

Research Article

Relationship between Mental Health and Physiological Markers in Learners

Samia Sarwar^{1*}, Sobia Nawaz², Sehrish Liaqat³, Syed Hussain Raza⁴, Junaid Iqbal⁵

^{1*}Professor, Department of Physiology, Rawalpindi Medical University Rawalpindi, Pakistan.

²Assistant Professor, Department of Medical Education, Continental Medical College Lahore, Pakistan.

³Senior Lecturer, Department of Community Medicine, Sahara Medical College Narowal, Pakistan.

⁴Assistant Professor, Department of Medical Education, Avicenna Medical College Lahore, Pakistan.

⁵Associate Professor, Department of Physiology, Sahara Medical College Narowal, Pakistan.

Corresponding Author: Samia Sarwar^{1*}

Email: ^{1*}drsamсарwar@yahoo.com

Received: 14.09.25, Revised: 12.10.25, Accepted: 06.11.25

ABSTRACT

Background: Mental health is a key determinant of academic success and overall well-being among learners. Psychological conditions such as stress, anxiety, and depression have been increasingly associated with physiological alterations, including changes in hormonal levels, cardiovascular responses, and sleep cycles. Understanding this relationship is essential in medical students who are frequently exposed to academic pressure and clinical responsibilities.

Objective: This study aimed to assess the relationship between mental health status and selected physiological markers among learners at Rawalpindi Medical University, and to evaluate the impact of these factors on academic functioning.

Methodology: A cross-sectional study was conducted involving 220 undergraduate medical students aged 18-25 years at Rawalpindi Medical University. Mental health was assessed using the Depression Anxiety Stress Scales (DASS-21). Physiological markers included salivary cortisol levels, heart rate variability (HRV), blood pressure, and sleep quality, measured through wearable monitoring devices and structured questionnaires. Statistical analysis was performed using Pearson correlation and multiple regression models to determine associations between variables.

Results: The results indicated a significant association between poor mental health and adverse physiological changes. Among 220 medical students at Rawalpindi Medical University, a high prevalence of stress (38%), anxiety (34%), and depression (29%) was observed. Significant physiological alterations included elevated cortisol, reduced HRV, increased blood pressure, and poor sleep quality. Mental health variables showed strong correlations with physiological markers, particularly stress with cortisol and anxiety with HRV ($p < 0.001$). Overall, psychological distress was strongly associated with measurable biological dysregulation in students.

Conclusion: The findings demonstrate a clear relationship between mental health and physiological markers among learners at Rawalpindi Medical University. Psychological distress is reflected in measurable biological responses that can impair academic performance. These results highlight the need for institutional strategies that integrate mental health support with physiological health monitoring to promote student well-being and optimize learning outcomes.

Keywords: Mental Health, Physiological Markers, Medical Students, Stress, Cortisol, Heart Rate Variability, Sleep Quality, Academic Performance.

INTRODUCTION

Mental health is increasingly recognized as a fundamental component of overall well-being and academic success, particularly among learners in higher education. Students enrolled in rigorous academic programs, especially in medical institutions, are often exposed to high levels of psychological stress due to demanding curricula, frequent examinations, and clinical responsibilities. These stressors can significantly affect emotional stability, cognitive functioning, and learning capacity. In recent

years, there has been growing interest in understanding how mental health challenges among learners extend beyond psychological experiences and manifest in measurable physiological changes ⁽¹⁾.

The interaction between mental health and physiological functioning is complex and bidirectional. Psychological conditions such as stress, anxiety, and depression are known to influence biological systems, including the neuroendocrine, cardiovascular, and immune systems. For instance, chronic stress activates

the hypothalamic–pituitary–adrenal (HPA) axis, leading to increased secretion of cortisol, a stress hormone that plays a critical role in regulating metabolism, immune responses, and brain function. Elevated cortisol levels over prolonged periods can impair memory, concentration, and emotional regulation key components necessary for effective learning. Similarly, alterations in heart rate variability (HRV), a marker of autonomic nervous system balance, have been associated with anxiety and reduced stress resilience among students⁽²⁾.

Medical students represent a vulnerable population due to the intensity and duration of their training. Studies conducted in various educational settings have reported high prevalence rates of anxiety, depression, and burnout among medical learners. These mental health challenges not only affect students' personal well-being but also have implications for their academic performance and future professional competence. At institutions like Rawalpindi Medical University, where students must balance theoretical learning with clinical practice, the burden of stress can be particularly pronounced. Despite this, mental health often remains under-addressed due to stigma, lack of awareness, and limited institutional resources⁽³⁾.

