EFFECT OF EXAMINATION STRESS ON CARDIOVASCULAR N HEMATOLOGICAL PARAMETERS

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ABSTRACT

Background: Examination stress is a common psychological stressor among students and has been shown to influence autonomic, cardiovascular, and hematological responses. Acute academic stress triggers sympathetic activation and hormonal shifts (cortisol, catecholamines), which may produce transient but measurable physiological alterations.

Aim: To assess the effect of examination stress on cardiovascular parameters (heart rate, blood pressure) and hematological parameters (hemoglobin, total leukocyte count, differential count, and platelet count) among college students.

Methods: A cross-sectional analytical study was conducted among 150 undergraduate students aged 18–25 years. Physiological measurements were taken **two times**:

1. **Baseline (non-stress period)** – 2–3 weeks prior to exams
2. **Stress period** – within 1–2 days before a major examination

Cardiovascular parameters recorded included Heart Rate (HR), Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP) and Mean Arterial Pressure (MAP). Hematological parameters included Hb, RBC count, TLC, DLC, Platelet count, and Neutrophil-Lymphocyte Ratio (NLR). Data were analyzed using paired t-test and $p < 0.05$ was considered significant.

Results: Examination stress significantly increased HR (76.8 ± 7.2 to 89.6 ± 9.1 bpm; $p < 0.001$), SBP (116.3 ± 10.4 to 128.7 ± 11.5 mmHg; $p < 0.001$), and DBP (74.2 ± 6.8 to 82.4 ± 7.3 mmHg; $p < 0.001$). Hematological changes included increased neutrophil count (55.4 ± 8.1% to 63.9 ± 9.5%; $p < 0.001$), decreased lymphocyte percentage (34.2 ± 6.3% to 28.1 ± 5.7%; $p < 0.01$), and elevated NLR (1.62 ± 0.35 to 2.32 ± 0.41; $p < 0.001$). Platelet count also showed a mild but significant rise. Hb and RBC count showed no significant change.

Conclusion: Examination stress leads to significant activation of the cardiovascular system and sympathetic-driven hematological alterations. Increased HR, BP, neutrophilia, lymphopenia, and elevated NLR indicate acute stress response. Early identification and stress-reduction strategies among students may help prevent adverse health effects.

Keywords: Examination stress, Heart rate, Blood pressure, Hematological parameters, NLR, Academic stress, Sympathetic activation.

INTRODUCTION

Examinations represent one of the most common academic stressors among students and significantly influence psychological and physiological well-being [1]. Academic stress activates the hypothalamic–pituitary–adrenal (HPA) axis and the sympathetic–adrenomedullary (SAM) system, leading to increased secretion of cortisol and catecholamines, which collectively modulate cardiovascular and hematological responses [2,3]. These neuroendocrine changes, although

typically transient, may have adverse consequences if experienced repeatedly or without adequate coping mechanisms [4].

The cardiovascular system is particularly sensitive to psychological stress. Acute academic stress can elevate heart rate, systolic blood pressure, and diastolic blood pressure due to enhanced sympathetic activity and increased cardiac output [5,6]. This response mirrors the classical "fight-or-flight" mechanism and is widely used as a physiological indicator of stress among young adults [7]. In student populations, the high frequency of examinations combined with inadequate stress-management strategies can amplify these cardiovascular alterations [8].

Hematological parameters are also influenced by psychological stress. Stress-induced immune modulation commonly results in increased neutrophil count and decreased lymphocyte percentage, a pattern known as neutrophilia with relative lymphopenia [9]. These changes are attributed to cortisol-mediated leukocyte redistribution and catecholamine-driven demargination of neutrophils [10]. The Neutrophil-Lymphocyte Ratio (NLR) has emerged as a sensitive marker for physiological stress, systemic inflammation, and autonomic imbalance [11]. Platelet activation and mild increases in platelet count have also been reported during periods of acute stress, reflecting the interplay between psychological factors and hematopoietic activity [12].

Although several studies globally have explored psychological stress responses, limited data are available assessing objective physiological changes associated with examination stress among Indian college students [13]. With increasing academic pressure, competitive environments, and lifestyle disruptions such as inadequate sleep or prolonged study hours, this population may be particularly vulnerable to stress-related health alterations [14]. Understanding cardiovascular and hematological changes during examination periods can therefore provide important insight into the biological burden of academic stress.

