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Research Article

UNDERSTANDING THE RESPONSE OF ACADEMIC STRESS ON STUDENT'S BODY AND SYMPATHETIC NERVOUS SYSTEM

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ABSTRACT

Background: Stress is considered as a significant problem in the modern world, which leads to many systemic complications.[1] it is believed that many undergraduate students undergo considerable stress. Some undergraduate students can see these transitions as a positive experience that can be exciting, but some students seem to be threatened by this change.[2]

Objective: The present study was carried out to assess stress and its effect on sympathetic nervous system during academic examination in medical students.

Methodology: A total of 60 subjects were studied. PR, RR, body temperature and GSR were taken before and during mental arithmetic task.

Result: There was highly significant difference in PR (P<0.001), RR (P<0.001), body temperature (P<0.001), GSR amplitude (P<0.001) and GSR latency (P- value 0. 018) during MAT. There was significant difference between genders in peak wave height (P- value 0.017), other parameters did not show any change. Year level did not show any significant difference.

Conclusion: It can be concluded that there does occur, increased sympathetic activity in students subjected to MAT, extrapolated to conclude that students undergo stress resulting in sympathetic stimulation before/during examinations.

Key words: Galvanic skin response, mental arithmetic task and Stress.

INTRODUCTION

Stress is considered as a significant problem in the modern world, which leads to many systemic complications.[1] It is believed that many undergraduate students undergo considerable stress due to the demands associated with change: leaving home, becoming independent decision makers, and competing against new standards. Some undergraduate students can see these transitions as a positive experience that can be exciting, but some students seem to be threatened by this change.[2]

One of the main causes of academic stress is test anxiety. [3] Most undergraduate students seem to be more emotionally vulnerable due to examinations. Increased anxiety from tests has a debilitating effect on their performance. When information generated by worrying about the test reduces the capacity for performing the task, the result is that performance breaks down and the result becomes self-confirming. After completing an examination, there is a period of depression when students reflect on their performance and compare it to how their colleagues did. Poor confidence and a perception of poor performance can be an important reason for depression that occurs after examination and no further changes are possible. More emphasis is needed on understanding the impact of examinations on students, on identifying vulnerable individuals, and on the appropriateness of the current examination process.[2]

One bridge between the mind and body is the study of stress and its impact on human performance. Understood today as an orchestration of physiological mechanisms, the physiological stress response is initiated by sub-cortical structures in the brain, principally the amygdala, which initiates a chain of events to prepare the individual for "fight or flight" in response to the perceived stressor. First, the paraventricular nucleus of the hypothalamus releases corticotropin-release factor (CRF). CRF activates the loecus coeruleus, causing release of norepinephrine throughout the brain CRF stimulates the anterior pituitary to release adrenocorticotropic hormone (ACTH) into the bloodstream. ACTH, in turn, stimulates the adrenal cortex to secrete glucocorticoids, mineralocorticoids and androgens. Cortisol, also known as the stress hormone, is a glucocorticoid that causes immunosuppression and increases blood glucose concentrations through glycogenolysis and gluconeogenesis. This pathway is known as the hypothalamic-pituitary-adrenal (HPA) axis. [4] The stress response also stimulates secretion of catecholamines, primarily epinephrine and norepinephrine, through the release of acetylcholine from sympathetic preganglionic nerve fibers; this mechanism is known as the sympatho-adrenal pathway. [4, 5]

In addition to HPA and sympatho-adrenal activation, target organs are influenced through the stress-induced activation of the sympathetic nervous systems (SNS) and the inhibition of the parasympathetic nervous system (pSNS). However persistent activation of sympathetic nervous system during and after stress makes the autonomic nervous dysfunction. Since we are interested to see whether there occurs SNS activation in students while undergoing academic stress, we will examine these students for detection for SNS activation by application of non-invasive autonomic function tools. Allostatic is the adaptive process of quieting the SNS and returning the ANS back to homeostasis. Chronic and persistent activation of SNS in medical undergraduates after academic tests indicates the dysfunction of ANS which may be the mediator of failure of stress coping mechanism in the students.[6]

Tests and exams are identified stressor for all students alike thus we will measure parameter like skin conductance, Pulse rate, temperature and blood pressure in first year and second year medical undergraduates providing them arithmetic task. The task is based on performing serial subtraction (usually 100 minus 7 or 1000 minus 13) which aims at activating sympathetic outflow.[6, 7, 8, 9]