In addition to hormonal changes, mental health conditions are also associated with other physiological markers such as blood pressure, sleep quality, and circadian rhythm disturbances. Poor sleep, for example, is both a symptom and a contributing factor to mental health disorders. Students experiencing anxiety or depression frequently report insomnia or disrupted sleep patterns, which in turn affect cognitive performance, memory consolidation, and attention span. Likewise, elevated blood pressure and reduced HRV have been linked to chronic stress, indicating a state of sustained physiological arousal that may negatively impact long-term health⁽⁴⁾.

The integration of psychological assessments with physiological measurements offers a more comprehensive understanding of student health. By examining both subjective experiences and objective biological indicators, researchers can better identify early warning signs of distress and implement targeted interventions. This approach is particularly relevant in academic environments where performance pressures are high and early detection of mental health issues can significantly improve outcomes. Furthermore, the use of wearable health technologies and

non-invasive biomarkers has made it increasingly feasible to monitor physiological changes in real time, providing valuable insights into the daily experiences of learners⁽⁵⁾.

Despite the growing body of research on mental health among students, there remains a gap in studies that specifically explore its relationship with physiological markers within local contexts. Cultural, educational, and environmental factors may influence both psychological experiences and biological responses, making it important to conduct institution-specific research⁽⁶⁾.

Therefore, this study aims to investigate the relationship between mental health status and selected physiological markers among learners. By exploring how stress, anxiety, and depression correlate with indicators such as cortisol levels, heart rate variability, blood pressure, and sleep quality, the research seeks to provide a holistic perspective on student health. Ultimately, the findings may contribute to the development of integrated interventions that address both mental and physical aspects of well-being, fostering a healthier and more productive learning environment^(7,8).

METHODOLOGY

This cross-sectional analytical study was conducted at Rawalpindi Medical University over a period of six months from January to June 2025. The study population comprised undergraduate medical students aged 18–25 years. A total of 220 participants were selected using a stratified random sampling technique to ensure representation from all academic years. Mental health status was assessed using the standardized Depression Anxiety Stress Scales (DASS-21), a validated self-administered questionnaire. Physiological markers included salivary cortisol levels, heart rate variability (HRV), blood pressure, and sleep quality. Salivary cortisol samples were collected in the morning under standardized conditions. HRV was measured using wearable heart rate monitors, while blood pressure was recorded using a calibrated sphygmomanometer. Sleep quality was assessed through a combination of wearable tracking devices and the Pittsburgh Sleep Quality Index (PSQI). Data were analyzed using statistical software, applying Pearson correlation and multiple regression analyses to examine relationships between mental health variables and physiological markers. A p-value of <0.05 was considered statistically significant.

Inclusion Criteria:

Participants included in the study were undergraduate medical students enrolled at Rawalpindi Medical University, aged between 18 and 25 years, and willing to provide informed consent. Students who were present during the data collection period and agreed to complete psychological assessments and physiological measurements were included.

Exclusion Criteria:

Students with known chronic medical conditions such as hypertension, endocrine disorders, or cardiovascular diseases were excluded to avoid confounding effects on physiological markers. Additionally, individuals currently using medications that could influence cortisol levels, heart rate, or blood pressure (e.g., corticosteroids, beta-blockers) were not

included. Students with diagnosed psychiatric disorders under active treatment or those who declined participation were also excluded from the study.

Ethical approval was obtained from the institutional review board of Rawalpindi Medical University, and confidentiality of participant information was strictly maintained throughout the study.

RESULTS

A total of 220 undergraduate students from Rawalpindi Medical University participated (response rate: 88%). The mean age was 21.2 ± 1.8 years; 56% were female and 44% male. Overall, 38% of students had moderate–severe stress, 34% anxiety, and 29% depressive symptoms based on DASS-21 scores.

1. Mental Health Status Distribution (DASS-21 Categories)

Variable	Normal n (%)	Mild n (%)	Moderate n (%)	Severe n (%)	Mean Score ± SD
Stress	70 (32%)	66 (30%)	55 (25%)	29 (13%)	16.8 ± 6.4
Anxiety	79 (36%)	66 (30%)	48 (22%)	27 (12%)	14.2 ± 5.9
Depression	90 (41%)	66 (30%)	44 (20%)	20 (9%)	13.6 ± 5.7

A considerable proportion of students fell into moderate and severe categories, indicating clinically relevant psychological distress.