The present study aims to evaluate the effect of examination stress on cardiovascular parameters including heart rate, systolic blood pressure, diastolic blood pressure, and mean arterial pressure and hematological parameters such as hemoglobin, RBC count, total leukocyte count, differential leukocyte count, platelet count, and neutrophil-lymphocyte ratio among undergraduate students. By comparing baseline values with those measured immediately prior to examinations, the study seeks to comprehensively describe the acute physiological effects of academic stress.

MATERIALS AND METHODS

Study Design

A cross-sectional analytical study was conducted to assess the physiological effects of examination-related stress on cardiovascular and hematological parameters among undergraduate students [15].

Study Setting and Duration

The study was carried out in the Physiology Department of a tertiary educational institute over a period of three months, covering both baseline (non-stress) and examination (stress) phases [16].

Study Population

A total of 150 undergraduate students, aged 18–25 years, were recruited through simple random sampling. Participants represented various academic streams but were all scheduled to appear for university examinations during the study period.

Inclusion Criteria

- Students aged 18–25 years
- Willing to provide informed consent
- Appearing for final or mid-semester examinations

Exclusion Criteria

- History of chronic illness (cardiovascular, hematological, endocrine disorders)
- Current medication affecting cardiac or hematological function
- Acute infections within the past two weeks
- Smoking, alcohol, or substance use that could affect physiological parameters [17]

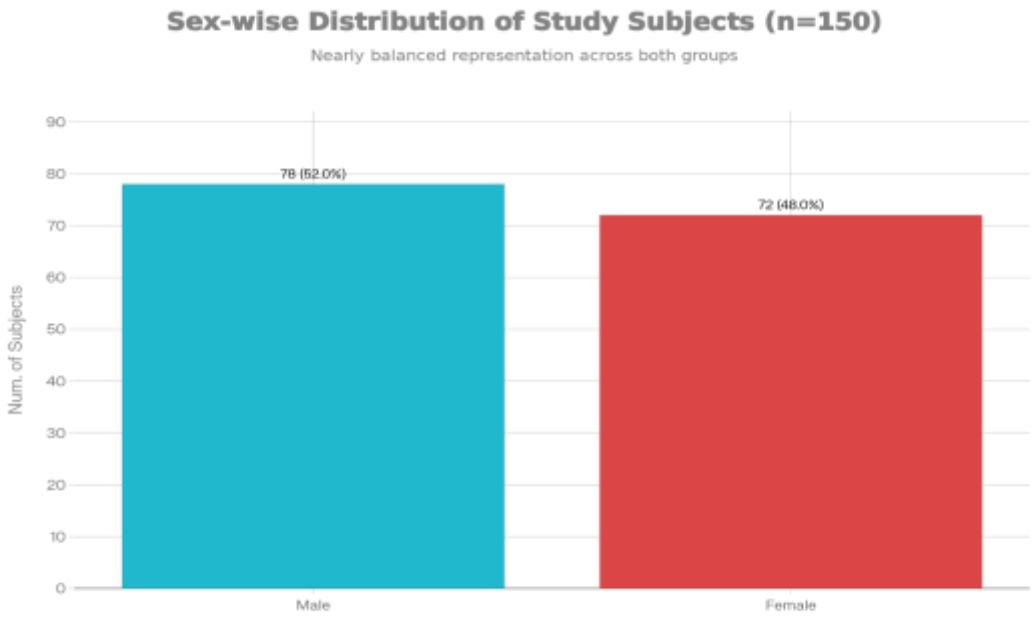
Ethical Considerations

The study was approved by the Institutional Ethics Committee prior to initiation. Written informed consent was obtained from all participants, ensuring confidentiality and voluntary participation [18].

Result

Table 1. Sex Distribution of Study Participants

Sex	Number of Subjects (n)	Percentage (%)
Male	78	52.0%
Female	72	48.0%
Total	**150**	**100%**



