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Assessing the Association between Rotating Shift Work and Metabolic Syndrome among the Staff of Pars Special Economic Energy Zone of Iran

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Abstract

Background: To examine the association between metabolic syndrome, and rotating shift work, this study examined the prevalence of metabolic syndrome, and its components among rotating shift workers and day workers in Pars Special Economic Energy (Bandar-e-Asalouyeh), southwest Iran.

Material and Methods: We conducted a cross-sectional study using the data of 1249 workers in the petrochemical industry. Statistical significance was assessed using Chi-square and independent t-tests. A multivariate and univariate analysis was used to assess the metabolic syndrome impact factors.

Results: Shift workers were younger and had less education than day workers. The prevalence of metabolic syndrome was 11.6% among study participants, 13.4% among day workers, and 8.9% among shift workers. In the multivariate analysis, shift workers had an odds ratio of 0.9 for developing metabolic syndrome (95% CI= 0.58–1.37, p=0.619). Day workers were likelier to have low high density lipoprotein than shift workers (OR: 0.57, CI: 0.44-0.74, p=0.000). Physical activity at shift time (OR =0.84, CI =0.72-0.98, p=0.031), and increasing age (OR 1.05; 95% CI; 1.03-1.07; p<0.000) show an association with metabolic syndrome.

Conclusion: In the Iranian workers, metabolic syndrome was less prevalent than general population. A statistical difference in the metabolic syndrome prevalence was not found between shift workers and daytime workers. A rotating shift with night and day work schedules is probably not associated with metabolic syndrome. The adverse effects of working night shifts can be alleviated by physical activity.

Keywords: Syndrome Metabolic, Shift work, Hypertriglyceridemia, Blood pressure, Obesity

Introduction

Many industries practice shift work as a common employment practice [1]. In shift work, two or more teams (shifts) are scheduled to work at various times. Over the past few decades, shift work has become increasingly popular worldwide as industries, and economies flourish. Over 20% of all employees in industrialized nations are reportedly shift workers [2].

Regarding the growing importance of shift work and night work in modern society, research into how such schedules affect workers' health is of utmost importance [3].

It is recognized that shift work results in many health outcomes in terms of the interruption of humans' circadian rhythms [3, 4]. Circadian cycles are known to affect sleep, dietary intake, body temperature, brain wave activity, hormone release, and several other biological functions [5]. Sleep deprivation has been linked to diseases of the autonomic nervous system. Moreover, chronic illnesses resulting from autonomic nervous system problems may arise [1, 6]. Each of these mechanisms contributes to chronic metabolic diseases whenever circadian rhythms change.

Based on a meta-analysis recently published, night shift work was linked to a greater risk of Metabolic Syndrome (MetS) [4]. Another meta-analysis of cohort researchers found that shift work was linked to overweight and diabetes, whereas the association with lipid metabolism and hypertension was not supported [7]. However, some studies established inconsistent shift work results with MetS [8, 9]. Khosravipour et al. found that some shift work schedules were unrelated to MetS development [8]. Different companies may operate based on different shift frequencies and durations, as well as different rotation directions and consecutive work days that may affect risk outcomes [3].

MetS increases the risk of future coronary heart disease by nearly twice as much [10, 11], strokes by two to three times as much [12, 13], and diabetes by an even greater amount [14]. Iranian health system is burdened by a large number of metabolic syndrome patients at greater risk of CVD, diabetes, and stroke [15]. Understanding and managing the risk factors that increase metabolic syndrome risk is essential.

The Pars Special Economic Energy Zone is a significant economic sector that necessitates shift work and is renowned for its gas and energy industry. It is imperative to evaluate the detrimental effects of shift work on the health of employees in these sectors. Therefore, the objective of the present study was to evaluate the correlation between rotating shift work and MetS and its components in the Pars Special Economic Energy Zone (Bandar-e Asalouyeh, Iran).

