ORIGINAL RESEARCH ARTICLE

Cortisol Levels and Their Association with Workplace Stress in IT Workers

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ABSTRACT

Background: Workplace stress is increasingly recognized as a physiological and psychological burden in cognitively demanding occupations such as information technology. Chronic stress activates the hypothalamic-pituitary-adrenal (HPA) axis and can lead to cortisol dysregulation, measurable through serum biomarkers. Objectives: To evaluate the association between workplace stress and diurnal serum cortisol levels among IT professionals in Chennai, India.

Methods: A cross-sectional study was conducted involving 300 full-time IT professionals aged 25 to 45 years. Participants completed the Health and Safety Executive (HSE) Management Standards Indicator Tool to assess occupational stress across seven domains. Serum cortisol was measured via chemiluminescent immunoassay at two-time points morning (8–9 AM) and evening (6–7 PM) to evaluate diurnal variation. Associations were analyzed using correlation and multivariate regression, adjusting for age, gender, BMI, and smoking.

Results: Mean cortisol levels were higher in the morning (418.3 ± 96.4 nmol/L) than evening (211.7 ± 85.2 nmol/L). A flattened diurnal rhythm, defined as a morning–evening cortisol difference of less than 150 nmol/L, was observed in 22% of participants. Lower scores in job control, role clarity, and workplace relationships were significantly associated with cortisol dysregulation. Female gender and smoking were additional risk factors.

Conclusions: Serum cortisol alterations reflect psychosocial stress exposure. Diurnal cortisol assessment may serve as a useful biomarker of work-related stress, supporting the need for organizational interventions.

Keywords: Cortisol, Occupational stress, IT professionals, Circadian rhythm, Job control, Workplace relationships, HPA axis, Diurnal cortisol

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INTRODUCTION

Workplace stress has emerged as a significant occupational health challenge in the modern era, particularly in sectors characterized by high job demands, long hours, and rapid technological advancement. The Information Technology (IT) industry is emblematic of such a high-pressure environment, and professionals within this field often experience sustained exposure to psychosocial stressors such as performance anxiety, project deadlines, night shifts, and job insecurity. In India, a global IT hub, cities like Chennai host a dense concentration of IT professionals whose mental and physiological health may be vulnerable to these occupational stressors. Chennai is a major IT hub with over 1,000 IT firms employing approximately 780,000 professionals, and presents a unique environment for studying occupational stress.[1]

Work-related stress (WRS) is defined by the European Agency for Safety and Health at Work as the harmful physical and emotional response that occurs when the requirements of the job do not match the capabilities, resources, or needs of the worker.[2] Physiologically, stress activates the hypothalamic-pituitary-adrenal (HPA) axis, culminating in the release of cortisol, a glucocorticoid hormone produced by the adrenal cortex. Cortisol plays a central role in the body's adaptation to stress by regulating metabolism, immune function, and cardiovascular responses.[3,4] Chronic dysregulation of cortisol secretion is associated with negative health outcomes, including metabolic syndrome, depression, cardiovascular disease, and impaired cognitive performance.[5-7]

Cortisol secretion follows a diurnal rhythm, peaking shortly after waking and gradually declining throughout day. Assessing cortisol levels at different times of the day, particularly in the morning and evening, allows researchers to evaluate the integrity of this rhythm and identify potential alterations caused by chronic stress exposure.[8] Although both serum and salivary cortisol have been utilized as biomarkers for stress, serum level offers direct measurement of circulating hormone levels and is a validated index of acute and chronic stress responses.

Previous studies have investigated the relationship between cortisol levels and occupational stress, employing both subjective assessments (e.g., standardized questionnaires) and objective measures (e.g., blood or urinary cortisol).[9] De Sio et al. conducted a comprehensive observational study and found that urinary cortisol levels, more so than serum levels, were significantly associated with work-related variables such as role clarity and perceived control in an Italian working population.[10] However, no studies have specifically examined serum cortisol diurnal variation in the Indian IT sector, highlighting a critical gap in occupational stress research in this population. Serum cortisol offers direct measurement of circulating hormone levels and is a validated index of stress responses, showing higher sensitivity to acute stress compared to salivary cortisol.[11] There is limited evidence from South Asian populations, particularly within the IT sector, where cultural and occupational dynamics differ significantly.