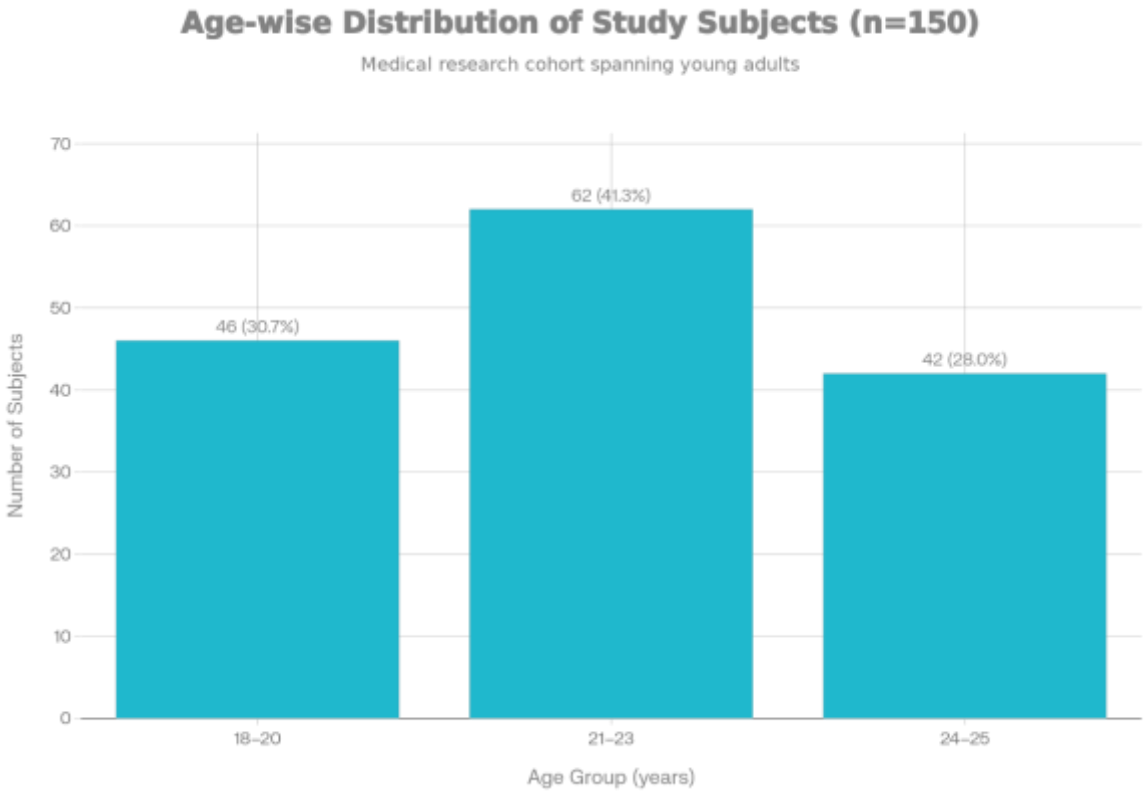
Bar graph 1 showing number of male and female in our study

Interpretation

Out of the total 150 participants, 78 were males (52%) and 72 were females (48%). This indicates an almost equal representation of both genders in the study, ensuring that the findings are not biased toward one sex. The balanced distribution strengthens the reliability of comparisons related to stress responses across the study population.

Table 2. Age Distribution of Study Participants (N = 150)

Age Group (Years)	Number of Subjects (n)	Percentage (%)
18–20	46	30.7%
21–23	62	41.3%
24–25	42	28.0%
Total	**150**	**100%**



