Examination stress and its effect on EEG

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Abstract

Background: Medical curriculum is highly stressful because of mismatching of time and curricular activity. Some stress is also required for the study. Therefore, this study is designed to find out the changes in brain owing to examination stress, which is evaluated by electroencephalogram (EEG).

Objective: To find out the changes in EEG waves owing to examination stress.

Material and Methods: Sixty-two medical students were selected by questionnaire method (Medical Students Stressor Questionnaire). They were grouped in four categories of stress—mild, moderate, high, and severe. EEG was recorded in all the subjects in two settings [i.e., in normal day-to-day life (baseline) and during examination stress]. Paired *t*-test was applied to compare the changes in both the situations.

Result: In subjects with mild and moderate stress, the baseline EEG was alpha wave, and the EEG in examination stress was beta wave. In subjects with high stress, the baseline EEG and the EEG in examination stress was beta wave. In subjects with severe stress, the baseline EEG was beta wave and the EEG in examination stress was theta wave. In each level of stress, the change is statistically significant. Subjects with mild and moderate stress subjects were able to cope with the situation; so, baseline EEG was alpha wave. But, during the period of examination, their levels of stress increased and were unable to cope; so, EEG showed beta waves. In subjects with high stress, both baseline EEG (low frequency wave) and EEG in examination stress (high frequency wave) were beta waves. In subjects with severe stress, baseline EEG was beta wave but the examination stress EEG showed theta wave because of frustration and disappointment.

Conclusion: This study concludes that examination stress can alter the brain function to a certain degree, which is quantified by EEG.

KEY WORDS: Medical students, stress, EEG

Introduction

Stress is an emotional disturbance or any change to environment caused by stressors. Some stress in medical college is essential for learning.[1] Stress may be two types i.e. favorable stress and unfavorable stress. Favorable stress promotes learning whereas unfavorable stress suppress learning.[1] The same stressors may be perceived in different way by different medical students on the basis of their cultural background, personal traits, experience and coping skills. Unfavorable stress is associated with difficulties in solving interpersonal conflicts, increased alcohol and drug consumption, anxiety and depression, reduced concentration and academic dishonesty, sleeping disorders.[1-8] Unfavorable stress is also associated with inhibition of students' academic achievement and personal growth development.[1] As a result, medical students may feel inadequate and unsatisfied with their career as a medical practitioner in the future. Therefore many researchers have stated the importance of early diagnosis as well as effective psychological services, which can prevent possible future illnesses among medical students. Stressors of medical students generally were grouped into

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six categories; academic related stressors (ARS), intrapersonal and interpersonal related stressors (IRS), teaching and learning-related stressors (TLRS), social related stressors (SRS), drive and desire related stressors (DRS), and group activities related stressors (GARS). There is evidence that the stressors affecting medical students wellbeing seems to be related to the medical training.[9-13] A study reported that top stressors are tests and examinations, time pressure and getting behind in work as well as conflicting demands, not getting work done within time planned and heavy workload, etc.[12] Another study reported that students having high self-expectations are at greater risk for psychological distress.[14] It may be due to high self-expectation to do well in examinations.[11] All of these stressors were related to the academic matter.[9-13] Intrapersonal conflict, interpersonal interaction and relationship were reported as stressors for medical students, such as poor motivation to learn, conflict with other students, teachers and personnel.[11-13] These stressors were basically related to intrapersonal and interpersonal relationship matters. Dissatisfaction with quality of education, with lectures, with guidance and feedback from teachers and with recognition of work done as well as uncertainty of what is expected from the students was also perceived as stressors.[9,11,12,15] All of these stressors were generally related to the teaching and learning process. The level of dissatisfaction in social activities is associated with psychological distress among medical students.[9] There is significant relationship between emotional disorder and medical students' relationship with their family and friends.[9] A study reported that, facing illness or death of patients and unable to provide appropriate answer to patients were sources of stress for medical students.[11,16] Dissatisfaction with social activities is associated with emotional disorder.[9,17] These stressors were generally related to the social relationship between the students with other people such as family and patients. Different studies have reported that political and family pressures as well as fear of wrong career choice and unwilling to study medicine were recognized as stressors in medical students.[9,12] All the stressors were related to the motivation of the students to learn medicine. The group learning environment, including tutor performance, and interactions with peers and patients caused little stress.[16] Feeling of the need to do well (imposed by others) in learning activities was also reported as one of the stressors.[11,12] These stressors were related to the group activities during their study. Any stress stimuli recognize are transmitted first upward through the brainstem and eventually to the median eminence of hypothalamus from which corticotropin releasing hormone (CRH) is secreted into Hypothalamo-Hypophysial Portal system. CRH increases adrenocorticotropic hormone (ACTH) secretion from anterior pituitary that leads to secretion of large quantity of cortisol from adrenal cortex. CRH also activates the sympathetic nervous system including adrenal medulla and catecholamines are released.[18] Mental stress can also cause an equally rapid increase in ACTH secretion. This is believed to be result from increased activity in limbic system especially in the region of amygdala and hippocampus. Both of which then transmit the signals to the posterior medial hypothalamus.

