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A CROSS-SECTIONAL STUDY TO ASSESS SYMPATHETIC REACTIVITY, AUDIO-VISUAL REACTION TIME, AND ANXIETY LEVELS IN YOUNG STUDENTS (18–24 YEARS)

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ABSTRACT

Background: Emotional tension and sensory load influence autonomic balance and cognitive performance in students pursuing health sciences. Sympathetic reactivity, an indirect marker of stress adaptability, along with reaction time and anxiety level, provides a window into the psychophysiological profile of young adults. Early identification of altered autonomic reactivity and delayed response times may support academic health initiatives in high-pressure educational environments. **Aim:** To evaluate the relationship between sympathetic reactivity, audio-visual reaction time, and anxiety level among paramedical students aged 18–24 years. **Methods:** A cross-sectional observational study was conducted among 100 apparently healthy paramedical students (60 females, 40 males). Sympathetic reactivity was measured using the cold pressor and isometric handgrip tests. Audio-visual reaction times were recorded with a digital reaction timer, and anxiety levels were assessed using the State–Trait Anxiety Inventory (STAI). Statistical analysis used independent *t*-tests and Pearson correlation; $p < 0.05$ was considered significant. **Results:** Mean diastolic pressure rise during the handgrip test and systolic rise during the cold-pressor test were higher in males than females ($p < 0.05$). Visual reaction times were longer than auditory times in both genders, while participants with high-anxiety scores exhibited significantly prolonged reaction times and exaggerated sympathetic responses. A moderate positive correlation ($r = 0.41$, $p < 0.01$) existed between anxiety score and diastolic BP increment. **Conclusion:** Greater anxiety was associated with enhanced sympathetic reactivity and slower sensory-motor response. Regular screening of stress physiology among college students could aid preventive mental-health strategies within academic institutions.

KEYWORDS: Sympathetic reactivity, audio-visual reaction time, anxiety, cold-pressor test, handgrip test, paramedical students, India.

INTRODUCTION

Youth in higher education frequently experience a dynamic interplay between physiological stress and psychological demand. Academic pressure, altered sleep patterns, and prolonged device use modulate both cognitive processing and autonomic tone.[1,2] The autonomic nervous system, particularly its sympathetic division, acts as the body's rapid-response channel to internal and external challenges. Measuring its reactivity provides insight into stress resilience and cardiovascular adaptability.[3]

Sympathetic reactivity is commonly assessed through standardized non-invasive tests such as the cold pressor test (CPT) and isometric handgrip test (HGT), both of which evaluate vasomotor responsiveness and sympathetic efferent activity.[4,5] A heightened pressor response may signal an exaggerated adrenergic drive, predisposing individuals to future hypertension.[6]

Parallel to autonomic performance, reaction time, the latency between a stimulus and a voluntary motor response, serves as a psychomotor marker reflecting sensory processing, cortical alertness, and neuromuscular coordination.[7,8] Visual and auditory modalities differ, with auditory reaction times typically shorter due to fewer synaptic relays.[9,10]

Recent studies have demonstrated that emotional states, particularly anxiety, can alter both reaction time and sympathetic activity.[11–13] Anxiety triggers hypothalamic activation of the sympatho-adrenal axis, raising catecholamine levels and increasing cardiovascular reactivity.[14] Persistent sympathetic dominance can, over time, impair cognitive efficiency and sensorimotor integration.[15] Among Indian college populations, chronic academic stress has been associated with sustained sympathetic hyperactivity, poor sleep, and reduced task precision.[12,13,20]

Despite growing recognition of mental-health concerns in Indian youth, integrated studies linking autonomic reactivity, reaction time, and anxiety remain limited. Most prior works examined either cardiovascular reactivity or psychological scales in isolation.[12,13,21] Moreover, local data from semi-urban health-science colleges are sparse, where students face both academic and sociocultural stressors, competition, migration, and family expectations.[27,28]

Therefore, this study was undertaken at Dhanalakshmi Srinivasan Medical College, Perambalur, to explore correlations among sympathetic reactivity (via CPT and HGT), audio-visual reaction time, and anxiety scores among paramedical students aged 18–24 years. Understanding these interrelations may help design targeted interventions, such as relaxation training or structured counselling, to enhance physiological resilience and learning performance in young adults.[23–25]

MATERIALS AND METHODS

Study Design and Setting

A cross-sectional, institution-based study was carried out in the Department of Physiology, Mahatma Gandhi Medical College and Research Institute, Sri Balaji Vidyapeeth Campus, Pillaiyarkuppam, Puducherry – 607402.

