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Cardiometabolic Risk Clustering and Occupational Lifestyle Behaviors Among Sedentary Employees: An Analytical Cross-Sectional Study

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Abstract

Sedentary occupations have emerged as a significant determinant of cardiometabolic health; however, the interplay between workplace sitting patterns, dietary habits, physical activity, and sleep quality remains insufficiently characterized in developing workforce populations. This study aimed to determine the prevalence of cardiometabolic risk clustering and examine the independent associations between occupational lifestyle behaviors and metabolic risk burden among sedentary employees. A cross-sectional study was conducted among 240 sedentary employees aged 25-60 years recruited from corporate offices, academic institutions, and banking sectors. Cardiometabolic risk clustering was defined as the presence of >=2 abnormal markers among elevated waist circumference (>=90 cm for men, >=80 cm for women), elevated blood pressure (>=130/85 mmHg), elevated fasting blood glucose (>=100 mg/dL), and elevated body mass index (>=25 kg/m2). Lifestyle behaviors were assessed using the International Physical Activity Questionnaire-Short Form (IPAQ-SF), Pittsburgh Sleep Quality Index (PSQI), and a structured dietary habits questionnaire. Multivariable logistic regression was used to identify independent predictors of risk clustering. The overall prevalence of cardiometabolic risk clustering was 31.3% (n = 75). Low physical activity (adjusted OR = 2.84; 95% CI: 1.42-5.68; p = 0.003), poor sleep quality (PSQI >5) (adjusted OR = 2.21; 95% CI: 1.18-4.15; p = 0.013), prolonged work sitting time (>8 hours/day) (adjusted OR = 1.94; 95% CI: 1.05-3.58; p = 0.034), and unhealthy dietary patterns (adjusted OR = 1.73; 95% CI: 1.02-2.93; p = 0.042) were independently associated with cardiometabolic risk clustering after controlling for age, sex, smoking, and family history. Nearly one-third of sedentary employees exhibited cardiometabolic risk clustering, with occupational lifestyle behaviors serving as significant independent predictors. Workplace wellness programs targeting physical activity promotion, sleep hygiene, and dietary modification may represent effective strategies for cardiometabolic disease prevention in this high-risk occupational group.

Keywords: Cardiometabolic Risk, Metabolic Syndrome, Sedentary Behavior, Occupational Health, Physical Activity, Sleep Quality, Dietary Patterns, Cross-Sectional Study

INTRODUCTION

The global burden of non-communicable diseases (NCDs) has reached unprecedented levels, with cardiovascular disease, type 2 diabetes mellitus, and their shared antecedent risk factors accounting for over 70% of all deaths worldwide [1]. Cardiometabolic risk clustering-defined as the co-occurrence of multiple

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metabolic abnormalities including abdominal obesity, elevated blood pressure, dysglycemia, and dyslipidemia-represents a critical intermediate phenotype linking adverse lifestyle behaviors to overt cardiovascular and metabolic disease [2]. The concept of metabolic syndrome, first formalized by Reaven in 1988 as "Syndrome X" [3], has evolved substantially over subsequent decades, with the National Cholesterol Education Program Adult Treatment Panel III (NCEP-ATP III) and the International Diabetes Federation (IDF) establishing widely adopted diagnostic frameworks [4], [5].

Contemporary epidemiological evidence indicates that occupational characteristics constitute an increasingly important determinant of cardiometabolic health. The proliferation of desk-based employment, digital workflow systems, and remote work arrangements has precipitated a dramatic shift toward prolonged sedentary time during working hours [6]. Studies conducted across diverse geographical and occupational contexts have consistently demonstrated that employees in sedentary occupations accumulate substantially greater sitting time compared to their counterparts in physically demanding roles, with average daily sitting times exceeding 8-10 hours among office workers [7], [8]. This occupational sedentarism operates through multiple mechanistic pathways, including reduced energy expenditure, compromised insulin sensitivity, diminished lipoprotein lipase activity, and unfavorable alterations in vascular function [9], [10].

Beyond occupational sitting patterns, the broader constellation of lifestyle behaviors exhibited by sedentary workers warrants systematic investigation. Physical inactivity, poor sleep quality, and unhealthy dietary habits frequently co-occur among desk-based employees, potentially generating synergistic effects on metabolic risk that exceed the additive impact of individual behaviors [11], [12]. The phenomenon of "risk behavior clustering"-wherein multiple unhealthy behaviors aggregate within the same individuals-has been documented across diverse populations and represents a key target for integrated preventive interventions [13]. Sleep deprivation and poor sleep quality, in particular, have emerged as potent modulators of metabolic function through disruption of circadian glucose regulation, appetite hormone signaling, and sympathetic nervous system activity [14], [15].

