which run counter to the classical acute sympathetic stress response, are discussed in relation to the chronic and self-reported nature of the stress measure used and the cross-sectional design of the study.

Introduction

Stress is classically defined as a non-specific physiological response of the body to any demand placed upon it, first characterised by Selye as the "general adaptation syndrome" comprising alarm, resistance, and exhaustion phases [1,2]. Psychological models subsequently reframed stress as a transaction between the individual and the environment, in which a stressor is appraised as threatening or demanding relative to the person's coping resources [3]. Within this framework, the Perceived Stress Scale developed by Cohen et al. remains one of the most widely used instruments for quantifying subjectively experienced stress, and has been validated across numerous populations, including Arabic-speaking samples [4–6]. University students represent a population at particularly high risk of academic stress, arising from examinations, workload, and performance pressure.

Cross-sectional surveys report that a large proportion of students, and especially those in health-related faculties, experience moderate-to-severe academic stress at some point during their studies [7]. The relationship between such stress and academic performance itself has been the subject of systematic review and meta-analysis, with generally negative, if heterogeneous, associations reported between stress or anxiety and measures of academic achievement [8,9]. Physiologically, acute psychological stress is understood to activate the sympatho-adrenal-medullary axis, producing transient increases in heart rate and blood pressure through catecholamine release [10]. Several studies in student populations support this pattern, showing that anxiety and work-related stress are associated with elevated blood pressure and hypertension risk in young adults [11,12], in line with contemporary blood pressure classification guidelines [13]. However, other real-life, ambulatory studies of examination stress have reported more complex or even paradoxical findings: for example, Koudela-Hamila et al. found that ambulatory systolic blood pressure was, if anything, lower during the examination period than at baseline, despite clear increases in subjective stress and cortisol reactivity [14]. Similarly, studies of heart rate variability (HRV) during university examinations have shown that autonomic markers of stress do not always align neatly with self-reported stress or with simple heart rate elevation, and that findings vary with the timing of measurement relative to the stressor, sex, and habituation to repeated examinations [15–23].

Anxiety and mental stress have also been shown experimentally to alter breathing: individual anxiety level is associated with increased respiratory frequency and minute ventilation independent of metabolic rate, suggesting a direct link between psychological arousal and respiratory rate [25]. Chronic activation of the HPA axis has also been linked to metabolic

Received: *07-06-2026 -* ***Accepted:*** *04-08-2026 -* ***Published:*** *11-08-2026*

changes, including a tendency toward increased adiposity and higher body mass index (BMI), through cortisol-mediated effects on appetite and fat distribution [26]. Meta-analytic evidence indicates that perceived stress is associated with visceral obesity, dyslipidaemia, elevated blood pressure, and metabolic syndrome more broadly [27,28], although effect sizes are heterogeneous and some individual studies, including in student samples, have failed to find a significant stress–adiposity association [30].

BMI itself is conventionally classified using World Health Organization thresholds [29]. In addition, stress has been associated with poorer sleep quality in student populations, which may represent an intermediate pathway linking psychological stress to physiological dysregulation [31]. Given the mixed and sometimes counterintuitive findings in the literature regarding the direction of the stress–physiology relationship in student samples, the present study aimed to examine, in a sample of university students, the association between a self-reported academic stress score (treated both continuously and as low/moderate/high categories) and four physiological parameters: heart rate, respiratory rate, blood pressure, and BMI.

Methods

Design and participants

A cross-sectional study was conducted among 121 university students. Academic stress was quantified using a stress score (range 8–40) and additionally categorised a priori into three groups: low (8–18), moderate (19–29), and high (30–40) stress. Outcome variables were heart rate (beats per minute), respiratory rate (breaths per minute), diastolic and systolic blood pressure (mmHg, recorded as two separate readings per participant using standard sphygmomanometry), and BMI (kg/m^2), calculated from measured height and weight. BMI data were missing or not reliably interpretable for 2 of the 121 participants; these two cases were excluded on a pairwise basis from BMI-specific analyses only, yielding an effective sample of n = 119 for BMI, while all other variables retained the full sample of N = 121 (Table 1).

Statistical analysis

The normality of distribution of all continuous variables was assessed using the Shapiro–Wilk test [33]; all variables deviated significantly from a normal distribution ($p < 0.05$), and non-parametric methods were therefore used throughout. Spearman's rank correlation coefficient (ρ) was used to examine the association between the continuous academic stress score and each physiological variable. The Kruskal–Wallis H test [35] was used to compare outcomes across the three a priori stress groups. Where the Kruskal–Walli's test indicated a statistically significant overall difference, pairwise post-hoc comparisons were performed using the Mann–Whitney U test [34] with Bonferroni correction for multiple comparisons (adjusted $\alpha = 0.05/3 = 0.017$). A p-value < 0.05 was considered statistically significant for all other tests. All analyses were two-tailed. Blood pressure, heart rate, and respiratory rate were recorded following standard clinical procedure; international recommendations for standardised blood pressure measurement, including cuff selection, resting time, and observer technique, have been described in detail elsewhere [32].