Materials and Methods

We performed a retrospective cross-sectional study to assess rotating shift work history using the data of 1333 petrochemical workers from Pars Special Economic Energy Zone (PSEEZ) at Bandar-e-Asalouyeh, southwest Iran, who participated in the health examinations from 2012 to 2014. Participants agreed to provide blood samples, and complete questionnaires. Demographic, occupational, pharmacological, medical history, and lifestyle data were obtained using standardized questionnaires. Blood pressure (BP) and anthropometric measurements, including weight, height, and waist circumference (WC), were evaluated by physical examination. After 12 hours of fasting, the blood was collected to measure lipid panel (total cholesterol, Triglyceride (TG), High density lipoprotein (HDL), and Low density lipoprotein (LDL), uric acid, and fasting blood sugar (FBS) levels.

Ascertainment of Shift Work: Rotating shift work information was gathered via questionnaires. Shift work refers to any work schedule that involve irregular or unusual working time instead of a regular day schedule: 7:00 AM to 4:00 PM. Pars Special Economic Energy Zone has a rotating shifts schedule: 12 h working at day for seven days, 12 h working at night for seven days, and then seven days resting. Moreover, shift workers with a history of at least one year of shift work were included.

Ascertainment of Metabolic Syndrome: Following a 12 hours fast, all workers were examined by medical specialists at Pars Special Economic Energy Zone health examination center. MetS were defined based on the diagnostic criteria suggested by the NCEP ATP III; individuals who met three or more of the following components were classified as MetS patients: (1) FBS > 100 mg/dl, (2) fasting TG level > 150 mg/dl, (3) fasting HDL cholesterol level < 40 mg/dl (men) or 50 mg/dl (women), (4) BP> 130/85 mmHg and (5) WC > 102 cm (men) or 88 cm (women) [16].

Using Chi-square, and Student t-tests, demographic, lifestyle, and occupational features of rotating shift participants and day participants were compared. The odds ratios (ORs) and 95% confidence intervals (CIs) were conducted by a logistic regression analysis.

In univariate analysis, none of the confounders were controlled. In multivariate-adjusted models, variables sex, age, education (Diploma or below, Diploma, Collage, Academic), current smoking status (no, yes), passive smoking status (no, yes), physical activity at work time ((Inactive: no physical activity per week; moderately inactive: having one day of physical activity per week; moderately active: having two days of physical activity during week; Active: having three or more days of physical activity during week) (Physical activity is defined as having at least 20 minutes of moderate activity during day), and residency were controlled. In all analysis, day workers were used as the comparison group. A two-sided p-value, 0.05 was measured statistically significant. IPSS was performed for all statically analysis.

Results

The research was conducted on 1333 employees at the Pars Special Economic Energy Zone (Bandar-e-Asalouyeh). The plurality of participants were men

(95.9%, n=1279), while the remaining women (4.1%, n=54) comprised the remaining participants. The majority of women (n=45) labored during the day (p<0.001). 549 (41.18%) of the participants worked schedules, while 784 (58.82%) worked during the day. The baseline characteristics and occupational history of this cohort are presented in Table 1. Staffs were aged 21 to 63 years, with a mean (SD) age of 34.39 years. Shift workers was younger than day workers (Mean ± SD for day workers was 35.25 ± 8.56 and for shift work was 33.15 ± 6.17, p<0.001). The percentage of shift workers with lower education was higher (69.9%) than that of day workers (32.5%). A significance difference was not found between two groups for smoking (p=0.165) and Family history of CVD (p =0.317). Shift staffs were more physically active than day staffs during work time (p<0.001).

