Obesity, Oxidative Stress, And the Moderating Role Of Overcommitment: An Exploratory Analysis In Female Nurses From A Cross-Sectional Study In Western India

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Abstract

Objectives: This study explored whether job stress, specifically the extrinsic and intrinsic components of the Effort Reward Imbalance (ERI) model, moderates the relationship between obesity and oxidative stress among female nurses. **Methods:** We conducted an exploratory analysis from a cross-sectional study involving female nurses at a tertiary hospital. The study assessed the prevalence of obesity and overweight, examined correlations among obesity markers and oxidative stress markers, and explored if there is a moderator role of job stress on the relationship between obesity and oxidative stress. **Results:** The combined prevalence of overweight and obesity in the study population was 74%. Significant positive correlations were found between age, obesity-related parameters (BMI, PBF, WHR), and oxidative stress markers (Protein carbonyl content - PCC and Glutathione S-Transferase - GST). Higher levels of PCC and lower levels of GST were associated with higher BMI, PBF, and WHR. The relationship between obesity and oxidative stress markers was moderated by overcommitment. Nurses with high overcommitment exhibited stronger associations between age, obesity, and oxidative stress markers compared to those with low overcommitment. **Conclusions:** Our findings suggest that intrinsic job stress, particularly overcommitment, moderates the relationship between obesity and oxidative stress. This indicates that job stress should be considered in interventions targeting obesity among nurses. Further studies with larger samples are needed to confirm these findings and develop effective interventions addressing job stress and overcommitment.

Key messages:

What is already known on this topic

Previous research has established that job stress and obesity are individually associated with oxidative stress, with high levels of oxidative stress linked to increased risks of various health complications. However, the interplay between job stress, particularly its intrinsic and extrinsic

components, and the relationship between obesity and oxidative stress in a specific occupational group like nurses has not been extensively explored.

What this study adds

This study reveals that intrinsic job stress, especially overcommitment, significantly moderates the relationship between obesity and oxidative stress among female nurses. It highlights that nurses with high levels of overcommitment experience stronger associations between obesity-related parameters and oxidative stress markers compared to those with lower overcommitment.

How this study might affect research, practice, or policy

The findings suggest that interventions aimed at reducing obesity in nursing populations should also address job stress, particularly overcommitment, to be more effective. This study provides a basis for future research to further investigate these relationships and supports the development of workplace policies and intervention programs targeting both job stress and obesity to improve health outcomes among nurses.

Introduction

Obesity among nurses is a global concern threatening healthcare systems. A meta-analysis from 29 countries reported a 47% prevalence of combined overweight and obesity in nurses, higher than in the general population and other healthcare personnel (1,2). Earlier studies in the Indian scenario reported 40-80% prevalence of combined overweight and obesity among nurses (3,4). This obesity rate poses significant health risks, including cardiovascular, metabolic, reproductive, and mental health issues (5–8). A recent Lancet report identifies obesity as a key contributor to young-onset diabetes, with a study highlighting high central obesity prevalence and co-morbid pre-diabetes and diabetes in female nurses (3,9). High work stress and shift work further exacerbate obesity risks and its consequences (10). Additionally, obesity among healthcare employees is linked to lower productivity and higher healthcare utilization, increasing the economic burden on organizations (11,12). Given this high prevalence, understanding how obesity adversely affects nurses' physical and mental health in the context of job stress is crucial.

A significant body of research highlights the relationship between oxidative stress, obesity, and its associated health consequences. Oxidative stress is an imbalance between reactive oxygen species production and antioxidant defense in the body leading to tissue and cellular damage (13). Protein carbonylation, an irreversible marker of oxidative stress is linked to adiposity, serum free fatty acids, and insulin resistance (14,15). The American Heart Association states that oxidative stress, coupled with inflammation and drives atherosclerosis in obese young adults (5). This is particularly relevant for nurses, where obesity is prevalent, and job stress is also a known factor to aggravate oxidative stress.

Oxidative stress, a critical factor in work-related stress, is linked to burnout and shift work, particularly affecting females. Healthcare workers with prolonged work hours exhibit increased oxidative stress due to high workload and psychological stress (16). Among healthcare workers, including nurses, lipid peroxidation biomarkers correlate with burnout, and evening and night

shifts further increase oxidative stress markers (17). In the Indian population, shift work heightens oxidative stress and metabolic risks, reducing antioxidant capacities (18). This trend extends to the general working population, with the effort-reward imbalance (ERI) model highlighting high overcommitment and elevated malondialdehyde levels in nurses (19). Bardhan et al. found elevated malondialdehyde levels in nurses with high overcommitment, reflecting the ERI model's intrinsic and extrinsic components (20). Females with high psychological stress and perceived workload show increased oxidative stress markers but not in males (21,22).

Studies on stress and obesity show mixed results. Some research suggests a significant correlation (23), possibly due to unhealthy eating habits linked to job stress and shift work (24). Conversely, other studies find no significant relationship, suggesting that job stress might not need consideration when addressing obesity (25,26). Reflecting on these conflicting findings and the high prevalence of obesity in our study population, we conducted an exploratory analysis with an all-female nursing sample. We explored if job stress (both extrinsic and intrinsic components of Effort Reward Imbalance) moderates the relation between obesity and oxidative stress. The premise for this exploration was based on the findings that effort-reward imbalance moderated the relationship between overcommitment and inflammation (27), and that job stress was associated with health risks only in obese women (28). Although the relationship between obesity and work stress may not be direct, job stress could moderate the biological effects of obesity. Our analysis suggests that job stress, particularly overcommitment—a key component of effort-reward imbalance—may moderate the link between obesity and oxidative stress. This provides a strong basis for further testing this hypothesis.

Materials and Methods

This study conducted an exploratory analysis of primary data that investigated associations between job stress, sleep quality, and inflammatory markers. The data was derived from a cross-sectional design involving female nurses who volunteered for the study working at a government

tertiary hospital in western India. Inclusion criteria included nurses who are involved in clinical work for at least six months. We excluded anyone with a history of untreated medical and psychiatric disorders. The primary study was approved by the Institutional Ethical Committee. The study was conducted in September-November 2022 at the participants' workplace. Demographic details, including age and smoking and alcohol habits (with no history of smoking or alcohol consumption), as well as work factors such as hours of work, night duties, place of work, and years of work, were collected. Night duties were minimal as the original study excluded participants with frequent night duties in the preceding months.