This study seeks to contribute to the understanding of occupational stress physiology in the Indian IT workforce and assess the viability of serum cortisol as a stress marker in this population.

METHODOLOGY

Study Design and Participants: This cross-sectional observational study was conducted between January and August 2024 among IT professionals employed in major software and technology firms located in Chennai, India. A total of 300 full-time IT professionals were recruited through corporate partnerships and internal communication channels. The sample size of 300 was calculated to detect a minimum correlation coefficient (r) of 0.20 between workplace stress scores and serum cortisol levels, with 80% statistical power and a significance level of $\alpha = 0.05$, allowing for subgroup analysis by gender and smoking status. The calculation was guided by standard power analysis recommendations.[12] The sample size was determined to ensure sufficient statistical power for detecting moderate to small associations between workplace stress and serum cortisol levels, and to allow subgroup analysis by gender, smoking status, and job role.

The study was approved by the Institutional Human Ethics Committee of Sree Balaji Medical College & Hospital, Bharath Institute of Higher Education and Research, Chennai (Ref. No. 483/SBMCH/IHEC/2024/0152). Written informed consent was obtained from all participants. All procedures were conducted in accordance with the ethical standards outlined in the Declaration of Helsinki and all collected data were anonymized and stored securely to maintain confidentiality, in accordance with National Ethical Guidelines for Biomedical and Health Research issued by the Indian Council of Medical Research (ICMR), 2017.[13]

Inclusion and Exclusion Criteria

Participants were included in the study if they had been employed in the Information Technology (IT) sector for a minimum of one year. Eligible participants were required to be between 25 and 45 years of age and to have regular working shifts, with those working exclusively night shifts being excluded.

The exclusion criteria[14] comprised several health and lifestyle factors that could influence study outcomes. Individuals with a current diagnosis of endocrine or psychiatric disorders were not included. Similarly, those using corticosteroids, antidepressants, or undergoing hormonal therapy were excluded due to the potential effects on hormonal balance. Additional exclusions were made for participants engaged in shift

work, those who were pregnant, or those suffering from chronic illnesses such as diabetes, which are known to impact cortisol physiology. Furthermore, participants who had consumed alcohol or engaged in intense physical activity within 48 hours prior to sample collection were also excluded from the study.

Stress Assessment: Workplace stress was assessed using the Health and Safety Executive (HSE) Management Standards Indicator Tool, which consists of 35 items covering seven domains: demands, control, support (managers and peers), relationships, role clarity, and change management. The Indian-adapted version of the HSE tool was used for cultural relevance. Occupational stress was assessed using the Indian-adapted version of the Health and Safety Executive (HSE) Management Standards Indicator Tool, which evaluates seven psychosocial domains. This tool has demonstrated acceptable psychometric properties and internal consistency in Indian occupational settings, with domain-wise Cronbach's alpha values ranging from 0.72 to 0.87 in prior validation studies[15]. In our study, the tool was pilot-tested in a subsample of 30 participants, yielding an overall Cronbach's alpha of 0.83, confirming good internal consistency. Responses were recorded on a 5-point Likert scale, with higher scores indicating lower perceived stress.

Serum Cortisol Measurement: Serum cortisol was assessed at two time: between 8:00–9:00 AM (morning sample) and between 6:00–7:00 PM (evening sample). Participants were instructed to avoid caffeine, heavy meals, and physical exertion at least 2 hours prior to sampling. Participants were required to fast for at least 4 hours prior to each blood draw, as recent food intake can influence circulating cortisol concentrations.[16] Morning samples were collected between 8:00–9:00 AM and evening samples between 6:00–7:00 PM to standardize diurnal variation.

Blood samples were analyzed using a chemiluminescent immunoassay (CLIA) at a NABL-accredited laboratory. Intra- and inter-assay coefficient variations were maintained below 5%. Diurnal variation was calculated as the difference between morning and evening cortisol levels.