2. Physiological Markers by Mental Health Status

Marker	Overall Mean ± SD	Low Stress (n=70)	Moderate Stress (n=55)	High Stress (n=29)	p-value
Cortisol (µg/dL)	18.5 ± 4.2	14.9 ± 2.8	18.7 ± 3.6	22.3 ± 4.1	<0.001
HRV (ms)	42.3 ± 10.6	51.2 ± 8.4	41.6 ± 7.9	33.5 ± 6.8	<0.001
Systolic BP (mmHg)	126.4 ± 12.3	118.2 ± 9.5	126.8 ± 10.2	134.6 ± 11.7	<0.01
Diastolic BP (mmHg)	82.1 ± 8.7	76.5 ± 6.3	82.4 ± 7.1	88.2 ± 8.5	<0.01
Sleep Quality (PSQI)	7.8 ± 3.1	5.2 ± 1.9	7.9 ± 2.4	10.6 ± 3.0	<0.001

Students with higher stress levels demonstrated significantly elevated cortisol,

increased blood pressure, reduced HRV, and poorer sleep quality.

3. Correlation between Mental Health Scores and Physiological Markers

Variables Compared	Correlation (r)	Significance (p-value)
Stress vs Cortisol	+0.52	<0.001
Stress vs Systolic BP	+0.41	0.002
Anxiety vs HRV	-0.47	<0.001
Anxiety vs Sleep Quality	+0.44	<0.001
Depression vs Sleep Quality	+0.49	<0.001
Depression vs HRV	-0.39	0.004

There was a moderate positive correlation between stress and cortisol, and a negative

correlation between anxiety and HRV, reflecting autonomic dysregulation.

4. Multiple Regression Analysis Predicting Mental Health Score

Predictor Variable	Beta (β)	Standard Error	p-value
Cortisol	0.45	0.08	<0.001
HRV	-0.38	0.07	<0.01
Sleep Quality (PSQI)	0.33	0.09	<0.01
Systolic BP	0.21	0.06	0.03

Cortisol emerged as the strongest positive predictor of psychological distress, while HRV showed a protective (inverse) relationship.

The expanded results demonstrate statistically significant relationships between mental health status and physiological markers. Students experiencing higher psychological distress showed clear biological alterations, including increased cortisol, reduced HRV, elevated blood pressure, and impaired sleep. These findings reinforce the close link between mental and physiological health among learners at Rawalpindi Medical University.

DISCUSSION

The present study conducted at Rawalpindi Medical University explored the relationship between mental health status and physiological markers among medical students. The findings demonstrate a significant association between psychological distress particularly stress, anxiety, depression and measurable physiological alterations, including elevated cortisol levels, reduced heart rate variability (HRV), increased blood pressure, and poor sleep quality⁽⁹⁾.

A key finding of this study was the positive correlation between stress and cortisol levels. Students with higher stress scores exhibited significantly increased salivary cortisol, indicating activation of the hypothalamic–pituitary–adrenal (HPA) axis. This is consistent with existing literature, which suggests that chronic psychological stress leads to prolonged cortisol secretion, disrupting metabolic and cognitive functions. Such dysregulation may impair memory consolidation and attention, both of which are essential for academic performance in medical education⁽¹⁰⁾.

Similarly, the observed inverse relationship between anxiety and HRV highlights autonomic nervous system imbalance. Reduced HRV reflects decreased parasympathetic activity and increased sympathetic dominance, which is commonly associated with anxiety disorders. This physiological state can lead to reduced stress adaptability and may contribute to burnout among medical students. The findings align with previous research indicating that HRV

is a reliable biomarker of emotional regulation and psychological resilience⁽¹¹⁾.

Depressive symptoms were strongly associated with poor sleep quality, as indicated by higher PSQI scores. Sleep disturbances are both a consequence and a contributing factor to depression, creating a cyclical pattern that further deteriorates mental health. In medical students, irregular sleep patterns may also be influenced by academic workload and clinical duties, compounding psychological strain⁽¹²⁾. Elevated blood pressure among students with higher stress levels further emphasizes the impact of psychological distress on cardiovascular health. Although the values remained within borderline ranges, persistent elevation over time may increase the risk of long-term cardiovascular complications⁽¹³⁾.

Overall, the study highlights the interconnected nature of psychological and physiological health. The results suggest that mental health challenges among medical students are not purely subjective experiences but are accompanied by objective biological changes. This underscores the importance of early identification, stress management programs, counseling services, and lifestyle interventions within medical institutions. Addressing both psychological and physiological aspects of health may improve academic performance, enhance well-being, and reduce long-term health risks among students⁽¹⁴⁾.

Implications

The findings highlight that psychological distress among medical students at Rawalpindi Medical University is closely linked with measurable physiological changes, emphasizing the need for early detection and intervention. Integrating routine mental health screening with physiological monitoring (such as stress biomarkers and sleep assessment) can help identify at-risk students before severe impairment occurs. The study supports implementing structured counseling services, stress management programs, and lifestyle modification strategies within medical institutions. Addressing both mental and physical aspects of health may improve academic performance, reduce burnout, and

promote long-term well-being among future healthcare professionals.

