Original Article

Effects of examination-induced stress on memory and blood pressure

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Abstract

Stress has been defined in many ways as a state of psychological arousal that results when the external demand is beyond what one can cope with. Stress is caused by various factors called stressors. Medical students are subjected to different kinds of stressors, such as pressure of academics with obligation to succeed, an uncertain future and difficulties of integrating into the system and different teaching protocols, which may affect their learning ability and performance. Stress has a great impact on brain mainly in the form of impaired memory and on cardiovascular function in the form of increased heart rate and blood pressure. The study was planned to assess the effects of examination induced stress on memory and blood pressure. The study was longitudinal in nature conducted at Department of Physiology, Santosh Medical College, Ghaziabad, India. Initially 100 subjects were selected from 17-24 years of age group then all the subjects were divided into two groups of 'slow-learners' and 'fast-learners' based upon their past academic performances. Readings were taken at two stages of academic year, 05 months before pre-prof examination and 03 days before pre-prof examination. Blood Pressure were measured and the memory assessments were done by using 10 subtests of PGI memory scale. We found a significant increase in stress level 3 days before the examination, compared to 5 months before the examination which in turn affected both blood pressure and memory functions. But, slow-learners were affected more compared to fast-learners.

Keywords: Academic examinations, blood pressure, memory, stress

Introduction

Stress starts when the emotional, environmental and physical needs of the individual start to compete with one another and exceed that which one can cope with.[1] Stress is caused by various factors called stressors. These stressors are fear of the unknown or of failure, frustration, conflict, poor relationships, family problems, insecurity, anxiety, high workload and so on.[2]

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Academic stressors include overloaded study programmes, too many academic assignments to tackle, the student's perception of the extensive knowledge base required and his perception of the inadequate time to develop it, and fear of failure at academic examinations.[3] Stress has been found to be a major contributing factor in all academic performance. An optimal level of stress can enhance learning ability, but too much stress can cause physical and mental health problems, which consecutively affect academic performance.[4]

Stress is one of the common factors which induce physiological changes, like increased heart rate and sweating. Stress can also affect memory and reasoning. Stress-causing primary hormone cortisol is one of the widely investigated topics.[5] In cases of stress response and memory retrieval stressful events, there

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is activation of both the sympathetic nervous system (SNS), leading to the release of noradrenaline and adrenaline into the bloodstream by the adrenal medulla, and also the hypothalamic–pituitary–adrenal (HPA) axis, leading to the secretion of glucocorticoids (cortisol) into the blood by the adrenal cortex.[6]

Cortisol released during stressful events directly affects the hippocampus and the amygdala, structures involved in memory and emotional processes.[7] Cortisol can cross the blood-brain barrier and bind to glucocorticoid receptors in the hippocampus, which in turn modulate hippocampal function, and, consequently, modulate encoding and retrieval of long-term memories. When the stressor occurs just before the retrieval of consolidated information, memory performance is impaired, as in the case of the student who knows the subject but cannot remember its contents during a high-stakes test.[8]

Stress has a severe effect on the normal function of the cardiovascular system. The first effect of stress on the cardiovascular system is increased heart rate. Depending upon the sympathovagal response, the heart rate will either increase or decrease. The consecutive effect is increased blood pressure. Stress increases the vasoconstriction due to stimulation of autonomic SNS, which causes an increase in blood pressure, an increase in blood lipids, blood clotting disorders, vascular changes, and atherosclerosis, which can lead to cardiac arrhythmia and myocardial infarction. When one risk factor is coupled with other stress-producing factors, the effect on blood pressure is multiplied.[9]

Medical students are exposed to different kinds of stressors, such as the pressure of academics with the obligation to succeed, an uncertain future and difficulties in integrating into the system and different teaching protocols, which may affect their learning ability and performance.[10] The stress level increases as examination approaches, and in some cases, the stress becomes acute on chronic, resulting in panic attacks with the symptoms of depression and anxiety.[11] This academic examination-induced stress results in physiological consequences. The psychological consequences can be observed in an effect on memory and the learning process. The cardiovascular changes reflect changes in heart rate and blood pressure.[12]

Aim of the study

The aim of this study was to investigate the effects of examination-induced stress on memory and blood pressure among 'slow learners' and 'fast learners' (based on their past academic performances) in first-year MBBS students at Santosh Medical College, Ghaziabad.

Objectives of the study

1. To find out the effects of examination-induced stress on blood pressure, heart rate and memory status among 'slow learners' and 'fast learners' in medical students of first-year MBBS.
2. To compare these parameters between these two groups recorded at different stages of the academic curriculum (starting of the second semester and 3 days before the pre-prof exam).

