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Original Research Paper

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ALTERATIONS IN FASTING BLOOD GLUCOSE LEVELS IN INDIVIDUALS EXPOSED TO HIGH PROFESSIONAL STRESS

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ABSTRACT Stress refers to processes involving perception, appraisal and response to noxious events or stimuli. While acute stress can activate adaptive responses, chronic stresses are detrimental to health by altering various physiological parameters[1]. One such change involves blood glucose levels. This study was done to detect any alterations in blood glucose levels on exposure to chronic mental stress. Mental stress was assessed using the Stress scale of the DASS – 42 questionnaire. Correlation between stress perception and altered blood glucose levels was seen. Reasons for this change range from effects of stress hormones on carbohydrate & lipid metabolism to changes in brain which promote stress eating. There is increased risk for obesity, Diabetes Mellitus and Metabolic syndrome in future. Interventions to reduce this risk include lifestyle modifications which include caloric restriction, increasing physical activity and getting involved in customised activities which reduce stress.

KEYWORDS : Mental stress, Cortisol, Blood sugar levels, Stress eating, DASS-42

INTRODUCTION:

Stress is a term which is heard very often since quite a few years. Although it is synonymous with tension, worry etc… in common terms, yet it is properly defined from the physiologic point of view. It is defined as any change in the environment which changes or threatens to change the existing steady state within the body i.e homeostasis[2].

Originally stress response was designed for protection and survival, but with the changes in lifestyle it is being associated with deterioration of health – both physical and mental. Job stress is one of the commonest stressors, with IT sector being one of the most affected. The reasons vary from stress of meeting deadlines/targets, working odd hours, travel time, higher intake of unhealthy/junk food etc.

The stress faced by the workers in the IT sector can come under many categories – it is mental stress, long lasting, occupational stress. They face an overload of stressors which lead to high demand but low control at work[3,4]. Chronic stress such as this leads to release of stress hormones by HPA axis (Hypothalamo-Pituitary-Adrenal) and activation of Sympathetic nervous system for long periods of time[5,6].

Release of stress hormones such as Cortisol and release of catecholamines such as Epinephrine and Norepinephrine cause a lot of alterations in the body – many physiological parameters change, one of which is the blood glucose. Elevated blood sugar levels are seen. This is due to its effect on carbohydrate metabolism which is altered – there is increased gluconeogenesis by liver, decreased utilization of glucose by the cells, and decreased uptake of glucose by the cells[7].

High levels of cortisol antagonize insulin's effect on GLUT-4-mediated glucose uptake into skeletal muscle and adipose tissue[7].

In response to this plasma insulin levels rise, yet hyperglycaemia persists due to decreased insulin sensitivity[7]. This occurs as the glucocorticoids mobilize lipids from fat depots, leading to higher circulating levels of Free fatty acids (FFA). These FFA impair the action of insulin on tissues.[7]

Additionally, cortisol also plays a role in lipid metabolism - in chronically elevated cortisol states, there is decrease in lipolysis, Increased appetite, increased triglyceride synthesis, lipogenesis and conversion of pre-adipocytes to adipocytes.[8]

AIMS AND OBJECTIVES:

To study the alterations in blood glucose levels in IT company employees.

METHODOLOGY:

(I) **Materials And Methods:** Clearance for this study was given by the Institutional Ethics Committee, Gandhi Medical College, Scuderia, Telangana. A letter of informed consent was taken from the volunteers.

(II) **Study Population**: 50 individuals, comprising of 28 males and 22 females, aged 20-30 years working in IT companies.

(III) Format for collection of personal information was given to the volunteers.

(IV) General Physical examination was done.

Parameters Assessed:

1. **Fasting blood glucose levels – GOD/POD method**
2. **Dass Score** –using a Questionnaire
3. **BMI** – calculated by estimating height and weight

Establishment of normal levels of all physiological parameters were done at the beginning of the study by collecting a blood sample before exposure to chronic stress. It helped in establishing baseline values individually and as a group so that they can be compared post stress exposure. According to the study design, any subject with aberrant values was no longer a part of the study. Hence, 2 blood samples collected from each subject under aseptic precautions at an **interval of about 6 months between their collections.**

Collection of blood samples – The first sample was collected when the subjects of this study had recently joined their respective organizations. This was to ensure that the fasting blood glucose values of all subjects were within the normal range. **2nd sample was collected after the subjects were exposed to their stressful environment for at least 6 months.** In order to remove the influence of other confounding factors, the subjects were not on night time shifts for 1 month prior to 2nd blood test so that altered sleep schedule doesn't cause any changes in the sugar levels.

