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The effects of rotating and extended night shift work on the prevalence of metabolic syndrome and its components

Masoud Khosravipour [a, b, c], Mostafa Shahmohammadi [b, c], Hossein Valadi Athar [b, c, *]

[a] Research Center for Environmental Determinants of Health (RCEDH), Health Institute, Kermanshah University of Medical Sciences, Kermanshah, Iran
[b] Department of Occupational Health Engineering, School of Public Health, Kermanshah University of Medical Science, Kermanshah, Iran
[c] Student Research Committee, Kermanshah University of Medical Sciences, Kermanshah, Iran

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A B S T R A C T

Background: Some studies indicated night shift work can be associated with the higher risk of metabolic syndrome (MetS). However, the effect of both rotating and extended night shift work (12-hr rotating night) on MetS has not well-known. We aimed to examine and clarify the association among petrochemical workers.
Methods: We recruited 1575 eligible workers in this study. According to shift work schedules the participants were divided into following groups: 12-hr fixed day and 12-hr rotating night. Biochemical data, including fasting blood sugar and lipid panel (TC, TG, LDL, and HDL) were determined by blood tests. Demographic data was obtained by interview at the time of blood pressure and anthropometric indices measurements. The National Cholesterol Education Program (NCEP) Adult Treatment Panel III (ATP III) was applied to identify subjects with MetS. The Logistic regression models were used to predict risk of MetS and its components between study groups.
Results: The prevalence of MetS was showed 18.4% (290/1575). We found a significant difference between study groups in the prevalence of MetS ($p < 0.05$). The odds ratios (ORs) and 95% confidence intervals (CIs) in the 12-hr rotating night group in comparison to the 12-hr fixed day shift group according to unadjusted and full adjusted logistic regression models were estimated 1.26 (0.96, 1.65) and 1.34 (1.01, 1.76), respectively. Among MetS components, we observed the significant higher risk in TG and HDL ($P < 0.05$).
Conclusion: This study suggests 12-hr rotating night shift as the high-risk group for MetS. More studies needed to confirm our findings.

1. Introduction

Shift work is an ambiguous term that refers to work in outside of conventional daytime hours such as fixed night and rotating among night, evening and day [1,2]. Currently, many workers have to work in different shift work schedules due to personal needs and job requirements [3]. It is estimated that approximately 29% of workers in the United States and 19% of all employees in European countries have to work in the different shift work schedules [4,5]. Several adverse health effects can be associated with shift work. Some studies have reported shift workers compared with non-shift workers are in the higher risk of sleep disorders [6,7], metabolic disorders [8], Cancer [9,10], occupational accidents [11], and cardiovascular disease (CVD) [12,13].

Cardiovascular morbidity and mortality are increasing. According to recent data, the CVD accounts for leading cause of mortality in worldwide [14]. Furthermore, from 2007 to 2017, age−standardized rate and total count of CVD increased by 4.5% and 34.3%, respectively [15]. Thus. It is important that to Identify and control the risk factors which could impact in the incidence of CVD. Metabolic syndrome (MetS) which defined as way co-occurrence three or more of following criteria by the National Cholesterol Education Program (NCEP) Adult Treatment Panel III (ATP III): obesity, lipid metabolism dysfunction, hypertension, and insulin resistance, was applied as a good tool to screen the high risk subjects by researchers [16]. Meanwhile, considerable studies have confirmed that MetS subjects are the more risk for both CVD

* Corresponding author. Department of Occupational Health Engineering, School of Public Health, Kermanshah University of Medical Science, Kermanshah, Iran.
E-mail address: hossein.valadi@kums.ac.ir (H.V. Athar).

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mortality and morbidity [17,18].