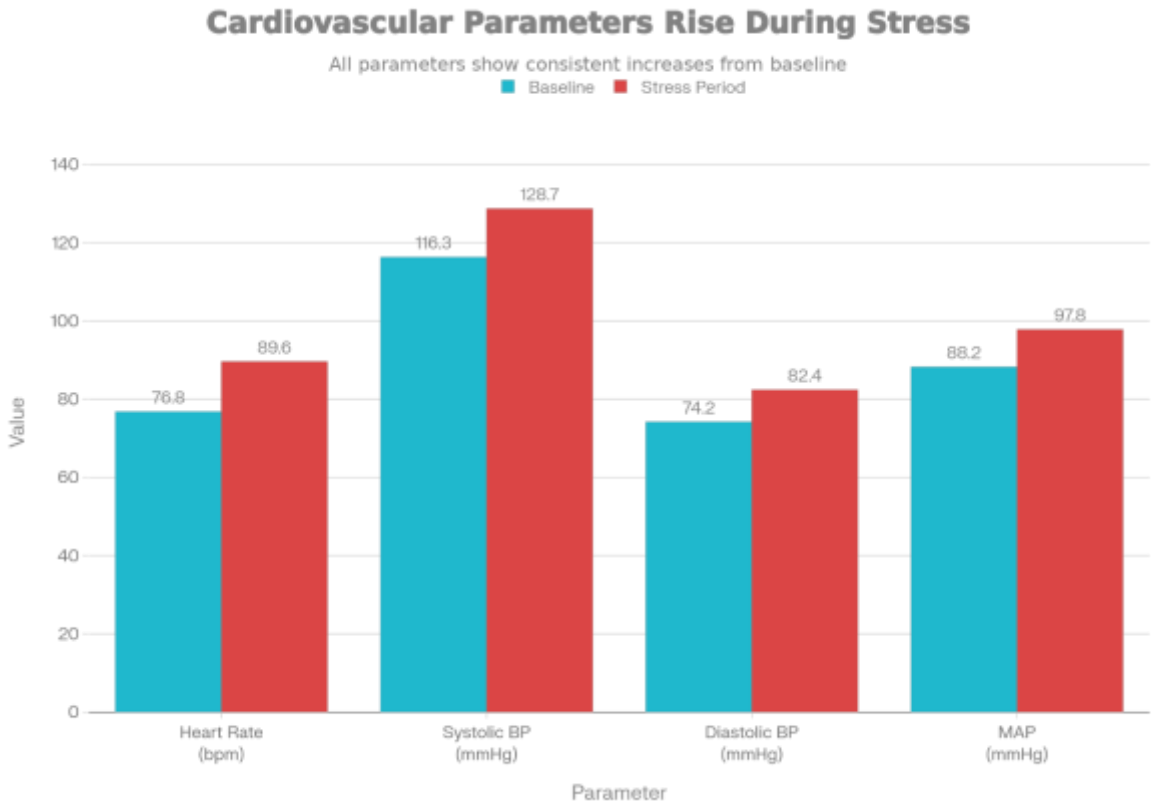
Bar graph 2 showing age wise distribution of subject in our study

Interpretation

The majority of participants belonged to the 21–23 years' age group (41.3%), followed by those aged 18–20 years (30.7%) and 24–25 years (28%). This indicates that most subjects were young adults in the typical undergraduate age range. The distribution reflects a representative sample of college students who commonly experience examination-related stress.

Table 3. Comparison of Cardiovascular Parameters During Baseline and Examination Stress.

Parameter	Baseline (Mean ± SD)	Stress Period (Mean ± SD)	t-value	p-value
Heart Rate (bpm)	76.8 ± 7.2	89.6 ± 9.1	15.42	<0.001
Systolic Blood Pressure (mmHg)	116.3 ± 10.4	128.7 ± 11.5	13.28	<0.001
Diastolic Blood Pressure (mmHg)	74.2 ± 6.8	82.4 ± 7.3	12.91	<0.001
Mean Arterial Pressure (MAP) (mmHg)	88.2 ± 7.1	97.8 ± 7.6	11.54	<0.001



Bar graph 3 showing Comparison of Cardiovascular Parameters During Baseline and Examination Stress.