The fight and flight reaction which linked emotional expressions such as anxiety, fear to physiological changes in the periphery is associated with activation of the sympathetic adrenal medullary (SAM) system. The markers of the fight and flight reaction are the catecholamines i.e. epinephrine and norepinephrine which increase when stress appears. Thus, the SAM system is activated when the individual is challenged in its control of the environment, or is threatened, and this defense reaction prepares the body for battle or escape. Epinephrine is also related to mental effort and cognitive performance. Under normal levels of stress increased epinephrine is associated with improved performance. In fact, several studies showed that stress, but only up to a certain level, improve performance, e.g. on selective attention tasks.[19]

The General Adaptation Syndrome (GAS) that reflects the physiological changes following adverse emotional stimulation that is prolonged stress. GAS consisted of three phases – an alarm phase, a resistance phase and an exhaustion phase – and the bodily stress response is proposed to be nonspecific irrespective of the stressor. The hypothalamic-pituitary-adrenal (HPA) axis has a central part of GAS. Activation of the HPA system is associated with release of the hormones ACTH and cortisol. The activation of HPA and SAM leads to increased arousal, which means that energy is mobilized and aids the body in the physical fight or flight. Activation or arousal of the stress systems leads to a cluster of behavioral and physiological changes that are remarkably consistent. The stress response related to behavioral adaptation includes increased alertness and vigilance, improved cognition and focused attention, and inhibition of vegetative functions, such as appetite, feeding and reproductive function. The stress response related to physical adaptation aims at promoting an adaptive redirection of energy to the body sites where they are needed most, increased cardiovascular activity (elevated heart rate and blood pressure), increased respiratory rate and intermediate metabolism – all work in concert to promote availability of vital substrates. Electrical brain activity (measured with EEG) shows a desynchronized pattern during stress and strong excited emotions (e.g. fear) and beta frequencies are dominating. In a relaxed, non-stressful state, the EEG contains an alpha activity.[20] Although mechanisms underlying EEG generation are not fully understood, interactions between thalamic and cortical networks are assumed to play a key role in various rhythmical EEG activities.[21] Several thalamic, thalamocortical, and cortical neurons display intrinsic oscillatory patterns, which in turn generate rhythmic EEG oscillations. The thalamus, in particular, has been described as a key player in the generation of alpha and beta oscillations. Accordingly, thalamic oscillations in the 8-13 Hz frequency range have been shown to activate the firing of cortical neurons.[21] Similarly, corticocortical and thalamocortical interactions during information processing have been postulated in the generation of oscillations at higher frequencies, including the beta band (13-30 Hz). Notably, the thalamus has been also implicated in the generation of delta waves (1-4 Hz), which might arise through interactions between deep cortical layers and the thalamus that are normally inhibited by afferents from the ascending reticular activating system. In addition, the septohippocampal system and various limbic regions (e.g., hippocampus, cingulate cortex) have been implicated in the generation of theta oscillations.[22-23]

Materials and Methods

The study was conducted in the Department of Physiology, V.S.S. Medical College, Burla, Sambalpur, Odisha, India. The study was done during the period from August 2013 to June 2014 and was approved by institutional ethical committee, V.S.S. Medical College, Burla. Medical students were taken as the subjects for this study. Initially, Medical Student Stressor Questionnaire (MSSQ) was distributed among 75 medical students. The questionnaire consisted of 40 questions, grouped into different stressor groups such as ARS, SRS, IRS, TLRS, DRS, and GARS. Students were instructed to answer these questionnaires within 15 min. Data regarding the age, sex, academic year, and any disease history were taken. The questionnaires were analyzed after return, which formed the basis of the selection of subjects. Students having any type of disease were excluded from study. A total of 62 students were selected for study. Those students were grouped into four groups according to their level of stress (i.e., mild, moderate, high, and severe). The number of students in mild, moderate, high, and severe group was 18, 20, 15, and 9, respectively. The purpose of study and its output was clarified to the subjects. A written consent was taken from each subject. EEG was done for each subject at two settings for each subject in the department of Physiology. First, EEG was done in a normal study setting when there is no stress of examination (i.e., in normal day-to-day life), and the EEG recorded was termed as baseline EEG. Second, the EEG of each subject was done during the period of examination. Then, the EEG of each subject of normal study setting and examination stress were analyzed by paired *t*-test. Statistical software SPSS, version 16, was used for statistical analysis. The different EEG waves obtained were theta (4-8 Hz), alpha (8-13 Hz) and beta (13-30 Hz) and gamma (30–80 Hz). Tables and graphs were generated by Microsoft Word.