Need of the study

1. As the objective of the study is very clear that medical students remain under sturdy pressure throughout their academic course. Therefore, it has been realised if it is not taken care of, they may move towards serious psychological consequences like high anxiety, panic, phobia and feeling of isolation which may lead to depression. Therefore, the findings in this study will be relevant to help these said students.
2. These findings will emphasise the need for greater attention to the psychological well-being of students under medical training.
3. We can advise students on various yoga exercises, pranayama to reduce stress and its effect.

Materials and Methods

Study design

The study was longitudinal in nature, and the procedure of sampling was based on the proposed method. Initially, 100 subjects were selected from 17 to 24 years of age group, depending upon the inclusion and exclusion criteria. Later, all the subjects were divided into two groups of 'slow learners' and 'fast learners' based on their past academic performances. Readings were taken at two stages of academic year, first at the beginning of second semester (5 months before pre-prof examination) and second 3 days before pre-prof examination. Heart rate and blood pressure were measured, and the memory assessments were conducted by using 10 subtests of the Post Graduate institute (PGI) memory scale. The study was conducted in the Department of Physiology, Santosh Medical College, Ghaziabad.

Inclusion criteria

Normal healthy subjects who fulfilled the following criteria were included in the study: age between 17 years and 24 years; subjects willing to complete the study.

Exclusion criteria

Participants having any medical history or risk causing or at risk were excluded from the study like history of any neuropsychiatric illness, any substance abuse, any cardiovascular illness, any history of diabetes, hypothyroidism, renal disease or malignancy.

Ethical clearance

Ethical clearance was obtained from the institutional ethical committee.

Materials used

The subjects selected for this study were 100, out of which 67 were fast learners and 33 were slow learners.

Anthropometric parameters

1. Age: Age was taken in years.
2. Blood Pressure: It was measured in mmHg in a sitting position using the Aneroid Sphygmomanometer of Chopra Bros. Industries. A stethoscope of SS Surgical Co was used.

3. Pulse Rate: Heart rate was measured in beats per minute using a palpatory method by palpation of radial pulse.

PGI memory scale

(Dwarka Persad and N N Wig): It contains ten sub-tests. Subjects were asked to sit comfortably, and the procedure was explained in detail. Ten different sets of questionnaires and tasks were used to interpret the level of memory status. Ten sub-tests were: Remote Memory, Recent Memory, Mental Balance, Attention and Concentration, Delayed Recall, Immediate Recall, Verbal Retention for Similar Pairs, Verbal Retention for Dissimilar Pairs, Visual Retention, and Recognition. Different scores were adopted as per the guidelines for all the ten sub-tests, and the total maximum possible score for the full test = 6 + 5 + 9 + 15 + 10 + 12 + 5 + 15 + 13 + 10 = 100. And the memory levels were assessed using the following criteria given in Table 1.

Sample size

Sample Size for Comparing Two Means

Input Data

Confidence Interval (two-sided)		95%	
Power		80%	
Ratio of sample size (Group 2/Group 1)		1	
	Group 1	Group 2	Difference*
Mean	71.7	64.4	7.3
Standard deviation	14.1	7.3	
Variance	198.81	53.29	
Sample size of Group 1		67	
Sample size of Group 2		33	
Total sample size		100	

*Difference between the means

Results from Open Epi, Version 3, open-source calculator—SS Mean.

Reference: Ajayi NO and Adegboro JS, in June 2020.

Observations and results

Group A and B contained 67 and 33 subjects, respectively [Table 2].

Table 1: Norms for interpretation of percentiles

Percentile range	Level of memory
P80–P100	Excellent Memory
P60–P80	Above Average Memory
P40–P60	Average/Moderate Memory
P20–P40	Below Average Memory
P00–P20	Low-Level Memory

Table 2: Distribution of fast learners and slow learners

Learner	Percentage
Fast learners	67 (67%)
Slow learners	33 (33%)
Total	100 (100%)

Table 3: Distribution of subjects according to age group

Age group (years)	Fast learners group A	Slow learners group B
17-19	29	19
19-21	21	11
22-24	17	7
Total	67 (100%)	33 (100%)
Mean SD	22.33±6.11	12.33±6.11
F	0.242	
P	0.051	

Table 4: Distribution of subjects according to gender

Gender	Group A fast learner	Group B slow learners	Total
Male	36 (53.7%)	20 (60.6%)	56 (56%)
Female	31 (46.2%)	13 (39.4%)	44 (44%)

Table 5: Average age of participants according to academic performance

Learner	Average age (years)
Fast learners	20.37
Slow learners	21

Table 6: Average age of participants based on their gender

Gender	Average age (years)
Male	21.03
Female	20.23

Discussion

The PGI memory scale was used to measure the level of stress at different points in academic session. We found a significant increase in stress level 3 days before the examination, compared to 5 months before the examination. The participants had some behavioural problems in the form of difficulty in relaxation, higher irritability, agitated and intolerant 3 days before the examination compared to the start of second semester. The only major stressor was the examination induced.

