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Evaluation of HbA1c and Insulin Resistance-Related Measures in IT Employees With Shift Work Patterns: A Cross-Sectional Study

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Abstract

Background and objective: Shift work can disrupt circadian alignment and often coexists with sedentary behavior, irregular sleep, and altered meal timing. Information technology (IT) employees working night or rotating schedules may therefore be vulnerable to early metabolic dysfunction. This study compared glycated hemoglobin (HbA1c), fasting glucose, fasting insulin, and insulin resistance-related measures between shift-working and non-shift-working IT employees and described accompanying adiposity, lipid, physical activity, and sleep profiles.

Methodology: This workplace-based analytical cross-sectional study included 400 IT employees in Chennai, India, between February and May 2025: 200 shift workers and 200 non-shift workers. Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI), and physical activity was assessed using the International Physical Activity Questionnaire-Short Form (IPAQ-SF). The prespecified primary outcomes were HbA1c and fasting serum insulin. The group-level Homeostatic Model Assessment of Insulin Resistance using the original HOMA1 model (HOMA1-IR) index was included as a descriptive supporting insulin-resistance-related measure. Secondary outcomes included fasting plasma glucose, lipid profile, body mass index (BMI), waist circumference, waist-to-hip ratio, total physical activity <600 MET-min/week, PSQI global score, and poor sleep quality.

Results: Shift workers had higher mean BMI (27.1 ± 3.4 vs. 24.6 ± 3.1 kg/m²) and waist circumference (94.8 ± 9.2 vs. 88.3 ± 8.5 cm). They also had higher fasting plasma glucose (104.2 ± 10.1 vs. 96.5 ± 8.8 mg/dL; mean difference 7.70 mg/dL, 95% confidence interval (CI) 5.84-9.56), fasting serum insulin (18.5 ± 6.2 vs. 11.3 ± 3.9 µIU/mL; mean difference 7.20 µIU/mL, 95% CI 6.18-8.22), and HbA1c (6.1 ± 0.4% vs. 5.5 ± 0.3%; mean difference 0.60 percentage points, 95% CI 0.53-0.67). The descriptive group-level HOMA1-IR index was numerically higher in shift workers (4.76) than in non-shift workers (2.69). Shift workers also had a less favorable lipid profile, a greater proportion with total physical activity <600 MET-min/week (61.0% vs. 47.0%; prevalence ratio 1.30, 95% CI 1.08-1.56; $P = 0.005$), and a higher prevalence of poor sleep quality (68.0% vs. 34.5%; prevalence ratio 1.97, 95% CI 1.59-2.44; $P < 0.001$).

Conclusions: Shift-working IT employees demonstrated a less favorable metabolic and sleep profile, including higher fasting insulin and HbA1c and a numerically higher descriptive group-level HOMA1-IR index, consistent with a greater insulin-resistance-related burden. The cross-sectional design precludes causal inference, and the group-level HOMA1-IR estimate should not be interpreted as an individual diagnostic measure. These findings support occupational strategies addressing metabolic risk, sleep quality, physical activity, and recovery from night work.

Categories: Occupational Health, Public Health, Endocrinology/Diabetes/Metabolism
Keywords: diabetes, glycated hemoglobin, homa1-ir, information technology employees, insulin resistance, shift work, sleep quality

Introduction

Shift work is integral to industries that provide continuous services across time zones. Working during the biological night and sleeping during the day may be associated with circadian misalignment, in which behavioral cycles such as sleep, activity, and food intake occur at times that are inconsistent with the endogenous circadian system. The circadian system coordinates several physiological processes involved in metabolic homeostasis, including glucose regulation, insulin secretion, cortisol release, appetite, and energy expenditure. Controlled human studies have shown that experimentally induced circadian misalignment can increase glucose concentrations and reduce insulin sensitivity, even when important behavioral factors

are controlled [1,2].

Epidemiological evidence has also associated prolonged night or rotating shift work with adverse metabolic outcomes. In two large prospective cohorts, longer exposure to rotating night work was associated with a progressively higher risk of type 2 diabetes mellitus [3]. Occupational studies involving healthcare workers have reported higher fasting insulin concentrations and Homeostatic Model Assessment of Insulin Resistance (HOMA-IR) values among shift workers than among daytime workers [4]. However, effect estimates vary among studies because shift-work definitions, exposure duration, timing of blood collection, insulin assays, sleep characteristics, adiposity, and lifestyle covariates differ substantially across populations.

Insulin resistance can precede persistent fasting hyperglycemia. The Homeostatic Model Assessment of Insulin Resistance using the original HOMA1 model (HOMA1-IR), derived from fasting glucose and fasting insulin, is widely used in epidemiological research as a surrogate measure of basal insulin resistance [5]. It is not a stand-alone diagnostic test, and thresholds vary according to population characteristics and insulin assay. HbA1c provides complementary information because it reflects cumulative glycemic exposure over the preceding weeks and is used in the assessment of dysglycemia [6]. Evaluation of fasting glucose, fasting insulin, HbA1c, and appropriately interpreted insulin resistance-related measures may therefore provide complementary information regarding glucose-insulin regulation.