Despite the recognition of occupational sedentarism as a cardiometabolic risk factor, significant knowledge gaps persist regarding the specific lifestyle behavior profiles that characterize high-risk individuals within sedentary workforce populations. Most published studies have examined physical activity, diet, and sleep as isolated variables rather than integrated behavioral patterns, limiting the ability to identify high-yield intervention targets [16], [17]. Furthermore, the majority of existing evidence derives from high-income Western populations, with limited representation of workforce cohorts from low- and middle-income countries where the epidemiological transition is occurring most rapidly [18], [19].

The present study was designed to address these gaps by conducting a comprehensive analytical cross-sectional investigation of cardiometabolic risk clustering and its associations with occupational lifestyle behaviors among sedentary employees. The specific objectives were: (i) to determine the prevalence and pattern of cardiometabolic risk factor clustering in a community-based sample of sedentary workers; (ii) to examine the bivariate associations between individual lifestyle behaviors and risk clustering; and (iii) to identify the independent predictors of cardiometabolic risk clustering through multivariable logistic regression analysis. We hypothesized that low physical activity, poor sleep quality, prolonged occupational sitting time, and unhealthy dietary patterns would each demonstrate significant independent associations with cardiometabolic risk clustering after controlling for established demographic and clinical confounders.

MATERIALS AND METHODS

Study Design and Setting

This analytical cross-sectional study was conducted between March 2025 and June 2025 across multiple workplace settings in an urban metropolitan area. The study conducted in accordance with the principles of ethical standards. All participants provided written informed consent prior to data collection.

Participants and Sampling

The study population comprised sedentary employees aged 25-60 years working in corporate offices, academic institutions, banking sectors, and government administrative departments. A sedentary occupation was defined as one in which the employee spent >=70% of working hours in a seated position and did not

engage in regular occupational physical activity [20].

A convenience sampling approach was employed, with recruitment conducted through workplace announcements, email invitations, and direct contact with human resource departments. The minimum required sample size was calculated using the formula for estimating a single population proportion with 95% confidence level, assuming an anticipated prevalence of cardiometabolic risk clustering of 30% with 5% absolute precision [21]. The calculated minimum sample size was 323; however, accounting for an anticipated 25% non-response rate, the target sample was set at 430. Ultimately, 267 individuals consented to participate, of whom 240 completed all assessments and were included in the final analysis.

Inclusion criteria were: (i) age 25-60 years; (ii) employed in a sedentary occupation for >=1 year; (iii) ability to provide informed consent; and (iv) willingness to undergo anthropometric and clinical measurements. Exclusion criteria were: (i) known diagnosis of diabetes mellitus, cardiovascular disease, or chronic kidney disease; (ii) current pregnancy or lactation; (iii) use of medications affecting blood pressure, glucose metabolism, or lipid profiles; and (iv) presence of acute illness at the time of assessment.

Data Collection Procedures

Data collection was conducted during working hours at designated assessment stations within participating workplaces. Each participant completed a single assessment session lasting approximately 45 minutes, comprising anthropometric measurements, clinical assessments, and structured questionnaire administration.

Anthropometric and Clinical Measurements

Height was measured to the nearest 0.1 cm using a wall-mounted stadiometer with the participant standing erect without shoes. Weight was measured to the nearest 0.1 kg using a calibrated digital scale (Omron HN-289, Japan) with participants wearing light clothing and no shoes. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared [22].

Waist circumference was measured at the midpoint between the lower margin of the last palpable rib and the top of the iliac crest using a non-stretchable measuring tape, recorded to the nearest 0.1 cm [23]. Two measurements were obtained and averaged; a third measurement was taken if the first two differed by >1 cm.

Blood pressure was measured using a calibrated automatic digital sphygmomanometer (Omron HEM-7120, Japan) after the participant had rested in a seated position for at least 10 minutes. Two measurements were obtained at 5-minute intervals, and the average was recorded [24].

Fasting blood glucose was measured using a portable glucometer (Accu-Chek Active, Roche Diagnostics) from capillary blood samples obtained via fingertip puncture following a minimum 8-hour overnight fast [25]. Quality control was maintained using standard glucose control solutions provided by the manufacturer.