Table 1. The characteristic of study population base on shift work

Variable		Total (N = 1334)(%)	Day worker (N = 785)(%)	Shift worker (N = 549)(%)	P-value
Gender	**Male**	1279 (95.9%)	739 (94.3 %)	540 (98.4%)	< 0.001
	Female	54 (4.15)	45 (5.7%)	9 (1.6%)	
Age		34.39 ± 7.73	35.25 ± 8.56	33.15 ± 6.17	<0.001
Education	**≤ Diploma**	40 (3.0%)	32 (4.1%)	8 (1.5%)	< 0.001
	Diploma	582 (43.6%)	223 (28.4%)	359 (65.4%)	
	Collage	235 (17.6%)	138 (17.6%)	97 (17.7%)	
	Academic	477 (35.8%)	392 (49.9%)	85 (15/5%)	
Family HX of CVD		9 (0.7%)	7 (0.9%)	2 (0.4%)	0.317*
Smoking	**No**	1188 (89.1%)	686 (87.5%)	502 (91.4%)	0.158*
	Yes	100 (7.5%)	67 (8.5%)	33 (6.0%)	
	Withdrawal	42 (3.2%)	28 (3.6%)	14 (2.6%)	
Physical activity	**Inactive**	513 (40.0%)	338 (45.5%)	175 (32.5%)	<0.001
	Moderately inactive	272 (21.2%)	145 (19.5%)	127 (23.6%)	
	Moderately active	209 (16.3%)	121 (16.3%)	88 (16.4%)	
	Active	287 (22.4%)	139 (18.7%)	148 (27.5%)	

Abbreviation: BMI (Body Mass Index). Variables are presented in frequency form for categorical data. The Chi-square test was performed to calculate the P value for categorical data.
* Fisher's Exact Test

Table 2 showed the differences in waist circumference, blood pressure, lipid profile, fasting blood sugar, and blood hematological traits between shift and day employees. A significant difference was not found between Shift workers and day worker in blood pressure either in SBP (p=0.576) or in DBP (p=0.846), FBS (p=0 .161), and TG (p=0.529), while HDL (p<0.001) was higher, and LDL (p=0.408), and total cholesterol (p=0.015) was lower in shift worker group.

Table 2. Baseline characteristics of medical examination participants based on their shift work

	Total	Day worker	Shift worker	P-value
Waist	90.798 ± 9.544	90.81 + 9.43	90.88 + 9.34	.883
BMI	25.679 ± 4.378	25.65 + 4.53	25.70 + 4.15	.824
SBP		113.45 + 11.36	112.87 + 10.22	.327
DBP		77.66 + 7.51	77.76 + 6.95	.801
Fasting glucose (mg/dl)		86.48 + 21.89	84.85 + 19.81	.156
TC (mg/dl)		184.60 + 40.47	179.48+ 36.50	**.018**
TG (mg/dl)		151.92 + 88.11	154.59 + 88.16	.586
HDL-C (mg/dl)		36.92 + 8.86	38.84 + 8.40	**.000**
LDL-C (mg/dl)		111.85 + 30.40	107.53 + 29.99	**.011**
Urea		30.56 + 7.48	31.51 + 14.07	.168
Creatinine		1.09 + 0.15	1.12 + .11	**.000**
Uric Acid		5.73 + 1.26	5.64 + 1.29	.245
Hg		14.79 + 1.84	14.85 + 1.40	.502

Abbreviation: SBP (Systolic blood pressure), DBP (diastolic blood pressure), RBC (red blood cell), WBC (white blood cell), TC (total cholesterol), TG (total triglycerides), HDL-C (high-density lipoprotein cholesterol), LDL-C (low-density lipoprotein cholesterol).

P-values were calculated by independent sample t-test for numerical data.

We illustrated the association between shift work with MetS and its components in Table 3. The main outcome, the prevalence of metabolic syndrome, was 11.6% across study participants, 13.4% among day workers, and 8.9% among shift workers; the difference was statistically significant (p=0.012). There was an association between shift work and lower MetS among all participants before eliminating any potential

confounders (OR = 0.63, 95% CI= 0.44-0.90, p=0.013). However, following adjusting for factors that significantly affected univariate analysis, we performed multiple logistic regression, and the odds ratio was not significant, 0.9 (95% CI= 0.58- 1.37, p= 0.619).

