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Original Article

Biochemistry Section

Occupational Stress and its Impact on Perceived Stress, Serum Cortisol and Insulin Resistance: A Comparative Study Across Professions

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ABSTRACT

Introduction: Occupational stress affects both physical and mental well-being. It is closely linked to different health issues, including insulin resistance. Because stress levels differ by profession, studying their effects on the body is important. Very few studies have compared stress and its biological effects among various professions.

Aim: To determine job-related stress using biochemical markers, the Perceived Stress Scale (PSS-14) questionnaire and Homeostatic Model Assessment of Insulin Resistance (HOMA-IR) across different occupations.

Materials and Methods: The present cross-sectional study was conducted in the Department of Biochemistry at BLDE (DU) Sri B.M. Patil Medical College, Vijayapur, Karnataka, India, for one year, from January to December 2014. A total of 315 randomly selected male participants were enrolled, representing three different occupational groups, including police constables, bank employees, and a control group. The study collected data regarding biochemical parameters such as fasting glucose, serum cortisol, insulin, Glycated Haemoglobin A1c (HbA1c), PSS-14, questionnaire and HOMA-IR. A one-way ANOVA was conducted to compare anthropometric and biochemical parameters across three groups, followed by Tukey's post-hoc test to identify significant intergroup differences. Means and standard deviations were computed for each parameter in both control and study groups.

Results: In the study group, police constables were the youngest, with an average age of 42.17±1.00, the highest Body Mass Index (BMI) (25.94±0.21) and waist/hip ratio (1.01±0.01). Bank employees had the highest waist (91.71±0.99 cm) and hip circumference (97.77±0.79 cm). PSS significantly increased in study subjects compared to control subjects. HOMA-IR analysis revealed high discrimination for bank employees (AUC=0.92). A significant correlation between HOMA-IR and fasting blood glucose was observed across the studied groups, with the strongest correlation found among bank employees (r=0.574, p=0.001), followed by police constables (r=0.275, p=0.004).

Conclusion: The present study found that the effect of occupational stress on health varies with different occupations. The observations emphasise the need for regular health screenings and lifestyle modifications to prevent long-term complications like diabetes and Cardiovascular Disease (CVD).

Keywords: Diabetes, Cardiovascular disease, Sedentary lifestyle, Biomarkers, Health screening

INTRODUCTION

A workplace must be favourable to promote good health and well-being, as it is where most individuals spend their maximum time. Stress, a normal part of modern life, arises from work-related conditions and imposes a significant impact on both mental and physical health. Stressful situations can stimulate hormonal and neurological networks, complicating interactions and leading to various health issues, including chronic illnesses and mental health problems [1]. Chronic stress may ultimately cause the overactivation of the Hypothalamic-Pituitary-Adrenal (HPA) axis and result in the release of cortisol, the primary stress hormone. Persistently elevated cortisol levels can lead to oxidative stress, inflammation, and metabolic problems, contributing to endothelial dysfunction, insulin resistance, and high blood pressure [2]. Paying more attention to and managing occupational stress effectively is essential because it significantly indicates the employee's health, discomfort, and severe health consequences.

The excess workload, job insecurity, poor relationships with co-workers, and night duties are job-related stressors that could adversely affect an individual's productivity and the standard of their work [3]. The job environment of some professionals is more stressful than others, such as police constables and bank employees, whose working patterns involve more sedentary and stressful schedules [4].

Persistent psychological stress increases the risk of developing insulin resistance and diabetes mellitus, which can be linked to metabolic dysfunction and CVDs [5]. The diminished insulin activity results in insulin resistance, a critical pathophysiological factor. The impaired regulation of insulin receptors resulting from high blood sugar leads to increased synthesis of insulin, a condition where insulin resistance exists despite a high insulin level.

Few studies observed that insulin resistance may lead to CVD by developing elevated glucose levels and impaired lipid metabolism, with hypertension and proinflammatory status [6,7]. Given the limited exploration of the connection between occupational stress and insulin resistance [8,9], the present study evaluated stress levels in the selected occupations and examined their impact on insulin resistance.

MATERIALS AND METHODS

The present cross-sectional study was conducted at the Department of Biochemistry in BLDE (DU) Sri B.M. Patil Medical College, Vijayapura, Karnataka, India, for one year, from January to December 2014. Before commencing, approval from the Institutional Ethical Committee (EC Approval no: 13/11, dated 05-04-11) as per the revised Helsinki Declaration was obtained. All volunteered and randomly selected participants were preintimated about the purpose of the study, possible risks such as mild discomfort during blood collection, and the benefits of contributing to scientific research. Written informed consent was obtained from all participants.