Lifestyle Behavior Assessment

Physical activity was assessed using the International Physical Activity Questionnaire-Short Form (IPAQ-SF), a validated seven-item instrument that captures the frequency and duration of vigorous-intensity activity, moderate-intensity activity, and walking during the preceding seven days [26]. Total metabolic equivalent-minutes per week (MET-min/week) were calculated, and participants were categorized as low (<600 MET-min/week), moderate (600-3000 MET-min/week), or high (>=3000 MET-min/week) physical activity according to standard IPAQ scoring protocols [27]. For the primary analysis, moderate and high activity categories were combined and contrasted with the low activity category.

Sleep quality was evaluated using the Pittsburgh Sleep Quality Index (PSQI), a 19-item self-rated questionnaire that assesses sleep quality and disturbances over the preceding month [28]. The PSQI generates a global score ranging from 0 to 21, with higher scores indicating poorer sleep quality. A global PSQI score >5 was used as the cutoff for poor sleep quality, consistent with established diagnostic conventions [29].

Dietary habits were assessed using a structured dietary habits questionnaire adapted from previously validated instruments [30], [31]. The questionnaire captured information on meal frequency, consumption of fruits and vegetables, whole grains, processed foods, sugary beverages, and fried foods. A dietary habit score was constructed by assigning 1 point for each favorable behavior (>=5 servings of fruits/vegetables daily, regular breakfast consumption, >=3 whole grain servings weekly, limited processed food intake, limited

sugary beverage consumption, and limited fried food consumption). Participants scoring <=3 points were classified as having unhealthy dietary patterns, while those scoring >=4 points were classified as having healthy dietary patterns.

Work sitting time was assessed using a single-item question: "On a typical workday, how many hours do you spend sitting during working hours?" Response categories were: <4 hours, 4-6 hours, 6-8 hours, and >8 hours [32]. For analysis, participants were dichotomized as having prolonged sitting (>8 hours/day) versus non-prolonged sitting (<=8 hours/day).

Definition of Cardiometabolic Risk Clustering

Given the resource constraints of a community-based study, a modified definition of cardiometabolic risk clustering was operationalized based on the presence of >=2 abnormal markers among the following four parameters, adapted from the NCEP-ATP III and IDF criteria [4], [5]:

1. Elevated waist circumference: >=90 cm for men, >=80 cm for women
2. Elevated blood pressure: systolic >=130 mmHg and/or diastolic >=85 mmHg
3. Elevated fasting blood glucose: >=100 mg/dL
4. Elevated body mass index: >=25 kg/m2

This modified definition has been employed in previous epidemiological studies in resource-limited settings where comprehensive lipid profiling was not feasible [33], [34]. The absence of lipid data was acknowledged as a study limitation.

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics for Windows, Version 26.0 (IBM Corp., Armonk, NY, USA). A two-tailed p-value <0.05 was considered statistically significant for all analyses.

Categorical variables were presented as frequencies and percentages, while continuous variables were presented as means with standard deviations (SD) or medians with interquartile ranges (IQR) depending on distribution normality. The normality of continuous variables was assessed using the Shapiro-Wilk test.

Bivariate associations between lifestyle behaviors and cardiometabolic risk clustering were examined using the Chi-square test or Fisher's exact test for categorical variables, and the independent samples t-test or Mann-Whitney U test for continuous variables, as appropriate.

Multivariable logistic regression analysis was conducted to identify independent predictors of cardiometabolic risk clustering. Variables demonstrating $p < 0.20$ in bivariate analysis were entered into the multivariable model [35]. The final model adjusted for age (continuous), sex (male/female), smoking status (current/former/never), and family history of diabetes or cardiovascular disease (yes/no) as potential confounders. Adjusted odds ratios (aOR) with 95% confidence intervals (CI) were reported.

Model fit was assessed using the Hosmer-Lemeshow goodness-of-fit test, and multicollinearity was evaluated using variance inflation factors (VIF), with VIF >10 indicating problematic collinearity [36].

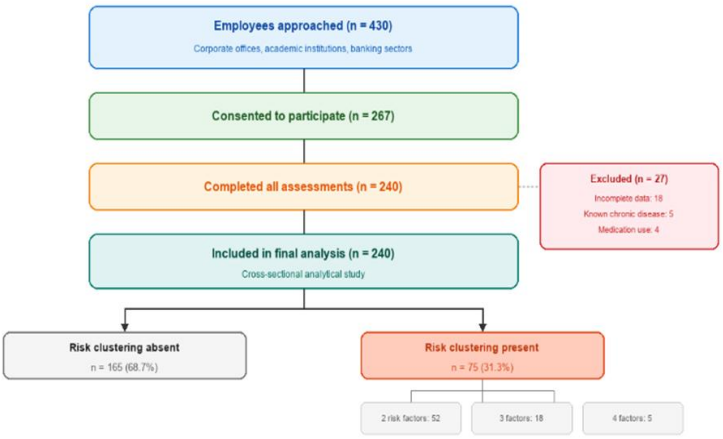


Figure 1. Study Flowchart.