For this study, the following obesity-related parameters were the main outcome. Body mass index (BMI), Percentage Body Fat (PBF), and Waist-Hip Ratio (WHR) were collected using body impedance analysis (InBody 270 analyzer, Cerritos, CA, USA) (29), with BMI classified according to Misra et al. (30) and PBF and WHR classified according to WHO standards. The predictors included job stress by the effort-reward imbalance model (31) and was assessed using effort-reward imbalance (ERI) and overcommitment scales. Overcommitment phenotype is characterized by difficulty detaching from work and constant rumination about work. Effort scores ranged from 6-24, reward scores 10-40 and overcommitment ranged from 6-24. Effort reward ratio was calculated by the formula E/R*c where c is the correction factor for number of questions in effort and reward subscales (6/10 here). A higher effort reward ratio meant high job stress. We treated effort-reward imbalance as a continuous score and grouped them into two based on median splits. For overcommitment, we converted the raw scores (range 6-24) to scores ranging from 0-100 by the following formula: OC percentage scores = ((oc_total-6)/18)*100); with 6 being the minimal scores in overcommitment questionnaire and 18 being the difference between maximum (24) and minimum (6) scores. After this we grouped them into two based on lesser than 50% as low and >= 50 being high overcommitment. Physical activity was assessed by asking if

they indulged in any physical activity consistently. If affirmative, type of activity, their duration and frequency in a week were recorded.

Oxidative stress markers, including Protein Carbonyl Content (PCC), Glutathione S-Transferase (GST), Glutathione (GSH), Lipid Peroxidation (LPO), Protein total (PTN), and Superoxide Dismutase (SOD), were measured using ELISA. Using a Synergy H1MD, BioTek, USA, multimode analyzer, all the biochemical parameters were assessed in the serum samples separated from 5ml whole blood collected from participants. Oxidative stress markers were evaluated as per the earlier described protocols (32). All the samples were run in duplicates.

Several measures were taken to address potential sources of bias: Participants were all female nurses working at the same tertiary hospital, minimizing variability due to different work environments. Data on job stress, and obesity markers, were collected using validated instruments and standardized procedures to ensure consistency. Transcription of data to analysis sheet was verified individually by two personnel for quality checks. Participants with frequent night duties in the preceding months were excluded to control for the confounding effect of irregular work hours on sleep quality and stress levels. We made sincere efforts to ensure high participation rates by conducting the study at convenient times and providing detailed explanations of the study's importance to potential participants.

This study is a pilot investigation, and a sample size of 50 female nurses was chosen. The sample size was determined based on practical considerations, including the availability of participants and resources. This preliminary sample allows for an initial exploration of the relationships between job stress, obesity, and oxidative stress, providing valuable insights for subsequent larger studies. For detailed information on the number of individuals at each stage of the study, reasons for non-participation, and participant flow, please refer to our original study (27).

Statistical Analysis

We employed a multi-step statistical analysis approach. We first assessed the prevalence of obesity and overweight among the participants, then examined the correlations among obesity markers (BMI, PBF, WHR) and oxidative stress markers using Pearson correlation coefficients. Finally, for the oxidative markers significantly associated with obesity-related variables, we conducted a series of correlations grouped by median splits of job stress scores (extrinsic: ER ratio, intrinsic: overcommitment). To control for physical activity, we ran linear regressions with each predictor and physical activity in the model separately for high and low overcommitment groups.

Statistical tests were considered significant if p values were < 0.05.

The exploratory analysis plans were pre-registered in OSF at https://osf.io/c8dtp/. The analysis was conducted using R version 4.1.1 (2021-08-10) (33).

Results

The overall aim of the study was to explore the moderation effects of job stress—both extrinsic and intrinsic components—on the relationships between obesity and oxidative stress. Data were cross-sectionally collected from 50 female nurses working at a tertiary hospital.

There were 50 participants (100% female) with a mean age of 31.6 years (SD = 7.2, range: 21-47), a mean education of 15.0 years (SD = 0.5, range: 12-17), and a mean working experience as a nurse of 45.66 months (SD = 4.9, range: 36-72). Data was available for all 50 participants, except for PBF and WHR, for which 3 participants were missing data. The participants' descriptive table is presented in Table 1.

Table 1: Descriptive statistics of the study population

Variable	**High overcommitment**, N = 27[1]	**Low overcommitment**, N = 23[1]	**p-value**[2]
Age (years)	31 (7)	32 (8)	0.9
Work hours per week	46.85 (6.11)	44.26 (2.51)	0.11
Overcommitment (%)	64 (10)	34 (13)	**<0.001**
Effort-Reward Ratio	0.93 (0.24)	0.75 (0.21)	**0.025**
Body Mass Index (kg/m2)	25.1 (5.2)	26.5 (4.7)	0.4
Percentage Body Fat (%)	40 (8)	42 (6)	0.5
Missing data	2	1	
Waist-Hip Ratio	0.89 (0.06)	0.91 (0.06)	0.3
Missing data	2	1	
Protein Carbonyl Content (µM/ml)	85 (13)	86 (10)	0.9
Glutathione-S-transferase (nmol/ml/min)	10.9 (4.5)	11.8 (4.7)	0.5
Lipid peroxidation (mM/L)	0.48 (0.37)	0.53 (0.44)	0.9
Glutathione (nmol/ml)	0.20 (0.10)	0.22 (0.13)	0.7
Superoxide dismutase (U/ml)	4.59 (2.36)	5.14 (2.63)	0.3
Total Protein (mg/ml)	153 (33)	143 (31)	0.5

[1]Mean (SD)

[2]Wilcoxon rank sum test

High prevalence of obesity and overweight in the study population

There was a high prevalence of obesity and overweight in the study population with a combined prevalence of 74% (overweight = 14%, obesity = 60%). This was based on the BMI classification of > 24.99 as obese and > 22.99 as overweight for Asian females (30).

When considering percentage body fat (PBF), the combined prevalence was 86% (overweight: 8% [PBF of 30-35%], Obese: 78% [PBF >35%]).

The prevalence of central obesity was 76% based on the WHR classification of ≥ 0.85 for Asian females. Notably, 62% of the study population were not physically active.

Supplementary Table-1: Prevalence of obesity and overweight in the study population compared to global and Indian prevalence rates

	Obesity (%)	Overweight (%)
India - females	6.3	17.2
Nurses - Global	16.3	31.2
Study sample	14	60

Obesity associated with increased oxidative stress markers

To investigate if obesity-related markers - BMI, PBF, WHR were associated with oxidative stress markers, we ran a panel of correlations Figure 1. There is a significant correlation between age, obesity-related parameters (BMI, PBF, WHR) and oxidative stress markers specifically protein carbonyl content (PCC) and glutathione-S-transferase (GST). Higher levels of PCC and lower levels of GST were associated with higher BMI, PBF and WHR. This suggests there is an association among obesity-related variables and 2 of the tested oxidative stress markers.