Inclusion criteria:

- Male subjects aged between 30 and 60 were randomly selected for the study;
- Individuals working as bank employees and police constables formed the study group;
- Individuals not employed in these occupations were included as the control group.

Exclusion criteria:

- Individuals below 30 or above 60 years of age were excluded;
- Female participants were not included in the study. Since the number of female police constables available for the study was very low, only male participants were included in all the groups;
- Subjects diagnosed with infectious diseases, any form of cancer, tuberculosis, or psychiatric disorders were excluded.

Sample size calculation: The following sample size calculation formula was used:

$$n=Z^2\frac{P(1-P)}{d^2}$$

Z statistic (Z): For the level of confidence of 95%, the Z value is 1.96.

This study presents the results with 95% Confidence Intervals (CI).

P=Prevalence rate 35% [10].

D=Precision, 0.1;

n=(1.96)2 *0.35 (1- 0.35)/(0.1)2

=3.8416* 0.35* 0.65/0.01; n=87.4 (Rounded to >90 in each group)

The selection of participants was random, resulting in unequal group sizes. Additionally, some individuals joined after the study had already commenced, resulting in variations in group sizes in total three different occupational groups were included:

- Group I (N=110) control subjects
- Group II (N=97) bank employees
- Group III (N=108) police constables.

Study procedure

In total 315 males were included in the study. A total of 10 mL of venous blood samples were collected from each participant following an overnight fast. Samples were collected in Ethylenediaminetetraacetic Acid (EDTA)-containing tubes for Glycated Haemoglobin (HbA1c) estimation. Sodium fluoride tubes were used for blood glucose measurement. All other biochemical analyses were performed using blood collected in plain vacutainer tubes.

Assessment of occupational stress: The PSS-14, consisting of 14 items, was used to measure participants perceived stress levels. Responses were rated on a five-point scale, with total scores ranging from 0 to 56; higher scores indicated greater stress. A cut-off score of 28 was used to classify individuals as “stressed” or “non-stressed” based on previous studies conducted in Pakistan and India [11,12]. The subjects who preferred the local language were given the questionnaire in Kannada.

Assessment of insulin resistance: Insulin resistance was evaluated using the Homeostasis Model Assessment of Insulin Resistance (HOMA-IR) [13]. Fasting blood glucose levels were measured using an enzymatic method, while serum insulin concentrations were determined through the Enzyme-Linked Immunosorbent Assay (ELISA). Insulin resistance for each participant was calculated using the HOMA-IR formula:

HOMA-IR: {fasting insulin (μU/mL)×fasting glucose (mg/dL)}/405 The value above 2.9 indicates established insulin resistance [14]. Similarly, serum cortisol was estimated using an ELISA method and a microplate reader [15]. The normal reference range for serum cortisol is 5 to 15 μg/dL [16].

STATISTICAL ANALYSIS

One-way Analysis of Variance (ANOVA) was used to compare anthropometric and biochemical parameters across the study and control groups. Results on continuous measurements were presented as mean Standard Deviation (SD). The bivariate correlation analysis was performed using Pearson’s correlation coefficient (r) or the intraclass correlation coefficient (whichever was applicable) to test the strength and direction of relationships between interval-level variables. The p-value of less than 0.05 was considered statistically significant, while values greater than 0.05 were deemed insignificant. All statistical analyses were performed using Statistical Package for Social Sciences (SPSS) software, version 16.

RESULTS

Police constables exhibited the highest height, weight, BMI, and waist-hip ratio, indicating a larger overall body size and greater central fat distribution. They also had elevated pulse rates, suggesting increased physiological stress. Bank employees showed the highest waist and hip circumferences and elevated BMI and waist-hip ratio, reflecting central obesity and higher abdominal fat accumulation [Table/Fig-1].