Schematic diagram illustrating the recruitment, screening, and analysis process. Of 430 employees approached, 267 consented to participate, and 240 completed all assessments and were included in the final analysis. Reasons for exclusion included incomplete data (n = 18), known chronic disease (n = 5), and current medication use affecting metabolic parameters (n = 4) (Figure 1).

RESULTS

Participant Characteristics

A total of 240 sedentary employees were included in the final analysis. The mean age of participants was 41.2 +/- 9.6 years, and 132 (55.0%) were male. The majority of participants were married (71.3%), held a university degree or higher (68.3%), and had a monthly income in the middle-income bracket (58.3%). The mean BMI was 26.8 +/- 4.2 kg/m2, and the mean waist circumference was 88.4 +/- 11.2 cm. Detailed sociodemographic and clinical characteristics are presented in Table 1.

Table 1. Sociodemographic and Clinical Characteristics of Study Participants (N = 240)

Characteristic	n (%) or Mean +/- SD
Age (years)	41.2 +/- 9.6
25-34	58 (24.2)
35-44	82 (34.2)
45-54	68 (28.3)
55-60	32 (13.3)
Sex	
Male	132 (55.0)
Female	108 (45.0)
Marital status	
Married	171 (71.3)
Single	52 (21.7)
Divorced/Widowed	17 (7.1)
Education level	
High school or below	32 (13.3)
University degree	125 (52.1)
Postgraduate degree	83 (34.6)
Monthly income	
Low (<$800)	48 (20.0)
Middle ($800-$2000)	140 (58.3)
High (>$2000)	52 (21.7)
Smoking status	
Current smoker	42 (17.5)
Former smoker	28 (11.7)
Never smoked	170 (70.8)
Family history of diabetes/CVD	89 (37.1)
Body mass index (kg/m2)	26.8 +/- 4.2
Waist circumference (cm)	88.4 +/- 11.2
Systolic blood pressure (mmHg)	128.6 +/- 14.3
Diastolic blood pressure (mmHg)	82.4 +/- 9.8
Fasting blood glucose (mg/dL)	102.8 +/- 18.6

Prevalence of Cardiometabolic Risk Factors and Clustering

The prevalence of individual cardiometabolic risk factors was as follows: elevated waist circumference in 112 participants (46.7%), elevated blood pressure in 98 participants (40.8%), elevated fasting blood

glucose in 76 participants (31.7%), and elevated BMI in 142 participants (59.2%). The overall prevalence of cardiometabolic risk clustering (>=2 abnormal markers) was 31.3% (n = 75).

The distribution of risk factor combinations among participants with risk clustering is shown in Table 2. The most common combination was elevated BMI plus elevated waist circumference (n = 28, 37.3%), followed by elevated BMI plus elevated blood pressure (n = 18, 24.0%).

Table 2. Prevalence of Cardiometabolic Risk Factors and Clustering Patterns (N = 240)

Risk Parameter	n (%)
Individual risk factors	
Elevated waist circumference	112 (46.7)
Elevated blood pressure	98 (40.8)
Elevated fasting blood glucose	76 (31.7)
Elevated BMI (>=25 kg/m2)	142 (59.2)
Cardiometabolic risk clustering	
0 risk factors	48 (20.0)
1 risk factor	117 (48.8)
>=2 risk factors (clustering)	75 (31.3)
Clustering combinations (among n = 75)	
BMI + waist circumference	28 (37.3)
BMI + blood pressure	18 (24.0)
BMI + blood glucose	12 (16.0)
Waist + blood pressure	8 (10.7)
Waist + blood glucose	5 (6.7)
Blood pressure + blood glucose	4 (5.3)

