e-ISSN: 0975-1556, p-ISSN:2820-2643

Available online on www.ijpcr.com

International Journal of Pharmaceutical and Clinical Research 2024; 16(10); 607-612

Original Research Article

Cross-Sectional Examination of Heart Rate Variability in Relation to Stress Levels in Different Occupational Groups

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Received: 25-07-2024 / Revised: 23-08-2024 / Accepted: 26-09-2024
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Conflict of interest: Nil

Abstract:

Background: Heart Rate Variability (HRV) is a non-invasive indicator of autonomic nervous system function and is strongly associated with stress levels. Occupational stress varies widely across professions, with certain high-stress environments, such as healthcare, known to impact both mental and physical health. Examining HRV in relation to stress levels across different occupational groups can provide insights into how workplace stress affects physiological health.

Objective: This study aimed to explore the relationship between HRV and perceived stress levels across different occupational groups, including healthcare workers, teachers, office employees, and manual laborers, to determine how stress impacts HRV in each profession.

Method: A cross-sectional design was employed, involving 100 participants selected from four occupational groups. HRV was measured using wearable ECG devices, and stress levels were assessed through the Perceived Stress Scale (PSS). Statistical analyses, including ANOVA, were conducted to compare HRV metrics (e.g., SDNN, RMSSD) and stress scores across the occupational groups.

Results: The mean age of participants was 38.5 years (SD = 8.2), with a gender distribution of 56% female and 44% male. Healthcare workers reported the highest average stress levels (PSS = 26.7 ± 4.5) and the lowest HRV metrics (SDNN = 45.6 ± 12.5 ms; RMSSD = 32.4 ± 10.2 ms). In contrast, teachers had the lowest stress (PSS = 18.9 ± 3.6) and the highest HRV scores (SDNN = 58.3 ± 13.0 ms; RMSSD = 42.5 ± 12.1 ms). ANOVA revealed significant differences in HRV (SDNN: $F = 4.32$, $p < 0.01$; RMSSD: $F = 3.91$, $p < 0.05$) and stress levels ($F = 6.87$, $p < 0.001$) between occupational groups. Post hoc analysis indicated that healthcare workers had significantly lower HRV and higher stress compared to teachers, with effect sizes of $\eta^2 = 0.12$ for HRV and $\eta^2 = 0.19$ for PSS.

Conclusion: The findings support the role of HRV as a reliable marker of stress and highlight the impact of occupational stress on autonomic function. HRV monitoring could be useful in occupational health programs, particularly in high-stress professions like healthcare, to identify at-risk workers and implement stress-reduction interventions.

Keywords: Heart Rate Variability (HRV), Occupational Stress, Autonomic Nervous System, Perceived Stress Scale (PSS), Healthcare Workers, Time-domain HRV Metrics, Stress Resilience, Workplace Stress.

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Introduction

The autonomic nerve system (ANS) regulates heart rate through heart rate variability [1]. The parasympathetic nervous system promotes rest and recovery, while the sympathetic nervous system triggers the "fight or flight" response. HRV is a useful autonomic function indicator since it reflects how well these two systems are harmonized [2]. A healthy person with a high HRV has well-regulated autonomic response and can adapt to stress. In contrast, poor HRV is connected to stress, emotional instability, and cardiovascular illness. Occupational health practitioners are using HRV to measure the physiological impacts of job stress non-invasively. Workplace stress varies widely. Healthcare personnel, emergency responders, and corporate executives are stressed by workload,

decision-making pressure, and time constraints [3]. However, administrative and academic workers may suffer less stress. HRV monitoring helps us understand how work-related stress affects health and how it manifests in the body.

HRV and stress correlations in different occupational groups are needed to understand how stress affects the autonomic nerve system. Since stress increases the likelihood of mental and physical health issues, finding groups with lower HRV may illuminate workplace stress management and solutions [4]. Quantifying this physiological signal is important because HRV is an objective measure of stress response, unlike self-reported stress levels, which might be subjective. By exploring this relationship, politicians and companies can enhance occupational health by creating better stress management programs.

This research aims to determine how occupations affect heart rate variability and stress. This study examines whether business executives and healthcare professionals with high stress levels had lower HRV than those with low stress. The study's main purpose is to illuminate workplace stress's physiological impacts and offer methods to improve workers' well-being.

