Original article

Effect of psychological stress on time and frequency domain parameters of heart rate variability in undergraduate medical students

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ABSTRACT

Background: Psychological stress disrupts student capabilities along with several physiological and psychological processes including functioning of autonomic nervous system. Heart rate variability is an important indicator which reflects the functioning of autonomic nervous system. The objective of this study was to measure and compare the effect of stress on time and frequency domain parameters of heart rate variability among stressed and stress-free medical students.

Subjects and methods: This cross-sectional study was carried out at Power lab room, department of Physiology at Islamic International Medical College, Rawalpindi from September 2016 to January 2017. Students were randomly divided into two groups i.e. stressed and stress-free group on the basis of their Depression Anxiety Stress Scale questionnaire score. Ten minutes Electrocardiogram (ECG) of each participant was measured in power lab room and parameters of heart rate variability, including time domain (heart rate and Root Mean Square of the Successive Differences (RMSSD) of R-R intervals) and frequency domain (low frequency (LF), high frequency (HF) and LF/HF ratio) were analyzed by using lab chart 8 pro software.

Results: Stress significantly reduces Heart Rate Variability (HRV). Among parameter of HRV, Heart rate, Low Frequency (LF), LF/HF ratio was significantly raised in stress group as compare to stress free group ($p<0.05$). High Frequency (HF) parameter of HRV was significantly increased in stress free group as compared to stress group ($p<0.05$).

Conclusion: Stress upsurges cardiac sympathetic nerve activity and reduces cardiac parasympathetic nerve activity as reflected by parameters of Heart rate variability.

Keywords:
Depression Anxiety Stress Scale, Electrocardiogram, Heart Rate Variability, Stress, Medical students

INTRODUCTION

Stress is a state of endangered homeostasis which disturbs numerous physiological processes in the body.[1] Medical education is considered stressful and remains an area of concern worldwide. Academic achievement in a competitive environment may produce drastic effects on young vulnerable medical students.[2] Unidentified and unattended stress diminishes a student's self-esteem, cognitive functioning, academic achievement which can lead to deterioration in relationships and even dropout from medical school.[3,4] Brain takes an effective reaction to the stressful life events and initiates various central and peripheral physiological responses recognized as reactivity. Reactivity is associated with individual's emotions and behaviors and leads to the activation of the various homeostatic regulatory systems like Hypothalamic–Pituitary–Adrenal axis and sympathoadrenal axis.[5] Perceived level of stress in an individual can be measured by using validated and reliable DASS (Depression Anxiety Stress Scale) questionnaire. On the basis of the score an individual can be labeled as stress free or suffering from mild, moderate, severe or extreme severe stress.[6] Stress results in an upsurge in sympathetic discharge and a decline in parasympathetic discharge enhance it disturbs the functioning of autonomic nervous system.[7]

Autonomic nervous system respond towards various stressors by alternating arousal, breathing and heart rate.[8] Enhanced sympathetic activity affects various cardiovascular functions of the body including blood pressure, heart rate, ventricular depolarization and heart rate variability (HRV).[9] Reduced parasympathetic activity of the body can be reflected by reduced cardiac vagal tone.[10] The capability of

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autonomic nervous system to deal with stressors depends upon high level of resting vagal tone.[7] Reduced resting vagal tone shows an individual's inability to meet situational demand and makes him more prone towards developing life threating conditions including rhythm disturbances of heart.[11]

Stress-induced sympatho-vagal imbalance can be investigated by analyzing HRV. Fluctuations in the activity of autonomic nervous system exert changes on heart rate and are reflected by HRV. The overall effect of sympathetic or parasympathetic nervous system on heart rate can be determined by calculating R-R intervals (RMSSD), a time domain component of HRV. Beat to beat frequency variations can be analyzed by spectral analysis of HRV in terms of high frequency (HF) and low frequency (LF) components.[12] High frequency component of HRV is regulated by vagal tone. Whereas changes in outflow of both vagal and sympathetic tone is reflected by change in lower-frequency component of HRV. The LF/HF ratio shows the balance among parasympathetic and sympathetic nervous system. Stress is accompanied by a decrease in HF component of heart rate variability and increase in LF/HF ratio due to a significant increase in sympathetic activity reduction in parasympathetic activity.[13] In order to minimize skewness of distribution LF and HF components of HRV are measured in normalized units.

Alternation in heart rate variability is an important indicator for cardiovascular mortality and morbidity. Since medical education is known for its stressful effects, this study is conducted to measure and compare the effect of stress on autonomic nervous system by determining time and frequency domain components of HRV in stressed and stress-free medical students.

