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Original Article

A Cross-sectional Study on Psychological Stress and Heart Rate Variability among First Year Medical Undergraduate Students

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Abstract

Objectives: Stress is a result of interactions between an individual and the environment. Academic stress in short duration can help increase concentration and long-term stress leads to attention deficits, poor decision-making leading to poor academic performance. The Kessler Psychological Distress Scale (K10) is a widely used tool for the measurement of psychological stress. Heart rate variability (HRV) gives an accurate understanding of the ability of the body to cope with stressors and acts as an indicator of psychological stress.

Materials and Methods: Participants from the first professional MBBS students were administered the K10 questionnaire. The responses were classified as doing well, likely to have mild stress, likely to have moderate stress, and likely to have severe stress. HRV analysis was carried out on a representative group of gender and age matched the study population.

Results: Among the 148 participants, 86 were female (58.1%), and 62 were male (41.9%). Analysis showed 20.9%were not under stress, 20.3% with mild stress, 14.2% with moderate stress and 44.6% showed severe stress. Among females, severe stress was noticed in 71.2%. Gender comparison revealed a $P = 0.0037$. HRV analysis showed the average low frequency (LF) value of 50.82 ± 6.17 in females compared to males (43.26 ± 7.83). High-frequency (HF) analysis in females was 47.07 ± 5.81, and in males was 55.20 ± 7.42. The LF/HF ratio in the male population was 1.2 and 1.5 in the female population.

Conclusion: Medical graduates experience a large amount of stress in their formative years of education. The prevalence of stress is more among females. The HRV analysis did not show any marked anomalies. The study underlines the need to sensitize time management, which may help the students handle the academic stressors better, leading to better academic performance.

Key words: Autonomic nervous system, Heart rate variability, Medical undergraduate students, Perceived stress scale, Stress, Sympathovagal balance

INTRODUCTION

Stress is an unavoidable experience that arises from the complex interactions between an individual and their environment.[1] Handling stress varies from person to person. Short-term stress can be beneficial as it results in the formation of new neurons, increases motivation and concentration. Long-term or chronic stress may lead to a wide range of physical and mental health problems, including heart disease, cancer, stroke, anxiety, depression, and burnout. Stress can reduce an individual's self-esteem, hinder academic performance, and interfere with personal and professional development.[2] Stress activates the body's autonomic nervous system, stimulating the prefrontal cortex, limbic system, and sympathetic systems, which lead to the increased production of stress hormones such as epinephrine, norepinephrine, and cortisol. Stress may also instigate negative health behaviors such as smoking, alcohol abuse, and substance use.[3] It is a well-documented

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fact that stress can diminish cognitive functions such as attention and decision-making, further exacerbating its negative effects on academic and professional success.[4]

Medical students, in particular, experience unique stressors due to the demanding nature of their education.[2] The level of stress among medical participants has been shown to depend on factors such as the medical curriculum, examination system, and administrative practices at the institutional level. The academic pressure that a medical student undergoes to acquire vast amounts of knowledge and skills is overwhelming, and the constant evaluation, peer competition, and unpredictable schedules create an environment ripe for stress.[5,6] In addition to the academic challenges, medical participants face emotional stressors such as exposure to death, human suffering, ethical dilemmas, and a lack of time for personal relaxation.[7] Studies have found that medical students' mental health at the beginning of their course is similar to that of their non-medical peers; however, as the course progresses, especially in the 1st year, it is particularly stressful for most students, as they adjust to the rigors of medical education.[8]

The Kessler Psychological Distress Scale (K10) and its adaptation of a 6-item scale called K-6 are widely used and validated tools for the measurement of psychological stress.[9-11] It is easy to use and can be used in multiple populations. It has been used in multiple settings such as military personnel, employees, adults with non-communicable diseases, adolescents, and the general adult population.[12-19] K10 has been validated in different populations such as Australia,[20] South Africa,[21] France[22] New Zealand,[23] Hong Kong, and American Indian population.[24]