Table 3. Prevalence and Odds ratio of metabolic syndrome and its subcomponents in the day worker vs. shift worker

Variable	Total (N=1333)(%)	Day work (N=784)(%)	Shift work (N=549)(%)	Univariate OR (95% CI)	P-value	Multivariate OR (95% CI)	P-value
Metabolic syndrome	154 (11.6%)	105 (13.4%)	49 (8.9)	0.63 (0.44-0.90)	**0.013**	0.9 (0.58-1.37)	0.619
Blood pressure	133 (10%)	91 (11.6)	42 (7.7)	0.63 (0.43-0.92)	**0.018**	0.75 (0.49-1.15)	0.191
Diabetes	110 (8.3%)	74 (9.4)	36 (6.6)	0.67 (0.44-1.01)	0.061	0.85 (0.51- 1.40)	0.533
Low HDL	916 (68.7%)	577 (73.6)	339 (61.7)	1.07 (0.86-1.34)	0.515	1.05 (0 .80-1.37)	0.708
Hypertriglyceridemia	559 (41.9%)	323(41.2)	236 (43)	0.58 (0.46-0.73)	**0.000**	0.57 (0.44- 0.74)	**0.000**
Visceral obesity	156 (11.7%)	101 (12.9)	156 (11.7)	0.75 (0.53-1.06)	0.110	0.98 (0.64-1.5)	0.937

Data are presented as N (%).
BP, blood pressure; HDL, high-density lipoprotein.
Univariate analysis: single factor logistic regression.
Multivariable analysis: adjusted for age (continuous), gender (male. female), education, residency, current smoking status (no, yes), passive smoking (no, yes), and physical activity.

A mean age increase of 2.1 years was observed among day workers. Based on multivariate analysis, increasing age was related to metabolic syndrome (OR 1.05; 95% CI; 1.03-1.07; p<0.000). Multivariate analysis showed an association between physical activity at shifting time and a lower metabolic syndrome (OR =0.84, CI =0.72-0.98, p=0.031). Other variables, such as smoking, education, and sex did not markedly correlate with metabolic syndrome development in multivariate analysis.

With an OR 0.58 (CI=0.46-0.73), p=0.000, the prevalence of Hypo-HDL was 68.7% among study participants, 73.6% among day workers, and 61.7% among shift workers (p<0.001). This connection was significant after multivariate analysis (OR: 0.57, CI: 0.44-0.74), p=0.000. Participants had a 10% prevalence of high blood pressure, day workers 11.6%, and shift workers 7.7%, with an OR of 0.63 (CI=0.43-0.92, p=0.018). When confounders were adjusted in the multivariate analysis, these results were insignificant (OR 0.75, CI 0.49-1.15, p= 0.191). Day and shift workers did not have statistically different prevalence of diabetes, obesity, and hypertriglyceridemia (Table 4).

Discussion

The prevalence of MetS observed in the current study was lower than the national prevalence rate of MetS in Iran (38.3%) and 23.8% in another study [17, 18], as well as compared with global adult population (20-25%) [19]. Some studies showed that shift work increases MetS risk [20-23]. A recent systematic review study found that rotating shift workers are more likely to develop MetS than day workers (OR: 1.29 (1.06, 1.52)) [23]. Khosravipour et al. found an elevated risk of MetS in 12-hr rotating shift worker than day workers in Iran (OR: 1.34 (1.01, 1.76) [20]. It is possible that "healthy worker effect" contributed to the low prevalence of MetS in our research. Regardless of their position, the employees were typically recruited from individuals who were generally healthy and robust. They were required to undergo regular health screenings and provide athletics services at their place of employment. The results may also be influenced by the fact that the majority of the laborers in our study were men (95%), as well. In previous research, it was found that the prevalence of MetS increased with age and was higher among females (25.5%) than males (17.16%) [18]. Similar to our study, an association between two-shift work and a lower risk of MetS was found in a study of 3007 Japanese male staffs at a car manufacturer (OR 0.77 (0.61-0.98) [24]. Besides, the prevalence of MetS increases with age; hence, Probably the younger age of our study participants contributed to the lower prevalence of MetS in the current study [25]. The prevalence of MetS in Iran between 30-39 years (the mean age of our study was 32 years old) was 24.9 [25]. A study of 11023 workers (male majority and night shift workers tended to be younger), who worked for more than 10 years show no association between shift work and MetS [26].