There are a variety of coping skills that can be used to help students with stress that they have. One of the first ways to begin coping and managing stress is, knowing the physical and emotional limits. In order to eliminate negative stress that may be occurring in a student's life: s/he needs to identify the cause of the stressor. It is well known that psychology and physiological processes are closely linked as enumerated earlier by scientists like Wilhelm Wundt, Ivan Pavlov and Edward Thorndike who looked to physiological process to understand behavior and mind. [5]

MATERIALS AND METHODOLOGY

A total of 60 subjects were studied. There were 15 male and 15 female from 1st year and 15 male and 15 female from 2nd year. After obtaining written consent, a questionnaire about personal details was recorded. Subjects were asked to sit on chair and relax. Subject was connected to AD instrument set up with appropriate transducer performed. Thereafter, collection of the first set of data before inducing stress was recorded. Subjects were provided with a set of mental arithmetic questionnaire used as standard test of autonomic function to induce mental stress. [5, 6, 7, 8] When subjects were busy calculating (Appendix I) the answer another set of data was recorded.

Parameters recorded were pulse rate, respiratory rate, body temperature and galvanic skin response. Pre-test recording was made as baseline and while performing mental arithmetic as control.

Procedure:

Galvanic Skin Resistance:

It was recorded with the help of computerized AD instrument. Palmer G.S.R. was recorded with two silver electrodes on index and middle finger of right hands on passing mild electric current through the electrodes the instrument records the resistance offered by the skin. Before starting the experimental recording habituation was done in which multiple questions were asked to habituate before recording baseline.

Pulse Rate:

Transducer for pulse was applied on left hand middle figure that continuously recorded the pulse. Autoanalyser sowed extra number of peak due to noise recorded by instrument there by manual peak counting was done for surety.

Body Temperature:

Axillary temperature was continuously recorded throughout procedures by therimestor pod of AD instrument. At the start of recording temperature sensitivity starts from lower temperature until it reaches body temperature which must be taken in to precaution, as it reaches normal body temperature it becomes stable then data recording was done.

Respiratory Rate:

It was continuously recorded with the help of respiratory belt of the AD instrument throughout the procedure. The belt was kept at the level of 4th intercostals space. It records in fashion of the stethograph. For galvanic skin response peak wave analysis was done by the AD Instrument analyzer which chooses the peak through sine shaped peak detection method where minimum peak height was 2 S.D. Latency, rise time, amplitude and peak wave height was obtained from the autoanalyser spread sheet.