In the last decades, the large number of studies investigated the risk of MetS among workers in different shift work schedules. The results of some studies indicated that shift workers in comparison to fixed day workers significantly had the higher risk of MetS [19–21]. A meta-analysis which pooled the results of the thirteen studies indicated night shift workers significantly had 57% the more risk of MetS compared to fixed day workers [22]. On the other hand, although some studies reported the stronger risk of MetS among rotating shift workers compared with fixed day shift workers, there are controversial findings related to the types of rotating shift work schedules. In some studies three-rotating [23,24] and in others two-rotating [25–27] shift work schedules significantly were associated with the more risk of MetS. According to the results of a systematic review study, there was not sufficient researche related to the relationship between shift work and MetS [28].

Up to date, according to the best of our knowledge, the effect of both rotating and extended night shift work (12-hr rotating night shift work) on the risk of MetS has not well-known. We found a study which investigated the relation [26]. This study was aimed to compare the prevalence of MetS among 12-hr rotating night in comparison to 12-hr fixed day shift workers.

2. Methods

2.1. Study population

This study was carried out in the three petrochemical industrials, which are located at south of Iran, in Assaluyeh. We examined all of the employees who were working during November 25, 2017 to July 19, 2018 (1665 subjects). According to considered inclusion criteria, we investigated only subjects having male sex (59 females) and did not have history of the related diseases such as cardiovascular, kidney, and thyroid diseases (31 subjects). In addition, all participants had age older than 20 years. Overall, we assessed 1575 subjects. In the current study, demographic data including age, anthropometric indices (weight, height), smoking status, and shift work schedules obtained by interview time. Born years of subjects extracted from bBirth certificate and then age of participants were computed. weight and height of subjects were measured by dDigital sScale and stadiomete, respectively. Also, smoking habit was asked form each subjecs and documented at the interview time.

2.2. Shift work schedule

The data related to the types of shift work schedules was collected at the interview time. We observed that the participants worked as following Shift work schedules: fixed day and two-rotating shift work between day and night. The duration of each shift work was 12 -hour and continued for three weeks. Then, 10 days rest time gave to each subject.

2.3. Metabolic syndrome components measurements

Blood pressure of participants was measured at the beginning of shift work by an occupational physician according to the standard protocol [29]. For each subject we performed twice measurements with 10 minute intervals. Then, the mean of them was computed and considered. To measure biochemical data, including serum lipid panel (TC, TG, LDL, and HDL) and blood sugar, we asked for each subject that attended to a validated medical lab as way overnighting fasting. 5 ml L blood sample obtained from all participants to measure the mentioned data. The levels of lipid panel and blood sugar extracted from lab reports for each participant.

2.4. Metabolic syndrome identification

To diagnose subjects with MetS, we applied NCEP/ATPIII guideline [16]. Based on the NCEP/ATPIII, metabolic syndrome defined as way co-occurrence at least three of the five following criteria for each subject: 1. Fasting blood glucose $\geq$100 mg/dl or taking glucose lowering drugs 2. Serum triglyceride $\geq$150 mg/dl or triglyceride lowering drugs 3. Serum HDL-C $\leq$40 mg/dl or taking HDL-C increasing medications 4. Systolic blood pressure $\geq$130 mmHg or diastolic pressure $\geq$85 mmHg or use of blood pressure lowering drugs and 5. Waist circumference $\geq$102 cm. Because we unable to measure waist circumference, we considered BMI $\geq$30 instead of it.

2.5. Statistical analysis

We used Shapiro-Wilk test to measure normality of quantitative variables. Accordingly, Non-parametric Mann–Whitney test was applied to determine differences between study groups. Moreover, for qualitative variables Chi-square test was used. In the present study. Mean (standard deviation) and number (percentage) presented for quantitative and qualitative variables, respectively. We considered statistically significant at the levels of $p < 0.05$. Simple and multiple logistic regression models with a 95% confidence interval (CI) were used to predict the risk of MetS. Data was analyzed using SPSS version 22.