Characteristics	Group-I (N=110) Control Subjects	Group-II (N=97) Bank employees	Group-III (N=108) Police constables	p-value
Age (years)	46.52±0.73	47.28±0.71	42.17±1.00	0.001
Height (cm)	162.68±0.91	166.0±1.02	170.82±0.51	0.001
Weight (cm)	60.13±0.35	69.82±1.06	75.61±0.62	0.001
BMI (kg/m²)	22.99±0.32	25.51±0.45	25.94±0.21	0.001
Waist circumference (cm)	74.83±0.69	91.71±0.99	81.33±1.00	0.001
Hip circumference (cm)	89.18±0.68	97.77±0.79	81.59±1.38	0.001
W/H Ratio	0.84±0.01	0.94±0.01	1.01±0.01	0.001
Systolic blood pressure (mmHg)	120.52±0.78	125.28±1.11	123.06±1.18	0.001
Diastolic blood pressure (mmHg)	78.17±0.6	82.04±1.02	79.96± 0.92	0.001
Pulse Rate (bpm)	80.43±0.66	79.32±0.71	82.40±0.51	0.001

[Table/Fig-1]: Basic characteristics of individuals of different occupational groups.

[Table/Fig-2] presents a comparison of biochemical parameters across the three groups. Statistically significant differences were observed in all the measured variables (p<0.001). Bank employees and police constables showed higher levels of glucose, insulin, cortisol, and insulin resistance compared to the control group, suggesting greater stress-related physiological changes. A One-way ANOVA confirmed that the differences in mean values among the groups were significant for almost all parameters.

Characteristics	Group-I (N=110) Control Subjects	Group-II (N=97) Bank employees	Group-III (N=108) Police constables	p-value
Fasting blood glucose (mg/dL)	97.96±1.08	117.90±3.95	115.09±4.42	0.001
Glycated HbA1c(%)	4.89±0.06	6.04±0.13	5.88±0.12	0.001
Serum cortisol (μg/dL)	9.75±0.47	16.09±0.62	25.00±1.31	0.001
Serum insulin (μU/mL)	5.87±0.58	16.07±1.16	14.62±1.19	0.001
HOMA-IR	1.52±0.19	4.79±0.39	4.72±0.48	0.001
PSS	18.82±0.62	24.69±0.66	27.49±0.82	0.001

[Table/Fig-2]: Biochemical parameters in different occupational groups.

[Table/Fig-3] shows the correlation analysis after stratifying participants into stressed and non-stressed groups based on PSS scores. In the stressed subgroup, serum cortisol levels exhibited significant positive correlations with fasting blood glucose and HbA1c, indicating stress-related disruptions in glucose homeostasis. Conversely, no significant correlation was observed between cortisol and these metabolic markers in the non-stressed group, suggesting the absence of such relationships without stress.

Variables	Stressed (n=30) r-value	p-value	Non-stressed (n=67) r-value	p-value
Fasting blood glucose (mg/dL)	0.470	0.009**	0.033	0.788
Glycated HbA1c (%)	0.410	0.024*	-0.058	0.641
Serum Insulin (µU/mL)	0.034	0.857	-0.192	0.120
HOMA-IR	0.130	0.493	-0.162	0.190

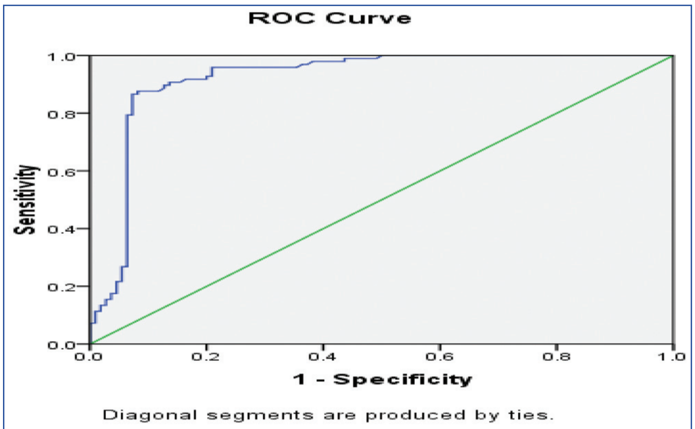
[Table/Fig-3]: Correlation analysis between serum cortisol and glucose homeostasis markers in stressed and non-stressed bank employees.
*p<0.05, **p<0.01, ***p<0.001

[Table/Fig-4] displays the correlation coefficients between serum cortisol levels and glucose homeostasis markers among stressed and non-stressed police constables. In the stressed subgroup, elevated cortisol levels were significantly associated with impaired glycaemic control and higher perceived stress. A negative correlation with HOMA-IR (r=-0.350, p=0.025) indicates a potentially complex metabolic response under stress conditions. In contrast, when stress is absent, the non-stressed group showed no significant correlations, indicating a lack of cortisol-related effects on glucose metabolism.