Statistical Analysis: Descriptive statistics were used to summarize demographic characteristics and key study variables. Normality of data was assessed using the Shapiro-Wilk test. Pearson correlation was applied for normally distributed variables, while Spearman correlation was used for non-normally distributed variables to examine associations between cortisol levels and HSE stress domains.[17]

Multivariate linear regression models were applied to assess the relationship between cortisol levels and workplace stress, adjusting for potential confounders including age, gender, BMI, and smoking status. All statistical analyses were conducted using SPSS version 25.0 (IBM Corp., Armonk, NY, USA), and a p-value of <0.05 was considered statistically significant.

RESULTS

Participant Characteristics: A total of 300 IT professionals participated in the study. The demographic characteristics of the study population are summarized in Table 1. The mean age was 33.8 ± 5.7 years, with a male-to-female ratio of approximately 3:2. A majority of participants (72%) were engaged in project management or software development roles. Smoking was reported by 24% of the sample, and 18% had a history of hypertension or other metabolic concerns.

Table 1: Demographic and Clinical Characteristics of Study Participants (n = 300)

Variable	Participants(%)
Age (years), mean ± SD	33.8 ± 5.7
Gender	
Male	180 (60)
Female	120 (40)
Job Role	
Developer	138 (46)
Project Manager	78 (26)
Support/QA	84 (28)
Smoking Status	
Smokers	72 (24)
Non-smokers	228 (76)
BMI (kg/m^2), mean ± SD	24.7 ± 3.2
Comorbid Conditions (hypertension, diabetes, dyslipidaemia), (%)	54 (18)

Serum Cortisol Profiles: The mean serum cortisol level was significantly higher in the morning (mean: 418.3 ± 96.4 nmol/L) compared to the evening (mean: 211.7 ± 85.2 nmol/L), confirming a normal diurnal rhythm among most participants. However, a flattened cortisol slope (morning-evening difference <150 nmol/L) was observed in 22% of the sample, predominantly among those reporting high perceived stress on the HSE questionnaire.

Morning and evening serum cortisol level represents the expected physiological decline in cortisol levels over the course of the day, and serves as a reference point for identifying participants with flattened diurnal rhythms in association with workplace stress domains assessed using the HSE tool.[18]

Significant correlations were found between morning cortisol levels and HSE control ($r = -0.29$, $p < 0.001$) and role clarity domains ($r = -0.21$, $p = 0.004$). Evening cortisol was positively associated with lower scores in the relationship domain ($r = -0.25$, $p = 0.002$).

Gender and Smoking Status Subgroup Analysis: Female participants demonstrated lower overall serum cortisol levels in both time periods, though the pattern of associations with stress scores remained consistent. Smokers had significantly higher evening cortisol levels (mean: 242.5 ± 78.6 nmol/L) compared to non-smokers (mean: 198.4 ± 82.1 nmol/L, $p < 0.01$).

Table 2: Serum Cortisol Levels and HSE Stress Domain Associations

Variable	Morning	Evening	Cortisol Diurnal Difference
Cortisol (nmol/L) (Mean ± SD)	418.3 ± 96.4	211.7 ± 85.2	206.6 ± 72.8
HSE Demand (r, p-value)	−0.12, 0.08	−0.10, 0.11	−0.15, 0.03
HSE Control (r, p-value)	−0.29, <0.001	−0.18, 0.01	−0.25, 0.002
HSE Role Clarity (r, p-value)	−0.21, 0.004	−0.14, 0.06	−0.19, 0.009
HSE Relationships (r, p-value)	−0.16, 0.02	−0.25, 0.002	−0.22, 0.005

Table 3: Multivariate Linear Regression Analysis: Association of HSE Stress Domains with Serum Cortisol Levels

Predictor Variable	Morning Cortisol (β, p-value)	Evening Cortisol (β, p-value)	Diurnal Difference (β, p-value)
Age	−0.14, 0.022	−0.10, 0.078	−0.12, 0.041
Gender (Female)	−0.18, 0.006	−0.21, 0.002	−0.16, 0.014
BMI	0.11, 0.067	0.09, 0.102	0.10, 0.082
Smoking (Yes)	0.16, 0.009	0.23, <0.001	0.19, 0.004
HSE Demand	−0.10, 0.075	−0.08, 0.142	−0.12, 0.036
HSE Control	−0.28, <0.001	−0.21, 0.003	−0.25, 0.001
HSE Role Clarity	−0.19, 0.004	−0.12, 0.046	−0.17, 0.008
HSE Relationships	−0.15, 0.016	−0.20, 0.002	−0.18, 0.007
Adjusted R^2	0.31	0.28	0.34