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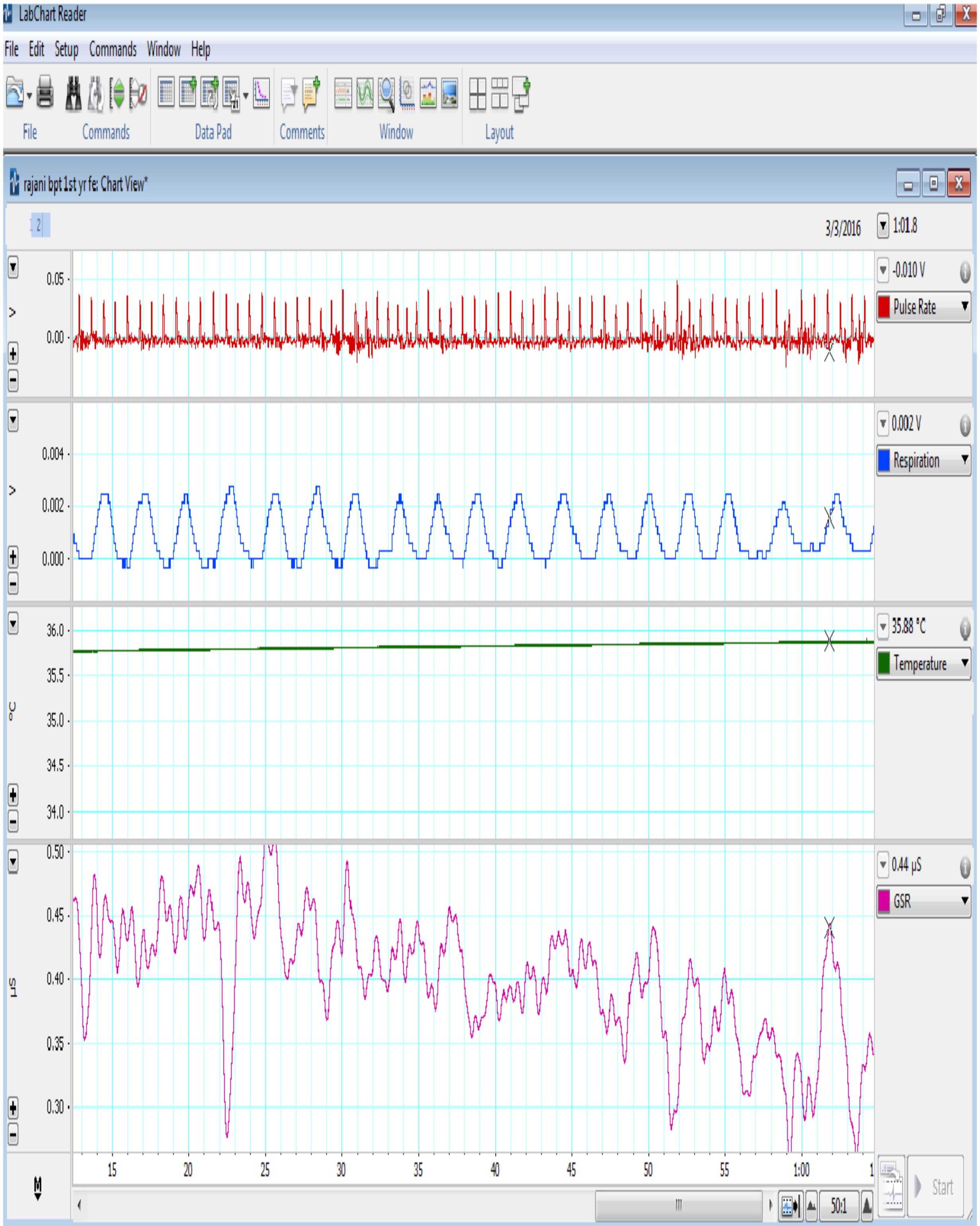
Data was analyzed by SPSS23. Normality plot showed non normal data thereby non parametric test (Related samples-Wilcoxon signed rank test) was carried out, in which p-value <0.05 was considered as significant and $p<0.01$ was considered as highly significant. Gender and year were variable was analyzed by independent samples Mann-Whitney test. For gender and year level comparison, difference between two conditions (baseline and control difference) was used to compare. Mean of baseline and mean of stress test recording were utilized to compare between first year and second year students. Above mentioned recording were utilized to compare gender differences also. Remaining stated variables in addition to GSR, were also compared, for male and female of first year and second year undergraduates.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RESULTS

Table I: Descriptive study

Variable	Mean ± MSE	Median
Pulse Rate (B)	78.20 ± 1.09 (Per/min)	76.00(Per/min)
Pulse Rate (M)	83.73 ± 1.44 (Per/min)	82.00(Per/min)
Respiratory Rate (B)	19.342 ±0.41 (Per/min)	19.00(Per/min)
Respiratory Rate (M)	22.742 ±1.19 (Per/min)	22.00(Per/min)
Temperature (B)	35.0873 ±0.07 (°C)	35.190(°C)
Temperature (M)	35.2918 ± 0.23 (°C)	35.310(°C)
Amplitude (B)	3.4035 ±0.85 (µS)	0.741(µS)
Amplitude (M)	4.5460 ± 0.99 (µS)	1.644(µS)
Latency(B)	3.13501 ± 2.04 (ms)	0.691(ms)
Latency(M)	1.8789 ± 0.47 (ms)	0.809(ms)
Rise Time (B)	1455.8843 ± 142.48 (ms)	3538.416(ms)
Rise Time (M)	1627.3100 ± 183.89 (ms)	1195.512(ms)
Peak Wave Height (B)	0.48991 ±0.07 (µS)	0.280(µS)
Peak Wave Height (B) (M)	0.6623 ± 0.16 (µS)	0.268(µS)

Table I: shows mean, median and standard error of entire data, where "B" indicates baseline and "M" indicates MAT.

Table II: Variation in baseline and MAT.