Results

Of the 121 participants, 33 (27.3%) were classified as having low academic stress, 39 (32.2%) moderate stress, and 49 (40.5%) high stress. Descriptive statistics (mean ± SD) for all variables across the three stress groups are presented in Table 1.

Table 1. Descriptive statistics (mean ± SD) by academic stress level

Variable	Low stress (n = 33)	Moderate stress (n = 39)	High stress (n = 49)	Overall (N = 121)
Academic stress score	13.09 ± 1.77	25.36 ± 2.51	37.24 ± 3.34	26.83 ± 10.21
Heart rate (bpm)	75.15 ± 8.19	75.46 ± 9.41	73.51 ± 8.69	74.59 ± 8.77
Respiratory rate (breaths/min)	15.58 ± 2.22	16.03 ± 1.83	15.35 ± 1.75	15.63 ± 1.92
Diastolic blood pressure (mmHg)	75.15 ± 8.34	73.03 ± 7.33	63.86 ± 8.53	69.89 ± 9.50
Systolic blood pressure (mmHg)	113.64 ± 6.99	117.41 ± 9.22	104.43 ± 10.13	111.12 ± 10.67
BMI (kg/m^2)	21.88 ± 2.30 (n=33)	22.69 ± 3.12 (n=37)	22.51 ± 3.23 (n=49)	22.39 ± 2.96 (n=119)

BMI was missing or not reliably interpretable for 2 of 121 participants and was excluded on a pairwise basis; n = 119 for this variable only.

Correlation and group-comparison analyses are summarised in (Table 2). Academic stress score showed no statistically significant correlation with heart rate (ρ = −0.094, p = 0.303), respiratory rate (ρ = 0.002, p = 0.979), or BMI (ρ = 0.110, p = 0.235), and the Kruskal–Wallis test likewise showed no significant differences in these variables across the low, moderate, and high stress groups (all p > 0.05). In contrast, academic stress score was significantly negatively correlated with both

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diastolic blood pressure (ρ = −0.568, $p < 0.001$) and systolic blood pressure (ρ = −0.474, $p < 0.001$). The Kruskal–Wallis test confirmed significant differences across the three stress groups for both diastolic ($H = 38.51$, $p < 0.001$) and systolic blood pressure ($H = 38.53$, $p < 0.001$), with the high-stress group showing the lowest mean diastolic and systolic readings (Table 1). Diastolic values (overall mean 69.89 ± 9.50 mmHg) and systolic values (overall mean 111.12 ± 10.67 mmHg) both fell within physiologically plausible, low-to-mid-normal ranges for healthy young adults.

Table 2. Spearman correlation and Kruskal–Wallis test results

Variable	Spearman ρ (stress score)	p-value (correlation)	Kruskal–Wallis H (3 groups)	p-value (KW)
Heart rate	−0.094	0.303	1.164	0.559
Respiratory rate	0.002	0.979	4.382	0.112
Diastolic blood pressure	−0.568	< 0.001*	38.505	< 0.001*
Systolic blood pressure	−0.474	< 0.001*	38.526	< 0.001*
BMI	0.110	0.235	0.860	0.651

Post-hoc pairwise comparisons for the two blood pressure variables (Table 3) showed that the high-stress group differed significantly from both the low-stress and moderate-stress groups (all $p < 0.001$, Bonferroni-adjusted). No significant difference was found between the low- and moderate-stress groups for either blood pressure value after correction for multiple comparisons.

Table 3. Post-hoc pairwise comparisons (Mann–Whitney U, Bonferroni-corrected) for blood pressure

Pairwise comparison	Mann–Whitney p (Diastolic BP)	Mann–Whitney p (Systolic BP)	Bonferroni-adjusted α
Low vs Moderate	0.775 (ns)	0.068 (ns)	0.017
Low vs High	< 0.001*	< 0.001*	0.017
Moderate vs High	< 0.001*	< 0.001*	0.017

** Statistically significant at p < 0.05. ns = not significant*

Discussion

This study examined the association between academic stress and four physiological parameters in a sample of university students. Contrary to the classical model in which acute psychological stress activates the sympatho-adrenal-medullary axis and raises heart rate and blood pressure [10–12], the present data showed that higher academic stress was associated with significantly lower, not higher, blood pressure readings, while heart rate, respiratory rate, and BMI showed no significant relationship with stress level. This pattern is not without precedent. Koudela-Hamila et al., using ambulatory monitoring across an entire examination period, similarly reported that systolic blood pressure was lower during examinations than at a non-stressful baseline, despite clear increases in subjective stress, task-related demand, and cortisol reactivity at awakening [14]. The authors suggested that anticipatory withdrawal and altered daily activity patterns during examination periods — for example, reduced physical activity, altered social contact, and changes in posture or time spent studying while seated — may attenuate or reverse the expected sympathetic pressor response measured under real-life, ambulatory conditions, as opposed to acute laboratory stressors.

