

PHYSIOLOGICAL STRESS IN ORAL VS WRITTEN EXAMINATIONS: HEART RATE VARIABILITY IN FIRST-YEAR MBBS STUDENTS

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ABSTRACT

Background: Medical examinations are potent academic stressors capable of eliciting significant autonomic nervous system responses. While written examinations primarily impose cognitive load, oral examinations (viva voce) introduce a social-evaluative component that may amplify physiological stress. This study aimed to compare autonomic stress responses during oral and written examinations in first-year MBBS students using heart rate variability (HRV) indices. **Materials and Methods:** A randomized crossover observational study was conducted among 60 healthy first-year MBBS students in a tertiary care medical college. Each participant underwent both oral and written examinations on separate days. Heart rate (HR) and HRV parameters, specifically the root mean square of successive differences (RMSSD), were continuously recorded using a wearable photoplethysmography-based device during three phases: baseline (pre-examination), examination, and recovery (post-examination). Data were analyzed using paired t-tests and repeated-measures ANOVA, with statistical significance set at $p < 0.05$. **Results:** Both examination formats produced significant autonomic alterations compared to baseline. Oral examinations were associated with higher mean heart rate and significantly lower RMSSD values compared to written examinations ($p < 0.001$). Recovery of autonomic parameters was incomplete within 10 minutes post-examination, with greater persistence of autonomic arousal observed following oral examinations. **Conclusion:** Oral examinations induce significantly greater autonomic stress than written examinations in first-year medical students, as evidenced by heightened sympathetic activation and reduced parasympathetic modulation. These findings highlight the substantial physiological burden associated with socially evaluative assessment formats.

INTRODUCTION

The pursuit of a medical degree is widely regarded as one of the most academically demanding forms of professional education. Undergraduate medical training involves an extensive curriculum, frequent high-stakes assessments, and sustained cognitive demands, particularly during the preclinical years. For first-year Bachelor of Medicine, Bachelor of Surgery (MBBS) students, the transition into medical college represents a critical period characterized by heightened academic pressure and increased psychological vulnerability. During this phase, examinations function not only as evaluative tools but also as potent psychosocial stressors capable of eliciting measurable physiological responses.^[1]

Examination-related stress is primarily mediated through activation of the autonomic nervous system (ANS), which plays a central role in cardiovascular and metabolic regulation. In response to perceived threat or challenge, the sympathetic branch of the ANS is rapidly activated via the sympatho-adreno-medullary axis, resulting in increased heart rate, elevated blood pressure, and heightened arousal.^[2] Simultaneously, parasympathetic activity—predominantly mediated by the vagus nerve—is withdrawn, a phenomenon known as vagal withdrawal.^[3] While this autonomic shift facilitates short-term adaptive responses, excessive or prolonged activation may adversely affect cognitive performance and physiological recovery.^[4] Written examinations are commonly associated with stress arising from cognitive load, time constraints,

and performance expectations. Previous studies have demonstrated significant increases in heart rate, reductions in heart rate variability (HRV), and elevations in stress hormone levels during written academic assessments.^[5-7] Oral examinations (viva voce), however, introduce additional stressors that extend beyond cognitive demand. The viva voce is a face-to-face evaluation requiring immediate verbal recall in the presence of examiners, incorporating elements of social judgment, unpredictability, and perceived loss of control, which collectively intensify the stress response.^[8]

The concept of social-evaluative threat refers to situations in which an individual's performance is directly judged by others and has potential implications for self-esteem and social standing.^[9] Experimental evidence indicates that socially evaluative contexts elicit disproportionately stronger physiological stress responses compared with non-social cognitive tasks.^[10] These responses are characterized by pronounced sympathetic activation and suppression of parasympathetic modulation, mediated through interactions between limbic structures, the hypothalamic-pituitary-adrenal axis, and the ANS.^[11]

Heart rate variability has emerged as a reliable, non-invasive marker for assessing autonomic regulation under stress. HRV reflects beat-to-beat fluctuations in cardiac cycle length and represents the dynamic balance between sympathetic and parasympathetic influences on the sinoatrial node.^[12] Reduced HRV is consistently associated with psychological stress, anxiety, and impaired self-regulatory capacity.^[13] Among time-domain indices, the root mean square of successive differences (RMSSD) is widely accepted as a surrogate marker of cardiac vagal tone and short-term parasympathetic activity.^[14]

Despite the importance of both oral and written examinations in medical education, few studies have directly compared their real-time physiological impact within the same cohort. Most existing literature relies on subjective questionnaires or intermittent biochemical markers, which lack temporal resolution. Continuous HRV monitoring using wearable technology offers an objective approach to capturing examination-related autonomic fluctuations.