Variable	Baseline (Mean ± MSE)	MAT(Mean ± MSE)	P-value
Pulse Rate (Per/min)	78.20 ±1.09	83.73 ± 1.44	<0.001 *
Respiratory Rate (Per/min)	19.342 ± 0.41	22.742 ± 1.19	<0.001 *
Temperature (°C)	35.0873 ± 0.07	35.2918 ± 0.23	<0.001 *
Amplitude (µS)	3.4035 ± 0.85	4.5460 ± 0.99	<0.001 *
Latency (ms)	3.13501 ± 2.04	1.8789 ± 0.47	0.018 *
Rise Time (ms)	1455.8843 ± 142.48	1627.3100 ± 183.89	0.357
Peak Wave Height (µS)	0.48991 ± 0.07	0.6623 ± 0.16	0.324

Table II shows variation in baseline and control. PR, RR, TEMP, AMP and LATENCY were highly significant, while, RISE TIME AND PEAK WAVE HEIGHT has no statically significant difference between two conditions.

Table III: Comparison between male and female

Variables	Male(Mean ± MSE)	Female(Mean ± MSE)	P-value
Pulse Rate (Per/min)	3.66 ± 0.91	7.40 ± 1.37	0.094
Respiratory Rate (Per/min)	2.46 ± 0.38	4.33 ± 2.19	0.526
Temperature (°C)	0.15 ± 0.46	0.25 ± 0.05	0.574
Amplitude (µS)	1.55 ± 0.86	0.73 ± 0.20	0.813
Latency (ms)	1.31 ± 0.90	-3.82 ± 4.11	0.101
Rise Time (ms)	32.07 ± 135.27	310.77 ± 241.02	0.220
Peak Wave Height (µS)	0.40 ± 0.29	-0.064 ± 0.06	0.017 *

Table III shows comparison of differences (baseline and control difference) in between male and female. PEAK WAVE HEIGHT was significant. No other parameters between two groups were statically significant.

Table IV: Comparison between first year and second year

Variables	1 st year undergraduate (Mean ± MSE)	2 nd year undergraduate (Mean ± MSE)	P-value
Pulse Rate (Per/min)	6.10 + 1.21	4.96 + 1.21	0.651
Respiratory Rate (Per/min)	4.50 + 2.18	2.30 + 0.40	0.869
Temperature (°C)	0.49 + 0.31	-0.08 + 0.33	0.679
Amplitude (µS)	0.79 + 0.46	1.48 + 0.76	0.626
Latency (ms)	-3.83 + 4.12	1.32 + 0.88	0.636
Rise Time (ms)	481.27 + 202.20	-138.42 + 173.84	0.067
Peak Wave Height (µS)	0.01 + 0.12	0.32 + 0.27	0.544

Table IV shows comparison between first year and second year by the difference (baseline and control). There was no statically significant difference between first year and second year.

DISCUSSION

The present study tested the hypothesis that mental arithmetic task stimulates sympathetic nervous system and our results showed an increased reactivity of sympathetic nervous system during mental arithmetic task.

Previous studies have shown that academic stress affect stress level of student.[31, 37] It is similar with our finding. There was gender specific change in PEAK WAVE HEIGHT which is similar finding in literature.[24] It may be indicates male had stronger sympathetic flow to eccrine gland during mental arithmetic task.

Stress is a condition that puts mind in a state of fear or anxiety and is most commonly observed prior to and during examinations. [10, 18] Examination stress is one of the most widely suffered problems in medical students throughout the world. [2] However, stress is only healthy as a short-lived response. Excessive or prolonged stress can lead to illness and physical and emotional exhaustion. [3]

In our study there was highly significant increase in pulse rate, respiratory rate, body temperature and amplitude of GSR while significant increase in GSR latency was observed. This indicates MAT is good tool to stimulate sympathetic nervous system. There was no change observed in GSR rise time and GSR peak wave height during baseline when compared with MAT.

Galvanic Skin Response:

Since eccrine sweat gland is controlled by the sympathetic nervous system, measuring skin conductance is a good indicator of physiological stimulation. Mental arithmetic task was hypothesized to elicit the sympathetic nervous system, causing the participants stress and to sweat more. The galvanic skin response (GSR) readings measured the electrical conductance of the participant skin before and during mental arithmetic task.