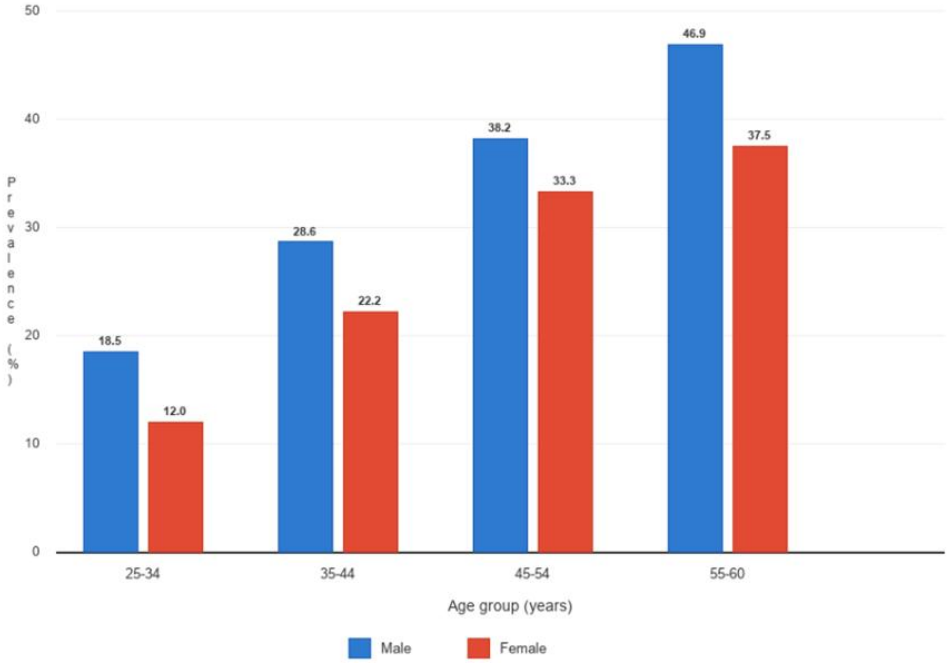


Figure 2. Prevalence of Cardiometabolic Risk Clustering by Age Group and Sex.

Bar chart in Figure 2 is showing the percentage of participants with cardiometabolic risk clustering (>=2 abnormal markers) stratified by age group (25-34, 35-44, 45-54, 55-60 years) and sex. The prevalence increased progressively with age in both males and females, with the highest prevalence observed in the 55-60 age group (males: 46.9%; females: 37.5%).

Lifestyle Behavior Profiles

The distribution of lifestyle behaviors among the study population is summarized in Table 3. Low physical activity was observed in 108 participants (45.0%), poor sleep quality in 96 participants (40.0%), prolonged work sitting time in 124 participants (51.7%), and unhealthy dietary patterns in 88 participants (36.7%).

Table 3. Distribution of Occupational Lifestyle Behaviors (N = 240)

Lifestyle Behavior	n (%)
Physical activity level	
Low (<600 MET-min/week)	108 (45.0)
Moderate (600-3000 MET-min/week)	92 (38.3)
High (>=3000 MET-min/week)	40 (16.7)
Sleep quality (PSQI)	
Good (<=5)	144 (60.0)
Poor (>5)	96 (40.0)
Work sitting time	
<=8 hours/day	116 (48.3)
>8 hours/day	124 (51.7)
Dietary pattern	
Healthy (score >=4)	152 (63.3)
Unhealthy (score <=3)	88 (36.7)

Bivariate Associations with Cardiometabolic Risk Clustering

The bivariate associations between sociodemographic variables, lifestyle behaviors, and cardiometabolic risk clustering are presented in Table 4. Participants with risk clustering were significantly older (45.3 +/- 8.9 vs. 39.4 +/- 9.4 years; $p < 0.001$), had higher BMI (29.6 +/- 4.1 vs. 25.5 +/- 3.6 kg/m2; $p < 0.001$), and were more likely to have a family history of diabetes or cardiovascular disease (48.0% vs. 32.1%; $p = 0.021$) compared to those without clustering.

Significant bivariate associations were observed for all four lifestyle behaviors. The prevalence of risk clustering was higher among participants with low physical activity (42.6% vs. 22.0%; $p = 0.001$), poor sleep quality (43.8% vs. 23.6%; $p = 0.001$), prolonged work sitting time (38.7% vs. 23.3%; $p = 0.011$), and unhealthy dietary patterns (43.2% vs. 24.3%; $p = 0.003$).