Overcommitment moderated association between obesity and oxidative stress markers

To explore if occupational stress moderates the relationships between obesity-related markers and oxidative stress markers, we ran a series of scatterplots faceted by the overcommitment group (split at 50%) and the effort-reward imbalance (ERI) ratio (split at the median).

Figure 2 (for PCC marker) and Figure 3 (for GST marker) indicate the moderating effect of overcommitment on the association between age, obesity, and oxidative stress markers. In the presence of high overcommitment among nurses, the relationship between age, obesity, and oxidative stress markers is stronger compared to nurses with low overcommitment. These findings suggest that overcommitment is a moderator for obesity- and age-associated oxidative stress changes, observed only in those with high overcommitment.

Regressions controlling for physical activity among all the previously described predictors with PCC and GST are provided in Supplementary Table 2. The results remained consistent even after controlling physical activity in the models.

Additionally, the detailed percentages of responses to all six overcommitment questionnaire items are depicted in Supplementary Figure 1. Although the majority disagreed with feeling overwhelmed due to time pressures at work, most participants strongly agreed when asked if they think about work first thing in the morning and if it rarely leaves their mind at bedtime. Many participants also reported trouble staying asleep at night if they had postponed something at work. The majority disagreed with the statement about easily switching off from work after reaching home. All these points indicate a high overcommitment phenotype characterized by an inability to detach from work.

Supplementary Figures 2 and 3 depict the moderative effects of the effort-reward ratio on the relationships between obesity and oxidative stress markers. No significantly different relationships were observed between the effort-reward ratio groups (high and low) in the association between obesity and oxidative stress on PCC. Similar to overcommitment, there is a pattern but only with GST (not for WHR). This suggests that ERI may act as a moderator in obesity-associated oxidative stress, but only for GST and not for PCC.

Ranges of all the six tested oxidative stress markers is depicted in Supplementary table 3.

Discussion

Given that oxidative stress is a potential mechanism for adverse health consequences related to both obesity and job stress, we explored whether job stress (extrinsic ERI and intrinsic overcommitment) moderates the relationship between obesity and oxidative stress markers. In an all-female nursing population with a high prevalence of obesity, we found that overcommitment moderated the relationship between obesity and oxidative stress. Specifically, in those with high overcommitment, the relationship between obesity (measured by WHR, PBF, and BMI) was significantly associated with increased oxidative stress and decreased antioxidant capacities, determined by two markers: PCC and GST. Similar findings of moderation were also observed with age and oxidative stress.

Overcommitment to work—marked by a strong attachment to work and difficulty detaching—significantly contributes to perceived stress and its psychological effects. Elevated oxidative stress with PCC and reduced GST, an antioxidant marker, indicate a link between overcommitment and stress-related biomarkers. Our findings suggest that individuals who struggle to relax after work may benefit from targeted interventions to reduce their associated health risks. Participants often report lacking time for physical activity, emphasizing the need for workplace interventions during work hours. Even after adjusting for physical activity, the

significant impact of stress underscores the necessity for occupational stress interventions beyond the typical focus on physical activity. Additionally, addressing the knowledge, attitudes, and practices (KAP) gap among nurses could be valuable, given the high prevalence of obesity in this group.

Protein carbonyl is associated with diabetes and increased mortality in the literature, suggesting that overcommitment may exacerbate obesity-associated metabolic syndrome, particularly through the PCC marker (34,35). An earlier study noted that overcommitment, rather than effort-reward imbalance (ERI), showed biological consequences related to job stress (36). Our data support this understanding and highlight the necessity of shifting the focus from extrinsic to intrinsic stressors when studying oxidative stress and work stress. Additionally, one earlier study noted that overcommitment was associated with mental health issues, whereas ERI was not (37). This finding further supports our results, emphasizing the significant role of intrinsic stressors, such as overcommitment, in affecting mental health.

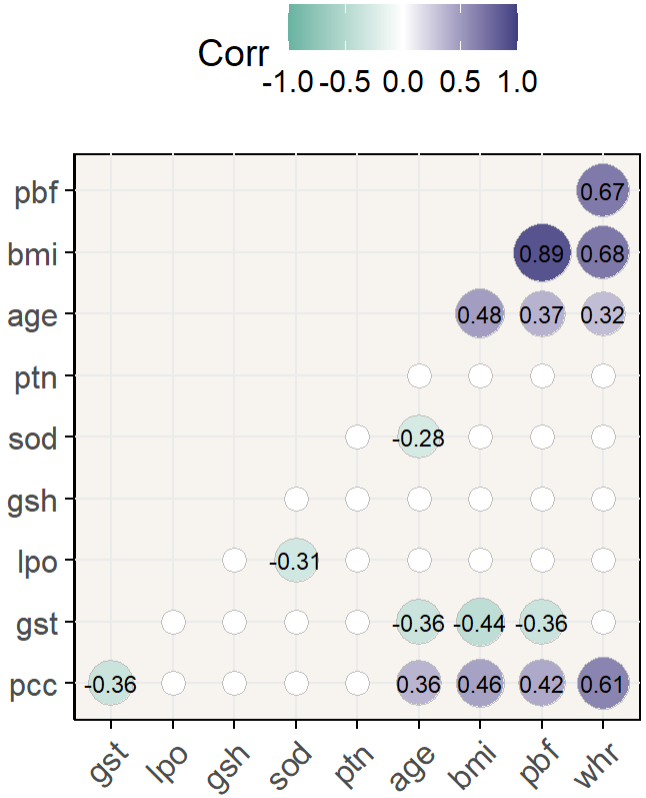
The study's clean sample is a notable strength, as our participants were exclusively non-smoking, non-drinking females. Despite the small sample size, the magnitude and consistency of the results underscore the importance of these findings from the exploratory analysis. The bidirectional relationship between obesity and oxidative stress, along with the study's cross-sectional nature, does not diminish the implications. The findings of this study may have limited generalizability due to the specific population of female nurses in a single tertiary hospital in Western India. However, the consistent relationships observed between job stress, obesity, and oxidative stress suggest that similar mechanisms may be present in other populations with high job stress and obesity rates. Future research should test these findings in larger, more diverse samples to confirm the generalizability of these results and to explore the potential impact of cultural and occupational differences. This is crucial for those focusing on obesity, as work stress plays a significant role, and for those in occupational health, considering that obesity may amplify the consequences

related to work stress. Interventions targeting overcommitment should test for the weakening of these associations, thus positioning overcommitment as a target for reducing obesity-associated consequences in the nursing population.