One of the obstacles is the lack of consensus on how to define the stress of an individual. Two predominant methods of evaluating stress are by using psychological measurement tools and biological markers of stress, such as cortisol and amylase. However, heart rate variability (HRV) gives an accurate understanding of the ability of the body to cope with the stressor and is considered a reliable tool as an indicator of psychological stress. The most noticeable change in many studies is the low parasympathetic activity, which can be seen as an increase in low frequency (LF) and a decrease in high frequency (HF). Although large sample studies are required to confirm, there is evidence to suggest that HRV may be linked to cortical regions of the brain that are involved in the assessment of stressful situations.[25]

Cardiac autonomic function is assessed with the help of numerous autonomic function tests, such as heart rate response to standing, blood pressure (BP) response to standing, heart rate response to passive tilting, assessment of baroreceptor sensitivity, Valsalva ratio, cold pressor test, Nor-epinephrine spillage technique, standing to lying ratio, and Spectral analysis of HRV. The HRV analysis is the most common and easily reproducible non-invasive autonomic function test.[26]

HRV is a non-invasive electrocardiographic marker that reflects the activity of the Autonomic Nervous System (ANS) on the sinus node. It detects the variation in both the instantaneous heart rate and R wave Intervals (RR intervals). HRV analysis assesses the cardiac autonomic function of an individual.[27] It gives information regarding the sympathovagal balance of the person. Decreased HRV in a person with cardiac disease indicates impending sudden cardiac death. Altered HRV is also associated with autoimmune diseases, yoga, exercise, and sleep.[28]

The exact physiological mechanism of HRV remains unclear. HRV is the general term that is accepted to describe the oscillations of the interval between consecutive and instantaneous heart rates. The rhythmic changes in the heart rate at any given point in time are due to the complex interactions between the autonomic nervous system and the mechanical activity of the heart. The rate and rhythm of the heart are regulated automatically by the autonomic nervous system during resting conditions. It is also modulated by the central oscillators, like the vasomotor center, the respiratory center, and the peripheral oscillators, like arterial BP changes. HRV analysis gives us information regarding the state and functioning of the autonomic nervous system.[29]

MATERIALS AND METHODS

The study was conducted with participants from first professional MBBS students at Chettinad Hospital and Research Institute under the aegis of Chettinad Academy of Research and Education, situated in the southern part of Tamil Nadu. The study was carried out after obtaining Institutional Ethical clearance. As the questionnaire required a certain amount of self-analysis and required avoidance of interference from peers or family members, it was decided to send the questionnaire as a Google Form as well as hard copies, as per the choice of the participant, and the results were entered on an Excel sheet. As the name suggests, the questionnaire contains ten questions, and the answers had to be selected on a scale of 1–5 where 1 indicated none of the time, and 5 indicated all of the time. The participants were given an introduction to the grading scale and were told that they would have to base their responses on their last 30 days of experience. Each question was given a score of 5 per question. A total score of <20 indicates that he/she is doing well, 20–24 is likely to have mild stress,

25–29 is likely to have moderate stress, and score of above 30 is likely to have severe stress. The Kessler K10 psychological distress scale is a screening instrument and requires clinical judgment to decide on the requirement of treatment, if any. The questionnaire was voluntary in nature, and students were given the full freedom to opt out if they were not interested in the study.

Among the participants, one-third of the students were selected as a representative sample for a short-term HRV analysis using the AD Instruments PowerLab machine 2T. The participants were age and gender matched to have equal representation from both genders. Participants who were already on treatment for stress-related disorders were excluded from the study. The participants were advised to avoid exposure to any stimulants or depressants that may alter the recordings. Upon arrival, the participants were explained about the procedure and made to sit in the Research laboratory to achieve their baseline heart rate. After 15 min their height, weight, pulse, and BP were recorded as per the standard protocol. If the pulse or BP was elevated, they were advised to rest, and then the recordings were repeated. The electrodes were connected as per the recommendation of the manufacturers. A 5-min Lead II electrocardiogram recording in supine position devoid of artifacts was taken up for analysis.

RESULTS

A total of 148 participants who consented to the study were included. Of the 148 participants, 86 were female participants (58.1%) and 62 were male participants (41.9%). The average age of the study group was 18.4 ± 2.29. Among the study participants, 24 (16.2%) had a family history of hypertension, and 4 male participants were hypertensive on treatment. Analysis of responses to K10 showed 31 (20.9%) participants scored <20, leading to the conclusion of likely to be well. 30 (20.3%) participants scored between 20 and 24 were experiencing mild stress, 21 (14.2%) participants scored between 25 and 29 showed to have moderate stress, and 66 (44.6%) participants scored between 30 and 50 were experiencing severe stress [Table 1]. Among the participants with severe disorder, 19 (28.8%) were male and 47 (71.2%) were female. Among the hypertensive participants, 2 participants scored 50, indicating severe stress, and the other 2 participants scored 28, indicating moderate stress. The responses of participants to questions are tabulated in [Table 2].