Table 4. Bivariate Associations with Cardiometabolic Risk Clustering

Variable	Risk Clustering Present (n = 75)	Risk Clustering Absent (n = 165)	p-value
Age (years), mean +/- SD	45.3 +/- 8.9	39.4 +/- 9.4	<0.001
Sex, n (%)	0.182		
Male	46 (61.3)	86 (52.1)	
Female	29 (38.7)	79 (47.9)	
Family history, n (%)	36 (48.0)	53 (32.1)	0.021
Smoking status, n (%)	0.086		
Current	18 (24.0)	24 (14.5)	
Former	12 (16.0)	16 (9.7)	
Never	45 (60.0)	125 (75.8)	
Low physical activity, n (%)	46 (61.3)	62 (37.6)	0.001
Poor sleep quality, n (%)	42 (56.0)	54 (32.7)	0.001
Prolonged sitting (>8h), n (%)	48 (64.0)	76 (46.1)	0.011
Unhealthy diet, n (%)	38 (50.7)	50 (30.3)	0.003

Multivariable Logistic Regression Analysis

The results of the multivariable logistic regression analysis are presented in Table 5. After adjusting for

age, sex, smoking status, and family history of diabetes or cardiovascular disease, four lifestyle behaviors demonstrated significant independent associations with cardiometabolic risk clustering.

Low physical activity was the strongest predictor (adjusted OR = 2.84; 95% CI: 1.42-5.68; p = 0.003), followed by poor sleep quality (adjusted OR = 2.21; 95% CI: 1.18-4.15; p = 0.013), prolonged work sitting time (adjusted OR = 1.94; 95% CI: 1.05-3.58; p = 0.034), and unhealthy dietary patterns (adjusted OR = 1.73; 95% CI: 1.02-2.93; p = 0.042). Age also demonstrated a significant association (adjusted OR = 1.06; 95% CI: 1.02-1.10; p = 0.002), while sex, smoking status, and family history did not retain significance in the multivariable model.

In Figure 3 below, a forest plot displays the adjusted odds ratios and 95% confidence intervals for the four significant lifestyle predictors identified in the multivariable logistic regression model. The vertical line at OR = 1.0 represents no association. Low physical activity (aOR = 2.84), poor sleep quality (aOR = 2.21), prolonged sitting (aOR = 1.94), and unhealthy diet (aOR = 1.73) all demonstrated statistically significant positive associations.

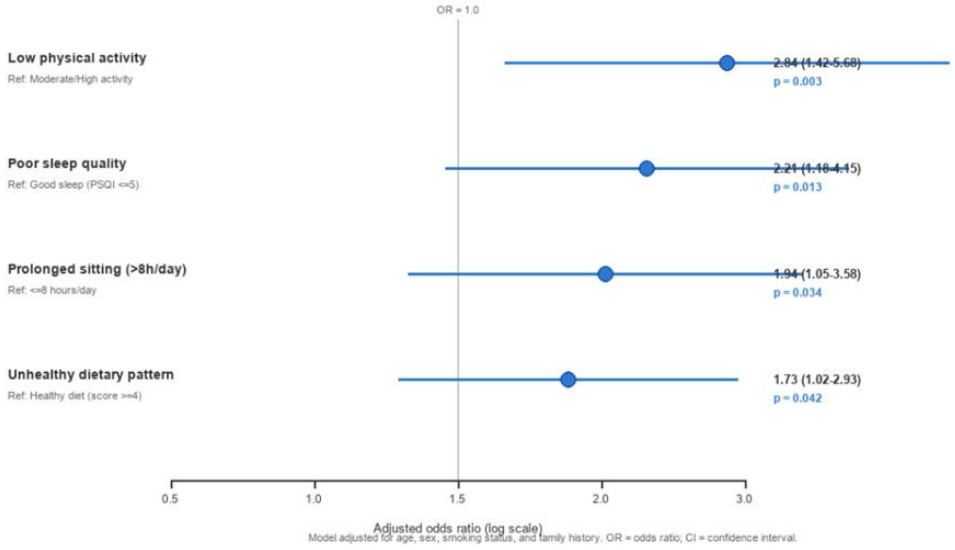


Figure 3. Adjusted Odds Ratios for Independent Predictors of Cardiometabolic Risk Clustering

The Hosmer-Lemeshow goodness-of-fit test indicated adequate model fit (chi2 = 7.84, p = 0.448), and all variance inflation factors were <2.0, indicating absence of multicollinearity.