Result

Table 1 shows the distribution of subjects in different stress groups. The age of all subjects was between 18 and 23 years, and they were from all academic years. Both male and female subjects were included in this study. Table 2 shows the comparison of mean frequency of EEG waves of subjects of "mild" stress group in normal day-to-day life (baseline EEG) and EEG during examination stress. Baseline EEG showed alpha wave, and EEG wave during examination stress showed beta wave. This difference in frequency was statistically significant. Table 3 shows the comparison of mean frequency of EEG waves of subjects of "moderate" stress group in normal day–to-day life (baseline EEG) and EEG during examination stress. Baseline EEG showed alpha wave, and EEG wave during examination stress showed beta wave. This difference in frequency was statistically significant. Table 4 shows the comparison of mean frequency of EEG waves of subjects of "high" stress group in normal day-to-day life (baseline EEG) and EEG during examination stress. Baseline EEG showed beta wave, and EEG wave during examination stress also showed beta wave. Here, in both cases, the wave was beta but the difference in frequency was significant. Table 5 shows the comparison of mean frequency of EEG waves of subjects of "severe" stress group in normal day-to-day life (baseline EEG) and EEG during examination stress. Baseline EEG showed beta wave, and EEG wave during examination stress showed theta wave. This difference in frequency was statistically significant.

Table 1: Number of subjects in different stress groups

Level of stress	No. of subjects
Mild	18
Moderate	20
High	15
Severe	9

Table 2: Comparison of mean frequency of EEG waves of subjects of mild stress group

Study settings	Number of subjects	Mean frequency of EEG (Hz)	SD	*t*	*P*
Baseline EEG	18	9.94	1.30	–11.28	0.000000
EEG during examination stress	18	23.22	5.12		

Table 3: Comparison of mean frequency of EEG waves of subjects of moderate stress group

Study settings	Number of subjects	Mean frequency of EEG (Hz)	SD	*t*	*P*
Baseline EEG	20	9.30	1.03	–32	0.000000
EEG during examination stress	20	25.10	2.73		

Table 4: Comparison of mean frequency of EEG waves of subjects of high stress group

Study settings	Number of subjects	Mean frequency of EEG (Hz)	SD	*t*	*P*
Baseline EEG	15	20.53	3.70	–2.94	0.010685
EEG during examination stress	15	22.20	3.12		

Table 5: Comparison of mean frequency of EEG waves of subjects of severe stress group

Study settings	Number of subjects	Mean frequency of EEG (Hz)	SD	*t*	*P*
Baseline EEG	9	24.55	1.50	–38.89	0.000000
EEG during examination stress	9	6.22	0.83		

Discussion

Medical curriculum is highly stressful. The cause may be because of mismatching of time and academic career or other associated factors such as social factors, socioeconomic status of parents, choosing profession, etc. Different studies have reported that tests and examinations are the top stressors for medical students. The purpose of this study was to find out the effect of examination stress on EEG waves. Stress is caused by human resistance toward new challenges or stressors emotionally, mentally, or physically. In other words, stress causes an imbalance of sympathetic and parasympathetic response in human autonomous nervous system (ANS). The changes in ANS owing to stressors can be apparently and effectively represented by EEG signals. Researchers have reported the characteristic change of EEG signals owing to the change of human cognitive states after performing some mental tasks.

In this study, different outputs came out. In subjects with mild and moderate stress, the EEG in normal day-to-day life showed alpha wave, because they were mentally relaxed and might have coped with the situation. But, the same subjects with mild and moderate stress subjects when exposed toward examination, their attention was focused in examination while alertness and anxiety level increased for which the alpha wave was replaced by the beta wave.[20,24,25] In subjects with high stress, the EEG in both normal day-to-day life and examination stress was beta wave. They might not be coped with the curriculum in normal day-to-day life, which resulted in a high degree of stress, and their EEG showed beta wave. When they were exposed toward examination, their stress level further increased for which they showed the beta wave in EEG. The frequency of beta wave during examination stress was more than the frequency of baseline.[20,24] In subjects with severe stress, the EEG in normal day-to-day life was beta wave, because they were alert and the attention was focused. But, when they were exposed to examination stress, their EEG was theta wave, may be because of frustration, disappointment, or an impaired information processing.[26]

Conclusion

This study concludes that medical curriculum is a stressful environment for the students who do not cope or adjust with the situation. But, those who cope with the situation, they feel less stress. However, at the time of examination, all students experience more stress because the course is so difficult, and they have to perform well in examination also. There are so many biosignal channels such as electrocardiogram (ECG), EEG, electrooculography (EOG), electromyography (EMG), sympathetic skin response (SSR), estimation of blood hormone, etc. In this study, the stress was quantified by biosignal channel EEG. Medical students are future doctors of the society, and they should remain stress free for their benefit and for the society. Thus, students are advised to release stress by different techniques such as yoga, exercise, etc.

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