Table 4: Prevalence of Flattened Cortisol Rhythm by Stress Domains and Participant Characteristics

Variable	Flattened Rhythm (%)	Normal Rhythm (%)	p-value*
Total (n = 300)	66 (22.0)	234 (78.0)	–
Gender			0.041
Male (n = 180)	33 (18.3)	147 (81.7)	
Female (n = 120)	33 (27.5)	87 (72.5)	
Smoking status			0.019
Smoker (n = 72)	24 (33.3)	48 (66.7)	
Non-smoker (n = 228)	42 (18.4)	186 (81.6)	
HSE Control Domain			<0.001
Low control (bottom tertile)	35 (35.0)	65 (65.0)	
Medium control	20 (20.0)	80 (80.0)	
High control (top tertile)	11 (11.0)	89 (89.0)	
HSE Role Clarity			0.008
Poor role clarity (bottom tertile)	28 (28.6)	70 (71.4)	
Medium clarity	22 (22.0)	78 (78.0)	
High clarity	16 (16.0)	86 (84.0)	

Definition: Flattened cortisol rhythm = Morning–Evening serum cortisol difference <150 nmol/L
*p-values based on chi-square test of independence

A statistically significant difference was observed in mean morning cortisol levels between smokers (445.6 ± 102.3 nmol/L) and non-smokers (410.2 ± 91.8 nmol/L) (p = 0.017). The effect size, calculated using Cohen's d, was 0.37, indicating a small to moderate magnitude of difference.[19]

These regression results provide a robust picture of which aspects of work stress are most closely linked to physiological stress response via cortisol. The Control and Role Clarity domains appear to be the most influential across cortisol measures.

The prevalence of **flattened cortisol rhythm** was notably higher among **Females** (27.5%), **Smokers** (33.3%) and Individuals with **low perceived job control** (35.0%) and **poor role clarity** (28.6%).

This reinforces the role of workplace psychosocial stressors in altering physiological stress responses.

DISCUSSION

This study evaluated the relationship between workplace stress and diurnal serum cortisol levels in a sample of 300 IT professionals from Chennai, India. The findings confirm that occupational stress, especially in the domains of low control and unclear roles, is significantly associated with dysregulation in the physiological stress response, as reflected by altered serum cortisol profiles.

The presence of a circadian rhythm, with significantly higher morning cortisol compared to evening levels, aligns with the expected functioning of the hypothalamic-pituitary-adrenal (HPA) axis in healthy individuals.[2,3] However, approximately 22% of participants exhibited a flattened cortisol rhythm, defined as a morning-evening cortisol difference of less than 150 nmol/L, a pattern commonly associated with chronic stress and maladaptive HPA axis

regulation.[4,5]

These findings build on the evidence provided by De Sio et al., who found that urinary cortisol, rather than serum levels, was associated with stress-related domains like job control and role clarity using the HSE Management Standards Indicator Tool[6]. Unlike that study, our use of both morning and evening serum cortisol measurements allowed for assessment of diurnal variation, offering a more nuanced understanding of stress physiology among knowledge-sector employees.

In multivariate analysis, we observed that low job control, poor role clarity, and strained workplace relationships were significantly associated with elevated cortisol levels or flattened diurnal slope. This supports previous research where psychosocial risk factors notably low autonomy and unclear job responsibilities were predictive of cortisol dysregulation.[7,8]

Our findings are consistent with results from high-stress occupational groups. In a study among Indian police constables, serum cortisol was significantly elevated in those reporting high stress on the Perceived Stress Scale (PSS), and 38% were diagnosed with metabolic syndrome.[9] Similarly, a cohort study in China demonstrated that hair cortisol concentration (HCC) was positively correlated with increasing occupational stress and was predictive of hypertension, suggesting long-term systemic effects of chronic workplace stress.[10]