IT employees may represent an occupational group at increased metabolic risk because their work commonly involves prolonged sedentary time, extended screen exposure, irregular meal timing, occupational stress, and work schedules aligned with international business hours. Research among corporate IT employees in South India has documented substantial burdens of overweight, central adiposity, dyslipidemia, metabolic syndrome, and behavioral risk factors [7]. More recent research among IT employees in Hyderabad has also reported frequent occupational sitting, inadequate sleep, shift work, physical inactivity, and metabolic abnormalities [8]. These observations provide a rationale for examining glycemic, insulin-related, anthropometric, physical activity, and sleep characteristics according to shift-work status in IT employees.

Indian evidence specifically comparing insulin-resistance-related measures between shift-working and non-shift-working IT employees remains limited. Previous Indian studies in IT populations have predominantly examined metabolic syndrome, fatty liver disease, sedentary behavior, and other lifestyle-related risk factors, whereas detailed comparisons of fasting insulin and insulin-resistance-related measures according to shift-work status have been less frequently reported. A recent South Indian observational study assessed HOMA-IR in night-shift and day-shift workers, but the between-group difference in mean HOMA-IR was not statistically significant [9]. However, evidence specifically comparing shift-working and non-shift-working IT employees remains limited, particularly with respect to HbA1c and fasting serum insulin, together with sleep quality, physical activity, adiposity, lipid parameters, and other metabolic characteristics. The present study therefore addresses this specific gap by characterizing glycemic and insulin-related differences between shift-working and non-shift-working IT employees while describing their accompanying metabolic, behavioral, and sleep profiles.

Sleep disruption may represent one plausible pathway linking shift schedules with adverse metabolic profiles, while central adiposity, physical activity, dietary patterns, and cumulative shift exposure may confound or modify the observed associations. The present study therefore aimed to compare HbA1c and fasting serum insulin between shift-working and non-shift-working IT employees in Chennai, India, while also examining fasting plasma glucose and describing accompanying anthropometric, lipid, physical activity, and sleep profiles. A descriptive group-level HOMA1-IR index was additionally derived from the corresponding group mean fasting glucose and insulin values. We hypothesized that shift workers would demonstrate a less favorable glycemic and insulin-related metabolic profile than non-shift workers.

Materials And Methods

Study design and setting

This workplace-based analytical cross-sectional study was conducted between February and May 2025 among IT employees recruited from four multinational IT companies located in Chennai, Tamil Nadu, India. Both shift-working and non-shift-working employees were recruited from each of the four participating organizations. Employees working regular daytime schedules, fixed night shifts, and rotating schedules were represented. The job categories of participating employees were identified and recorded as part of the occupational information collected during recruitment. Organizational identities were not disclosed to preserve employee and company confidentiality.

The study compared metabolic, anthropometric, lifestyle, physical activity, and sleep characteristics according to work schedule. Reporting followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) recommendations for cross-sectional studies [10], and the completed STROBE checklist is provided as Figure *1*.

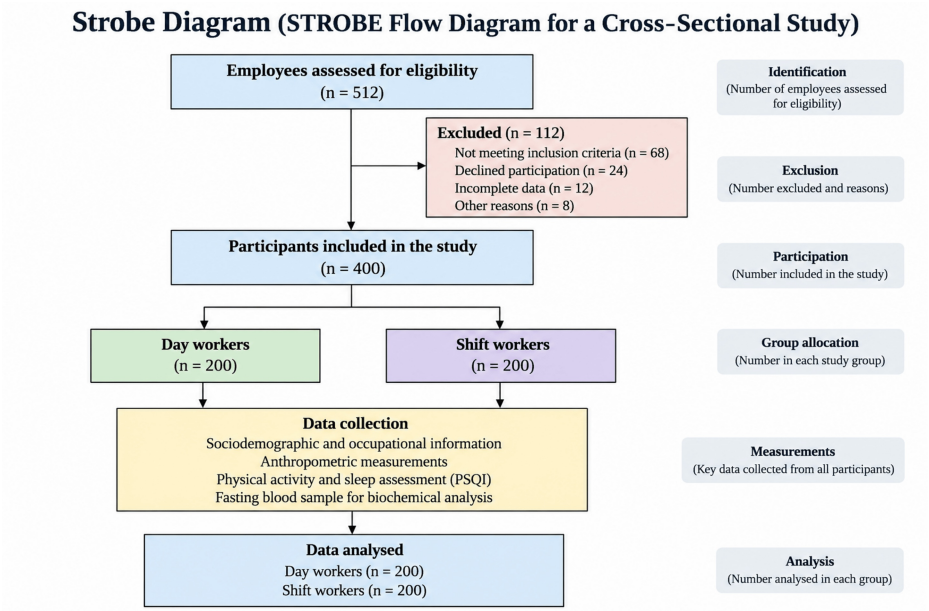


FIGURE 1: STROBE participant flow diagram showing participant assessment, inclusion, and the final analytic sample.

STROBE, Strengthening the Reporting of Observational Studies in Epidemiology

Study population

Male and female IT employees aged 25-50 years were eligible if they had completed at least one year of continuous employment in their current organization and provided written informed consent. The age range of 25-50 years was selected to focus on actively employed adults with relatively stable occupational exposure and to limit the influence of age-related metabolic variation.