Table 5. Multivariable Logistic Regression Predicting Cardiometabolic Risk Clustering

Variable	Adjusted OR	95% CI	p-value
Age (per year increase)	1.06	1.02-1.10	0.002
Sex (Male vs. Female)	1.42	0.78-2.58	0.251
Smoking (Current vs. Never)	1.68	0.82-3.44	0.158
Family history (Yes vs. No)	1.45	0.82-2.56	0.201
Low physical activity	2.84	1.42-5.68	0.003
Poor sleep quality	2.21	1.18-4.15	0.013
Prolonged sitting (>8h/day)	1.94	1.05-3.58	0.034
Unhealthy dietary pattern	1.73	1.02-2.93	0.042

Subgroup Analysis by Age and Sex

Exploratory subgroup analyses revealed that the association between poor sleep quality and risk clustering was more pronounced among female participants (OR = 2.89; 95% CI: 1.28-6.54) compared to male participants (OR = 1.72; 95% CI: 0.74-4.01), although the interaction term was not statistically

significant (p = 0.312). Similarly, the association between prolonged sitting and risk clustering was stronger among participants aged >=45 years (OR = 2.34; 95% CI: 1.12-4.88) compared to those aged <45 years (OR = 1.52; 95% CI: 0.62-3.74). These subgroup findings should be interpreted with caution given the limited statistical power for interaction testing.

DISCUSSION

This analytical cross-sectional study examined the prevalence and lifestyle determinants of cardiometabolic risk clustering among 240 sedentary employees. The principal findings were threefold. First, nearly one-third of participants (31.3%) exhibited cardiometabolic risk clustering, indicating a substantial burden of subclinical metabolic dysfunction in this occupational group. Second, all four examined lifestyle behaviors-low physical activity, poor sleep quality, prolonged work sitting time, and unhealthy dietary patterns-demonstrated significant independent associations with risk clustering after adjustment for demographic and clinical confounders. Third, low physical activity emerged as the strongest modifiable predictor, with sedentary employees being nearly three times more likely to exhibit risk clustering compared to their more physically active counterparts.

The observed prevalence of 31.3% aligns closely with estimates from comparable studies conducted in sedentary workforce populations. A cross-sectional investigation among Indian information technology professionals reported a metabolic syndrome prevalence of 28.4% using IDF criteria [37], while a study of South Korean office workers documented a prevalence of 26.8% based on NCEP-ATP III criteria [38]. Similarly, research among Brazilian bank employees identified metabolic syndrome in 29.6% of participants [39]. The consistency of these findings across diverse geographical and occupational contexts underscores the generalizability of cardiometabolic risk clustering as a pressing occupational health concern.

The identification of low physical activity as the predominant independent predictor of risk clustering is consistent with an extensive body of epidemiological evidence. Meta-analytic data have demonstrated that regular physical activity reduces the risk of metabolic syndrome by approximately 30-40%, with dose-response relationships evident across the activity spectrum [40], [41]. The mechanistic basis for this protective effect encompasses enhanced insulin sensitivity through GLUT4 translocation, improved endothelial function via nitric oxide bioavailability, favorable modulation of adipokine profiles, and reduction of visceral adiposity [42], [43]. Notably, the magnitude of association observed in the present study (aOR = 2.84) was somewhat larger than that reported in several prospective cohorts, potentially reflecting the particularly low baseline activity levels characteristic of this sedentary workforce population.

Poor sleep quality demonstrated the second-strongest association with cardiometabolic risk clustering (aOR = 2.21), supporting the growing recognition of sleep as a fundamental pillar of metabolic health. The mechanisms linking sleep disruption to metabolic dysfunction are multifactorial and include dysregulation of hypothalamic appetite-regulating hormones (increased ghrelin, decreased leptin), impaired glucose tolerance via reduced insulin sensitivity, activation of the hypothalamic-pituitary-adrenal axis with consequent cortisol elevation, and low-grade systemic inflammation marked by elevated C-reactive protein and interleukin-6 [14], [44], [45]. The prevalence of poor sleep quality in 40% of the study population is concerning and suggests that sleep-focused interventions could yield meaningful cardiometabolic benefits in this workforce.

The independent association between prolonged occupational sitting and cardiometabolic risk clustering (aOR = 1.94) adds to the evidence base implicating sedentary behavior as a distinct metabolic risk factor separate from physical inactivity. This distinction is epidemiologically important: an individual may meet physical activity guidelines while simultaneously accumulating excessive sitting time, and these behaviors exert partially independent effects on metabolic outcomes [46], [47]. The "sitting disease" hypothesis posits that prolonged uninterrupted sitting suppresses lipoprotein lipase activity in skeletal muscle, reducing triglyceride clearance and HDL cholesterol production, while also compromising insulin-mediated glucose uptake [9]. Workplace interventions incorporating standing desks, walking meetings, and structured activity breaks have shown promise in reducing occupational sitting time and improving cardiometabolic markers [48], [49].