SUBJECTS AND METHODS

This cross-sectional study was carried out at Department of Physiology at Islamic International Medical College, Rawalpindi from September 2016 to January 2017. Seventy healthy students of Islamic International Medical College from 1st and 2nd year MBBS with age of 18 to 25 years were included. At first, 21-item Depression Anxiety Stress Scale (DASS) proforma was distributed among 200 MBBS Students. Those who scored 19-25 on the proforma were categorized as moderate stress individuals while those who scored 0-14 on DASS proforma were categorized as stress-free. Individuals with any chronic ailment like hypertension diabetes or asthma were excluded from the study. Among the eligible students, 35 students were randomly selected in both groups through balloting method. Informed consent was taken from all the study participants and they were asked to visit the Power Lab Room of the department between 9.00 to 11.00 AM. They were instructed in advance to refrain from drinking tea or coffee. Once the participants arrived, they were asked to sit and relax for five minutes. Participants were instructed to remove any metallic items like keys, mobile phone, belt, etc. Measures were taken to avoid any noise distractions in the room. A ten minutes ECG was recorded by using power lab model Yam 4/25T in sitting posture. They were asked to avoid body movements during ECG recording. Heart rate variability of the participants was analyzed from recorded ECG according to the guidelines published by North American Society of Pacing Electrophysiology.[14] Low frequency component, High frequency component and the ratio of Low to High frequency components of HRV were measured by analyzing frequency domain parameter of HRV using fast Fourier transform (FFT) system. Time domain and Frequency domain parameters of HRV were measured and compared among stressed and stress-free group. In time domain components Heart rate and Root Mean Square of the Successive Differences (RMSSD) of R-R intervals were measured while in frequency domain parameters LF, HF and LF/HF ratio were measured. All the variables of HRV were log transformed in order to avoid skewness of distribution. For the analysis of data, Statistical Packages for Social Sciences (SPSS) version 21 was used. Significant statistical difference among two groups was assessed by the application of Independent sample t-test. A p-value of less than 0.05 was considered as statistically significant.

RESULTS

Depression Anxiety Stress Scale proforma was primarily given to 200 students. Among these students 183 returned the proforma so the response rate was 91.5%. Eighty-six (47%) students scored in a range of 19-25 while 42 (23%) scored in a range of 0-14. Table I compares Time domain and Frequency domain parameters of HRV among stress and non-stress group. Heart rate was significantly raised in stressed group as compared to stress-free group. Whereas RMSSD of R-R intervals was prolonged in stress-free group as compared to stress group. Among the Frequency domain parameters of HRV, high frequency component of HRV in terms of both absolute and normalized units was significantly reduced in stressed group, whereas low frequency component (normalized unit) of HRV & LF/HF ratio was markedly raised in stressed group.

Table 1. Comparison of time and frequency domain parameters of heart rate variability in stress and stress free group

Heart Rate Variability Parameters	Stressed group (Mean ± S.D)	Stress-free group (Mean ± S.D)	p-value
Heart rate (HR/minute)	79.74 ± 4.51	74.73 ± 5.17	.000*
RMSSD R-R interval	40.82 ± 12.79	46.94 ± 15.42	.075
LFms^2	1048.20 ± 347.60	883.80 ± 423.41	.080
HFms^2	606.45 ± 401.06	832.68 ± 463.12	.032*
LF/HF	4.13 ± 0.77	2.76 ± 0.54	.033*
LF nu	92.66 ± 4.27	89.36 ± 4.54	.017*
HF nu	1.42 ± 0.88	1.93 ± 1.07	.027*

*p value < 0.05 is significant

DISCUSSION

Stress in medical students is an area of global concern. It affects psychological well-being of medical students and affects the functioning and effects of autonomic nervous system. Time and frequency domain parameters of HRV, reflects the activity of autonomic nervous system. Present study determines the effect of stress on time and frequency domain parameters of heart rate variability. In comparison with the stress free individuals the stressed individuals showed an increase in heart rate, LF/HF ratio and LF parameter of HRV. Stressed individuals had a reduced RMSSD of R-R interval and HF component of HRV which shows that they have poor vagal activity as compared to the non-stressed individuals.

Montano and colleagues concluded that High Frequency component of HRV reflects the cardiac vagal nerve activity while Low Frequency component reflects the cardiac sympathetic nerve activity. LF/HF ratio acts as a weighing scale between cardiac sympathetic and parasympathetic nerve activity.[15] Current study endorses the belief that stress upsurges the sympathetic nerve activity and decreases the parasympathetic nerve activity as reflected by an increased heart rate and a reduced HF component of HRV in stressed group.

Findings of this study are in accordance with a previous study on a group of doctors who complained psychological stress at work. It was observed that in comparison with the stress-free subjects, the doctors had a reduced HF component of HRV, making them susceptible for developing cardiac rhythm disturbances.[16] Current study also seconds the findings reported by Eller and group who conducted study on stressed engineers & teachers and found decreased HF component of HRV as compared to stress free individuals.[17] In contrast to previous studies, this study measured both time and frequency domain parameters of HRV and compares these parameters among stress and stress-free medical students.

Increase in LF/HF ratio of HRV reveals cardiac autonomic imbalance with a predominance of cardiac sympathetic nerve activity. Hintsanen and coworkers performed a study on office workers and concluded that psychological stress in office workers resulted in an increase in LF/HF ratio which is in line with the findings of our study.[18] Takada and colleagues showed that use of stress coping strategies increases HF component of HRV and decreases LF/HF ratio.[19] This shows that stress coping strategies increase the Cardiac vagal nerve activity and decreases the cardiac sympathetic nerve activity. Similar findings were reported by Minakuchi and coworkers.[20]

LF Component of HRV reflects the cardiac sympathetic nerve activity and its value is raised as a result of stress. Collins and group reported an increase in LF component of HRV in high strain group.[21] Kemp and associates also reported similar findings with difference that they conducted the study on depressed individuals.[22]

CONCLUSION

Stress reduces HRV parameters associated with cardiac parasympathetic nerve activity and increases HRV parameters associated with cardiac sympathetic nerve activity. Heart rate variability can be used as a non-invasive tool to determine cardiac autonomic functioning in stressed individuals. Biochemical parameters MAY be assessed along with HRV for evaluating stress effects on cardiac autonomic functioning.

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