Employees were excluded if they had previously diagnosed diabetes mellitus; an endocrine disorder affecting glucose metabolism; current systemic corticosteroid or hormonal therapy known to influence glucose metabolism; pregnancy; previously diagnosed chronic kidney disease or cardiovascular disease; recent major blood loss or blood transfusion; a known hemoglobinopathy or another condition likely to interfere with HbA1c interpretation; or an acute illness at the time of blood collection. Employees with previously diagnosed diabetes were excluded to permit evaluation of glycemic and insulin-related differences among employees without known diabetes and to minimize the influence of diabetes treatment on the measured metabolic parameters. Screening was based on medical and medication history, together with occupational health information available to the investigators.

Definition of work schedule

Work schedule was classified according to the pattern followed during the preceding 12 months. Shift workers were employees engaged in fixed night shifts or rotating schedules that included night duty. Night work was operationally defined as a work period containing at least three hours between 10:00 PM and 6:00 AM. Classification as a shift worker required night duty on at least three days per week and at least one year in that schedule.

Non-shift workers worked regular daytime hours, generally between 9:00 AM and 6:00 PM, without night-shift duty during the preceding 12 months. Occupational information included the current shift pattern, frequency of night duty, shift duration, rotation, overtime, cumulative shift-work exposure, and previous night-shift work.

Sample size and recruitment

The sample size was calculated for a two-group comparison of the anticipated proportion of participants with elevated HOMA-IR. The calculation assumed proportions of 42% among shift workers and 28% among non-shift workers, a two-sided alpha of 0.05, 80% statistical power, and a 1:1 allocation ratio. Equal allocation was chosen because both groups were recruited from the same participating organizations, with comparable recruitment feasibility. For a fixed total sample size, a 1:1 allocation provides efficient statistical power when the two groups can be recruited under similar conditions.

For two independent proportions with equal allocation, the sample size per group was calculated using the following formula:

$$n = \frac{\left[Z_{1-\alpha/2}\sqrt{2\bar{p}(1-\bar{p})} + Z_{1-\beta}\sqrt{p_1(1-p_1)+p_2(1-p_2)}\right]^2}{(p_1-p_2)^2}$$

where $p_1 = 0.42$, $p_2 = 0.28$, $\bar{p}=(p_1 + p_2)/2$, $Z_{1-\alpha}/2=1.96$, and $Z_{1-\beta} = 0.84$. This yielded approximately 181 participants per group, which was rounded up to 182 participants per group. Allowing approximately 10% for nonresponse, incomplete information, inadequate fasting, or unavailable laboratory measurements, the target was increased to 200 participants per group, giving a final target sample of 400 employees. The calculation was performed using OpenEpi version 3.01, based on standard methods for comparing two independent proportions [new reference]. The anticipated difference was informed by occupational literature reporting greater HOMA-IR values and insulin-resistance-related abnormalities among shift workers than among non-shift workers [4].

Data collection

Data were collected using a pretested, semistructured questionnaire administered by trained investigators. Information included age, sex, occupational history, working hours, shift characteristics, sleep, physical activity, smoking, alcohol consumption, meal patterns, family history of diabetes, medication use, and previously diagnosed medical conditions. The questionnaire was administered in English, with clarification in Tamil, the local language, when required.

Of the 512 employees assessed for participation during the study period, 400 entered the final analytic sample after eligibility screening, nonparticipation, and exclusion due to incomplete core assessments. The final sample comprised 200 shift workers and 200 non-shift workers. A participant flow diagram summarizing the verified study recruitment and analytic sample is provided in Figure 2.

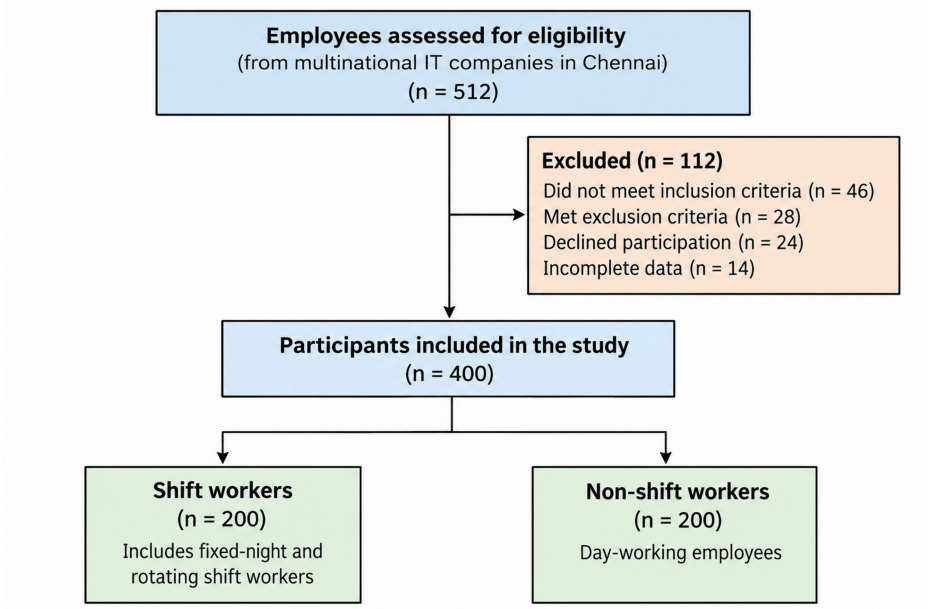


FIGURE 2: STROBE participant flow diagram of study recruitment and analysis.