HRV and Stress: An proven physiological indication of emotional regulation and stress, HRV has been around for a long. Multiple studies show that stress changes the autonomic nervous system (ANS), which is detected by HRV [5]. Chronic stress enhances sympathetic activity and lowers parasympathetic activity, lowering HRV. A high HRV indicates a more adaptive and resilient autonomic response, while a low HRV indicates a lack of stress tolerance and higher vulnerability to stress-related disorders. Higher HRV was associated with improved emotional control and decreased anxiety [6]. Since it links psychological and physiological health, HRV is a useful tool for monitoring stress response. The vagus nerve, a parasympathetic nervous system component, is essential to HRV-stress mechanisms. HRV rises when vagal tone is high, indicating the body's ability to handle stress and relax down [7]. Low vagal tone raises stress and diminishes stress tolerance, which increases the risk of cardiovascular disease, mental illness, and poor quality of life.

Occupational Stress: It's commonly known that occupational stress harms employees' mental and physical health. Jobs that involve quick decisions, emotional investment, and long hours increase stress. Several studies found that healthcare workers, emergency responders, and business executives have higher stress levels. [8] Found that emotionally taxing job requirements, long shifts, and fatigue caused high stress among healthcare professionals. According to [9], job instability and busyness cause moderate stress in office workers, but they are less stressed than those in high-stress industries. It's important to understand occupational stress since prolonged exposure to high-stress environments can cause burnout, anxiety, and depression. Research reveals that high-stakes and emotionally draining jobs are more likely to cause occupational stress and require specific therapies.

HRV in Occupational Groups: Several studies found that stressed workers have reduced HRV. [10] Found that emergency room nurses had considerably lower HRV than nurses in less stressful departments, suggesting higher autonomic stress. [11] Found that corporate executives with demanding occupations and small windows of opportunity had lower HRV, which may indicate chronic stress and future health issues. Not all results are equal. Because manual laborers experience varied types of physical stress, their HRV may not fall significantly when they report feeling physically stressed.

People in low-stress jobs like administrative or intellectual work had reduced autonomic stress and stable HRV, according to studies. There are few studies comparing different sorts of workers, although HRV and stress are linked. We don't know how stress and HRV link across sectors because most research only look at one profession. Many cross-sectional studies on HRV and perceived stress in low- and high-stress occupations are missing. This difference prevents the creation of comprehensive workplace solutions tailored to particular occupational needs. The current study examines HRV and stress levels across many occupational categories to fill this information gap and illuminate how stress affects physiological health at work.

Methodology

Study Design: This study compares HRV and stress in different occupational groups using a cross-sectional technique. The cross-sectional technique measures HRV and stress levels simultaneously within and across occupational groups by capturing their correlation at a single moment. This study examines several professional groups to determine if profession-specific demands and characteristics affect HRV and stress patterns.

Participants: The study examined 100 persons from healthcare, office, teaching, and physical labor. Stratified random sampling ensured group representation. Local hospitals, schools, corporate offices, and factories were scouted for participants. Each group has 25 people to assure occupational comparisons.

Inclusion Criteria

1. Individuals aged 25–55 years.

2. At least two years of experience in their respective occupations.
3. Physically healthy without any known cardiovascular or autonomic disorders.

Exclusion Criteria

1. Participants diagnosed with chronic diseases such as diabetes, hypertension, or neurological conditions.
2. Individuals on medications that could affect HRV (e.g., beta-blockers).
3. Those who had consumed alcohol, caffeine, or nicotine within 12 hours prior to HRV measurement.
4. Participants engaged in regular, structured physical exercise programs exceeding 5 hours per week, as high fitness levels may influence HRV.

Data Collection: HRV was measured using a portable electrocardiogram (ECG) that records heart rate variability. Participants sat comfortably with the gadget on for 5 minutes while their heart rhythms were measured.

The standard deviation of normal-to-normal intervals (SDNN) and root mean square of successive differences—time-domain HRV measurements—were used to evaluate the autonomic function. The widely verified Perceived Stress Scale (PSS) measured stress.

The 10-item PSS asks participants to rate their stress levels from the past month. Higher scores (0–40) indicate more severe stress. Participants completed the PSS after HRV measurements to avoid physiological disruption.

Ethical Considerations: The Institutional Review Board (IRB) of the college Nam approved the study to ensure it followed human subject's research guidelines. Before starting the trial, all participants supplied informed consent. Participants were informed of the study's goals, procedures, protocols, and protections, including their right to withdraw and data privacy. We assured participants that their HRV and stress levels would be anonymised and used for research.