Table 1: Distribution of scores in K-10 and gender

Scoring	Male	Female	Total
10–19	15	16	31
20–24	18	12	30
25–29	10	11	21
30–50	19	47	66

K-10: Kessler Psychological Distress Scale

The comparison between participants having less, mild, or moderate-to-severe stress among the male and female genders revealed a very statistically significant $P = 0.0037$. A representative sample of 50 participants, which included an equal number of participants from both genders, underwent 5 min short-term HRV recording, and the results showed the following. The average LF value in the female population was 50.82 ± 6.17 compared to males, whose value was 43.26 ± 7.83. If we consider the HF band, the females had an average value of 47.07 ± 5.81, whereas the male population had an average value of 55.20 ± 7.42. The difference in value is not statistically significant. The average LF/HF ratio in male population was 1.2 compared to female population, which was 1.5.

DISCUSSION

The World Health Organization defines stress as a state of worry or mental tension caused by a difficult situation. Undergraduate medical education in India under the new curriculum focuses more on self-directed learning and continuous evaluation of participants, not just during examinations. Every single aspect of medical training is assessed, and few are marked as certifiable competencies; evaluation can be done at any stage of the teaching–learning process. Hence, the participants are under constant stress to perform well on a day-to-day basis. However, the evaluation is justified considering that the participants are expected to meet the requirements of an Indian Medical Graduate.

The prevalence of severe stress among medical undergraduate participants in our study was 44.6%, and showed that female participants were more so under severe stress compared to males. Comparatively, in the group with nil stress, mild stress, and moderate stress, the gender prevalence was more or less equal. The study results resonated with some studies done in Ethiopia, Brazil, and Malaysia.[2]

HRV is analyzed mainly using the time domain and frequency domain.[30] The frequency domain method is also called the Power spectral density analysis. Frequency domain variables can be expressed both in absolute values (ms^2) and normalized units (n.u).[26] Spectral analysis explains the sympathovagal influence on the heart rate. The various spectral analysis variables are given in [Table 3].

HF or the HF component affects the vagal activity, which is proven by the electrical vagal stimulation, muscarinic

Table 2: Analysis of response to K-10 questionnaire

S. No.	Questions	Males (19)	Females (47)	Total (66)
1.	In the past 4 weeks, about how often did you feel tired out for no good reason?	3.53±1.17	3.11±1.26	3.23±1.40
2.	In the past 4 weeks, about how often did you feel nervous?	3.95±1.31	3.30±1.02	3.48±1.14
3.	In the past 4 weeks, about how often did you feel so nervous that nothing could calm you down?	4.16±1.21	2.79±1.31	3.18±1.42
4.	In the past 4 weeks, about how often did you feel hopeless?	4.31±0.89	4.21±0.69	4.24±0.75
5.	In the past 4 weeks, about how often did you feel restless or fidgety?	4.00±1.15	4.04±0.66	4.03±0.82
6.	In the past 4 weeks, about how often did you feel so restless you could not sit still?	3.32±1.34	3.51±1.16	3.45±1.20
7.	In the past 4 weeks, about how often did you feel depressed?	4.32±1.20	3.70±0.98	3.88±1.07
8.	In the past 4 weeks, about how often did you feel that everything was an effort?	4.05±1.13	4.15±0.59	4.12±0.78
9.	In the past 4 weeks, about how often did you feel so sad that nothing could cheer you up?	3.89±1.24	3.51±1.02	3.62±1.09
10.	In the past 4 weeks, about how often did you feel worthless?	3.37±1.46	4.26±0.94	4.00±1.18
	Total	38.89±6.95	36.57±4.15	37.24±5.17