STROBE, Strengthening the Reporting of Observational Studies in Epidemiology

Sleep quality

Sleep quality during the preceding month was assessed using the Pittsburgh Sleep Quality Index (PSQI) [11]. The seven component scores were summed to produce a global score from zero to 21, with higher values representing poorer sleep quality. A global score >5 was classified as poor sleep quality; in the original validation study, this threshold demonstrated a sensitivity of 89.6% and a specificity of 86.5% for distinguishing poor sleepers from good sleepers [11].

Participants also reported usual total sleep duration over 24 hours. For shift workers, this included principal daytime sleep and additional sleep episodes. Sleep duration was retained as a continuous measure, with <6 hours per 24 hours used as a descriptive short-sleep indicator.

Physical activity

Physical activity during the preceding seven days was assessed using the International Physical Activity Questionnaire-Short Form (IPAQ-SF) [12]. Walking, moderate-intensity activity, vigorous-intensity activity, and sedentary time were recorded and converted to metabolic equivalent task minutes per week (MET-min/week) using the IPAQ scoring approach.

Physical activity was considered primarily as a continuous measure of total MET-min/week. A secondary binary indicator identified participants accumulating <600 total MET-min/week as a pragmatic descriptive threshold for lower total activity volume. This threshold variable is reported explicitly as "total physical activity <600 MET-min/week" and is not labeled as the standard IPAQ low-activity category because the standard categorical IPAQ classification also incorporates frequency and duration criteria.

Anthropometric measurements

Body weight was measured to the nearest 0.1 kg using a calibrated digital weighing scale, with participants wearing light clothing and no footwear. Standing height was measured to the nearest 0.1 cm using a wall-mounted stadiometer with the head positioned in the Frankfort horizontal plane. BMI was calculated as weight in kilograms divided by height in meters squared. For descriptive interpretation, Asian BMI action points, rather than conventional WHO international BMI categories, were used: underweight <18.5 kg/m^2, normal 18.5-22.9 kg/m^2, overweight 23.0-27.4 kg/m^2, and obesity ⩾27.5 kg/m^2 [13].

Waist circumference was measured at the midpoint between the lower margin of the last palpable rib and the upper border of the iliac crest at the end of normal expiration. Hip circumference was measured at the widest circumference over the buttocks, and waist-to-hip ratio was calculated as waist circumference divided by hip circumference. Each anthropometric measurement was obtained twice; when readings differed by more than 0.5 kg for weight or 0.5 cm for height or circumference, a third measurement was obtained and the mean of the two closest readings was used.

Blood collection and biochemical analysis

Participants were instructed to maintain a 10-12-hour fast before blood collection. Water was permitted, while caloric food, sweetened beverages, smoking, alcohol, and strenuous physical activity were avoided during the fasting period. Blood collection was scheduled between 7:00 AM and 10:00 AM. Non-shift workers were sampled before starting daytime work. Shift workers were sampled after at least one principal recovery sleep period and were not sampled immediately after completing a night shift. Where operationally feasible, sampling occurred at least 24 hours after the most recent night shift. Participants who had not completed the required fast were rescheduled.

Venous blood was collected under aseptic precautions. Fasting plasma glucose was measured using the glucose oxidase-peroxidase method on an automated clinical chemistry analyzer. Fasting serum insulin was measured using a validated commercial sandwich enzyme-linked immunosorbent assay. HbA1c was measured using high-performance liquid chromatography standardized to the National Glycohemoglobin Standardization Program and aligned with the Diabetes Control and Complications Trial reference system. Total cholesterol, high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), and triglycerides were measured using standard enzymatic methods. The same laboratory methods and quality-control procedures were applied to both work-schedule groups.

Assessment of insulin resistance

Insulin-resistance-related assessment included fasting serum insulin and the original Homeostatic Model Assessment index (HOMA1-IR) [5]. The standard equation is HOMA1-IR = (fasting plasma glucose in mg/dL × fasting serum insulin in μIU/mL)/405.

For the group comparison reported in this manuscript, a summary-data HOMA1-IR index was calculated as the product of the group mean fasting plasma glucose and the group mean fasting serum insulin, divided by 405. This provides a transparent group-level index derived from the observed glucose-insulin profile. It is not mathematically identical to the arithmetic mean of individually calculated HOMA1-IR values and was therefore not used to classify individual participants, estimate the prevalence of insulin resistance, or generate participant-level adjusted associations.

Glycemic categories

HbA1c was interpreted using recognized glycemic cut points: <5.7% as normal, 5.7%-6.4% as the prediabetes range, and ⩾6.5% as the diabetes range [6]. Fasting plasma glucose was similarly interpreted as <100 mg/dL,

100-125 mg/dL, and ⩾126 mg/dL, respectively. A single result in the diabetes range was not regarded as sufficient to establish a diagnosis in an asymptomatic participant; abnormal values required clinical confirmation.

Study outcomes

The principal metabolic outcomes were HbA1c and insulin-resistance-related measures, including fasting serum insulin and the group-level HOMA1-IR index. Other outcomes were fasting plasma glucose, lipid profile, BMI, waist circumference, waist-to-hip ratio, total physical activity <600 MET-min/week, PSQI global score, and poor sleep quality.

Statistical analysis

Data were analyzed using IBM SPSS Statistics for Windows, version 25.0 (IBM Corp., Armonk, NY). Continuous variables are presented as mean ± standard deviation when approximately normally distributed, and categorical variables as numbers and percentages. Distributional assumptions were evaluated using graphical methods and the Shapiro-Wilk test. Normally distributed continuous variables were compared using independent-samples t tests, with Welch's correction when variances were unequal. Categorical variables were compared using Pearson's chi-square test or Fisher's exact test, as appropriate.