Data Analysis: Data analysis was done with SPSS 27. Descriptive statistics summarizing occupational demographics, HRV, and stress levels. ANOVA was used to examine the four occupational groups' HRV and stress levels to see if they differed substantially. When ANOVA results were statistically significant, post hoc analyses like Tukey's test were used to identify group differences. The relationship between HRV and perceived stress was examined using Pearson correlation coefficients for each group. A p-value of 0.05 or less indicated statistical significance for all tests.

Results

Participant Characteristics: The study included 100 participants—25 from each of the four occupational categories: healthcare, office, teaching, and physical labor. Participants were 38.5–40.2 years old, with a standard deviation of 8.2. The healthcare group had 72% females and 44% males, making the gender distribution 56% female and 44% male. Most participants had worked in their chosen fields for an average of 10.3 years (±5.7 years). The demographics of study participants are shown in Table 1.

Table 1:

Demographic Variable	Healthcare Workers (n=25)	Office Employees (n=25)	Teachers (n=25)	Manual Laborers (n=25)	Total Sample (n=100)
Mean Age (Years)	39.2 ± 7.5	36.8 ± 8.1	37.5 ± 8.7	40.2 ± 8.6	38.5 ± 8.2
Gender (Male/Female)	7/18	14/11	12/13	11/14	44/56
Work Experience (Years)	9.8 ± 6.3	11.5 ± 5.2	10.1 ± 6.5	9.6 ± 4.9	10.3 ± 5.7

HRV Results: HRV was assessed using SDNN and RMSSD as time-domain metrics. HRV findings varied widely by profession. In general, teachers had the highest HRV values and healthcare workers the lowest. The average SDNN and RMSSD HRV measurements for each group are shown in Table 2.

Table 2:

Occupational Group	SDNN (ms)	RMSSD (ms)
Healthcare Workers	45.6 ± 12.5	32.4 ± 10.2
Office Employees	52.1 ± 11.8	36.7 ± 9.6
Teachers	58.3 ± 13.0	42.5 ± 12.1
Manual Laborers	49.7 ± 12.1	34.8 ± 9.7

Table 2 demonstrates that educators had the most adaptable autonomic response, with SDNN values of 58.3 ms and RMSSD values of 42.5 ms.

With an average SDNN of 45.6 ms and RMSSD of 32.4 ms, healthcare workers had the lowest HRV measurements, indicating poor stress management.

Stress Level Results

The Perceived Stress Scale assessed stress in all professions. Healthcare workers reported the highest PSS stress at 26.7 points, while educators reported the lowest at 18.9. Table 3 shows the average PSS scores for all groups.

Table 3:

Occupational Group	Mean PSS Score
Healthcare Workers	26.7 ± 4.5
Office Employees	23.4 ± 3.8
Teachers	18.9 ± 3.6
Manual Laborers	22.5 ± 4.2

The results indicate that participants in high-stress professions, particularly healthcare workers, experienced significantly higher stress levels than those in lower-stress occupations, such as teachers. A negative correlation was observed between HRV and stress levels; higher stress levels were associated with lower HRV scores. For example, healthcare workers, who reported the highest stress, had the lowest HRV, while teachers, who reported the lowest stress, had the highest HRV.

Statistical Analysis: One-way ANOVA was used to compare HRV (SDNN and RMSSD) and stress (PSS) ratings across the four occupational groups. The data showed significant group-specific HRV and stress levels. ANOVA showed significant differences in SDNN levels between occupational groups ($F = 4.32$, $p < 0.01$). While office employees and manual laborers did not differ significantly, healthcare professionals had a significantly lower SDNN than instructors ($p < 0.01$).

Similar to p-values, RMSSD values showed significant group variance. Healthcare staff had significantly lower RMSSD values than teachers ($p < 0.05$). Significant stress levels differed among occupational groups in the ANOVA ($F = 6.87$, $p < 0.001$). Healthcare professionals reported higher stress levels than educators ($p < 0.001$) and office workers ($p < 0.01$).

