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Original Research Article

# Academic Stress and Its Association with Heart Rate Variability: A Study Among Medical Students

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**Abstract:**

**Introduction:** Stressors associated with academic overload, time pressure, competency, professionalism, and physical, mental, and emotional problems may be the cause of medical students' elevated stress levels. In order to reconcile the subjective and objective assessments of stress scores among medical students, this study sought to determine the subjective assessment of stress, stressors, and objective assessment of stress using heart rate variability (HRV).

**Materials and Methods:** A total of 100 participants were selected for the study. A validated Medical Student Stress Questionnaire (MSSQ) was used to measure academic stress. Students were divided into low, moderate, and high stress groups based on their overall stress level. A digital HRV analyser was used to monitor heart rate variability under standardised settings.

**Results:** The severity of stress categorized as low, moderate, and high were 20%, 48%, 32% respectively. HRV is measured by time domain, standard deviation of normal-to-normal RR intervals, root mean square of successive differences, and "frequency domain parameters," i.e., low frequency (LF), high-frequency (HF), and LF/HF ratio. The LF/HF ratio was found more in high stress individuals.

**Conclusion:** HRV and stress score were found to be positively correlated in the current study. Measurable academic stress was experienced by about 32% of medical students. The stress score showed a favourable correlation with both time domain and frequency domain characteristics.

**Keywords:** Academic, Heart Rate Variability, Medical Student Stress Questionnaire, Heart Rate, Stress.



## Introduction

Due to its intrinsic demands, medical school is often linked to high levels of academic stress [1]. Both physical and mental health can be negatively impacted by ongoing stress, especially if the autonomic nervous system is dysregulated [2]. A non-invasive indicator of autonomic function, heart rate variability (HRV) shows how sympathetic and parasympathetic activity are balanced. Chronic stress, cardiovascular risk, and poor psychological well-being have all been associated with lower HRV [3]. Identifying early physiological indicators of stress and directing therapies may be made easier with an understanding of the connection between academic stress and HRV in medical students [4]. The purpose of this study was to evaluate the relationship between medical students' academic stress levels and HRV metrics.

## Methods

**Study Duration:** The study was conducted over a period of 11 months.

**Participants:** A total of 100 participates were selected for this study.

**Study type:** This cross-sectional observational study was carried out in a Nalanda medical college and hospital, Patna, Bihar.

After gaining informed consent, 100 undergraduate medical students between the ages of 18 and 25 were enlisted. Students who had a history of smoking, diabetes, hypertension, mental illness, cardiovascular disease, or drugs that affected autonomic function were not allowed to enrol.

A validated Medical Student Stress Questionnaire (MSSQ) was used to measure academic stress.

Students were divided into low, moderate, and high stress groups based on their overall stress level.

A digital HRV analyser was used to monitor heart rate variability under standardised settings. After getting enough sleep, supine ECG recordings were taken for five minutes. Standard procedures were followed in the analysis of time-domain data (mean RR interval, SDNN, RMSSD) and frequency-domain parameters (LF, HF, LF/HF ratio).

Pearson's correlation coefficient was used in statistical research to evaluate the association between HRV characteristics and academic stress levels. HRV was compared among stress groups using a one-way ANOVA. p-values less than 0.05 were regarded as statistically significant.

**Results**

The majority of the 100 students reported moderate to high levels of academic stress as shown in table 1. Parasympathetic HRV indices were considerably lower among students who scored higher on stress.

**Table 1: Distribution of Medical Students According to Academic Stress Level (n = 100)**

| Stress level (MSSQ score) | Number (n) | Percentage (%) |
|---|---|---|
| Low stress | 20 | 20 |
| Moderate stress | 48 | 48 |
| High stress | 32 | 32 |
| Total | 100 | 100 |

The mean HR was calculated in all the three groups and the LF/HF ratio was calculated in moderate to high stress individuals. The LF/HF ratio was found more in high stress compared to low stress individuals as shown in table 2.

**Table 2. Comparison of Heart Rate Variability Parameters Across Stress Levels (Mean ± SD)**

| HRV parameter | Low stress (n=20) | Moderate stress (n=48) | High stress (n=32) | p-value |
|---|---|---|---|---|
| Mean HR (beats/min) | 64.8 ± 4.2 | 70.2 ± 5.1 | 74.9 ± 6.4 | <0.001 |
| Mean RR (ms) | 860 ± 68 | 820 ± 60 | 740 ± 62 | <0.001 |
| SDNN (ms) | 50.6 ± 10.2 | 42.6 ± 8.6 | 38.2 ± 8.2 | <0.001 |
| RMSSD (ms) | 42.4 ± 8.2 | 36.5 ± 8.4 | 32.4 ± 7.3 | <0.001 |
| LF ($ms^2$) | 500 ± 25 | 530 ± 30 | 490 ± 20 | 0.002 |
| HF ($ms^2$) | 600 ± 30 | 470 ± 20 | 390 ± 10 | <0.001 |
| LF/HF ratio | 0.83 ± 0.24 | 1.12 ± 0.36 | 1.25 ± 0.42 | <0.001 |

Statistical test: One-way ANOVA

$p < 0.05$ considered statistically significant

Academic stress ratings and time-domain HRV indicators like SDNN and RMSSD showed a substantial negative association, according to Pearson correlation analysis. As stress levels increased, frequency-domain analysis revealed a significant decrease in HF power and an increase in LF/HF ratio, suggesting sympathetic predominance. The SDNN and RMSSD values of the high-stress group were considerably lower than those of the low-stress group ($p < 0.001$). The high-stress group had a higher mean heart rate.

**Table 3: Correlation Between Academic Stress Scores and HRV Parameters**

| HRV parameter | Pearson correlation coefficient (r) | p-value |
|---|---|---|
| Mean heart rate | +0.42 | <0.001 |
| SDNN | −0.54 | <0.001 |
| RMSSD | −0.52 | <0.001 |
| HF power | −0.42 | <0.001 |
| LF power | +0.35 | <0.001 |
| LF/HF ratio | +0.56 | <0.001 |

**Discussion**

The current study shows a strong correlation between medical students impaired autonomic function and academic stress. Decreased parasympathetic activity and relative sympathetic dominance are suggested by lower HRV measures in students who experience high levels of academic stress [5]. These results are consistent with earlier research on autonomic imbalance in young adults caused by stress.

Sustained sympathetic activation brought on by ongoing academic stress may eventually raise cardiovascular risk [6]. This theory is supported by the reported rise in the LF/HF ratio among students

who are under a lot of stress. An objective method for identifying pupils who may be at risk for health problems connected to stress is HRV evaluation. Longitudinal studies are required to evaluate long-term autonomic alterations, and the cross-sectional approach restricts causal inference [7]. However, the results emphasise the value of stress-reduction techniques like mindfulness, exercise, and therapy in medical education [8]. Academic stress scores showed a significant negative correlation with parasympathetic HRV indices such as SDNN ($r = -0.54$) and RMSSD ($r = -0.52$), while LF/HF ratio demonstrated a strong positive correlation ($r = 0.56$), indicating sympathetic predominance with increasing stress.

## Conclusion

Medical students who experience academic stress had much lower heart rate variability, which is indicative of an autonomic imbalance with a sympathetic predominance. In this susceptible group, routine stress assessment and the application of preventive measures may assist enhance mental health and cardiovascular health.

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