For continuous outcomes, unadjusted mean differences with 95% confidence intervals (CIs) were reported. For binary outcomes, prevalence ratios (PRs) with 95% CIs were reported. The group-level HOMA1-IR index was treated as a descriptive summary derived from group mean glucose and insulin values and was not subjected to participant-level inferential testing. Because sampling and analysis were conducted at the individual participant level, company-level clustering was not explicitly modeled in the primary analyses. All statistical tests were two-sided, and P < 0.05 was considered statistically significant.

Results

Participant characteristics

The final analysis included 400 IT employees, with 200 shift workers and 200 non-shift workers. The observed age difference was small (33.6 ± 5.8 vs. 33.1 ± 6.1 years; mean difference 0.50 years, 95% CI -0.67 to 1.67; *P* = 0.401), as was the difference in the proportion of male participants (68.5% vs. 66.0%; PR 1.04, 95% CI 0.91-1.19; *P* = 0.594). In contrast, shift workers had higher BMI, waist circumference, and waist-to-hip ratio. The proportion accumulating <600 total MET-min/week was also greater among shift workers (61.0% vs. 47.0%; PR 1.30, 95% CI 1.08-1.56; *P* = 0.005), as shown in Table *1*.

Variable	Shift workers (*n* = 200)	Non-shift workers (*n* = 200)	Effect estimate (95% CI)	P-value
Age (years)	33.6 ± 5.8	33.1 ± 6.1	Mean difference 0.50 (-0.67 to 1.67)	0.401
BMI (kg/m²)	27.1 ± 3.4	24.6 ± 3.1	Mean difference 2.50 (1.86-3.14)	<0.001
Waist circumference (cm)	94.8 ± 9.2	88.3 ± 8.5	Mean difference 6.50 (4.76-8.24)	<0.001
Waist-to-hip ratio	0.93 ± 0.04	0.89 ± 0.03	Mean difference 0.040 (0.033-0.047)	<0.001
Male sex	137 (68.5%)	132 (66.0%)	PR 1.04 (0.91-1.19)	0.594
Total physical activity <600 MET-min/week	122 (61.0%)	94 (47.0%)	PR 1.30 (1.08-1.56)	0.005

TABLE 1: Sociodemographic, anthropometric, and physical activity characteristics.

CI, confidence interval

Glycemic and insulin resistance-related measures

Shift workers demonstrated higher fasting plasma glucose, fasting serum insulin, and HbA1c than non-shift workers. Mean fasting plasma glucose was 104.2 ± 10.1 mg/dL versus 96.5 ± 8.8 mg/dL (mean difference 7.70 mg/dL, 95% CI 5.84-9.56; *P* < 0.001). Mean fasting serum insulin was 18.5 ± 6.2 µIU/mL versus 11.3 ± 3.9 µIU/mL (mean difference 7.20 µIU/mL, 95% CI 6.18-8.22; *P* < 0.001). Mean HbA1c was 6.1 ± 0.4% versus 5.5 ± 0.3% (mean difference 0.60 percentage points, 95% CI 0.53-0.67; *P* < 0.001), as shown in Table *2*.

Variable	Shift workers (*n* = 200)	Non-shift workers (*n* = 200)	Effect estimate (95% CI)	*P*-value
Fasting plasma glucose (mg/dL)	104.2 ± 10.1	96.5 ± 8.8	Mean difference 7.70 (5.84-9.56)	<0.001
Fasting serum insulin (μIU/mL)	18.5 ± 6.2	11.3 ± 3.9	Mean difference 7.20 (6.18-8.22)	<0.001
HbA1c (%)	6.1 ± 0.4	5.5 ± 0.3	Mean difference 0.60 (0.53-0.67)	<0.001
Summary-data HOMA1-IR index	4.76	2.69	Descriptive difference 2.07	Not applicable

TABLE 2: Glycemic and insulin resistance-related measures.

HOMA1-IR, Homeostasis Model Assessment of Insulin Resistance using the original HOMA1 model; CI, confidence interval

The summary-data HOMA1-IR index was 4.76 in shift workers and 2.69 in non-shift workers, a descriptive difference of 2.07. Because this index was calculated from group mean glucose and insulin values, it should not be interpreted as the arithmetic mean of individual HOMA1-IR values, a diagnostic threshold, or a prevalence estimate.

Lipid profile

Shift workers also showed a less favorable lipid profile, as shown in Table *3*. Total cholesterol, LDL-C, and triglycerides were higher, while HDL-C was lower, with all displayed between-group differences statistically significant at $P < 0.001$.

Variable	Shift workers (*n* = 200)	Non-shift workers (*n* = 200)	Mean difference (95% CI)	*P*-value
Total cholesterol (mg/dL)	198.4 ± 32.1	183.2 ± 29.4	15.20 (9.15-21.25)	<0.001
LDL-C (mg/dL)	128.6 ± 24.9	112.7 ± 21.3	15.90 (11.34-20.46)	<0.001
HDL-C (mg/dL)	39.5 ± 6.1	44.2 ± 5.9	-4.70 (-5.88 to -3.52)	<0.001
Triglycerides (mg/dL)	171.3 ± 45.6	138.5 ± 41.7	32.80 (24.21-41.39)	<0.001

TABLE 3: Lipid profile according to work schedule.

HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol

Sleep quality

Sleep disturbance was prominent among shift workers, as shown in Table *4*. The mean PSQI global score was 8.2 ± 2.4 in shift workers and 5.9 ± 1.8 in non-shift workers (mean difference 2.30, 95% CI 1.88-2.72; $P < 0.001$). Poor sleep quality (PSQI > 5) was reported by 136 shift workers (68.0%) and 69 non-shift workers (34.5%), giving an unadjusted PR of 1.97 (95% CI 1.59-2.44; $P < 0.001$).

Variable	Shift workers (*n* = 200)	Non-shift workers (*n* = 200)	Effect estimate (95% CI)	*P*-value
PSQI global score	8.2 ± 2.4	5.9 ± 1.8	Mean difference 2.30 (1.88-2.72)	<0.001
Poor sleep quality (PSQI > 5)	136 (68.0%)	69 (34.5%)	PR 1.97 (1.59-2.44)	<0.001

TABLE 4: Sleep quality according to work schedule.

PSQI, Pittsburgh Sleep Quality Index; PR, prevalence ratio

Discussion

In this cross-sectional study of 400 IT employees, shift workers demonstrated a consistently less favorable cardiometabolic and sleep profile than non-shift workers. The largest metabolic differences involved fasting insulin, the group-level HOMA1-IR index, HbA1c, central adiposity, and triglycerides. The summary-data HOMA1-IR index was 4.76 in shift workers compared with 2.69 in non-shift workers, while fasting serum insulin was 7.20 µIU/mL higher and HbA1c was 0.60 percentage points higher. Taken together, these findings are consistent with a greater insulin-resistance-related burden among shift workers.

The interpretation should remain associative. The design was cross-sectional, and adiposity, sleep disruption, activity, meal timing, and other occupational or lifestyle characteristics may act as confounders, mediators, or effect modifiers. Accordingly, the study demonstrates a clear between-group metabolic pattern but does not establish that shift work caused the abnormalities or that the observed insulin-resistance-related difference is independent of all measured and unmeasured covariates.

Insulin resistance and glycemic findings

The higher fasting glucose, fasting insulin, HbA1c, and group-level HOMA1-IR index among shift workers are biologically plausible. Controlled laboratory experiments have shown that circadian phase and circadian misalignment can influence glucose tolerance, insulin sensitivity, and insulin secretion through partially distinct mechanisms [14,15]. Circadian misalignment has also been shown to compromise skeletal-muscle insulin sensitivity and alter metabolic gene expression [16]. When circadian disruption is combined with sustained sleep restriction, adverse changes in glucose regulation and pancreatic compensation have been observed in healthy adults [17].

Large occupational cohorts provide complementary evidence. In the UK Biobank, rotating night work and greater night-shift frequency were associated with higher odds of type 2 diabetes after adjustment for established risk factors [18]. In two cohorts of female nurses, rotating night-shift exposure and an unhealthy lifestyle were independently associated with incident type 2 diabetes [19]. A 14-year cohort of Japanese workers also reported adverse longitudinal changes in HbA1c in relation to shift work [20]. The present findings are compatible with these reports, although the current cross-sectional study cannot establish temporal sequence.

Fasting insulin was substantially higher among shift workers, a pattern compatible with compensatory hyperinsulinemia. Because fasting insulin varies with assay characteristics, recent sleep and work exposure, stress, and circadian phase, standardization of fasting conditions and avoidance of immediate post-night-shift sampling were important design features. The accompanying group-level HOMA1-IR index provides a complementary summary of the glucose-insulin profile at the group level, but its summary-data nature requires restraint: it should not be interpreted as an individual HOMA1-IR mean, diagnostic threshold, or prevalence estimate.

Adiposity, physical activity, and lipid profile

Shift workers had a mean BMI 2.5 kg/m² higher and waist circumference 6.5 cm greater than non-shift workers. Central and overall adiposity are strongly linked to insulin resistance, dysglycemia, and atherogenic dyslipidemia and may partly explain the glucose-insulin differences observed in this study. In addition, 61.0% of shift workers accumulated <600 total MET-min/week compared with 47.0% of non-shift workers. Reporting this variable as an explicit MET-min/week threshold avoids conflating it with the full IPAQ categorical scoring algorithm.

Prospective occupational studies have documented similar clustering of metabolic abnormalities. De Bacquer et al. reported a higher incidence of metabolic syndrome among rotating shift workers during follow-up, with increasing risk across accumulated years of shift work [21]. Pietroiusti et al. also found a higher incidence of metabolic syndrome among night-shift healthcare workers [22], while Karlsson et al. described clustering of obesity, high triglycerides, and low HDL-C in shift-working populations [23].

The lipid differences in the present study were substantial: total cholesterol was 15.2 mg/dL higher, LDL-C 15.9 mg/dL higher, triglycerides 32.8 mg/dL higher, and HDL-C 4.7 mg/dL lower among shift workers. These findings may reflect a combination of adiposity, lower activity, nocturnal eating, sleep disruption, and circadian effects on lipid handling. They reinforce the interpretation that the glucose-insulin abnormalities occurred within a broader adverse cardiometabolic phenotype rather than as isolated laboratory findings.