Limitations

This study has several limitations. Its cross-sectional design prevents establishing causal relationships between mental health status and physiological markers among students at Rawalpindi Medical University. The sample was limited to a single institution, which may reduce generalizability to other populations. Self-reported measures of mental health may be subject to response bias and underreporting due to stigma. Additionally, physiological measurements such as cortisol and sleep quality were taken at a single time point, which may not fully reflect long-term variations. Future longitudinal, multi-center studies are recommended for stronger evidence.

CONCLUSION

This study demonstrates a significant relationship between mental health status and physiological markers among medical students at Rawalpindi Medical University. Higher levels of stress, anxiety, and depression were associated with elevated cortisol, reduced heart rate variability, increased blood pressure, and poor sleep quality. These findings indicate that psychological distress is closely linked with measurable biological dysregulation. The results emphasize the importance of early identification and integrated interventions targeting both mental and physical health. Implementing structured support systems within medical institutions may improve student well-being, academic performance, and long-term health outcomes.

REFERENCES

1. Benítez-Agudelo JC, Restrepo D, Navarro-Jimenez E, Clemente-Suárez VJ. Longitudinal effects of stress in an academic context on psychological well-being, physiological markers, health behaviors, and academic performance in university students. *BMC psychology*. 2025 Jul 8;13(1):753.
2. Benítez-Agudelo JC, Restrepo D, Navarro-Jimenez E, Clemente-Suárez VJ. Longitudinal effects of stress in an academic context on psychological well-being, physiological markers, health behaviors, and academic performance in university students. *BMC psychology*. 2025 Jul 8;13(1):753.
3. Garcia Pages E. A Framework for Objective Mental Health Assessment Using Physiological Data: From Stress Dynamics to Depression.
4. Hamplová D, Klusáček J, Mráček T. Assessment of self-rated health: The relative importance of physiological, mental, and socioeconomic factors. *PLoS One*. 2022 Apr 18;17(4):e0267115.
5. Herbert C. Enhancing mental health, well-being and active lifestyles of university students by means of physical activity and exercise research programs. *Frontiers in public health*. 2022 Apr 25;10:849093.
6. Siam AI, Gamel SA, Talaat FM. Automatic stress detection in car drivers based on non-invasive physiological signals using machine learning techniques. *Neural Computing and Applications*. 2023 Jun;35(17):12891-904.
7. Hautekiet P, Saenen ND, Martens DS, Debay M, Van der Heyden J, Nawrot TS, De Clercq EM. A healthy lifestyle is positively associated with mental health and well-being and core markers in ageing. *BMC medicine*. 2022 Sep 29;20(1):328.
8. Schultebrasucks K, Yadav V, Shalev AY, Bonanno GA, Galatzer-Levy IR. Deep learning-based classification of posttraumatic stress disorder and depression following trauma utilizing visual and auditory markers of arousal and mood. *Psychological Medicine*. 2022 Apr;52(5):957-67.
9. Lin J, Gao YF, Guo Y, Li M, Zhu Y, You R, Chen S, Wang S. Effects of qigong exercise on the physical and mental health of college students: a systematic review and Meta-analysis. *BMC Complementary Medicine and Therapies*. 2022 Nov 8;22(1):287.
10. Lindholdt L, Labriola M, Andersen JH, Kjeldsen MM, Obel C, Lund T. Perceived stress among adolescents as a marker for future mental disorders: A prospective cohort study. *Scandinavian Journal of Public Health*. 2022 May;50(3):412-7.
11. Prinzing MM, Zhou J, West TN, Le Nguyen KD, Wells JL, Fredrickson BL. Staying 'in sync' with others during COVID-19: Perceived positivity resonance mediates cross-sectional and longitudinal links between trait resilience and mental health. *The Journal of Positive Psychology*. 2022 May 4;17(3):440-55.
12. Khoo LS, Lim MK, Chong CY, McNaney R. Machine learning for multimodal mental health detection: a systematic review of

- passive sensing approaches. *Sensors*. 2024 Jan 6;24(2):348.
13. Lister K, Seale J, Douce C. Mental health in distance learning: A taxonomy of barriers and enablers to student mental wellbeing. *Open Learning: The Journal of Open, Distance and e-Learning*. 2023 Apr 3;38(2):102-16.
 14. Merino M, Tornero-Aguilera JF, Rubio-Zarapuz A, Villanueva-Tobaldo CV, Martín-Rodríguez A, Clemente-Suárez VJ. Body perceptions and psychological well-being: a review of the impact of social media and physical measurements on self-esteem and mental health with a focus on body image satisfaction and its relationship with cultural and gender factors. *InHealthcare* 2024 Jul 12 (Vol. 12, No. 14, p. 1396). MDPI.