Gender-specific differences were also notable. Female IT workers were more likely to show flattened cortisol rhythms, an observation mirrored in multiple studies showing gender-based susceptibility to stress and cortisol dysregulation.[20,21] Smoking status was another significant predictor, with smokers displaying elevated evening cortisol and reduced diurnal variation, a pattern also documented in prior occupational health studies.[22,23]

The 22% prevalence of flattened diurnal cortisol rhythm observed in our IT cohort is lower than the 30% reported among healthcare workers, a population similarly exposed to high occupational stress.[24] This suggests that while IT professionals do experience stress-induced cortisol dysregulation, its prevalence may vary across sectors depending on job demands, work hours, and support systems. Bani-Issa et al. evaluated salivary cortisol and perceived stress in female healthcare professionals and found significant cortisol disruptions related to shift work and poor sleep quality, factors that may be paralleled by long work hours and irregular schedules in the IT sector.[24] Other studies have reinforced the role of chronotype in cortisol regulation, noting higher stress hormone levels in those working against their biological rhythms.[25]

Low job control and poor role clarity may contribute to chronic psychological stress, which in turn elevates allostatic load a cumulative burden on physiological systems responsible for adaptation to stress. Persistent activation of this stress response pathway can lead to dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis, resulting in a blunted or flattened cortisol rhythm.[26] Specifically, unpredictable work demands and unclear expectations can impair feedback inhibition within the HPA axis, prolonging cortisol secretion even when external stressors are no longer present.[27]

Interestingly, although our study used serum cortisol as the biomarker, the direction of associations mirrors those found in studies using urinary cortisol[28,29], salivary cortisol[30,31], and hair cortisol[20]. This convergence across biomarkers suggests a robust biological link between work-related psychosocial stress and HPA axis activity.

In terms of biological mechanisms, sustained occupational stress is thought to result in allostatic load, a chronic state of HPA axis activation that, over time, blunts the typical diurnal cortisol slope and may lead to health issues such as cardiovascular disease, depression, and metabolic disorders.[32,33] Chronic HPA axis dysregulation is associated with hippocampal atrophy, systemic inflammation, and insulin resistance providing a plausible physiological basis for the link between job stress and physical illness.[34,35]

Moreover, our study offers further support for Selye's General Adaptation Syndrome model, in which long-term exposure to stressors without adequate recovery leads to exhaustion of adaptive reserves and breakdown of homeostasis.[36] This concept has been reaffirmed in modern neuroendocrinology, which identifies cortisol as both an acute survival hormone and a chronic risk factor when dysregulated.[37]

A limitation of this study is the cross-sectional design, which precludes causal inferences. While our serum cortisol data was collected at two time points, future studies may benefit from incorporating hair cortisol to assess chronic stress over weeks to months, or salivary cortisol for non-invasive repeated measures. Further, subjective factors such as sleep quality and caffeine consumption were not controlled for, which may have influenced cortisol readings.[38,39] This study did not assess sleep duration, sleep quality, or chronotype, all of which can influence cortisol regulation and may act as potential confounders. For example, sleep restriction has been shown to elevate cortisol levels the following evening. Future studies may consider incorporating actigraphy or validated sleep assessment tools to better account for these variables.[40]

Nevertheless, with a robust sample size of 300 and integration of validated tools like the HSE questionnaire, this study contributes to the growing body of evidence on stress biomarkers in workplace settings. Given the increasing burden of mental and occupational health issues in India's IT sector, our findings underscore the need for organizational interventions aimed at increasing role clarity, enhancing job con-

trol, and improving interpersonal dynamics.

PRACTICAL IMPLICATIONS

Workplace wellness programs should incorporate both subjective assessments (like the HSE tool) and objective biomarkers (like cortisol) to identify at-risk employees. Tailored strategies such as stress management workshops, peer support systems, and flexible work structures could be especially beneficial in high-cognition, high-performance industries.