Sleep quality and behavioral pathways

Poor sleep quality was almost twice as prevalent among shift workers (68.0% vs. 34.5%; PR 1.97), and their mean PSQI score was 2.3 points higher. Daytime sleep after night duty is frequently shorter and more fragmented because it occurs at an adverse circadian phase and is vulnerable to environmental light, noise, domestic responsibilities, and social interruption.

Lajoie et al. likewise reported poorer sleep quality among hospital employees working rotating shifts, although sleep disturbance did not completely explain the relationship between shift work and cardiometabolic risk [24]. Poor sleep may therefore function as a pathway linking shift schedules with insulin resistance, but it may also coexist with long work hours, stress, sleep apnea, low physical activity, and irregular food intake. Cross-sectional data cannot determine the direction or relative contribution of these pathways.

Meal timing is another plausible mechanism. In a controlled simulated night-shift study, eating during the biological night altered glucose responses compared with restricting food intake to daytime hours [25]. For IT employees serving international time zones, nocturnal meals and snacks may accompany night work. Prospective studies using detailed dietary timing, actigraphy, and repeated metabolic testing would help separate the effects of work timing from associated behaviors.

Occupational health implications

The pattern observed in this study supports a broad occupational-health approach to metabolic risk in shift-working IT employees. Periodic assessment of BMI, waist circumference, blood pressure, fasting glucose or HbA1c, and lipid profile can help identify employees who require clinical evaluation. Fasting insulin and HOMA1-IR are useful research measures but should not be promoted as stand-alone clinical diagnostic tests because insulin assays and HOMA thresholds are not fully standardized across populations.

Workplace prevention may reasonably focus on modifiable exposures associated with shift work, including opportunities for physical activity, healthier food availability during night hours, predictable scheduling, adequate recovery intervals, sleep-health education, and confidential referral pathways for persistent sleep disturbance or abnormal metabolic results. The present study did not test intervention effectiveness; prospective evaluation is needed before attributing benefit to any specific workplace strategy.

Limitations

This study has several limitations. First, its cross-sectional design precludes determination of temporal sequence or causality between shift work and the observed metabolic abnormalities. Second, the principal between-group comparisons were unadjusted and may have been influenced by differences in adiposity, physical activity, sleep, dietary patterns, smoking, alcohol use, occupational stress, and other unmeasured factors. Third, fixed-night and rotating shift schedules were combined in the primary analysis, although their degree of circadian disruption may differ. Sleep quality and physical activity were assessed using self-reported instruments and may therefore be subject to recall and reporting bias.

Although both shift-working and non-shift-working employees were recruited from all four participating companies, the analyses did not explicitly account for potential within-company clustering; shared workplace policies, scheduling practices, occupational demands, and health-related programs may therefore have contributed to within-company similarity. The eligibility criteria excluded employees with several established medical conditions and may therefore have resulted in a comparatively healthier occupational sample, potentially limiting generalizability to the broader IT workforce.

In addition, biochemical measurements were obtained at a single assessment and may be affected by recent sleep, stress, food timing, physical activity, and the interval from the most recent night shift. The group-level HOMA1-IR index reported in this study was calculated from group mean fasting glucose and insulin values rather than from individual participant values; therefore, it cannot be used to determine individual insulin-resistance classifications, prevalence estimates, participant-level correlations, or adjusted associations. Finally, the study was conducted among employees of multinational IT companies in Chennai, which may limit the generalizability of the findings to other occupational groups, smaller organizations, or different geographic settings.

Conclusions

Shift-working IT employees had a less favorable metabolic, physical-activity, and sleep profile than

employees working regular daytime schedules. They demonstrated higher fasting serum insulin, a higher group-level HOMA1-IR index, higher fasting plasma glucose and HbA1c, greater overall and central adiposity, a less favorable lipid profile, a higher proportion with total physical activity <600 MET-min/week, and markedly poorer sleep quality. The concordant fasting insulin, HOMA1-IR, HbA1c, anthropometric, and lipid findings are consistent with a greater insulin-resistance-related and cardiometabolic burden among shift-working IT employees.

Because the study is cross-sectional and HOMA1-IR was summarized at the group level, the findings do not establish causality or an individual diagnostic prevalence of insulin resistance. They nevertheless support closer occupational attention to metabolic risk, sleep quality, physical activity, meal timing, and recovery from night work, alongside longitudinal participant-level research.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

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Disclosures

Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. Institutional Ethics Committee of Sri Venkateswaraa Medical College Hospital and Research Institute (IEC-SVMCH&RI) issued approval 021/01/2025/IE C/SVMCHRI; January 30, 2025. The research was conducted in accordance with the approved study protocol, and written informed consent was obtained from all participants. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