The present study therefore aimed to compare autonomic stress responses during oral and written examinations in first-year MBBS students using HRV indices, with the hypothesis that viva voce examinations would elicit greater sympathetic activation and parasympathetic withdrawal than written examinations.

MATERIALS AND METHODS

Study Design and Setting

A randomized crossover observational study was conducted in the Department of Physiology at a tertiary care medical college in India. A crossover

design was used to minimize inter-individual variability in autonomic responses by allowing each participant to serve as their own control. Ethical approval was obtained from the Institutional Ethics Committee, and written informed consent was secured from all participants.

Participants

Sixty healthy first-year MBBS students of both sexes, aged 18–19 years, were enrolled during routine internal assessment examinations. Inclusion criteria included enrollment as a first-year MBBS student and willingness to participate. Students with a history of cardiovascular, respiratory, metabolic, or psychiatric disorders, those on medications affecting autonomic function, habitual smokers or alcohol users, and those with recent acute illness were excluded. Participants were advised to avoid caffeine, strenuous exercise, and sleep deprivation for 24 hours prior to each recording session.

Study Protocol and Randomization

Participants were randomly allocated into two groups using a computer-generated sequence to counterbalance examination order. Group A underwent the written examination on Day 1 followed by the oral examination on Day 2, while Group B underwent the oral examination on Day 1 followed by the written examination on Day 2. A minimum washout period of 48 hours was maintained between examination sessions.

Data Collection

Physiological recordings were obtained during three phases on each examination day: a 10-minute baseline phase prior to the examination, a 30-minute examination phase, and a 10-minute recovery phase following completion of the examination. Written examinations consisted of structured essay and multiple-choice questions conducted in a standard examination hall, while oral examinations were conducted face-to-face by two faculty examiners.

Heart rate and inter-beat interval data were recorded continuously using a wearable photoplethysmography-based device. Heart rate and the root mean square of successive differences (RMSSD) were analyzed, with RMSSD serving as an index of cardiac parasympathetic activity. Inter-beat interval data were inspected for artifacts and corrected prior to analysis. Parameters were calculated separately for baseline, examination, and recovery phases.

Statistical Analysis

Data were analyzed using SPSS version 26.0. Results are presented as mean \pm standard deviation. Repeated-measures analysis of variance was used to assess changes across phases within each examination format, and paired t-tests were used for comparisons between oral and written examinations. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 60 first-year MBBS students (32 females and 28 males) completed both arms of the crossover study. The mean age of the participants was 18.2 ± 0.8 years. All recordings were of acceptable quality for HRV analysis, and no adverse events were reported during the study period.

Baseline heart rate values recorded prior to the written and oral examinations did not differ significantly, indicating comparable resting autonomic states on both assessment days ($p > 0.05$).

During the examination phase, both written and oral examinations produced a significant increase in heart rate compared to baseline ($p < 0.001$). However, the magnitude of tachycardia was significantly greater during the oral examination. Mean heart rate during the viva voce was markedly higher than during the written examination ($p < 0.001$).

In the recovery phase, heart rate values declined relative to examination levels but remained significantly elevated compared to baseline for both examination formats. The persistence of elevated heart rate was more pronounced following the oral examination.

Table 1: Comparison of Mean Heart Rate (bpm) across Study Phases

Phase	Written Exam (Mean \pm SD)	Oral Exam (Mean \pm SD)	p-value (Written vs Oral)
Baseline	78.4 ± 8.2	79.1 ± 9.5	> 0.05 (NS)
Examination	92.5 ± 10.1	112.3 ± 14.6	$< 0.001^*$
Recovery	84.2 ± 9.3	96.8 ± 11.2	$< 0.01^*$

Baseline RMSSD values were comparable prior to written and oral examinations ($p > 0.05$), indicating similar resting parasympathetic activity.

A significant reduction in RMSSD was observed during both examination formats compared to baseline ($p < 0.001$). The reduction in RMSSD during the oral examination was significantly greater than that observed during the written examination ($p <$

0.001), reflecting a more pronounced withdrawal of parasympathetic modulation.

During the recovery phase, RMSSD values demonstrated partial restoration but did not return to baseline levels within the 10-minute post-examination period. Recovery of RMSSD was slower and less complete following the oral examination compared to the written examination.