Conclusion

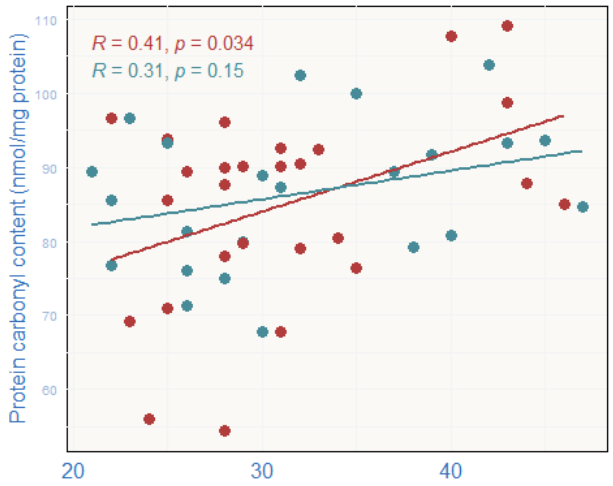
Our exploratory study presents a strong hypothesis for further testing with larger samples of nursing populations, suggesting that job stress, particularly intrinsic overcommitment, moderates the links between obesity and oxidative stress. Intervention studies focusing on obesity should consider job stress as a potential moderator, and more interventions targeting overcommitment in occupational settings should be implemented.

Figure 1: Correlation plot showing the relationship between oxidative stress markers and obesity-related parameters

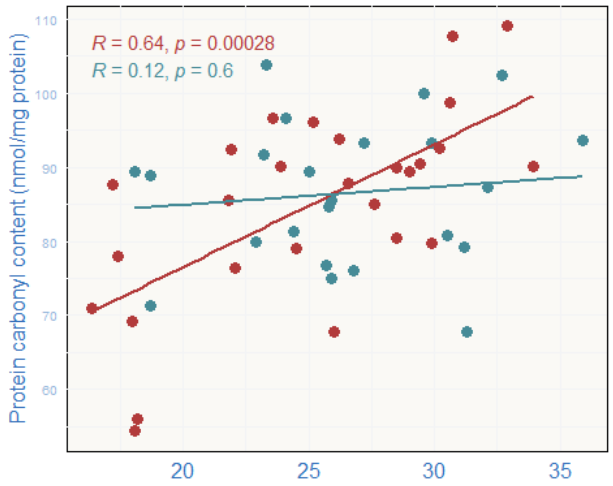


Note: The size and color intensity of the circles represent the magnitude and direction of the correlation, respectively. Positive correlations are indicated by shades of blue, while negative correlations are indicated by shades of green. The correlation values range from -1.0 to 1.0, as shown by the color scale at the top of the plot. Key oxidative stress markers include glutathione-S-transferase (gst), lipid peroxidation (lpo), glutathione (gsh), superoxide dismutase (sod), protein carbonyl content (pcc), and total protein (ptn). Obesity-related parameters include waist-to-hip ratio (whr), percent body fat (pbf), body mass index (bmi), and age.

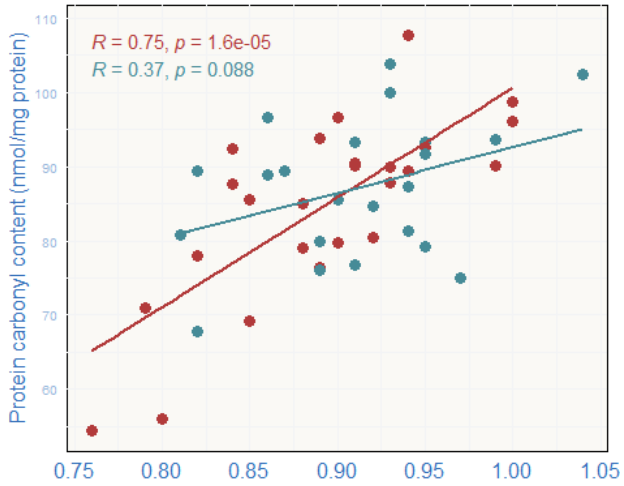
Figure 2: Scatter plots faceted by overcommitment for PCC



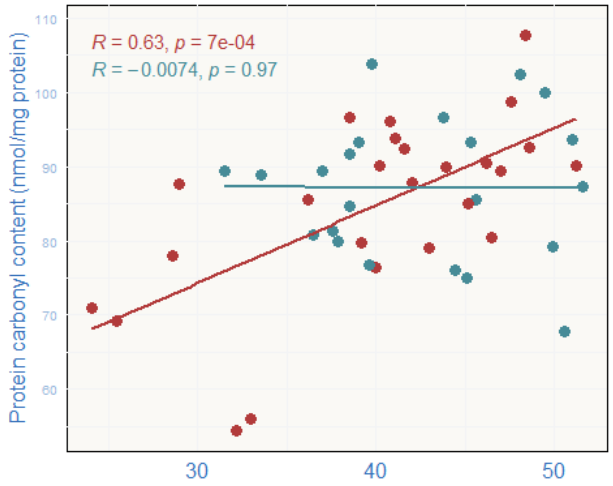
(a) Age and PCC



(b) BMI and PCC



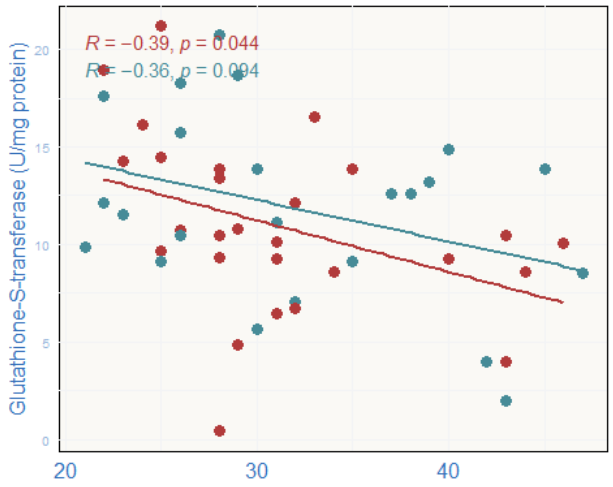
(c) WHR and PCC



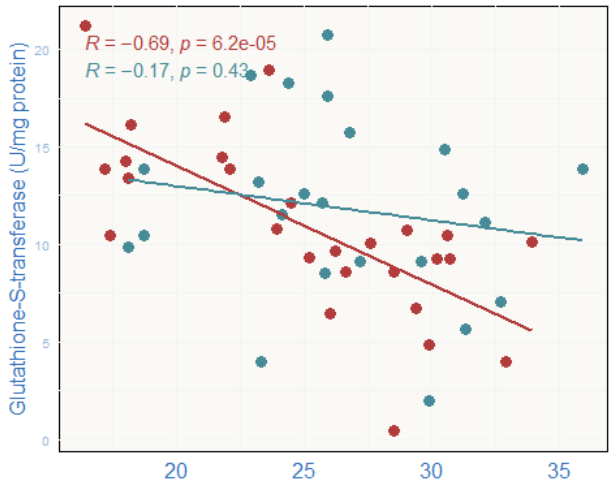
(d) PBF and PCC

Note. Scatter plots show the relationship between protein carbonyl content (PCC) and various parameters, faceted by overcommitment levels. Each plot includes the Pearson correlation coefficient (R) and the corresponding p-value. Panel a – age and PCC, Panel b – BMI and PCC, Pabel c – WHR and PCC, Panel d – PBF and PCC. All panels indicate significant positive correlations between protein carbonyl content (PCC) and age, BMI, WHR, and PBF in the high overcommitment group, with weaker or non-significant correlations in the low overcommitment group.