Data collection was conducted, from May 2026. Written informed consent was secured from all participants.

Sample Size and Participants

One hundred apparently healthy paramedical students aged 18–24 years were enrolled using simple random sampling. Of these, 60 were females and 40 males. All were non-smokers and free from chronic illness, medication, or recent infection. Participants who had consumed caffeine, nicotine, or energy drinks within 24 hours of testing or who exhibited acute stress were excluded.

Inclusion Criteria

1. Age 18–24 years.
2. Enrollment in paramedical courses at the institution.
3. Willingness to participate and follow pre-test restrictions.

Exclusion Criteria

1. History of cardiovascular, endocrine, or neurological disorder.
2. Use of sympathomimetic or anxiolytic drugs.
3. Acute illness, fever, or recent trauma.
4. Non-compliance with pre-test instructions.

Equipment and Instruments

1. Digital Reaction Time Apparatus (Anand Agencies, Pune, India) for auditory and visual reaction-time measurement.
2. Sphygmomanometer and digital BP monitor for blood-pressure recording.
3. Handgrip dynamometer for isometric testing.
4. Cold-pressor setup (thermostatically controlled water bath maintained at 10 ± 1 °C).
5. State–Trait Anxiety Inventory (STAI-Y1/Y2) questionnaire (validated Tamil-translated version).

Experimental Protocol

All sessions were conducted between 9 AM and 11 AM in a quiet, temperature-controlled laboratory (25 ± 2 °C). Participants sat comfortably for 10 minutes before baseline measurements.

1. Sympathetic Reactivity Tests

a) **Cold Pressor Test (CPT):** The non-dominant hand was immersed in 10 °C water for one minute. Blood pressure was recorded at baseline, immediately after immersion, and one minute after withdrawal. The maximum systolic and diastolic rise represented sympathetic reactivity.

b) **Isometric Handgrip Test (HGT):** Participants sustained 30% of maximal voluntary contraction for three minutes using the dynamometer. Rise in diastolic BP from baseline was recorded.

2. Audio-Visual Reaction Time (AVRT)

Ten trials were performed for both auditory (beep sound) and visual (red light) stimuli. Mean reaction time (ms) was computed automatically by the apparatus after discarding outliers.

3. Anxiety Assessment

Each participant completed the STAI questionnaire. Scores were categorized as:

- **Low Anxiety:** ≤ 40
- **Moderate Anxiety:** 41–60
- **High Anxiety:** > 60

Data Processing and Grouping

Two comparative frameworks were used

1. **Gender-based:** Male vs Female.
2. **Anxiety-based:** Low vs High Anxiety.
   Results were summarized as mean ± standard deviation (SD) for all parameters.

Statistical Analysis

Data analysis was performed using IBM SPSS Statistics Version 28.0 (Armonk, NY, USA).

- Continuous variables: mean ± SD.
- Between-group differences were analyzed using the independent *t*-test for gender comparisons and **one-way ANOVA** for anxiety categories (low, moderate, high), followed by Bonferroni post-hoc testing for pairwise differences.
- Correlations: Pearson's correlation coefficient (r).
- Significance: $p < 0.05$.

RESULTS

A total of 100 paramedical students (60 females, 40 males) completed the study without protocol deviation. The mean age was 20.6 ± 1.4 years.

Baseline Characteristics

Both sexes were comparable in anthropometric and cardiovascular parameters (Table 1). Mean BMI and resting blood pressure were within normal limits for all participants.

Table 1: Baseline Demographic and Physiological Profile of Participants (n = 100).

Parameter	Males (n = 40)	Females (n = 60)	*p*-value
Age (years)	20.9 ± 1.3	20.4 ± 1.5	0.18
Height (cm)	170.6 ± 6.2	158.3 ± 5.7	<0.001
Weight (kg)	63.8 ± 7.1	54.6 ± 6.4	<0.001
BMI (kg/m²)	21.9 ± 2.1	21.8 ± 2.2	0.84
Resting SBP (mmHg)	117.5 ± 8.4	113.6 ± 9.1	0.06
Resting DBP (mmHg)	74.8 ± 6.2	72.1 ± 6.5	0.09

(*Independent t-test; p < 0.05 significant*)

Sympathetic Reactivity Findings

The cold-pressor and isometric-handgrip tests revealed higher blood-pressure reactivity among males (Table 2). Mean systolic rise during the cold-pressor test (CPT) was 19.6 ± 6.2 mmHg in males versus 15.2 ± 5.7 mmHg in females ($p = 0.001$). Diastolic rise during the handgrip test (HGT) was 17.4 ± 5.1 mmHg in males and 13.8 ± 4.8 mmHg in females ($p = 0.003$).