Table 2: Comparison of RMSSD (ms) across Study Phases

Phase	Written Exam (Mean \pm SD)	Oral Exam (Mean \pm SD)	p-value (Written vs Oral)
Baseline	42.5 ± 12.4	41.8 ± 13.1	> 0.05 (NS)
Examination	31.2 ± 10.5	18.4 ± 8.2	$< 0.001^*$
Recovery	36.5 ± 11.2	28.6 ± 9.4	$< 0.05^*$

To assess the relative magnitude of autonomic stress, percentage changes from baseline were calculated for both examination formats. Oral examinations were associated with a substantially greater physiological stress response compared to written examinations.

Heart Rate: Mean heart rate increased by approximately 18% during written examinations and 42% during oral examinations.

RMSSD: Mean RMSSD decreased by approximately 26% during written examinations and 56% during oral examinations.

These findings demonstrate that oral examinations elicit a significantly greater shift toward sympathetic dominance than written examinations.

DISCUSSION

The present study demonstrates that oral examinations (viva voce) evoke significantly greater autonomic stress responses than written examinations among first-year MBBS students. This response was characterized by a marked increase in heart rate and a substantial reduction in heart rate variability, particularly RMSSD, reflecting pronounced parasympathetic withdrawal and sympathetic predominance. These findings provide objective physiological evidence that the format of

assessment substantially influences the magnitude of stress experienced by medical students.

Physiological regulation of cardiovascular function depends on a dynamic balance between sympathetic excitation and parasympathetic inhibition. Under resting conditions, vagal modulation predominates, stabilizing heart rate variability. Acute psychological stress disrupts this balance through activation of the sympatho-adreno-medullary axis and concurrent suppression of vagal outflow, resulting in tachycardia and reduced HRV.^[15] In the present study, both written and oral examinations elicited significant autonomic alterations compared with baseline, confirming that academic assessments function as genuine physiological stressors. However, the magnitude of autonomic disruption was considerably greater during viva voce examinations.

The pronounced reduction in RMSSD during oral examinations suggests near-complete withdrawal of cardiac vagal control, a response more typical of acute threat perception than routine cognitive effort. This differential response is most plausibly explained by the concept of social-evaluative threat. Viva voce examinations inherently involve real-time judgment by authoritative examiners, limited predictability, and reduced perceived control, all of which amplify stress responses. In contrast, written examinations

allow greater autonomy over pacing and minimize direct social scrutiny.^[16,17]

These findings align with experimental models such as the Trier Social Stress Test, which consistently demonstrate stronger autonomic and neuroendocrine activation during socially evaluative tasks compared with non-social cognitive challenges. The present results extend this evidence to authentic academic settings, highlighting that the evaluative context itself, rather than cognitive demand alone, is a key determinant of physiological stress.

Excessive sympathetic activation has important implications for cognitive performance. Acute stress is known to impair prefrontal cortical functioning through catecholaminergic mechanisms, adversely affecting working memory, attention, and executive control. While moderate arousal may enhance performance, excessive autonomic activation may push individuals beyond the optimal zone described by the Yerkes–Dodson law, resulting in retrieval failure despite adequate knowledge. Consequently, oral examinations may inadvertently assess stress tolerance rather than true academic competence, introducing construct-irrelevant variance into assessment outcomes.^[18]

The present findings are consistent with previous studies reporting significant academic stress and altered autonomic parameters among medical students. Saboo N et al,^[19] observed that over three-quarters of first-year medical students experienced measurable academic stress, with significant associations between stress scores and both time- and frequency-domain HRV indices. Similarly, Kaur R et al,^[20] reported significant stress-induced alterations in cardiovascular and respiratory parameters among undergraduate medical students, further supporting the physiological impact of academic stress.

An additional observation in this study was the incomplete recovery of autonomic parameters within 10 minutes following examinations, particularly after viva voce. Persistent elevation of heart rate and sustained suppression of RMSSD indicate delayed parasympathetic reactivation, which has been associated with cumulative stress burden and reduced stress resilience. This raises concerns regarding tightly scheduled assessment formats that allow insufficient recovery between evaluative components.

The physiological burden associated with oral examinations has important implications for assessment design in medical education. While viva voce remains valuable for evaluating communication skills and depth of understanding, unstructured or high-stakes oral assessments may exaggerate stress responses and compromise validity. Structured oral examination formats, repeated low-stakes exposure, peer-assisted learning environments, and incorporation of stress-mitigation strategies may help attenuate excessive autonomic activation while preserving the educational value of oral assessments.

Limitations

Several limitations of this study should be acknowledged. Heart rate variability was assessed using a wearable photoplethysmography-based device rather than electrocardiography; although acceptable agreement exists for time-domain indices such as RMSSD under low-movement conditions, stress-related changes in pulse transit time may influence absolute values. The single-center design and modest sample size may limit generalizability, and inclusion was restricted to first-year MBBS students, whose stress responses may differ from senior cohorts. Biochemical stress markers and psychological variables such as trait anxiety and coping strategies were not assessed and may have contributed to inter-individual variability.