Grading Mental stress:

Mental stress can't be evaluated as objectively as physical stress as it is more of a subjective sensation. Every person perceives varying levels of sensations of stress for the same challenge – this depends on age, experience, personality etc.

Hence feedback is one of the ways to label the level of stress. For this purpose, **DASS -42 questionnaire (Depression, Anxiety and Stress scale)** was used. Only Stress scale was used for the purpose of this study [9]. The Stress scale (items) is sensitive to levels of chronic non-specific arousal. It assesses difficulty relaxing, nervous arousal, and being easily upset/agitated, irritable/over-reactive and impatient.[15] The Stress scale, originally labelled "tension/stress", measures a syndrome that is factorially distinct from depression and anxiety, characterised by nervous tension, difficulty relaxing and irritability. DASS scale is very flexible – a single scale can be used or 2 scales or all 3 scales can be assessed too. Omitting other scale(s) doesn't affect the scores of the current scale being used. Its flexibility extends to assessing the stress levels over different periods of time – this can be fixed by the **examiner**[10]. Using the stress scale, the subjects were graded as having no/mild/moderate/severe stress, according to the DASS score. The subjects reported a sleep duration of 7 or more hours of sleep per day. They didn't have any addictions like cigarette smoking or alcohol which can affect the blood glucose levels.

DASS	*Name:*	*Date:*
Please read each statement and circle a number 0, 1, 2 or 3 which indicates how much the statement applied to you *over the past 6 months*. There are no right or wrong answers. Do not spend too much time on any statement.		
The rating scale is as follows: 0 Did not apply to me at all 1 Applied to me to some degree, or some of the time 2 Applied to me to a considerable degree, or a good part of time 3 Applied to me very much, or most of the time		
1	I found myself getting upset by quite trivial things	0 1 2 3
6	I tended to over-react to situations	0 1 2 3
8	I found it difficult to relax	0 1 2 3
11	I found myself getting upset rather easily	0 1 2 3
12	I felt that I was using a lot of nervous energy	0 1 2 3
14	I found myself getting impatient when I was delayed in any way (e.g., lifts, traffic lights, being kept waiting)	0 1 2 3
18	I felt that I was rather touchy	0 1 2 3
22	I found it hard to wind down	0 1 2 3
27	I found that I was very irritable	0 1 2 3
29	I found it hard to calm down after something upset me	0 1 2 3
32	I found it difficult to tolerate interruptions to what I was doing	0 1 2 3
33	I was in a state of nervous tension	0 1 2 3
35	I was intolerant of anything that kept me from getting on with what I was doing	0 1 2 3
	I found myself getting agitated	0 1 2 3

CATEGORY OF STRESS	DASS SCORE
No Stress	0-14
Mild	15-18
Moderate	19-25
Severe	26-33
Very Severe	34+

Inclusion And Exclusion Criteria:

Criteria for inclusion was apparently healthy volunteers who are not having any signs of chronic disease.

Criteria for exclusion was:

(i) Any chronic disease(s), anaemia, recent major trauma or surgeries.

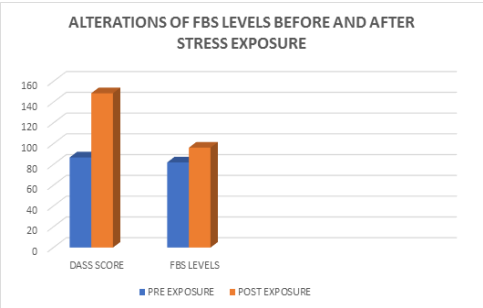
(ii) Any intake of medication for the above-mentioned conditions – eg: hypoglycaemic drugs.

STATISTICAL ANALYSIS:

Student 't' test was done. Analysis was done using GraphPad Instat Software.

Table 1: Table Showing Fbs Levels And Dass Score Pre And Post Exposure To Chronic Mental Stress

Parameter	Pre-mental Stress	Post Mental Stress	P Value	Level Of Significance
Dass Score (mean ± SD)	8.91±1.798	14.99±1.502	<0.001	Extremely Significant
Fasting Blood Glucose Levels (mg/dl) (mean ± SD)	82.05±6.04	96.287±18.28	0.0148	Significant