Study findings showed that shift workers (8.9%) were less likely to suffer from metabolic syndrome than day workers (13.4%). There are, however, differences between shift workers and daytime workers in terms of age (shift workers are usually younger), physical activity (shift workers are more active), and education (shift workers are less educated). In order to calculate the odds ratio for MetS among shift participants, multiple logistic regression was used. However, odds ratio was not statistically significant. For more details to

understand where factors are correlate to MetS, it was found that physical activity at shift time (OR =0.84, CI =0.72-0.98, p=0.031), and increasing age (OR 1.05; 95% CI; 1.03-1.07; p<0.000) show an association. However, other factors such as smoking and education were not associated. It gives us insight that more physical activity during the night shift work may alleviate the adverse effect of the night work.

The secondary outcome indicators, hypertension and low HDL, were more prevalent among day workers compared to shift workers. However, central obesity and hypertriglyceridemia were not significantly different between the two groups. The findings corroborate that metabolic illnesses are linked to several risk factors (genetic, environmental, lifestyle), complicating the attribution of the dose-response relationship to a singular risk factor [27, 28].The primary reason for our results can be explained by the rotating shift schedule of work in Pars Special Economic Energy Zone: 12 hours of daytime work for seven days, 12 hours of night work for seven days, and then seven days of rest. This rotating shift program may mitigate the adverse effect of shift working. Yu-Cheng Li et al. indicated that ever-rotating shift (both night and day working) was not related to metabolic syndrome in female workers compared to persistence-shift working [9]. A recent meta-analysis shows no static difference between 2-rotating and 3-rotating shifts and the odds of MetS in both the univariate and multivariate analysis. However, the 4-rotating shift was correlated with MetS [8]. In some studies, rotating shift work appears to reduce the risk for diabetes [29, 30] and obesity [31, 32]. Other studies indicate that rotating shift workers have a higher risk of MetS compared to their counterparts, as shown by both univariate and multivariate analysis [8]. The increased likelihood may stem from the fluctuating work hours and the extended and frequent night shifts associated with this rotating schedule. Therefore, A few studies presented discordant results when sleep duration was included as a confounder. As a result of considering the confounders, the authors concluded that shift work does not appear to be associated with prevalent metabolic syndrome [3, 33]. Evidence shows that working more night shifts per month negatively affects health [34]. This study did not find an association between increasing night duties and MetS development. Some of these reasons may account for the findings observed in our study of shift workers.

Another possibility for explaining our results is the reverse causation hypothesis. Reverse causality refers to a phenomenon in which the outcome precedes and causes the exposure [35], i.e. unhealthy employees prefer daytime jobs, whereas healthy employees prefer shift work [36].

This study had the advantage of addressing a common problem that affects one-third of the Iranian population; therefore, it is relevant. There is a dearth of study on metabolic syndrome and its components in Iranian industrial firms. This research has several drawbacks. It might be difficult to investigate occupational differences independently, yet they can have an impact on workers' lives and physical activity. We did not get a complete history of lifestyles, such as diet or alcohol use. The majorities of study participants were male (95%), which can influence the generality of the study.

Conclusion

Based on our study, 11.6% of participants had metabolic syndrome. Shift work did not appear to be associated with metabolic syndrome. Conversely, day workers were significantly more likely to have hypo-HDL levels. Future prospective longitudinal studies can shed light on the possible association between specific shift work schedules and odds of MetS metabolic syndrome.

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Conflict of interest

None declared.

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Ethical Considerations

All the participants provided inform consent before the study. All methods were performed in accordance with the relevant guidelines and regulations.

Code of Ethics

The Ethics Committees of Endocrinology and Metabolism Research Institute-Tehran University of Medical Sciences approved this study (Ethics code: IR.TUMS.EMRI.REC.1395-138891)

Authors' Contributions

Hadi Monji: wrote the manuscript. Leila Kargar: developed the theory and performed the computations. Zohreh Badamchizadeh: helped supervise the project. Farshad Sharifi: conceived of the presented idea, verified the analytical methods. Mohammad Jafar Mahmoudi: helped supervise the project. Elham Mahmoudi: helped supervise the project. Hossein Fakhrzadeh: conceived of the presented idea, supervised the findings of this work,

All authors discussed the results and contributed to the final manuscript.

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