Similarly, heart rate variability studies of examination stress have shown that autonomic responses to real-life academic stressors are heterogeneous and depend strongly on the timing of measurement relative to the stressor, habituation across repeated examinations, and individual differences in coping and self-assessed stress [15–23]. It is plausible that the cross-sectional, single time-point measurement design used here similarly failed to capture the acute pressor response that has been more consistently observed under controlled laboratory stress-induction paradigms such as the Trier Social Stress Test [10,17]. The absence of a significant association between academic stress and heart rate or respiratory rate is consistent with several studies noting that self-reported or trait-level stress measures do not always track short-term autonomic indices closely, particularly outside of the acute stress window itself [18–22]. It is also possible that the present stress score, reflecting a relatively stable or chronic appraisal of academic demand rather than an acute, time-locked stressor, is mechanistically more comparable to measures of chronic strain than to the acute stressors typically used to elicit sympathetic activation in laboratory studies.

It is also plausible that the present findings partly reflect the chronic, rather than acute, nature of the stress measure used. Chronic examination-related stress has been shown to blunt, rather than exaggerate, hypothalamic–pituitary–adrenal reactivity, as reflected in an attenuated cortisol awakening response among students undergoing sustained academic stress [24]. If a comparable blunting extends to cardiovascular and respiratory reactivity under chronic self-reported stress, this could help explain why the present sample showed no elevation — and, for blood pressure, a significant reduction — in physiological arousal with increasing stress, in contrast to the acute pressor and respiratory responses more consistently observed with laboratory-induced anxiety [25]. The lack of association between academic stress and BMI contrasts with

***Received**: 07-06-2026 - **Accepted**: 04-08-2026 - **Published**: 11-08-2026*

theoretical models linking chronic HPA-axis activation to increased adiposity via cortisol-mediated appetite and fat-distribution changes [26], and with meta-analytic evidence linking perceived stress to visceral obesity and metabolic syndrome more broadly [27,28]. However, such effects are generally described as emerging over a longer time-course than is likely to be captured in a single cross-sectional assessment, and BMI is influenced by numerous additional factors, including diet, physical activity, and genetic predisposition, that were not controlled for in this study.
Notably, this null finding is not without precedent: at least one study in college students similarly found no significant relationship between perceived stress and adiposity [30], underscoring the heterogeneity of this association across study populations and designs. This study has several limitations. First, its cross-sectional design precludes any causal interpretation of the observed associations. Second, blood pressure, heart rate, and respiratory rate were recorded at a single time point, without standardisation of factors such as time of day, recent physical activity, caffeine intake, or measurement posture, all of which are known to influence these parameters despite established recommendations for standardised measurement [32]. Third, academic stress was assessed using a single composite score rather than a validated multi-item instrument such as the Perceived Stress Scale [4–6], which may have introduced measurement imprecision. Fourth, the unequal and modest group sizes (33–49 per stress category) limit statistical power for detecting smaller effects, particularly for heart rate, respiratory rate, and BMI. Finally, potential confounders such as sex, sleep quality [31], physical activity level [8], and use of stimulants were not accounted for in the analysis. Future research would benefit from longitudinal or ambulatory designs that track physiological parameters across the academic cycle, incorporation of validated stress instruments and biomarkers such as salivary cortisol, and statistical adjustment for known confounders of cardiovascular and respiratory measurement.

Conclusion

In this cross-sectional sample of university students, academic stress was significantly and inversely associated with blood pressure, while no significant relationship was observed with heart rate, respiratory rate, or BMI. These findings diverge from the classical expectation of stress-induced sympathetic activation and instead echo other real-life, non-laboratory studies of examination stress that have reported similarly counterintuitive blood pressure patterns. Longitudinal studies incorporating validated stress instruments, ambulatory physiological monitoring, and biochemical stress markers are needed to clarify the mechanisms underlying this relationship.

Conflict of interest. Nil

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***Received**: 07-06-2026 - **Accepted**: 04-08-2026 - **Published**: 11-08-2026*

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https://doi.org/10.69667/lmj.26801

Libyan Medical Journal

https://lmj.ly/index.php/ojs/index eISSN: 3107-0426

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***Received**: 07-06-2026 - **Accepted**: 04-08-2026 - **Published**: 11-08-2026*