Five months before the examination, the mean remote memory of fast learners was statistically insignificant. In addition, mean recent memory and mean mental balance of fast learners and slow learners were statistically insignificant.

Further, mean attention and concentration of fast learners and slow learners was statistically significant. In addition, mean delayed recall of fast learners and slow learners was statistically significant. Furthermore, mean immediate recall of fast learners was statistically significant.

The findings of this study support the notion that examination stress can increase cortisol levels compared to a

Table 7: Memory performance 5 months before examination

Memory performance	5 months before examination		*P*
	Group A Fast learners	Group B Slow learners	
Remote memory	6.05±1.79	6.81±1.42	$P<0.05$
Recent memory	5.31±0.52	6.12±0.93	$P<0.05$
Mental balance	3.02±0.61	3.93±0.55	$P<0.05$
Attention and concentration	3.13±0.37	3.87±0.40	$P<0.05$
Delayed recall	5.10±0.81	5.72±0.25	$P<0.05$
Immediate recall	3.98±0.14	4.90±0.95	$P<0.05$
Retention for similar pair	4.65±0.66	4.84±0.92	$P<0.05$
Retention for dissimilar pair	3.88±0.59	5.60±2.89	$P<0.05$
Visual retention	7.97±0.55	9.72±0.75	$P<0.05$
Recognition	9.13±2.43	9.66±0.82	$P<0.05$

Table 8: Memory performance 3 days before examination

Memory performance	3 days before examination		*P*
	Group A Fast learners	Group B Slow learners	
Remote memory	6.25±0.98	6.93±0.52	$P<0.05$
Recent memory	5.13±0.95	5.90±0.31	$P<0.05$
Mental balance	2.86±0.39	3.84±0.99	$P<0.05$
Attention and concentration	3.88±1.41	4.87±1.91	$P<0.05$
Delayed recall	5.94±0.91	6.72±0.94	$P<0.05$
Immediate recall	3.79±1.57	4.87±1.35	$P<0.05$
Retention for similar pair	4.94±0.91	5.75±0.89	$P<0.05$
Retention for dissimilar pair	4.73±0.61	5.93±2.79	$P<0.05$
Visual retention	8.11±0.44	9.81±0.99	$P<0.05$
Recognition	8.35±0.75	9.90±0.91	$P<0.05$

Table 9: Mean SBP first term year (5 months before examination) of Group A and Group B

	5 months before examination		*P*
	Group A Fast learners	Group B Slow learners	
Mean SBP±SD (mm Hg)	112.9±11.2	114.6±9.1	$P<0.05$

Table 10: Mean SBP first term year (3 days before examination) of Group A and Group B

	3 days before examination		*P*
	Group A Fast learners	Group B Slow learners	
Mean SBP±SD (mm Hg)	128.9±10.6	139.8±9.8	$P<0.05$

baseline period. Even though there are many contradictory results appear in the literature, the current data robustly supports the major trend of studies in this area.[13]

In our study, additionally, mean retention for similar pair of fast learners and slow learners was statistically significant. Mean retention for dissimilar pair of fast learners and slow learners was statistically significant. The mean recognition of fast learners and slow learners was statistically significant.

Moreover, in addition, in our study mean remote memory of fast learners and slow learners was statistically insignificant. Mean recent memory of fast learners and slow learners was statistically significant and mean mental balance of fast learners and slow learners was statistically significant.

Three days before examination, an over-activation of the fight-or-flight response might be mediated by cortisol. As the HPA axis and the gonad system, which produces cortisol, depend on similar pathways, the significant increase in adrenaline and noradrenaline might also be indirectly modulated. Additionally, the main focus here was to assess short-term and long-term performance for both fast and slow learners.[14]

In addition, moreover, mean attention and concentration of fast learners and slow learners were statically not significant. In addition, the mean delayed recall of fast learners and slow learners was statistically not significant. Furthermore, the mean immediate recall of fast and slow learners was statistically significant 3 days before the examination. Results show a decrease in short-term memory (STM) and long-term memory (LTM) performance for slow learners with a rise in cortisol at examination compared to baseline testing session. However, both groups of learners, those who showed a rise in cortisol as well as those who did not at the examination session in comparison to baseline showed an improvement in memory performance. Here it has been demonstrated that examination stress induce an increase in cortisol levels.[15]

Additionally, mean retention for similar pair of fast learners and slow learners was statistically significant. Mean retention for dissimilar pair of fast learners and slow learners was statistically significant. In addition, slow learners with increased levels of cortisol had a decrease in performance in both the short-term and LTM test. This is in spite of the fact that compared to slow learners and fast learners had a significantly higher increase in cortisol from baseline to the academic examination stressor.