CONCLUSION

This study confirms a significant association between workplace stress and altered diurnal serum cortisol patterns among IT professionals in Chennai, India. Notably, domains such as low job control, unclear roles, and poor workplace relationships were closely linked with elevated or dysregulated cortisol responses, including a flattened morning-evening cortisol difference. These physiological changes, driven by chronic occupational stress, reflect maladaptive functioning of the hypothalamic-pituitary-adrenal (HPA) axis and may increase long-term risk for stress-related illnesses.

These findings highlight the need for workplace-level interventions targeting job control and role clarity. Human Resource departments and occupational health teams should consider implementing regular stress audits using standardized tools like the HSE Indicator Tool and providing structured stress management programs.

Future research should adopt longitudinal cohort designs ideally spanning 12 months or more to evaluate causal relationships between occupational stress and cortisol dynamics. Including additional biomarkers such as salivary alpha-amylase and dehydroepiandrosterone (DHEA) could offer a more comprehensive understanding of chronic stress physiology.

The findings contribute to the growing body of evidence suggesting that cortisol profiling, especially assessing diurnal variation can serve as a valuable biomarker for chronic workplace stress. Given the mental and physical health risks associated with prolonged stress exposure, organizations should prioritize psychosocial interventions that enhance role clarity, job autonomy, and peer support.

Given the cross-sectional nature of this study, causal relationships between workplace stress and cortisol dysregulation cannot be established. Future longitudinal studies are warranted to track cortisol patterns over time in response to targeted stress-reduction interventions, as demonstrated in prior neuroendocrine research.[41]

Further research using longitudinal designs and integrating additional biomarkers such as hair or salivary cortisol is warranted to explore the cumulative impact of occupational stress and the efficacy of stress reduction strategies. Tailored workplace wellness programs, particularly in cognitively demanding sectors like IT, are essential for sustaining workforce health and productivity.

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REFERENCES

1. NASSCOM. Indian Tech Industry FY2024 Report. National Association of Software and Service Companies; 2024. Available from: https://nasscom.in/knowledge-center/publications/technology-sector-india-strategic-review-2024
2. Hirokawa K, Ohira T, Nagao M, Nagayoshi M, Kajiura M, Imano H, Kitamura A, Kiyama M, Okada T, Iso H. Associations between occupational status, support at work, and salivary cortisol levels. Int J Behav Med. 2022;29(3):299-309. DOI: https://doi.org/10.1007/s12529-021-10020-2.
3. Tsigos C, Chrousos GP. Hypothalamic-pituitary-adrenal axis, neuroendocrine factors and stress. J Psychosom Res. 2002;53(4):865-871. DOI: https://doi.org/10.1016/S0022-3999(02)00429-4 PMid:12377295
4. Xu J, Wang B, Ao H. Corticosterone effects induced by stress and immunity and inflammation: mechanisms of communication. Front Endocrinol (Lausanne). 2025 Mar 20;16:1448750. DOI: https://doi.org/10.3389/fendo.2025.1448750 PMID: 40182637; PMCID: PMC11965140
5. Vogelzangs N, Beekman ATF, Milaneschi Y, Bandinelli S, Ferrucci L, Penninx BW. Urinary cortisol and six-year risk of all-cause and cardiovascular mortality. J Clin Endocrinol Metab. 2010;95(11):4959-4964. DOI: https://doi.org/10.1210/jc.2010-0192 PMid:20739384.
6. De Sio S, Letizia C, Petramala L, Pica B, Carlomagno F, Tarsitani G, et al. Work-related stress and cortisol levels: is there an association? Results of an observational study. Eur Rev Med Pharmacol Sci. 2018;22(24):9012-9017. https://doi.org/10.