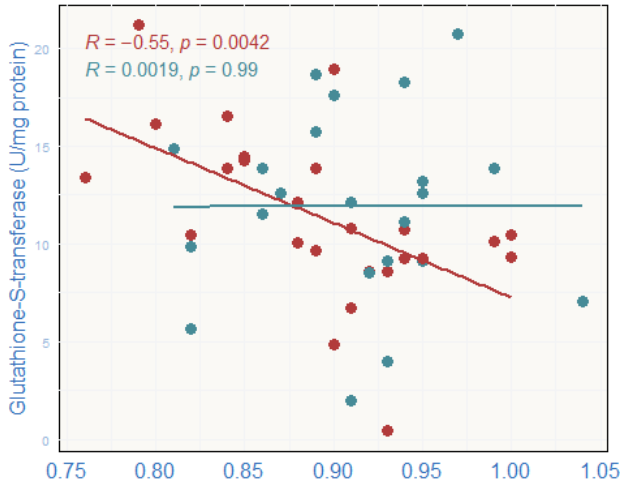
Figure 3: Scatter plots faceted by overcommitment for GST



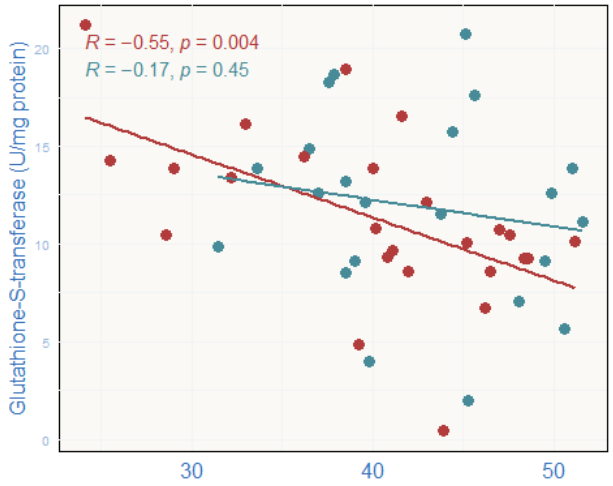
(a) Age and GST



(b) BMI and GST



(c) WHR and GST

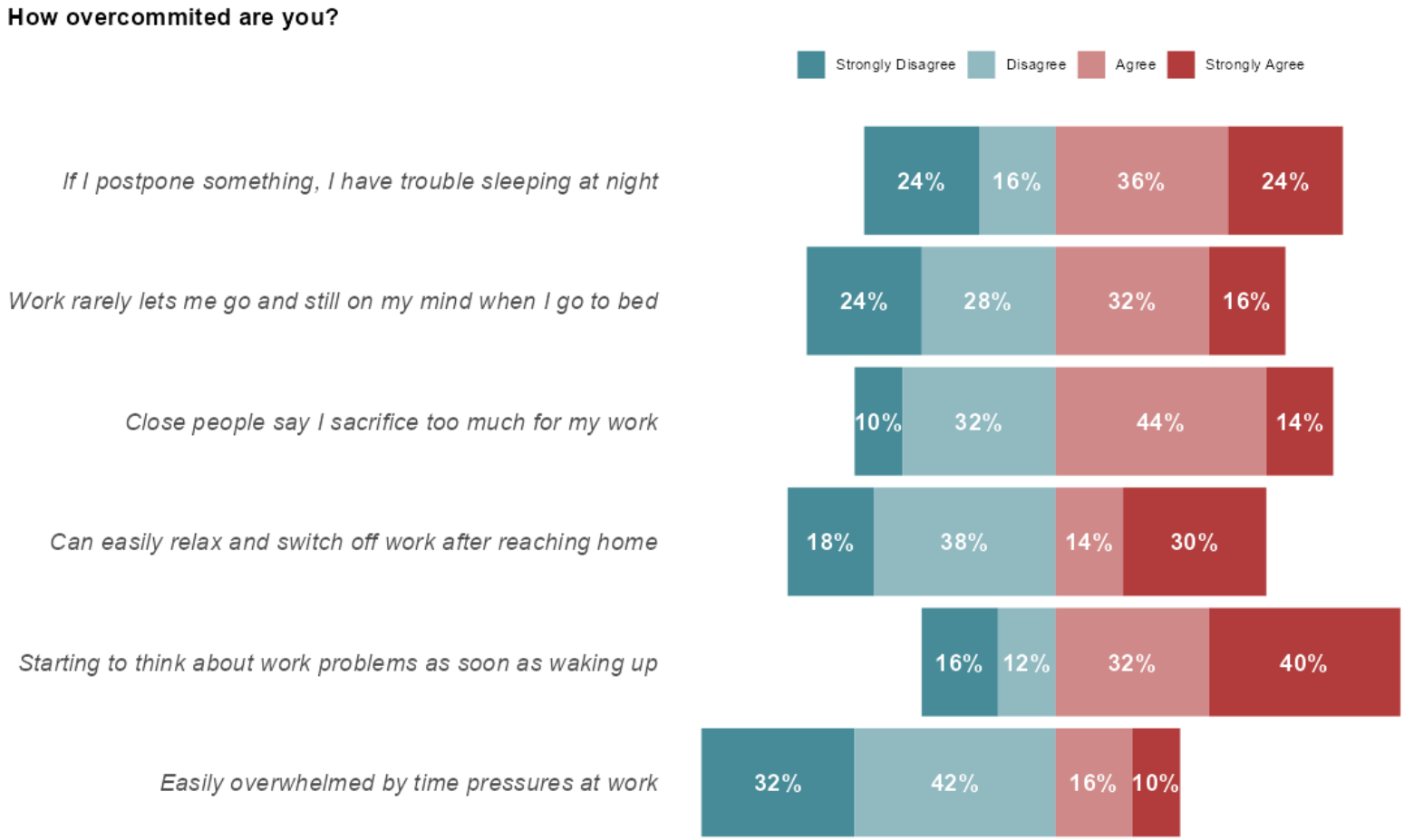


(d) PBF and GST

Note. Scatter plots show the relationship between Glutathione S-Transferase (*GST*) and various parameters, faceted by overcommitment levels. Each plot includes the Pearson correlation coefficient (R) and the corresponding p-value. Panel a – age and PCC, Panel b – BMI and PCC, Pabel c – WHR and PCC, Panel d – PBF and PCC. All panels indicate significant positive correlations between Glutathione S-Transferase (GST) and age, BMI, WHR, and PBF in the high overcommitment group, with weaker or non-significant correlations in the low overcommitment group.