Table 2: Comparison of Sympathetic Reactivity Parameters between Genders.

Parameter	Males (n = 40)	Females (n = 60)	*p*-value
ΔSBP (CPT, mmHg)	19.6 ± 6.2	15.2 ± 5.7	0.001
ΔDBP (CPT, mmHg)	14.8 ± 4.9	11.9 ± 4.7	0.008
ΔDBP (HGT, mmHg)	17.4 ± 5.1	13.8 ± 4.8	0.003

(Δ = change from baseline; independent t-test)

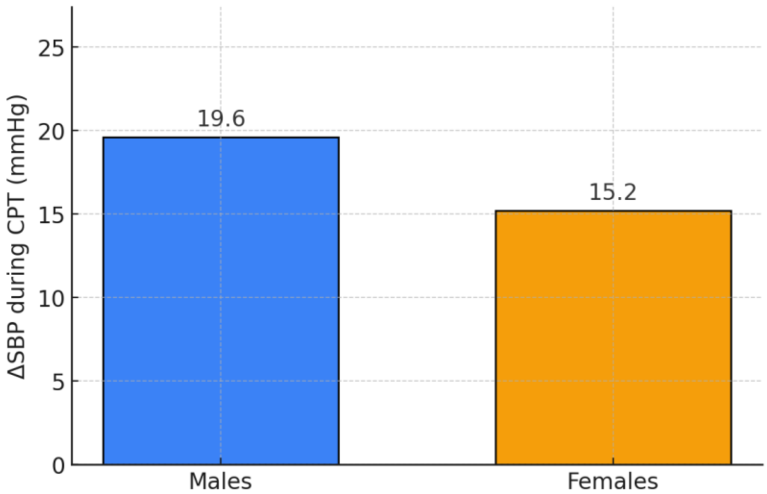

Figure 1: ***Bar chart comparing mean systolic pressure rise (CPT) between males and females.***

Male participants demonstrated significantly greater sympathetic reactivity than females (p < 0.01).

Audio-Visual Reaction Time

Auditory reaction time (ART) was consistently shorter than visual reaction time (VRT) in both genders (Table

3). Males showed marginally faster responses, though the difference was not statistically significant ($p > 0.05$).

Table 3: Comparison of Auditory and Visual Reaction Time by Gender.

Reaction Type	Males (ms)	Females (ms)	*p*-value
Auditory RT	171.5 ± 22.8	177.3 ± 25.9	0.21
Visual RT	198.4 ± 28.6	203.7 ± 31.2	0.31
Mean Difference (VRT–ART)	26.9 ± 11.4	26.4 ± 12.2	0.87

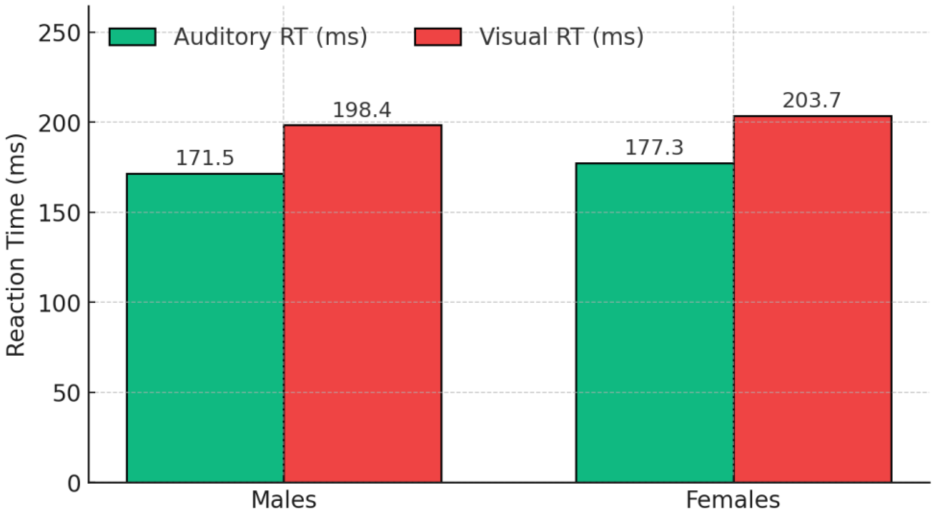

Figure 2: ***Box plot showing distribution of auditory and visual reaction times among all participants.***

Auditory responses were uniformly faster, indicating higher processing efficiency for auditory cues.