26355/eurrev_201812_16672

7. Knezevic E, Nenic K, Milanovic V, Knezevic NN. The role of cortisol in chronic stress, neurodegenerative diseases, and psychological disorders. Cells. 2023;12(23):2726. DOI: https://doi.org/10.3390/cells12232726 PMid:38067154.
8. Al-Madi T, Cathers I, Chow CM. Associations among work-related stress, cortisol, inflammation, and metabolic syndrome. Psychophysiology. 2013;50(9):821-830. DOI: https://doi.org/10.1111/psyp.12069 PMid:23758414
9. Randler C, Schaal S. Morningness-eveningness, habitual sleep-wake variables and cortisol level. Biol Psychol. 2010;85(1):14-18. DOI: https://doi.org/10.1016/j.biopsycho.2010.04.006 PMid:20450953
10. Hansen AM, Larsen AD, Rugulies R, Garde AH, Knudsen LE. A review of the effect of the psychosocial working environment on physiological changes in blood and urine. Basic Clin Pharmacol Toxicol. 2009;105(2):73-83. DOI: https://doi.org/10.1111/j.1742-7843.2009.00444.x PMid:19563453
11. Hellhammer DH, Wüst S, Kudielka BM. Salivary cortisol as a biomarker in stress research. Psychoneuroendocrinology. 2009;34(2):163-171. DOI: https://doi.org/10.1016/j.psyneuen.2008.10.026 PMid:19095358
12. Cohen J. Statistical Power Analysis for the Behavioral Sciences. 2nd ed. Hillsdale, NJ: Lawrence Erlbaum Associates; 1988.
13. Indian Council of Medical Research. National Ethical Guidelines for Biomedical and Health Research Involving Human Participants. New Delhi: ICMR; 2017. Available from: https://ethics.ncdirindia.org/asset/pdf/ICMR_National_Ethical_Guidelines.pdf
14. Jung C, Ho JT, Torpy DJ, Rogers A, Doogue M, Lewis JG, et al. A longitudinal study of plasma and urinary cortisol in pregnancy and postpartum. J Clin Endocrinol Metab. 2011;96(5):1533-1540. DOI: https://doi.org/10.1210/jc.2010-2395
15. Edwards JA, Webster S, Van Laar D, Easton S. Psychometric analysis of the UK Health and Safety Executive's Management Standards work-related stress Indicator Tool. Work Stress. 2008;22(2):96-107. DOI: https://doi.org/10.1080/02678370802166599
16. Markus R, Panhuysen G, Tuiten A, Koppeschaar H. Effects of food on cortisol and mood in vulnerable subjects under controllable and uncontrollable stress. Physiol Behav. 2000;70(3-4):333-342. DOI: https://doi.org/10.1016/S0031-9384(00)00265-1 PMid:11006432
17. Field A. Discovering Statistics Using IBM SPSS Statistics. 5th ed. London: SAGE Publications; 2017.
18. Tufte ER. The Visual Display of Quantitative Information. 2nd ed. Cheshire, CT: Graphics Press; 2001.
19. Gossain VV, Sherma NK, Srivastava L, Michelakis AM, Rovner DR. Hormonal effects of smoking--II: Effects on plasma cortisol, growth hormone, and prolactin. Am J Med Sci. 1986 May;291(5):325-7. DOI: https://doi.org/10.1097/00000441-198605000-00007 PMID: 3010721
20. Schnorpfeil P, Noll A, Schulze R, Ehlert U, Frey K, Diefenbach C, et al. Allostatic load and work conditions. Soc Sci Med. 2003;57(4):647-656. DOI: https://doi.org/10.1016/S0277-9536(02)00407-0 PMid:12821013
21. Walvekar SS. Study on serum cortisol and perceived stress scale in the police constables. J Clin Diagn Res. 2015;9(2):BC10-BC13. DOI: https://doi.org/10.7860/JCDR/2015/12015.5576 PMid:25859444 PMCid:PMC4378726
22. Wang J, Xiao J, Zhu L, et al. A cohort study on the association between changing occupational stress, hair cortisol concentration, and hypertension. PLoS One. 2023;18(5):e0285623. DOI: https://doi.org/10.1371/journal.pone.0285623
23. Rohleder N, Kirschbaum C. The hypothalamic-pituitary-adrenal (HPA) axis in habitual smokers. Int J Psychophysiol. 2006;59(3):236-243. DOI: https://doi.org/10.1016/j.ijpsycho.2005.10.012 PMid:16325948