CONCLUSION

The present study demonstrates that oral examinations induce significantly greater physiological stress than written examinations in first-year MBBS students. This heightened stress response is characterized by pronounced sympathetic activation, substantial withdrawal of parasympathetic modulation, and delayed autonomic recovery. The findings support the role of social-evaluative threat as a key mechanism underlying the exaggerated autonomic responses observed during viva voce examinations.

While oral assessments remain an essential component of medical education, excessive autonomic activation may impair cognitive retrieval and compromise assessment validity. Incorporation of structured oral examination formats, adequate recovery intervals, and stress-mitigation strategies may help reduce the physiological burden associated with high-stakes evaluations. Recognition of the physiological cost of assessment modalities is essential for optimizing both student well-being and the accuracy of academic evaluation.

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Conflicts of Interest

The authors declare that there are no conflicts of interest related to this study.

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Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

REFERENCES

1. Singh R, Goyal M, Tiwari S, Ghildiyal A, Nattu SM, Das S. Effect of examination stress on mood, performance and cortisol levels in medical students. *Indian J Physiol Pharmacol.* 2012;56(1):48–55.
2. McEwen BS. Protective and damaging effects of stress mediators. *N Engl J Med.* 1998;338(3):171–179.
3. Porges SW. The polyvagal theory: phylogenetic substrates of a social nervous system. *Int J Psychophysiol.* 2001;42(2):123–146.
4. Thayer JF, Lane RD. A model of neurovisceral integration in emotion regulation and dysregulation. *J Affect Disord.* 2000;61(3):201–216.
5. Preuss D, Schoofs D, Schlotz W, Wolf OT. The stressed student: influence of written examinations and oral presentations on salivary cortisol concentrations. *Stress.* 2010;13(3):221–229.
6. Hammoud S, Takkouche B, Said S, Atoui M, Karam R. Stress and heart rate variability during university final examination among Lebanese students. *Behav Sci.* 2019;9(1):3.
7. Kumar N, Singh SS, Singh RH. Heart rate variability during examination stress in medical students. *Indian J Physiol Pharmacol.* 2022;66(2):124–131.
8. Dickerson SS, Kemeny ME. Acute stressors and cortisol responses: a theoretical integration and synthesis of laboratory research. *Psychol Bull.* 2004;130(3):355–391.
9. Gruenewald TL, Kemeny ME, Aziz N, Fahey JL. Acute threat to the social self: shame, social self-esteem, and cortisol activity. *Psychosom Med.* 2004;66(6):915–924.
10. Kirschbaum C, Pirke KM, Hellhammer DH. The Trier Social Stress Test: a tool for investigating psychobiological stress responses in a laboratory setting. *Neuropsychobiology.* 1993;28(1–2):76–81.
11. Smith R, Thayer JF, Khalsa SS, Lane RD. The hierarchical basis of neurovisceral integration. *Neurosci Biobehav Rev.* 2017;75:274–296.
12. Thayer JF, Hansen AL, Saus-Rose E, Johnsen BH. Heart rate variability, prefrontal neural function, and cognitive performance. *Ann Behav Med.* 2009;37(2):141–153.
13. Shaffer F, Ginsberg JP. An overview of heart rate variability metrics and norms. *Front Public Health.* 2017;5:258.
14. Laborde S, Mosley E, Thayer JF. Heart rate variability and cardiac vagal tone in psychophysiological research. *Front Psychol.* 2017;8:213.
15. Jones B, Kenward MG. *Design and Analysis of Cross-Over Trials.* 3rd ed. Boca Raton: CRC Press; 2014.
16. World Medical Association. Declaration of Helsinki: ethical principles for medical research involving human subjects. *JAMA.* 2013;310(20):2191–2194.
17. Arnsten AFT. Stress signalling pathways that impair prefrontal cortex structure and function. *Nat Rev Neurosci.* 2009;10(6):410–422.
18. Yerkes RM, Dodson JD. The relation of strength of stimulus to rapidity of habit formation. *J Comp Neurol Psychol.* 1908;18:459–482.
19. Saboo N, Kacker S, Sorout J. A study to correlate stress score with heart rate variability among MBBS students at a tertiary care center, Jaipur. *Acta Medica International.* 2023 Jul 1;10(2):148–54.
20. Kaur R, Garg R, Kaur S, Gupta S. Impact of examination stress on cardiorespiratory parameters among medical students in Punjab. *National Journal of Physiology, Pharmacy and Pharmacology.* 2024;14(2):248–53.