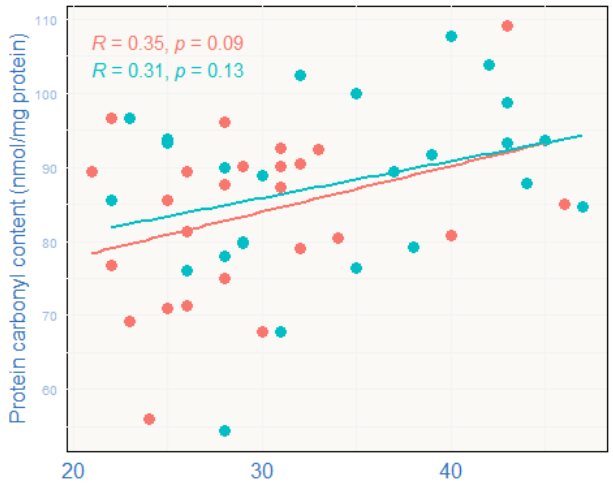
Supplementary Figures

Supplementary Figure 1: Diverging bar plot showing the responses to the overcommitment questionnaire

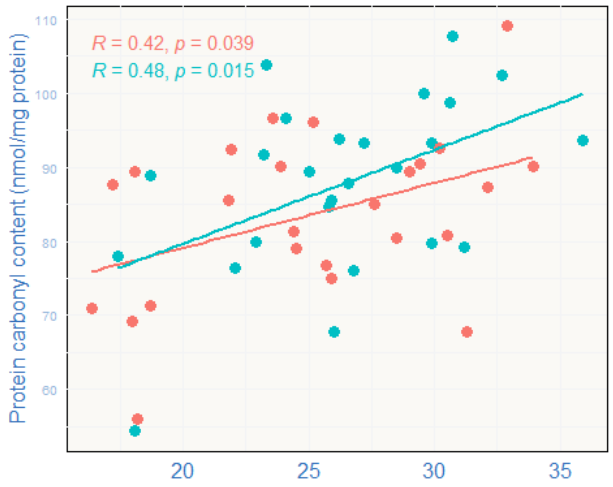


Note: Diverging bar plot showing the responses to the overcommitment questionnaire. The plot illustrates the distribution of responses across six questions related to overcommitment at work. Response categories include "Strongly Disagree," "Disagree," "Agree," and "Strongly Agree," represented by different shades of color. Percentages of responses in each category are shown within the bars for each question.

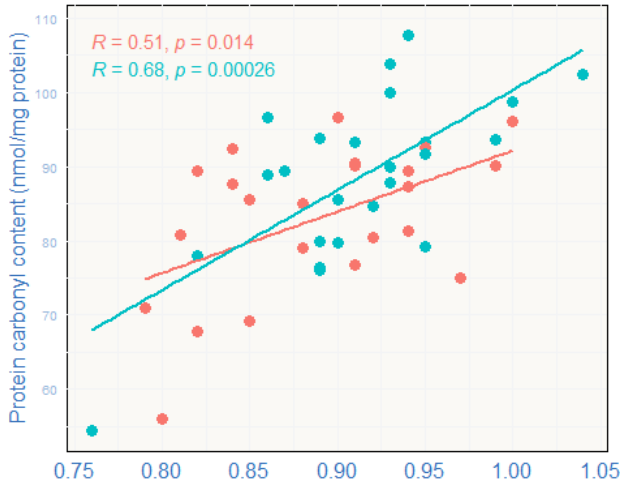
Supplementary Figure 2: Scatter plots faceted by Effort-Reward Imbalance for PCC