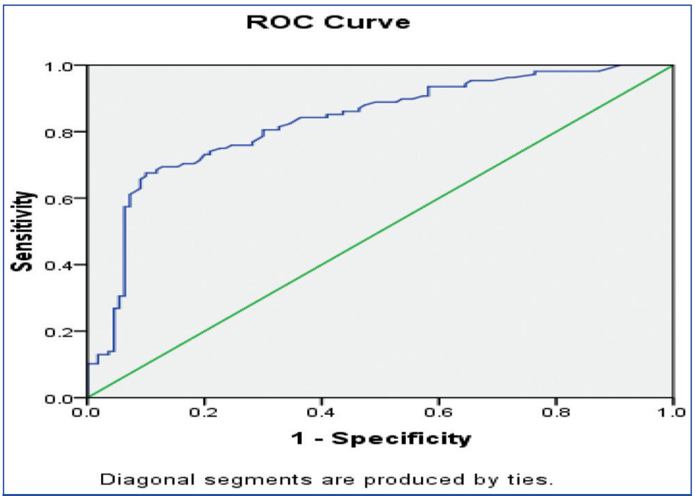
Variables	Stressed (n=41) 'r' value	p-value	Non-stressed (n=67) 'r' value	p-value
Fasting blood glucose (mg/dL)	0.357	0.011*	0.013	0.459
Glycated HbA1c (%)	0.424	0.003**	0.048	0.349
Serum insulin (µU/mL)	-0.183	0.253	-0.098	0.429
HOMA-IR	-0.350	0.025	-0.075	0.546

[Table/Fig-4]: Correlation analysis between serum cortisol and glucose homeostasis markers in stressed and non-stressed police constables.
* p<0.05, **p<0.01, ***p<0.001

The statistical analysis in [Table/Fig-5-7] indicates that HOMA-IR demonstrated significant diagnostic utility across all occupational groups, with AUC values significantly less than 0.5 (p<0.001). The discriminative performance was highest among bank employees (AUC=0.92, SE=0.021), indicating excellent accuracy. Police constables exhibited good discrimination (AUC=0.82, SE=0.028. HOMA-IR values generally range from 0.5 to 1.4; values of 1.9 or higher suggest early insulin resistance.



[Table/Fig-5]: Receiver operating characteristic (ROC) curve analyses of HOMA values for bank employees.



[Table/Fig-6]: Receiver Operating Characteristic (ROC) curve analyses of HOMA-IR values for police constables.

Groups	Area under the curve for HOMA-IR ROC	SE	p-value
Bank employees	0.92	0.021	0.001
Police constables	0.82	0.028	0.001

[Table/Fig-7]: HOMA-IR for scores of the study groups.

DISCUSSION

Occupational stress profoundly impacts employees' ability to meet job demands, affecting their emotional well-being, physical health, and job performance. Chronic stress can disrupt glucose metabolism and neuroendocrine function, elevating the risk of severe health conditions, like CVDs, mental health disorders, and metabolic issues, including insulin resistance [17]. However, many employees either underestimate or conceal their stress because of stigma or fear of repercussions, leading to unaddressed issues that heighten the risk of harmful health effects. It highlights the urgent need for proactive measures to address occupational stress, and it is essential for preventing health complications and improving employee well-being.

In the present study, the authors conducted biochemical assessments to evaluate the effects of occupational stress in three distinct job sectors by measuring serum cortisol levels and using HOMA-IR. The findings of the present study are consistent with those of Chandola T et al., who reported that high occupational stress increased the risk of metabolic syndrome [18]. Significant differences in physiological and biochemical parameters were observed among bank employees and police constables when compared to the control group. Key risk factors identified included high BMI, increased waist-to-hip ratio, obesity, elevated waist circumference, and high blood pressure, all of which are associated with an increased risk of CVD [19]. A Colombian study found that the Waist-To-Height Ratio (W-HtR) was the strongest adiposity marker linked to cardiometabolic risk, showing a more consistent and proportional association than BMI or waist circumference [20].

In the present study, bank employees who faced high stress and led sedentary lifestyles showed higher BMI, waist circumference, and blood pressure. Police constables with constant stress from irregular duty hours and job constraints had the highest stress scores (PSS-14), waist-hip ratios, blood pressure and higher BMI, suggesting an elevated risk of obesity-related health complications.