References

1. Scheer FA, Hilton MF, Mantzoros CS, Shea SA: Adverse metabolic and cardiovascular consequences of circadian misalignment. Proc Natl Acad Sci U S A. 2009, 106:4453-8. 10.1073/pnas.0808180106
2. Leproult R, Holmbäck U, Van Cauter E: Circadian misalignment augments markers of insulin resistance and inflammation, independently of sleep loss. Diabetes. 2014, 63:1860-9. 10.2337/db13-1546
3. Pan A, Schernhammer ES, Sun Q, Hu FB: Rotating night shift work and risk of type 2 diabetes: two prospective cohort studies in women. PLoS Med. 2011, 8:e1001141. 10.1371/journal.pmed.1001141
4. Ledda C, Cinà D, Matera S, Mucci N, Bracci M, Rapisarda V: High HOMA-IR index in healthcare shift workers. Medicina (Kaunas). 2019, 55:10.3390/medicina55050186
5. Matthews DR, Hosker JP, Rudenski AS, Naylor BA, Treacher DF, Turner RC: Homeostasis model assessment: insulin resistance and beta-cell function from fasting plasma glucose and insulin concentrations in man. Diabetologia. 1985, 28:412-9. 10.1007/BF00280883
6. American Diabetes Association Professional Practice Committee for Diabetes: Diagnosis and classification of diabetes: Standards of Care in Diabetes-2026. Diabetes Care. 2026, 49:S27-49. 10.2337/dc26-S002
7. Banerjee P, Reddy GB, Panda H, Angadi KK, Reddy T, Gavaravarapu SM: Diets, lifestyles and metabolic risk factors among corporate information technology employees in South India. Nutrients. 2023, 15:10.3390/nu15153404
8. Bhargava B, Rao PN, Kulkarni AV, Vishnubhotla R, Pramod N, Anitha CT, Mahadev K: Prevalence of metabolic dysfunction-associated fatty liver disease among information technology employees in India. Sci Rep. 2025, 15:10124. 10.1038/s41598-025-91482-2
9. Danda VS, Afzal MM, Kyatham V, Bhandiwad C: Comparative analysis of metabolic and endocrine parameters in night shift versus day shift workers: insights from an observational study. Indian J Endocrinol Metab. 2025, 29:610-5. 10.4103/ijem.ijem_67_25
10. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP: The Strengthening the

Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. Lancet. 2007, 370:1453-7. 10.1016/S0140-6736(07)61602-X

11. Buysse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer DJ: The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. Psychiatry Res. 1989, 28:193-213. 10.1016/0165-1781(89)90047-4
12. Craig CL, Marshall AL, Sjöström M, et al.: International physical activity questionnaire: 12-country reliability and validity. Med Sci Sports Exerc. 2003, 35:1381-95. 10.1249/01.MSS.0000078924.61453.FB
13. WHO Expert Consultation: Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet. 2004, 363:157-63. 10.1016/S0140-6736(03)15268-3
14. Morris CJ, Yang JN, Garcia JI, et al.: Endogenous circadian system and circadian misalignment impact glucose tolerance via separate mechanisms in humans. Proc Natl Acad Sci U S A. 2015, 112:E2225-34. 10.1073/pnas.1418955112
15. Qian J, Dalla Man C, Morris CJ, Cobelli C, Scheer FA: Differential effects of the circadian system and circadian misalignment on insulin sensitivity and insulin secretion in humans. Diabetes Obes Metab. 2018, 20:2481-5. 10.1111/dom.13391
16. Wefers J, van Moorsel D, Hansen J, et al.: Circadian misalignment induces fatty acid metabolism gene profiles and compromises insulin sensitivity in human skeletal muscle. Proc Natl Acad Sci U S A. 2018, 115:7789-94. 10.1073/pnas.1722295115
17. Buxton OM, Cain SW, O'Connor SP, et al.: Adverse metabolic consequences in humans of prolonged sleep restriction combined with circadian disruption. Sci Transl Med. 2012, 4:129ra43. 10.1126/scitranslmed.3003200
18. Vetter C, Dashti HS, Lane JM, et al.: Night shift work, genetic risk, and type 2 diabetes in the UK Biobank . Diabetes Care. 2018, 41:762-9. 10.2337/dc17-1933
19. Shan Z, Li Y, Zong G, et al.: Rotating night shift work and adherence to unhealthy lifestyle in predicting risk of type 2 diabetes: results from two large US cohorts of female nurses. BMJ. 2018, 363:k4641. 10.1136/bmj.k4641
20. Suwazono Y, Dochi M, Oishi M, Tanaka K, Kobayashi E, Sakata K: Shiftwork and impaired glucose metabolism: a 14-year cohort study on 7104 male workers. Chronobiol Int. 2009, 26:926-41. 10.1080/07420520903044422
21. De Bacquer D, Van Risseghem M, Clays E, Kittel F, De Backer G, Braeckman L: Rotating shift work and the metabolic syndrome: a prospective study. Int J Epidemiol. 2009, 38:848-54. 10.1093/ije/dyn360
22. Pietroiusti A, Neri A, Somma G, Coppeta L, Iavicoli I, Bergamaschi A, Magrini A: Incidence of metabolic syndrome among night-shift healthcare workers. Occup Environ Med. 2010, 67:54-7. 10.1136/oem.2009.046797
23. Karlsson B, Knutsson A, Lindahl B: Is there an association between shift work and having a metabolic syndrome? Results from a population based study of 27,485 people. Occup Environ Med. 2001, 58:747-52. 10.1136/oem.58.11.747
24. Lajoie P, Aronson KJ, Day A, Tranmer J: A cross-sectional study of shift work, sleep quality and cardiometabolic risk in female hospital employees. BMJ Open. 2015, 5:e007327. 10.1136/bmjopen-2014-007327
25. Grant CL, Coates AM, Dorrian J, et al.: Timing of food intake during simulated night shift impacts glucose metabolism: a controlled study. Chronobiol Int. 2017, 34:1003-13. 10.1080/07420528.2017.1335318