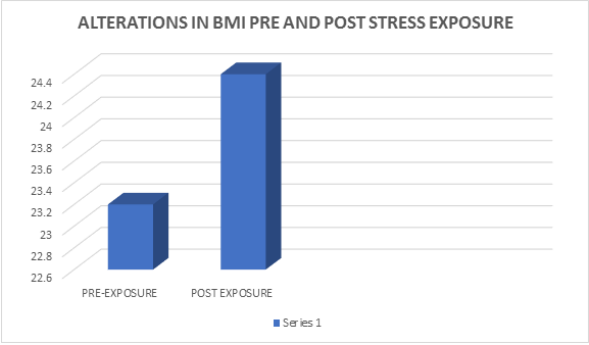


Graph 1: Graph Showing FBS Levels And Dass Score Pre And Post Exposure To Chronic Mental Stress

NOTE: Values of DASS score have been multiplied by 10 only in this graph (and not in the table) so that pre and post exposure alterations can be properly seen and compared with FBS levels.

Table 2: Table Showing BMI Values Pre And Post Exposure To Chronic Mental Stress

Parameter	Pre-mental Stress	Post Mental Stress	P Value	Level Of Significance
BMI (kg/m^2) (MEAN ± SD)	23.2±0.98	24.4±1.32	<0.001	Extremely Significant



Graph 2: Graph Showing BMI Values Pre And Post Exposure To Chronic Mental Stress

DISCUSSION:

This study was done to estimate the presence of any altered blood glucose levels in individuals working in high stress environment and therefore exposed to mental stress for

prolonged periods of time.

A group of 50 people, which included 28 males and 22 females, working in the IT sector were selected as subjects. Individuals working at similar positions were selected as subjects in order to minimise bias arising from differential stress levels. 2 blood samples were collected with a time interval of 6 months in between. The first sample acted as the baseline and acted as the control to compare any alterations in fasting blood glucose levels arising after being exposed to high levels of mental stress for 6 months. This was estimated from the 2nd blood sample collected. Measurements of perceived stress was done using DASS-42 questionnaire as it is more of a subjective sensation and difficult to measure objectively.

At the onset of study, the mean DASS score of the group was 8.91 which is categorised as under "NO STRESS" and the mean FBS levels were 82.05 mg/dl which are within normal range. Post stress exposure, the DASS questionnaire responses were analysed. Although the post stress DASS score showed increased values and made the group to be categorised under "MILD STRESS", the rise between pre and post exposure values was extremely significant with a p value of <0.001.

The FBS levels after stress exposure increased from 82.05 mg/dl to 96.28 mg/dl. Similar to DASS scoring which didn't show massive alterations scoring wise, even FBS levels are within normal range, yet their rise shows significant correlation with a p value of 0.0148.

Additionally, there is rise of BMI[32] from 23.2 to 24.4 kg/m^2 after exposure to stress, which is extremely significant with a p value of <0.001.

Stress hormones divert the energy stores to be used appropriately during emergency conditions, suppress appetite and even cause weight loss[11] This holds true in acute stress lasting for shorter durations where higher levels of circulating blood sugar levels are required. It's an example of Allostasis which refers to the physiological responses related to various systems of the body like Autonomic Nervous system, Hypothalamo-Pituitary-Adrenal axis, Cardiovascular system etc. which help in protection and adaptation of the organism to challenges.[12,13] Allostasis help in maintaining homeostasis. But it has an adverse effect too – the changes which occur to maintain homeostasis in face of challenge are referred to as Allostatic load[12,14,15]. Allostatic load is detrimental and represents wear and tear of various systems of the body. Usually, after cessation of stress, negative feedback control sets in and brings back the levels of all hormones of HPA axis to normal. But in conditions of chronic stress, the negative feedback of stress hormones such as cortisol on the higher centres is lost[7].

This is an example of allostatic load involving failure to habituate to the same stressor which leads to persistent elevation of mediators like cortisol. Cortisol production is prolonged and the subsequent effects continue, one of which is on blood sugar levels.[7]

The effects include increased gluconeogenesis by liver, decreased utilization of glucose by the cells, and decreased uptake of glucose by the cells. Insulin dependent GLUT-4-mediated glucose uptake into skeletal muscle and adipose tissue is decreased. As tissues demand glucose for their metabolic needs, plasma insulin levels rise, yet hyperglycaemia persists due to decreased insulin sensitivity[7]. This occurs due to the presence of higher circulating levels of free fatty acids which impair the action of insulin on tissues.