The association between unhealthy dietary patterns and risk clustering (aOR = 1.73), while statistically significant, was the weakest among the four lifestyle behaviors examined. This finding may reflect several

considerations. First, dietary assessment via questionnaire is subject to substantial measurement error and social desirability bias, which can attenuate observed associations toward the null [50]. Second, the dietary scoring approach employed in this study, while pragmatic for field settings, may not have captured the full complexity of dietary quality, including factors such as meal timing, portion sizes, and specific nutrient compositions. Third, dietary habits may exert their effects on metabolic risk through more protracted pathways than the relatively acute impacts of physical inactivity or sleep deprivation, potentially requiring longer follow-up periods to detect their full contribution [51].

The age-related increase in risk clustering risk (aOR = 1.06 per year) was expected given the well-documented age-dependent deterioration in insulin sensitivity, adipose tissue distribution, and vascular compliance [52]. However, the absence of a significant sex effect in the multivariable model was somewhat surprising, as female sex is generally considered protective against metabolic syndrome in premenopausal populations [53]. This null finding may reflect the relatively broad age range of the study sample, which included both premenopausal and postmenopausal women, potentially obscuring sex-specific effects.

Several limitations of this study should be acknowledged. First, the cross-sectional design precludes causal inference; while the identified associations are biologically plausible, prospective studies are needed to establish temporal relationships. Second, the reliance on a modified definition of cardiometabolic risk clustering that excluded lipid parameters may have underestimated the true prevalence, as dyslipidemia constitutes a core component of metabolic syndrome [4]. Third, lifestyle behaviors were assessed using self-reported instruments, which are susceptible to recall and social desirability biases. Objective measures such as accelerometry for physical activity and actigraphy for sleep would strengthen future investigations [54]. Fourth, the convenience sampling approach may have introduced selection bias, potentially overrepresenting health-conscious individuals who were more willing to participate. Fifth, the single-urban setting limits generalizability to rural or peri-urban workforce populations.

Despite these limitations, this study possesses several notable strengths. The analytical approach controlled for multiple potential confounders, enhancing confidence in the independence of observed associations. The use of validated instruments for lifestyle behavior assessment ensures comparability with international literature. The workplace-based recruitment strategy yielded a sample that is directly relevant to the target population for occupational health interventions. The comprehensive assessment of four key lifestyle domains-physical activity, sleep, sitting time, and diet-within a single analytical framework represents an integrated approach that mirrors the multifactorial nature of cardiometabolic risk.

From a public health perspective, the findings carry important implications for workplace wellness program design. The high prevalence of risk clustering (31.3%) suggests that screening programs identifying at-risk employees would yield a substantial yield. The identification of four independent modifiable predictors provides multiple entry points for intervention, allowing for tailored approaches that match individual risk profiles. Given that low physical activity was the strongest predictor, workplace interventions prioritizing structured exercise programs, active commuting incentives, and movement-promoting environmental modifications may offer the greatest metabolic return on investment [55]. Simultaneously, the significant contributions of sleep quality and sitting time highlight the need for holistic wellness programs that extend beyond traditional exercise promotion to encompass sleep hygiene education and sedentary behavior reduction strategies [56].

Future research should build upon these findings through prospective cohort designs that can establish temporal sequences, randomized controlled trials evaluating the efficacy of multicomponent workplace interventions, and qualitative investigations exploring the barriers and facilitators to lifestyle behavior change among sedentary employees. The integration of wearable sensor technologies for objective behavior monitoring could enhance measurement precision and enable personalized feedback systems [57]. Additionally, research examining the cost-effectiveness of workplace cardiometabolic prevention programs would provide essential evidence for employer and policy decision-making [58].

CONCLUSION

This study demonstrates that cardiometabolic risk clustering affects nearly one-third of sedentary employees and is significantly associated with low physical activity, poor sleep quality, prolonged

occupational sitting, and unhealthy dietary patterns. Low physical activity emerged as the strongest modifiable predictor, conferring a nearly threefold increased risk of risk clustering. These findings underscore the urgent need for integrated workplace wellness interventions that address multiple lifestyle domains simultaneously. Employers, occupational health professionals, and policymakers should prioritize the implementation of evidence-based programs that promote physical activity, optimize sleep hygiene, reduce occupational sitting time, and support healthy dietary choices among desk-based workers. Such interventions have the potential to reduce the substantial burden of cardiometabolic disease in the workforce while simultaneously improving productivity, reducing absenteeism, and generating favorable returns on health investment.

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