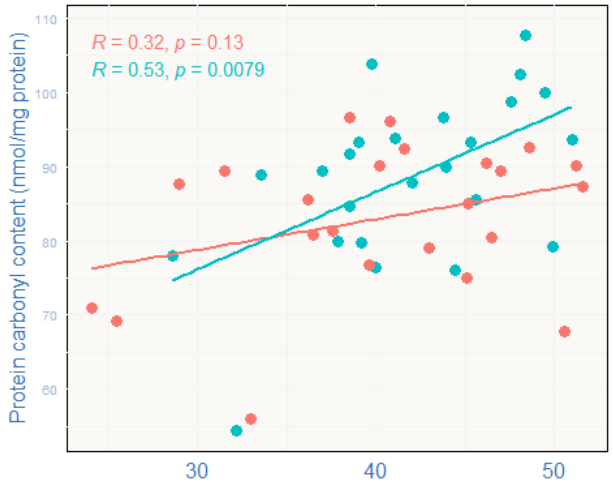
(a) Age and PCC



(b) BMI and PCC

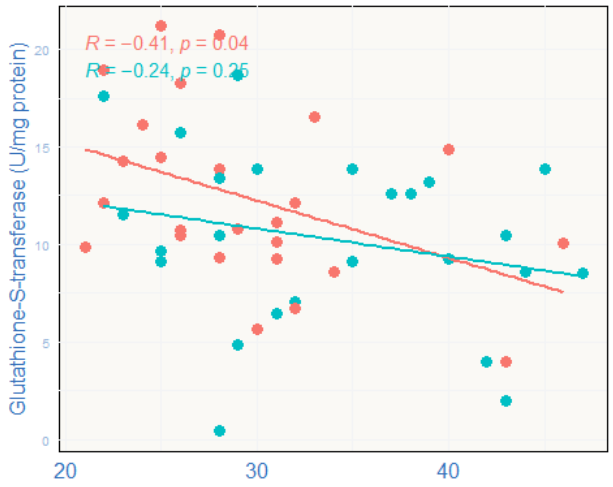


(c) WHR and PCC

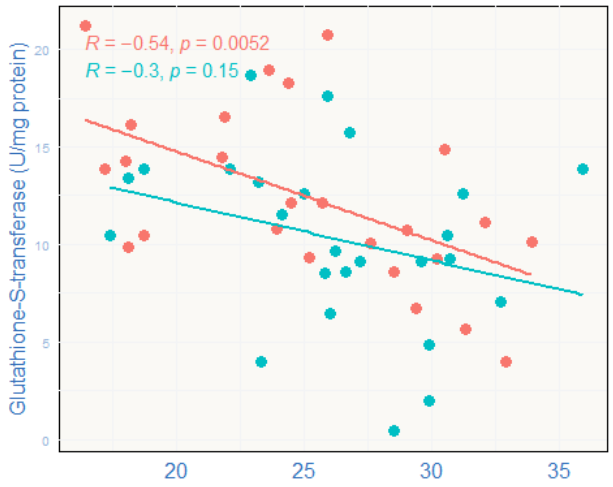


(d) PBF and PCC

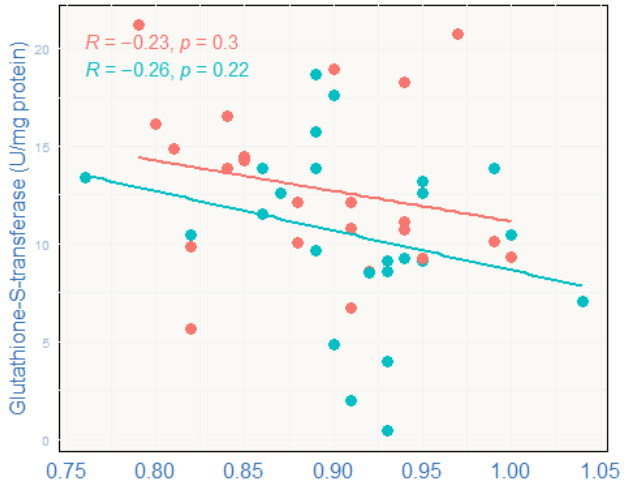
Supplementary Figure 3: Scatter plots faceted by Effort-Reward Imbalance for GST



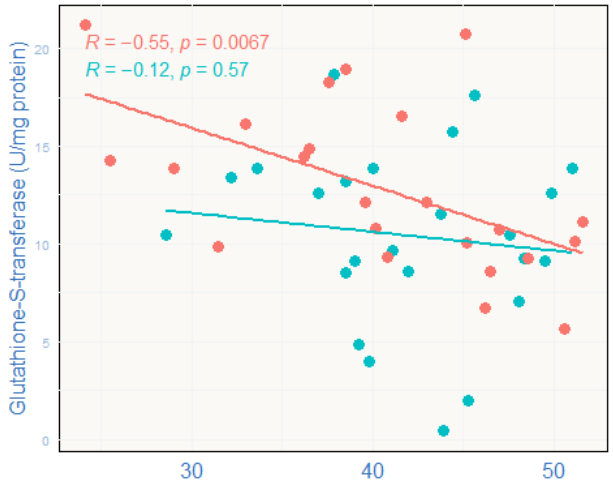
(a) Age and GST



(b) BMI and GST



(c) WHR and GST



(d) PBF and GST

Supplementary Table 2

Outcome	Predictors in the model		Beta	95% CI	*p*-value
Group = High overcommitment					
PCC	Age, Physical activity	Age	0.74	0.02, 1.5	**0.045**
		Physical activity	7.8	-2.1,18	0.12
GST	Age, Physical activity	Age	-0.25	-0.51,0.01	0.057
		Physical activity	-1.8	-5.3,1.7	0.3
PCC	BMI, Physical activity	BMI	1.5	0.68, 2.4	**0.001**
		Physical activity	3.4	-5.8,13	0.5
GST	BMI, Physical activity	BMI	-0.61	-0.89, -0.32	**< 0.001**
		Physical activity	-0.01	-3, 3	0.9
PCC	WHR, Physical activity	WHR	148	87, 209	**< 0.001**
		Physical activity	-0.05	-7.9, 7.8	0.9
GST	WHR, Physical activity	WHR	-37	-64, -10	**0.009**
		Physical activity	-0.36	-3.8, 3.1	0.8
PCC	Percentage Body Fat, Physical activity	Percentage Body Fat	1.0	0.43, 1.6	**0.002**
		Physical activity	0.68	-8.6, 9.9	0.9

GST	Percentage Body Fat, Physical activity	Percentage Body Fat	-0.32	-0.54, -0.09	**0.008**
		Physical activity	-0.25	-3.7, 3.2	0.9

Supplementary Table 3

Oxidative stress marker	Observed range	Measured units
Protein Carbonyl Content (PCC)	54.40-109.00	µM/ml
Glutathione S-Transferase (GST)	0.42-21.20	nmol/ml/min
Glutathione (GSH)	0.05 – 0.58	nmol/ml
Lipid Peroxidation (LPO)	0.11-2.06	mM/L
Protein Total (PTN)	64.60-211.00	mg/ml
Superoxide Dismutase (SOD)	0.51-12.20	U/ml

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References

1 Sadali UB, Kamal KKBN, Park J, *et al.* The global prevalence of overweight and obesity among nurses: A systematic review and meta-analyses. *Journal of Clinical Nursing*. 2023;32:7934–55. doi: 10.1111/jocn.16861

2 M A, Aa S, G S, *et al.* High prevalence of obesity among nursing personnel working in tertiary care hospital. *Diabetes & metabolic syndrome*. 2018;12. doi: 10.1016/j.dsx.2017.12.014

3 Kyle R, Neall R, Atherton I. Prevalence of overweight and obesity among nurses in scotland: A cross-sectional study using the scottish health survey. *International journal of nursing studies*. 2016;53:126–33. doi: 10.1016/j.ijnurstu.2015.10.015

4 Powell-Wiley TM, Poirier P, Burke LE, *et al.* Obesity and cardiovascular disease: A scientific statement from the american heart association. *Circulation*. 2021;143:e984–1010. doi: 10.1161/CIR.0000000000000973

5 Verma S, Hussain ME. Obesity and diabetes: An update. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*. 2017;11:73–9. doi: 10.1016/j.dsx.2016.06.017

6 Silvestris E, De Pergola G, Rosania R, *et al.* Obesity as disruptor of the female fertility. *Reproductive Biology and Endocrinology*. 2018;16:22. doi: 10.1186/s12958-018-0336-z

7 Jokela M, Hamer M, Singh-Manoux A, *et al.* Association of metabolically healthy obesity with depressive symptoms: pooled analysis of eight studies. *Molecular Psychiatry*. 2014;19:910–4. doi: 10.1038/mp.2013.162