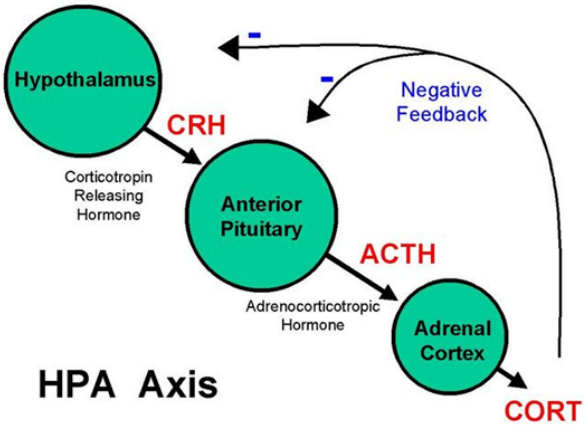


FIG 1: HPA Axis Showing Stress Response And Release Of Various Hormones From Various Glands[16]

Stress is also associated with change in lipid metabolism. Dyslipidaemia is also responsible for rise of blood sugar levels. Glucocorticoids also lead to differentiation and proliferation of adipocytes and redistribution of fat, leading to central adiposity. Decrease in activity of lipoprotein lipase enzyme leads to raised levels of free fatty acids, lower HDL cholesterol levels and high triglyceride levels. Chronic stress enhances these alterations.[17,18,19]

One of the unusual effects seen in chronic stress is that even with high levels of cortisol, weight gain is seen. In the current study too, there is significant rise of BMI from 23.2 to 24.4 kg/m^2 with a p value of <0.001. There is an interesting relationship between weight gain and blood sugar levels. Stress eating could explain this phenomenon.

REASON FOR STRESS EATING:

It has been observed that individuals facing moderate to high stress levels have greater food intake in order to feel better[11,20]. Endorphins are believed to play a role in improving the emotions here[20]. Glucocorticoids can alter the expression of hypothalamic neuropeptides such as CRF, Neuropeptide Y (NPY), Agouti related peptide and Proopiomelanocortin (POMC) – they play a role in feeding behaviours[1]. There is increased preference for consumption of hyperpalatable and energy dense high sugar, high fat foods[1,21,22]

Stress not only effects the endocrine system, but also causes changes in the brain too. Previous studies done in high stress groups have used MRI and confirmed changes in certain areas of the brain[11,23] such as:

- Amygdala – related to emotions
- Putamen – related to preparation and execution
- Anterior prefrontal cortex and anterior cingulate gyrus – deal with logic and strategy

Deactivation of frontal region and increased connectivity between Amygdala and Putamen have been observed. This means that greater emotional influence and lesser logical thinking is seen when it comes to making decisions regarding food intake[11,23,24]. The food which improves mood is preferred even when its unhealthy and likely to cause weight gain. Hence such individuals take high calorie food which increases the risk for obesity and Type 2 Diabetes[11,24]. Another consequence of dampening of activity of Prefrontal cortex is the display of behaviour which promote survival when confronted with stress – example being searching for food and food cues[1,25,26]

Activation of HPA axis is also linked to activation of the mesolimbic dopaminergic system. This system is related to perception of reward sensation. Stressors increasing CRF

secretion an also act on prefrontal and limbic regions through a series of neural connections. These regions are also part of brain reward system[1,27,28] and the pathways used could be dopaminergic. Dopamine is associated with reward sensitivity, conditioning and control related to food, with increased dopamine release seen in response to food and food related stimuli. Repeated stimulation of these dopaminergic pathways related to reward cause neurobiological adaptations, which may lead to compulsive behaviour[1,29,30]

SUMMARY AND CONCLUSION:

Stress refers to processes involving perception, appraisal and response to noxious events or stimuli[1,31]. The responses to chronic stress leads to allostatic load on various systems of the body, one of which is raised blood sugar levels due to persistently elevated cortisol. In this study, increased stress perception is associated with a significant rise in blood sugar levels.

The reasons for raised glucose levels could be due to effect of stress hormones on carbohydrate and lipid metabolism.
- Excess intake of high intake food due to alterations in certain regions of brain
- Involvement of reward pathways which favor consumption of high sugar, high fat foods

This leads to weight gain which predisposes to obesity, increased risk of Diabetes Mellitus and risk of Metabolic Syndrome[17].

Interventions Proposed:

- Restriction of high caloric foods – flexible restriction preferable as rigid restraint is associated with binge eating during stressful conditions
- Lifestyle modifications involving altering sedentary lifestyle by taking frequent breaks,[33] increasing physical activity, avoiding addictions like smoking, alcohol etc.
- Meditation has shown to reduce stress.
- Getting involved in hobbies or activities which reduce stress – this is specific for different individuals and they can make a choice about the best suited relaxant for them.

Conflict Of Interest: None

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