24. Bani-Issa W, Al Marzooq F, Khasawneh W, et al. Salivary cortisol, subjective stress and quality of sleep among female healthcare professionals. J Multidiscip Healthc. 2020;13:453-462. DOI: https://doi.org/10.2147/JMDH.S229396
25. McEwen BS. Protective and damaging effects of stress mediators. N Engl J Med. 1998;338(3):171-179. DOI: https://doi.org/10.1056/NEJM199801153380307 PMid:9428819
26. Chrousos GP. Stress and disorders of the stress system. Nat Rev Endocrinol. 2009;5(7):374-381. DOI: https://doi.org/10.1038/nrendo.2009.106 PMid:19488073
27. Söderfeldt M, Söderfeldt B, Ohlson CG, Theorell T, Jones I. The impact of sense of coherence and high-demand/low-control job environment on stress. Work Stress. 2000;14(1):1-15. DOI: https://doi.org/10.1080/026783700417195
28. Liao J, Brunner EJ, Kumari M. Is there an association between work stress and diurnal cortisol patterns? Findings from the Whitehall II study. PLoS One. 2013;8(12):e81020. DOI: https://doi.org/10.1371/journal.pone.0081020 PMid:24312516 PMCid:PMC3849138
29. Marchand A, Durand P, Juster RP, Lupien SJ. Workers' psychological distress, depression, and burnout symptoms: associations with diurnal cortisol profiles. Scand J Work Environ Health. 2014;40(3):305-314. DOI: https://doi.org/10.5271/sjweh.3417 PMid:24469265
30. Bringel JMA, De Almeida PC, Abreu I, et al. Health professionals' chronotype association with salivary cortisol and occupational stress. Int J Environ Res Public Health. 2023;20(9):5683. DOI: https://doi.org/10.3390/ijerph20095683
31. Garcés A, Weiderpass E, Canuto R, et al. Salivary cortisol, perceived stress, and metabolic syndrome: a matched case-control study. Horm Metab Res. 2017;49(7):510-519. DOI: https://doi.org/10.1055/s-0043-101822 PMid:28561183
32. Magnavita N. Validation of the Italian version of the HSE indicator tool. Occup Med (Lond). 2012;62(4):288-294. DOI: https://doi.org/10.1093/occmed/kqs025 PMid:22661665
33. Grynderup MB, Gullander M, Høgh A, et al. The associations between workplace bullying, salivary cortisol, and long-term sickness absence. BMC Public Health. 2017;17:675. DOI: https://doi.org/10.1186/s12889-017-4716-7.
34. Ohlson CG, Söderfeldt M, Söderfeldt B, et al. Stress markers in relation to job strain. Psychother Psychosom. 2001;70(5):268-275. DOI: https://doi.org/10.1159/000056265
35. McEwen BS. Protective and damaging effects of stress mediators. N Engl J Med. 1998;338(3):171-179. DOI: https://doi.org/10.1056/NEJM199801153380307 PMid:9428819
36. Selye H. The general adaptation syndrome and the diseases of adaptation. J Clin Endocrinol Metab. 1946;6(2):117-230. DOI: https://doi.org/10.1210/jcem-6-2-117 PMid:21025115
37. McVicar A, Ravalier J, Greenwood C. Biology of stress revisited: intracellular mechanisms and the conceptualization of stress. Stress Health. 2014;30(4):272-280. DOI: https://doi.org/10.1002/smi.2508 PMid:23868544
38. Harenstam A, Theorell T. Cortisol elevation in response to adverse job conditions. Biol Psychol. 1990;31(2):157-171. DOI: https://doi.org/10.1016/0301-0511(90)90015-O.
39. O'Connor DB, Thayer JF, Vedhara K. Stress and health: A review of psychobiological processes. Annu Rev Psychol. 2021;72:663-688. DOI: https://doi.org/10.1146/annurev-psych-062520-122331 PMid:32886587
40. Leproult R, Copinschi G, Buxton O, Van Cauter E. Sleep loss results in an elevation of cortisol levels the next evening. Sleep. 1997;20(10):865-870. DOI: https://doi.org/10.1093/sleep/20.10.865
41. Steptoe A, Wardle J, Marmot M. Positive affect and health-related neuroendocrine changes. Psychoneuroendocrinology. 2005;30(3):261-272. DOI: https://doi.org/10.1016/j.psyneuen.2004.08.001