In our study, mean recognition of fast learners and slow learners was statistically significant on 3 days before examination. Similarly, only eight out of sixteen male participants had an increase in cortisol levels between both periods. A larger sample size can increase confidence in data interpretation and decrease the possibility of error [Tables 3-8].

In this study, global stress was measured with the Perceived Stress Scale questionnaire. But, in spite of only measuring global stress, it was suggested that future research administer a questionnaire more relevant to examination anxieties.[16] This information could have been useful for correlation analysis between age and other variables, such as perceived stress. Although the questionnaire failed to account for such variability, most of the subjects were between the ages of 18 and 24.

Finally, epinephrine and norepinephrine are known to play a role in activating the fear-fight-flight response. This fast response is known to become activated in response to an immediate threat. Measuring cortisol is still important because chronic stress has

Table 11: Mean DBP first term year (5 months before examination) of Group A and Group B

	5 months before examination		*P*
	Group A Fast learners	Group B Slow learners	
Mean DBP±SD (mm Hg)	81.2±9.2	84.6±9.1	$P<0.05$

Table 12: Mean DBP first term year (3 days before examination) of Group A and Group B

	3 days before examination		*P*
	Group A Fast learners	Group B Slow learners	
Mean DBP±SD (mm Hg)	100.8±9.8	111.9±10.6	$P<0.05$

been known to increase during the examination period.[17] In some studies, it has taken about 30 minutes after the start of the stressor to have a significant increase in cortisol.[18]

In our study, 5 months before examination mean systolic blood pressure (SBP) among Group A and Group B was statistically insignificant. Three days before examination mean SBP among Group A and Group B was statistically significant. Our results bring into question the classic view of stress-induced BP (blood pressure) reactivity that larger responses are worse and smaller responses are better. BP reactivity to psychological stressors may have different associations with target organs in hypertension [Tables 9 and 10].[19]

The mechanisms of the cardiovascular reactivity to psychological stress remain to be determined, but have been speculated as (i) cognitive emotional reactions, which was determined by consciousness and adaptive behaviours; (ii) autonomic and endocrine outputs from the hypothalamus and brain stem; and (iii) peripheral tissue function. The first process leads to cognitive function but less so to the cardiovascular system. The third process reflects an individual's cardiovascular system. For example, excess BP reactivity is associated with altered α- and β-adrenoreceptor sensitivity, endothelial dysfunction, increased vascular resistance, and vascular remodeling.[20]

In our study, 5 months before examination mean diastolic blood pressure (DBP) among Group A and Group B was statistically insignificant. Three days before examination mean DBP among Group A and Group B was statistically significant. The first process may influence cognitive function. Therefore, lower BP reactivity may be a marker of emotional and motivational dysregulation (impairing the first process) and, consequently, lower cognitive function [Tables 11 and 12].

Other potential mechanisms exist underlying the association between lower BP reactivity and lower cognitive function. First, according to functional neuroimaging studies, those who show lower BP reactivity to psychological stress showed less neuron activity in the anterior cingulate and amygdala, the posterior cingulate and the insular cortex.[21] These brain regions are involved not only in autonomic nervous and cardiovascular regulation but in cognitive function too, particularly executive functions.[22]

Limitations

There were 100 participants divided into two groups, with 67 as fast learners and 33 as slow learners in this study. A larger sample size could allow for greater statistical power when stratifying a sample by gender.

Conclusion

The findings in this study have been partially supported by other research indicating fast learners have a stronger fight-or-flight response. An over-activation of the fight-flight response might be mediated by cortisol. As the HPA axis produces cortisol depending on similar pathways, the significant increase in noradrenaline and adrenaline might also be indirectly modulated. Additionally, the main focus here was to assess short-term and long-term performance for both fast learners and slow learners.

Results indicate a decrease in STM and LTM performance for slow learners with a rise in cortisol just before examination compared to baseline testing sessions. Here it has been demonstrated that academic examination stress induces an increase in cortisol levels. This is in spite of the fact that compared with fast learners, the slow learners had a significantly higher increase in cortisol from baseline to the academic examination stressor.

This study adds to the body of knowledge concerning students' academic examination stress and how to estimate them for the groups acting under the same stressor. The same method can be used to compare the examination stress in different colleges, and the knowledge of this will be very helpful to student counsellors and health educators because the findings show that fast learners and slow learners differ in their experience of stress imposed by academic examination.

The results of our study suggest not only is 'level' important to consider when aiming to identify those at younger age who may be at risk for cognitive impairment in later life, but also variability *per se* in BP levels should be investigated. Replication in different studies and further etiopathophysiological studies to understand biological mechanisms behind the association of lower stress-induced BP reactivity with lower cognitive function are warranted.

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Conflicts of interest

There are no conflicts of interest.

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