K-10: Kessler Psychological Distress Scale

Table 3: Frequency domain parameters

Variable	Units	Description	Frequency range
Analysis of short-term recordings			
5 min total power	ms^2	The variance of NN intervals over the temporal segment	Approximately≤0·4 Hz
VLF	ms^2	Power in VLF range	≤0.04 Hz
LF	ms^2	Power in LF range	0.04–0.15 Hz
LF norm	n.u	LF power in n.u.	LF/(Total power–VLF) × 100
HF	ms^2	Power in HF range	0.15–0.4 Hz
HF norm	n.u.	HF power in n.u.	HF/(Total power–VLF)×100
LF/HF		Ratio between LF and HF	LF (ms^2)/HF (ms^2)

VLF: Very low frequency, LF: Low frequency, HF: High frequency, Norm: Normalized Values, ms^2: Millisecond squared, n.u.: Normalized units

blockade, and vagotomy.[31,32] An increase in the HF component indicates increased vagal activity of a person. At the same time, a decreased HF value indicates decreased vagal activity. There exists a controversy regarding the interpretation of the LF or the LF component. Some researchers[32,33] suggest that the LF value is purely sympathetic when expressed in normalized units. An increase in LF value indicates an overactive sympathetic nervous system. The ratio between the frequency values, i.e., the LF/HF ratio, reflects the sympathovagal balance. An increase in the LF/HF ratio suggests an increase in sympathetic nervous system activity. A decreased LF/HF ratio suggests decreased activity of the sympathetic nervous system.

For this study, short-term recording with power spectral analysis was considered. The analysis of LF values showed higher values in female population compared to their male counterparts. Similarly, the HF value was lower in females compared to the male population. This indicates a slight preponderance of sympathetic overactivity in females and may correspond to increased prevalence of stress in the female study group. On the flip side, the male participants showed slightly higher HF values, indicating a parasympathetic predominance. The analysis of LF/HF ratio among the gender groups showed an average value of 1.2 among males and 1.5 among females, which is well within the normalized values presented in the Task Force guidelines of 1996. This could be explained by the participants' coping with stress and the short-term duration of stress experienced by the candidates. It may also be noted that no particular stressors were applied during the conduct of HRV measurement, and hence the effect of stress on HRV needs extensive large population studies under various circumstances experienced by the candidate during the course of their study. This study also outlines the importance of understanding the stress levels among medical undergraduate students right from the early stages, so that stress management strategies can be devised and implemented to ensure a healthy atmosphere of teaching and learning to fulfill the characteristics of an ideal Indian medical graduate. HRV analysis can be used as an effective tool to screen for the possibility of stress-related effects in a subset of candidates who may be prone to difficulties in handling their psychological stress and may not be able to approach for guidance for various reasons. Since a 5-min short-term analysis was conducted, frequency domain parameters were taken up for analysis, and LF and HF power (n.u) values were considered. The analysis did not show any variations from normal. The possible explanation is that the duration of exposure to stress was limited, as the study participants were in the 1st year of medical graduation.

CONCLUSION

Stress is an important factor determining the academic performance of the candidate, and more so in the formative

years of medical education. The medical undergraduates are exposed to harsher elements of health care and are under constant need to perform academically to be ahead of their peers. Some of the stressors are quantitatively more compared to their peers in other educational streams. The stress response varies with the individual's mindset, his/her past experience, and their ability to cope and chart out an academic plan on a day-to-day basis. This study highlights that a large number of medical undergraduates are under severe stress, and also that the female gender is more prone to academic stress. In most cases, it boils down to improper time management, which leads to the accumulation of academic work to be completed in a very short time.[34-36] The HRV analysis shows minimal changes, which are still under acceptable physiological limits. If the candidate is allowed to be under the same stressful environment, it may lead to significant changes in HRV analysis. This study highlights the importance of time management so that a few avoidable stressors can be managed, and the student should be able to cater to their academic requirements in a better way. It would be ideal if a session on time management is inculcated into their academic schedule, and the importance of early communication with their teachers is emphasized, so that the candidate might be able to use the minimal academic stresses positively and work towards the goals in a more positive manner.

Limitations of the Study

This study was based on a self-administered questionnaire, and hence, the assumption that all responses were genuine had to be made. Few of the participants may not have been comfortable declaring the family history of hypertension. The questionnaire had to be answered based on their experience in the past 4 weeks, which may or may not reflect the exact stress a medical graduate faces during his/her entire study period.

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