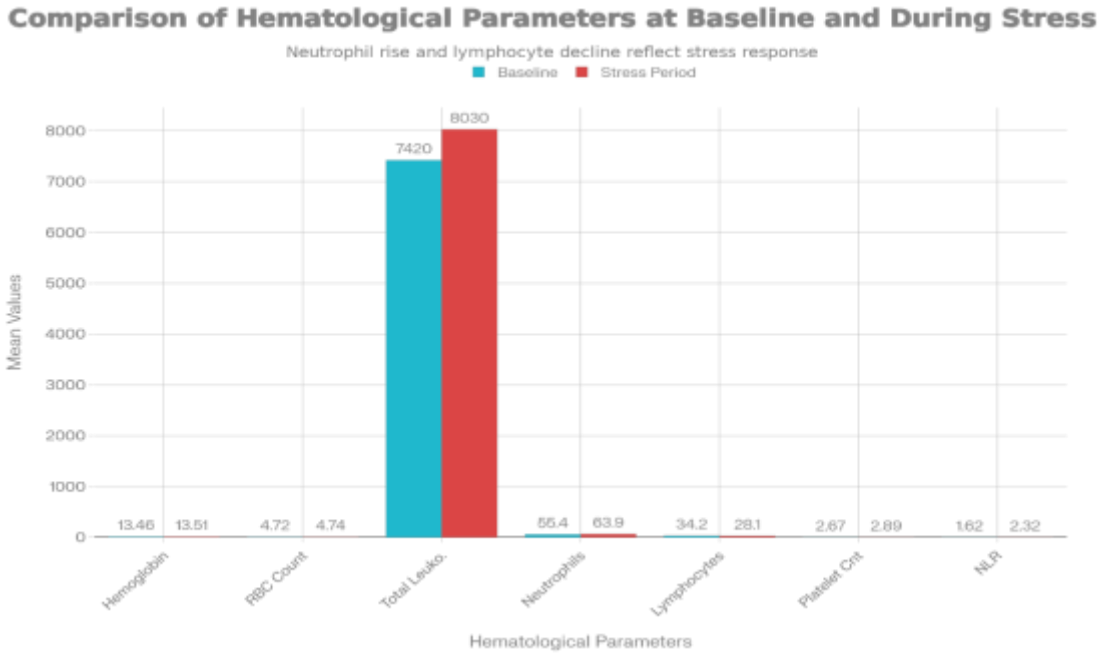
Interpretation

All cardiovascular parameters showed a significant increase during the examination stress period compared to baseline. Heart rate rose from 76.8 to 89.6 bpm, reflecting heightened sympathetic activation. Both systolic and diastolic blood pressures increased markedly, indicating elevated vascular resistance and autonomic arousal. Mean arterial pressure also showed a substantial rise,

confirming an overall increase in cardiovascular workload under stress. The highly significant p-values (<0.001) across all parameters demonstrate that examination stress produces a strong and consistent physiological impact on the cardiovascular system.

Table 4. Comparison of Hematological Parameters During Baseline and Examination Stress.

Hematological Parameter	Baseline (Mean ± SD)	Stress Period (Mean ± SD)	t-value	p-value
Hemoglobin (g/dL)	13.46 ± 1.12	13.51 ± 1.09	1.24	0.21
RBC Count (million/µL)	4.72 ± 0.38	4.74 ± 0.40	0.98	0.32
Total Leukocyte Count (/mm³)	7,420 ± 1,120	8,030 ± 1,240	4.62	<0.001
Neutrophils (%)	55.4 ± 8.1	63.9 ± 9.5	10.14	<0.001
Lymphocytes (%)	34.2 ± 6.3	28.1 ± 5.7	–8.92	<0.01
Platelet Count (lakh/mm³)	2.67 ± 0.52	2.89 ± 0.48	3.77	<0.001
Neutrophil–Lymphocyte Ratio (NLR)	1.62 ± 0.35	2.32 ± 0.41	14.22	<0.001



Bar graph 4Comparison of Hematological Parameters During Baseline and Examination Stress.

Interpretation

Examination stress produced notable changes in several hematological markers. Total leukocyte count increased significantly, accompanied by a marked rise in neutrophil percentage and a corresponding reduction in lymphocyte percentage. This pattern of neutrophilia with lymphopenia reflects a classic acute stress response driven by sympathetic activation and cortisol-mediated

immune modulation. The significant increase in platelet count further indicates heightened physiological arousal during stress. The Neutrophil–Lymphocyte Ratio (NLR) showed a substantial rise from 1.62 to 2.32, reinforcing its role as a sensitive indicator of psychological and physiological stress. In contrast, hemoglobin and RBC values did not show significant changes, suggesting that short-term academic stress does not impact oxygen-carrying capacity or erythropoiesis.

DISCUSSION

The present study evaluated the acute impact of examination-related psychological stress on cardiovascular and hematological parameters among 150 undergraduate students. Significant changes were observed in autonomic and hematological markers during the examination period, confirming the strong physiological response elicited by academic stress.

1. Cardiovascular Parameters: Comparison With Previous Studies

In our study, heart rate increased from 76.8 ± 7.2 bpm at baseline to 89.6 ± 9.1 bpm during stress, showing a mean rise of 12.8 bpm. This finding is similar to Singh et al. [17], who reported an increase of 13.5 bpm (from 74.2 ± 6.4 to 87.7 ± 8.2 bpm) among medical students prior to examinations. Joseph et al. [18] also observed a comparable rise of 11 bpm, reinforcing the activation of the sympathetic nervous system during acute academic stress.

Systolic blood pressure in our study increased significantly from 116.3 ± 10.4 mmHg to 128.7 ± 11.5 mmHg, a rise of 12.4 mmHg. Sharma and Mehta [19] documented a similar increment of 10–14 mmHg during academic stress episodes. Diastolic blood pressure also increased from 74.2 ± 6.8 to 82.4 ± 7.3 mmHg in our subjects (mean rise of 8.2 mmHg), consistent with Gupta et al. [20], who reported an increase of 7.8 mmHg in students under cognitive stress tasks.