Blood pressure raises cardiovascular health awareness. Bank employees expressed concerns over their high waist circumference and blood pressure, highlighting cardiovascular health risks. These observations are consistent with epidemiological studies emphasising BMI and waist circumference as critical indicators for identifying high-risk populations [21]. Chronic stress activates the HPA axis and Sympathetic Nervous System (SNS), leading to elevated levels of stress hormones, such as cortisol and adrenaline, which in turn trigger metabolic disturbances that can affect physical and mental health. Cortisol, a primary stress hormone, plays a central role in the stress response in the body [22]. Elevated stress levels and cortisol secretion have been observed in studies of sedentary workers, such as those conducted by Vrijkotte TGM et al., [23]. A study assessed stress levels using serum cortisol and PSS-14 scores, revealing significant differences among the occupational groups [24]. Harris KM et al., emphasised the consideration of individual variability and temporal changes in PSS scores when evaluating perceived stress [25]. Cortisol also stimulates gluconeogenesis, potentially leading to hyperglycaemia [26]. Furthermore, it disrupts insulin signaling, reduces glucose uptake, promotes weight gain and central adiposity, and is associated with inflammation and impaired insulin function [27,28].

HOMA-IR assessments help to evaluate insulin resistance and beta-cell function, enabling the early identification of metabolic disturbances that may lead to type 2 diabetes and other related disorders [29]. Elevated HOMA-IR values reflect reduced insulin sensitivity and are closely linked to the development of CVD, obesity, and metabolic syndrome [30]. In the present study, police constables showed higher cortisol levels and PSS scores, indicating chronic stress, while bank employees exhibited greater insulin resistance, as reflected by elevated HOMA-IR values.

Chronic stress-induced cortisol elevation promotes hepatic glucose production and insulin release, increasing the HOMA-IR values [31]. In this study, a significant correlation between HOMA-IR and fasting blood glucose was observed across the studied groups, with the strongest correlation found among bank employees ($r=0.574$, $p=0.001$), followed by police constables ($r=0.275$, $p=0.004$). Consistent with Ormazabal V et al., findings, this study's data revealed a close association between insulin resistance and the risk of CVD, obesity, and metabolic syndrome [32].

Few studies have shown that chronic job-related stress and factors like poor diet and lack of physical activity can worsen insulin resistance. Stress also disrupts sleep and lowers motivation to exercise, increasing HOMA-IR levels [33,34].

It was also observed that fasting blood glucose, HbA1c levels, and HOMA-IR were strongly correlated among the study subjects, highlighting their importance in assessing metabolic health. The studies involving the assessment of serum cortisol, blood glucose, and HbA1c reported similar findings [35]. These findings highlight the strong association between stress and insulin resistance, underscoring the importance of targeted health interventions for high-risk populations, particularly police constables. Employers should actively promote stress reduction programs to enhance employee well-being and develop prevention strategies tailored to individual risk profiles and stress levels. Significant differences in metabolic health indicators were observed across occupations. Bank employees and police officers exhibited strong correlations between fasting blood glucose and HbA1c levels, indicating increased metabolic risk. The lack of substantial findings related to waist circumference and blood pressure suggests that traditional metrics do not fully capture metabolic health issues in these groups. Instead, biomarkers, such as fasting blood glucose and serum insulin levels, can provide more detailed insights into the underlying health dynamics.

Limitation(s)

The present study emphasises the adverse effects of occupational stress across the professions. However, there were certain limitations. It was a cross-sectional study with only male participants and could not be applied to women. It was challenging to draw generalised conclusions about occupational stress as the responses to the PSS-14 varied from person to person. Increasing the sample size would help detect significant differences across the occupations more easily.

CONCLUSION(S)

The present study shows that occupational stress has a substantial adverse effect on cortisol, perceived stress and insulin resistance across different occupations. Bank workers and police constables have more metabolic problems, emphasising the need for focused interventions. These findings advocate for policies to mitigate the health risks associated with workplace stress. Future studies should focus on larger participant groups that include both men and women and utilise longitudinal designs to examine the relationship between occupational stress and metabolic changes accurately. Adding variables like the work environment sleep quality, and coping strategies may help explain some stress-related physiological changes. Moreover, there is a critical need for more research, in addition to developing and implementing frequent health campaigns, targeted towards stress-reduction strategies for high-risk occupations like banking and law enforcement, to formulate evidence-based workplace health policies.

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