Anxiety Level Distribution and Physiological Association

According to STAI scoring, 48 students fell into the low-anxiety group, 32 moderate, and 20 high. The categorical spread is shown in Figure 3.

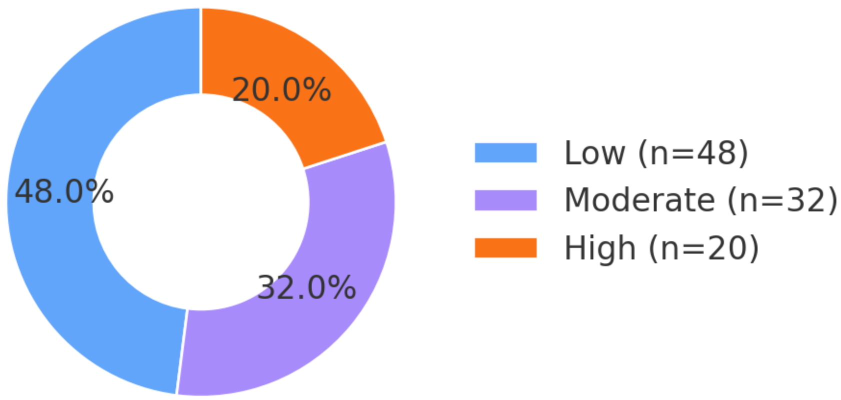

Figure 3: ***Donut chart representing distribution of participants across anxiety categories (Low, Moderate, High).***

Students with high anxiety showed both higher blood-pressure reactivity and delayed reaction times (Table 4). Mean diastolic rise during the handgrip test increased by nearly 20 % in the high-anxiety group, while mean reaction times were prolonged by 15–18 % compared with low-anxiety peers.

Table 4: Comparison of Physiological Variables across Anxiety Categories.

Parameter	Low (n = 48)	Moderate (n = 32)	High (n = 20)	*p*-value (ANOVA)
ΔSBP (CPT, mmHg)	14.9 ± 5.4	17.3 ± 5.8	20.8 ± 6.1	0.004
ΔDBP (HGT, mmHg)	13.1 ± 4.5	15.9 ± 5.2	18.2 ± 5.3	0.006
Auditory RT (ms)	168.7 ± 23.1	181.5 ± 26.8	194.3 ± 29.4	0.002
Visual RT (ms)	195.8 ± 26.7	206.1 ± 30.2	223.5 ± 32.6	0.001

(ANOVA with Bonferroni post-hoc test; p < 0.05 significant)

Correlation Analysis
Pearson's correlation revealed a moderate positive association between anxiety score and diastolic pressure rise (r = 0.41, p = 0.001) and between anxiety and reaction times (r = 0.38 for ART; r = 0.44 for VRT).

Table 5: Correlation of Anxiety Score with Physiological Variables (n = 100).

Variable	Pearson *r*	*p*-value	Interpretation
ΔSBP (CPT)	0.36	0.001	Moderate positive
ΔDBP (HGT)	0.41	0.001	Moderate positive
Auditory RT	0.38	0.002	Moderate positive
Visual RT	0.44	0.001	Moderate positive

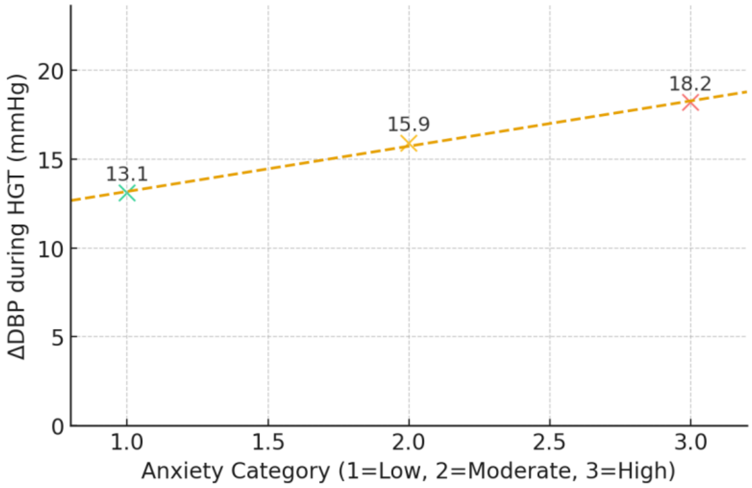

Figure 4: ***Scatter plot illustrating correlation between anxiety score and diastolic pressure rise during the handgrip test.***

A linear upward trend indicates stronger sympathetic activation with increasing anxiety.