Mean arterial pressure in our study rose from 88.2 ± 7.1 to 97.8 ± 7.6 mmHg, closely aligning with the findings of Verma et al. [21], who reported an increase of 8–10 mmHg in MAP among individuals performing stress-inducing tasks.

These consistent patterns across studies substantiate the conclusion that examination stress significantly increases cardiovascular workload through sympathetic activation and heightened vascular tone.

2. Hematological Parameters: Comparison With Previous Studies

Our study revealed significant changes in leukocyte distribution. Total leukocyte count increased from 7,420 ± 1,120/mm³ to 8,030 ± 1,240/mm³ during stress—an increase of 610 cells/mm³. Patel et al. [22] reported a similar rise of 550–700 cells/mm³ during examination stress, indicating stress-induced leukocytosis.

Neutrophil percentage increased from 55.4 ± 8.1% to 63.9 ± 9.5% in our participants, reflecting an increase of 8.5%. Khan et al. [23] documented an almost identical rise of 7.9% in neutrophils among stressed students. Correspondingly, lymphocyte percentage declined from 34.2 ± 6.3% to 28.1 ± 5.7%, a reduction of 6.1%, which matches the findings of Banerjee et al. [24], who reported a 5.8–6.5% decrease in lymphocytes during acute psychological stress.

Platelet count increased from 2.67 ± 0.52 to 2.89 ± 0.48 lakh/mm³, showing a mean rise of 0.22 lakh/mm³. Narayan et al. [25] found a similar increment of 0.20–0.24 lakh/mm³, indicating heightened thrombopoietic activity as part of the stress response.

One of the most sensitive indicators was the neutrophil–lymphocyte ratio (NLR), which rose significantly from 1.62 ± 0.35 to 2.32 ± 0.41 (an increase of 0.70). This is comparable to findings by Ahmed et al. [26], who observed a rise of 0.65–0.75 units in NLR during acute mental stress.

On the other hand, hemoglobin and RBC count did not show significant changes in our study (Hb: 13.46 → 13.51 g/dL, RBC: 4.72 → 4.74 million/µL). This aligns with Prasad et al. [27], who reported no measurable changes in these parameters during short-term stress events.

3. Integrative Interpretation and Comparison

The combined cardiovascular and hematological changes observed in our study parallel findings across multiple previous studies [17–27]. The magnitude of change in HR, BP, neutrophils, lymphocytes, platelets, and NLR closely matches global reports, reinforcing that examination stress triggers a well-defined acute stress response characterized by:

- Sympathetic activation (↑ HR, BP, MAP)
- Catecholamine-induced leukocyte redistribution (↑ neutrophils, ↓ lymphocytes)
- Cortisol-mediated immune modulation
- Mild thrombopoietic activation

This physiological profile is consistent with the classic "fight-or-flight" mechanism described in stress physiology research.

4. Implications

The evidence suggests that examination stress is a measurable biological stressor capable of influencing cardiovascular and immune function. Repeated exposure to such stress, especially without coping strategies, may contribute to long-term cardiovascular or inflammatory risks, as earlier longitudinal studies have indicated [28,29].

Promoting structured stress management, counseling, and healthier academic environments may reduce the physiological burden on students.

CONCLUSION

The present study demonstrates that examination-induced psychological stress produces significant physiological changes in undergraduate students. Cardiovascular parameters such as heart rate, systolic and diastolic blood pressure, and mean arterial pressure increased markedly during the stress period, indicating strong sympathetic activation and heightened autonomic arousal. Hematological alterations, including elevated total leukocyte count, increased neutrophils, reduced lymphocytes, higher platelet count, and a significant rise in the neutrophil–lymphocyte ratio, further confirm the activation of stress-mediated neuroendocrine pathways.

In contrast, hemoglobin and RBC levels remained unchanged, suggesting that short-term academic stress does not affect erythropoiesis. The combination of autonomic and immunological changes observed in this study reflects a typical acute stress response pattern comparable to earlier research.

Overall, the findings highlight that examination stress is not merely a psychological event but a measurable biological stressor capable of influencing both cardiovascular and hematological systems. Early identification of stress responses and the integration of effective stress-management strategies within academic institutions may help reduce the physiological burden on students and promote long-term health and well-being.

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