The effect sizes were calculated using η^2. A moderate influence of the occupational group on HRV (SDNN) was observed with $\eta^2 = 0.12$, whereas a bigger effect on stress levels was observed with $\eta^2 = 0.19$ for PSS scores. HRV and stress levels differed across educators and healthcare workers with SDNN confidence intervals of 6.5–12.4 ms and PSS scores of 5.3–9.1 ms. The results suggest that jobs with a lot of stress, like healthcare, have lower HRV and more perceived stress, whereas those with less stress, like teaching, have higher HRV and less stress. These findings emphasize the need for workplace stress-reduction treatments.

Discussion

This cross-sectional study found that HRV substantially correlated with stress across professions. Teachers had the lowest stress and highest HRV, while healthcare workers had the lowest HRV and most perceived stress. Previous study shows that high-stress employment negatively impact HRV, a good predictor of autonomic nervous system function and stress resilience. Our results match that. Insufficient HRV has been linked to stress and adversity resilience in extensive research. Healthcare workers have lower HRV than the general population, according to studies. Chronic stressors in high-pressure workplaces like hospitals may explain this. This study supports the hypothesis that healthcare workers are more prone to experience stress, which affects autonomic flexibility. Manual labourers and office workers, who were between healthcare workers and teachers, also showed workplace stress. Manual laborers reported lower stress than office workers, despite being more physically demanding. This supports the idea that mental stress, not physical exercise, determines HRV.

Relationship between HRV and Stress: The inverse relationship between stress and HRV in this study supports the assumption that HRV falls with stress. HRV indicates autonomic balance by assessing sympathetic and parasympathetic nervous system function. More variability means a good balance. Under chronic stress, the sympathetic nervous system takes over and lowers HRV. This study found that healthcare personnel had the lowest HRV values, indicating high PSS stress. In contrast, educators had the lowest stress and highest HRV, showing that calmer environments regulate internal organs better. This result shows that HRV can be used in occupational health evaluations as a non-invasive stress indicator.

Implications for Occupational Health: This study has major implications for occupational health, especially in high-stress fields like healthcare. Given the strong link between HRV and stress, regular HRV monitoring may help identify workers at risk of stress-related health issues. HRV can be monitored over time by employers and healthcare providers to detect early signs of chronic stress and take immediate action to improve health. Workplace HRV therapies including yoga, mindfulness, and other relaxation methods reduce stress and improve autonomic function. Certain

medicines benefit from healthcare personnel' high stress levels. Work-life balance, overtime limits, and breaks can lower stress and HRV in high-risk jobs. Teaching, which has lower stress levels, may benefit from a focus on workplace culture rather than stress reduction. This category includes peer support groups, stress management workshops, and professional development programs that help educators handle emotional pressures.

Limitations

This study illuminates the relationship between HRV and stress in numerous professional categories, notwithstanding some drawbacks. First, 100 people is plenty for a cross-sectional study, but it may not represent the stress levels of diverse vocations. Larger sample sizes may yield more trustworthy and useful results. Second, the study was cross-sectional, so we can't determine if stress increases or decreases HRV. Although there is a definite association, future study should follow patients over time to determine if chronic stress causes low HRV or if persons with low HRV are more likely to experience stress. Thirdly, the Perceived Stress Scale may cause response bias, causing people to overstate or underestimate their stress. HRV data and quantifiable stress markers like cortisol levels should improve future studies.

Future Research

Stress and HRV in different work situations should be studied using larger, longitudinal designs that track people over time to address these limits. Such studies may help researchers understand the relationship between stress and HRV and the long-term physical and mental health effects of workplace stress. Intervention studies investigating the effects of stress-reduction programs on HRV in high-risk occupations might also be helpful. These studies could examine how exercise, mindfulness, or workplace improvements affect HRV and health among stressed-out workers. Future studies should examine how sleep, exercise, and social support affect HRV and stress reactions across professions.

Conclusion

This study found significant differences in HRV and stress levels across occupational groups, with healthcare professionals having the lowest HRV and greatest stress levels and teachers having the opposite trend. Heart rate variability (HRV) is an objective indication of autonomic function and stress resilience since it inversely correlates with stress. These findings support past research on stress management for dangerous workers. HRV and occupational stress can help explain how different work environments affect employees' physical and emotional health. HRV monitoring should be part of occupational health programs to identify stress-related health issues. Mindfulness training, relaxation techniques, and better workplace policies can reduce stress and increase HRV. Future research should examine how occupational stress affects HRV over time and how focused therapies improve HRV and wellbeing in diverse employment. This study establishes the foundation for workplace stress management improvements that improve health and productivity.

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