There is no consensus on the things to do during recording and evaluation of the GSR in the literature. [38] There are two different approaches. The first is that the absence of GSR sign as a pathological indicator is regarded as a qualitative observation. [39, 40, 41] the other is the quantitative assessment. Another group of authors adopted only the latency measurements as there are very few latency changes.[39, 40] Another group has chosen to measure only the amplitude. [42] Some authors have taken the average of the response. [42, 44, 45] However, the average of the response varies by GSR pattern and adaptations. Some authors consider the absolute value of the latency and amplitude values of the response to the first stimulation on the basis of their experience. Others consider the absolute values of the highest amplitude and lowest latency values. [46, 47]

Latency:

Latency is the duration from stimulus onset to the onset of the phasic burst. Typically, responses arise within 1-5 seconds after stimulus onset. [48] In this study average latency during baseline was 3.13 ± 2.04 (ms) and during mental arithmetic task 1.87 ± 0.47(ms). There was statistically significant change of ($P<0.018$). The result indicates there was greater frequency of sympathetic outflow during mental arithmetic task.

Rise time:

Rise time is **t**he duration from onset to peak. [48] In this study average rise time during baseline was 1455.88 ± 142.48 (ms) and during mental arithmetic task 1627.31 ± 183.89 (ms). There was no statistically significant change (P-value 0.357).

Amplitude:

The amplitude is the difference between tonic skin conductance level, at the time the response was evoked, and the skin conductance at the peak of response. [47] In this study average amplitude during baseline was 3.40 ± 0.85 (μS) and during mental arithmetic task 4.54 ± 0.99 (μS). Statistical analysis showed significant change between two condition (P<0.001). Increase in amplitude of waves indicates, mental arithmetic task stimulated more eccrine sweat gland.

Peak wave height:

The peak wave height is the actual height of each wave. Average peak wave height was 0.48 ± 0.07(μS) during baseline while during mental arithmetic task it was 0.66 ± 0.16 (μS). There was no statistically significant change (P-value 0.324) between two conditions.

Pulse Rate:

The change in pulse rate was an indicator of an elevation of participant stress level in several studies from different type of stimuli. [22, 26, 31] Stressful situations are thought to trigger stress hormone release, which increase the heart rate. For example, epinephrine is a stress hormone that acts to increase heart rate via its binding to beta-1 adrenergic receptors located at the SA node of the heart. [2] The average heart rate for people aged 18-25 years is 74 bpm (American Heart Association, 2011) and the data obtained in subjects had 78.20 bpm as basal rate. It could be due to experiment anxiety. Result showed significant (<0.001) increase in pulse rate during mental arithmetic test. This indicates that cognitive load is a stressor for medical undergraduate student.

Respiration Frequency:

Respiratory frequency was measured using a respiratory transducer belt. After analyzing the respiration rate data, There was a significant increase in respiratory frequency with an increase of p-value of 0.001 during mental arithmetic task.

Few study showed however, the contradictory result which may be due to a much smaller sample size and emotional state of subjects as explained by author. [17]

Body temperature:

In this study we found highly significant increase in body temperature during mental arithmetic task. Study result showed similar result with literature. [22] Literature explained that increase in body temperature and sweating was produced as a result of increased sympathetic activity caused by stress. The body temperature is generated and maintained by heat production which is a principal by product of metabolism in various parts of body. An exceeded metabolism caused by effects of epinephrine, nor-epinephrine and sympathetic stimulation due to stress increases heat production.

Activation of sympathetic nervous system is known to increase core body temperature by increasing thermogenesis, including non-shivering thermogenesis in brown adipose tissue and by decreasing heat loss with peripheral vasoconstriction and increases body temperature. During emotional excitement the body temperature slightly increases due to involuntary increase tension in muscles.[49, 50]

SUMMARY AND CONCLUSION

This study investigated the effect of mental arithmetic task on PR, RR, GSR and body temperature in sixty medical undergraduate students. It can be concluded that there does occur, increased sympathetic activity in students subjected to MAT, extrapolated to conclude that students undergo stress resulting in sympathetic stimulation before/during examinations. A little stress is conducive to learning whereas excessive stress may result in stress related diseases.[2] This in a way, places responsibility on the teachers in medical schools to ensure that students are not subjected to excessive stress.

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