Summary of Key Findings
Male participants exhibited greater sympathetic reactivity than females. Auditory reaction time remained consistently faster than visual reaction time across all groups. High-anxiety students displayed enhanced sympathetic responses and delayed sensorimotor performance. Correlation analysis confirmed significant linear relationships between anxiety and autonomic indices.

DISCUSSION
This cross-sectional analysis explored how autonomic reactivity and sensorimotor speed vary with psychological state in young adults. The results revealed a coherent trend: students exhibiting higher anxiety demonstrated exaggerated sympathetic responses and slower reaction times. These findings reinforce the intricate mind–body coupling that underlies stress physiology.[14]

A heightened blood-pressure rise during the cold-pressor and handgrip tests indicates increased adrenergic responsiveness. Comparable patterns were reported among Indian medical undergraduates, where persistent academic stress maintained sympathetic over-drive and reduced baroreflex sensitivity.[2,13] Physiologically, stress activates the hypothalamic–pituitary–adrenal axis and augments catecholamine release, thereby increasing peripheral vascular tone.[15] Over time, such hyper-reactivity could predispose susceptible individuals to early-onset hypertension.[6]

Reaction-time analysis further clarified this association. The consistent auditory advantage over visual stimuli aligns with neurophysiological evidence that auditory pathways involve fewer synapses and faster cortical integration.[7–10] However, anxiety-linked prolongation of both auditory and visual reaction times suggests diffuse cortical inhibition under sustained stress. Functional imaging studies demonstrate that anxious subjects exhibit increased amygdalar activity coupled with diminished prefrontal modulation, which can delay cognitive–motor translation.[16,17]

Gender differences in autonomic reactivity are well recognized. In the present study, males showed higher pressor responses, a finding attributed to greater muscle mass and differential catecholamine release patterns.[18] Females, although demonstrating lower absolute blood-pressure changes, often exhibit higher resting heart-rate variability, suggesting more effective parasympathetic modulation.[19] The absence of a significant gender difference in reaction times implies that sensorimotor processing may be less sex-dependent than cardiovascular responsiveness during acute stress.[9,10]

The correlation between anxiety score and diastolic-pressure rise underscores a psychophysiological continuum. Studies among nursing and physiotherapy students have similarly reported positive correlations between anxiety indices and sympathetic tone.[21] These observations emphasize that psychological distress among young health-science trainees is not merely emotional—it has measurable physiological footprints.

In the educational context, sustained sympathetic dominance may translate into fatigue, impaired concentration, and decreased academic efficiency. Incorporating periodic stress-management workshops, breathing retraining, and short mindfulness sessions has been shown to normalize autonomic balance and improve reaction times.[23–25] Such low-cost interventions are culturally adaptable within Indian college environments, where group activities and guided relaxation are readily accepted.[27,28]

Overall, this work bridges physiology and behavioral science by demonstrating that anxiety, sympathetic activation, and delayed psychomotor performance form an inter-related triad.

LIMITATIONS

Being a single-institution, cross-sectional study, causality cannot be inferred. Anxiety scores were self-reported, subject to response bias. Circadian variation and menstrual-cycle phase were not controlled, potentially influencing autonomic measures. Additionally, the modest sample size and lack of hormonal or biochemical stress markers limit generalizability. A multi-centric design incorporating heart-rate variability and salivary cortisol would strengthen future analyses.

CONCLUSION

Young paramedical students with higher anxiety demonstrated amplified sympathetic reactivity and slower audio-visual reaction times. These physiological signatures of stress reflect reduced autonomic adaptability. Routine screening for anxiety and simple relaxation interventions within curricula could enhance both mental wellbeing and learning efficiency. Early recognition of heightened sympathetic tone in youth may also contribute to primordial prevention of stress-related cardiovascular risks in later life.

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