8 The Lancet Diabetes & Endocrinology. Alarming rise in young-onset type 2 diabetes. *The Lancet Diabetes & Endocrinology*. 2024;12:433. doi: 10.1016/S2213-8587(24)00161-X

9 M A, Aa S, G S, *et al.* High prevalence of obesity among nursing personnel working in tertiary care hospital. *Diabetes & metabolic syndrome*. 2018;12. doi: 10.1016/j.dsx.2017.12.014

10 Fang L, Hsiao L-P, Fang S-H, *et al.* The associations with work stress, social support and overweight/obesity among hospital nurses: A cross-sectional study. *Contemporary Nurse*. 2018;54:182–94. doi: 10.1080/10376178.2018.1476166

11 Elabd K, Basudan L, Alabduljabbar K. The Prevalence of Obesity Among Employees of a Tertiary Healthcare Organization in Saudi Arabia and Its Impact on the Organization. *Cureus*. Published Online First: 14 July 2022. doi: 10.7759/cureus.26834

12 Colombi AM, Wood GC. Obesity in the workplace: Impact on cardiovascular disease, cost, and utilization of care. *American Health & Drug Benefits*. 2011;4:271–8.

13 Frohnert BI, Sinaiko AR, Serrot FJ, *et al.* Increased Adipose Protein Carbonylation in Human Obesity. *Obesity*. 2011;19:1735–41. doi: 10.1038/oby.2011.115

14 Frohnert BI, Bernlohr DA. Protein Carbonylation, Mitochondrial Dysfunction, and Insulin Resistance. *Advances in Nutrition*. 2013;4:157–63. doi: 10.3945/an.112.003319

15 Powell-Wiley TM, Poirier P, Burke LE, *et al.* Obesity and cardiovascular disease: A scientific statement from the american heart association. *Circulation*. 2021;143:e984–1010. doi: 10.1161/CIR.0000000000000973

16 Buyukhatipoglu H, Kirhan I, Dag OF, *et al.* Oxidative stress increased in healthcare workers working 24-hour on-call shifts. *The American Journal of the Medical Sciences*. 2010;340:462–7. doi: 10.1097/MAJ.0b013e3181ef3c09

17 Casado ??Ngela, De Lucas N, L??pez-Fern??ndez E, *et al.* Lipid peroxidation, occupational stress and aging in workers of a prehospital emergency service: *European Journal of Emergency Medicine*. 2006;13:165–71. doi: 10.1097/01.mej.0000194404.61076.88

18 Gowda RH, Sukumar GM, Gowda SH. Association between metabolic risk, oxidative stress and rotating shift work in a tertiary health care facility. *Clinical Epidemiology and Global Health*. 2019;7:564–70. doi: 10.1016/j.cegh.2019.01.002

19 Zhang L, Liu B, Zhou L, *et al.* Analysis of occupational stress and its correlation with oxidative-antioxidant levels among employees of a power grid enterprise in guangdong. *BMC Psychiatry*. 2022;22:593. doi: 10.1186/s12888-022-04226-1

20 Bardhan R, Heaton K, Davis M, *et al.* A Cross Sectional Study Evaluating Psychosocial Job Stress and Health Risk in Emergency Department Nurses. *International Journal of Environmental Research and Public Health*. 2019;16:3243. doi: 10.3390/ijerph16183243

21 Irie M, Asami S, Nagata S, *et al.* Relationships between perceived workload, stress and oxidative DNA damage. *International Archives of Occupational and Environmental Health*. 2001;74:153–7. doi: 10.1007/s004200000209

22 Inoue A, Kawakami N, Ishizaki M, *et al.* Three job stress models/concepts and oxidative DNA damage in a sample of workers in japan. *Journal of psychosomatic research*. 2009;66:329334.

23 Klingberg S, Mehlig K, Johansson I, *et al.* Occupational stress is associated with major long-term weight gain in a Swedish population-based cohort. *International Archives of Occupational and Environmental Health*. 2019;92:569–76. doi: 10.1007/s00420-018-1392-6

24 Shinde VV. Relationship of body mass index to job stress and eating behaviour in health care professionals-an observational study. *Obesity Medicine*. 2019;14:100070. doi: 10.1016/j.obmed.2018.12.002

25 Kivimäki M, Singh-Manoux A, Nyberg S, *et al.* Job strain and risk of obesity: systematic review and meta-analysis of cohort studies. *International Journal of Obesity*. 2015;39:1597–600. doi: 10.1038/ijo.2015.103

26 Geda NR, Feng CX, Yu Y. Examining the association between work stress, life stress and obesity among working adult population in canada: Findings from a nationally representative data. *Archives of Public Health*. 2022;80:97. doi: 10.1186/s13690-022-00865-8

27 Singh G, Viramgami A, Makwana B, *et al.* Sleep quality a potential link in the relation between occupational stress and inflammation. doi: 10.31234/osf.io/65dnw

28 Heraclides AM, Chandola T, Witte DR, *et al.* Work stress, obesity and the risk of type 2 diabetes: gender-specific bidirectional effect in the Whitehall II study. *Obesity (Silver Spring, Md)*. 2012;20:428–33. doi: 10.1038/oby.2011.95

29 R Core Team. *R: A language and environment for statistical computing.* Vienna, Austria: R Foundation for Statistical Computing 2022.

30 Misra A. Ethnic-specific criteria for classification of body mass index: A perspective for asian indians and american diabetes association position statement. *Diabetes Technology & Therapeutics*. 2015;17:667–71. doi: 10.1089/dia.2015.0007

31 Song YR, Kim J-K, Lee H-S, *et al.* Serum levels of protein carbonyl, a marker of oxidative stress, are associated with overhydration, sarcopenia and mortality in hemodialysis patients. *BMC Nephrology*. 2020;21:281. doi: 10.1186/s12882-020-01937-z

32 Almogbel E. Protein mediated oxidative stress in patients with diabetes and its associated neuropathy: Correlation with protein carbonylation and disease activity markers. *JOURNAL OF CLINICAL AND DIAGNOSTIC RESEARCH*. Published Online First: 2017. doi: 10.7860/jcdr/2017/23789.9417

33 Coelho D, Yamaguchi S, Harb A, *et al.* Effort-reward and overcommitment at work and psychiatric symptoms in healthcare professionals: The mediation role of allostatic load. *Comprehensive psychoneuroendocrinology*. 2024;17:100225. doi: 10.1016/j.cpnec.2024.100225

34 Hinsch DM, Spanier K, Radoschewski FM, *et al.* Associations between overcommitment, effort-reward imbalance and mental health: findings from a longitudinal study. *International Archives of Occupational and Environmental Health*. 2019;92:559–67. doi: 10.1007/s00420-018-1391-7