3. Results

Table 1 shows characteristics of the study population, including age, BMI, smoking habit, blood pressure (SBP and DBP), fasting blood sugar (FBS), and lipid panel (TC, TG, LDL, and HDL). As illustrated, we found the significant differences between study groups in following variables: age, BMI, TG, and HDL ($P < 0.05$).

The results that presented in Table 2 shows the risk of MetS in the study groups. In both adjusted and unadjusted logistic regression models, the 12-hr rotating night group in comparison to the fixed day shift group significantly had the higher risk of MetS. Among MetS components, we observed only the significant higher risk in TG and HDL ($P < 0.05$).

4. Discussion

The main objective of this study was to investigate the effect of shift work on the risk of MetS. Accordingly, we recruited 1575 petrochemical workers and classified them according to types of shift work schedules into two groups, including fixed day and 12-hr rotating night shift works. Based on logistic regression, we found in both unadjusted and adjusted models, the 12-hr rotating night shift group significantly had a higher risk of MetS in comparison to fixed day group. Up to date, the limited studies have investigated the risk of MetS among 12-hr rotating night shift workers. In a study among Korean workers similar to our findings was reported that 12-hr rotating night in comparison to fixed day shift workers significantly had a higher risk of MetS [26]. Besides, in another study among Japanese workers observed 8-h rotating night shift compared to fixed day shift workers meaningfully had the stronger risk of MetS [25]. However, inconsistent with our study, in another study among Japanese workers reported 8-h rotating night shift workers significantly had the lower risk of MetS compared to fixed day workers [30]. In our study the shift work schedules differ from the mentioned studies in terms of duration of rest and working time. The participants worked constantly for 21 days and then rest for ten days.

Although the exact pathway for the assocation between shift

Table 1
Demographic characteristics and potential risk factors in the study groups.

Characteristics	Shift work		Total subjects (n = 1575)	P-value
	Fixed day (n = 578)	12-hr rotating night (n = 997)		
Age, (years.)				
Mean ± SD	38.9 ± 5.6	38.1 ± 5.2	38.4 ± 5.4	0.032[a]
BMI,(kg/m^2)				
Mean ± SD	26.5 ± 3.8	26.9 ± 3.5	26.7 ± 3.6	0.013[a]
Smoking,(Yes)				
No. (%)	91(15.7)	132(13.2)	223(14.2)	0.177[b]
SBP, (mmHg)				
Mean ± SD	119.4 ± 11.2	119.6 ± 10.1	119.6 ± 10.5	0.528[a]
DBP, mmHg				
Mean ± SD	76.1 ± 8.1	76.2 ± 7.9	76.2 ± 8.0	0.621[a]
FBS, mg/dl				
Mean ± SD	86.9 ± 14.6	87.0 ± 16.5	87 ± 15.9	0.741[a]
TC, mg/dl				
Mean ± SD	186.8 ± 36.6	188.2 ± 41.0	187.7 ± 39.4	0.468[a]
TG, mg/dl				
Mean ± SD	162.0 ± 92.4	179.3 ± 107.8	173.0 ± 102.7	0.002[a]
LDL, mg/dl				
Mean ± SD	112.9 ± 32.1	113.7 ± 35.3	113.4 ± 34.1	0.653[a]
HDL, mg/dl				
Mean ± SD	41.7 ± 8.8	39.7 ± 8.0	40.1 ± 8.4	<0.001[a]

Abbreviation: SD, standard deviation; BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; FBS, Fasting blood sugar; TC, Total cholesterol; TG, Triglyceride; LDL, Low-density lipoprotein; HDL, high-density lipoprotein.
[a] Mann–Whitney test for the difference among study groups.
[b] Chi-square test for the difference among study groups.

Table 2
The prevalence of metabolic syndrome and its components between study groups.

Variables	Study groups	Logistic regression models		
	12-hr rotating night vs. 12-hr fixed day	Simple	Multiple	
			Model[a]	Model[b]
	No. (%)	OR (95%CI)		
FBS ≥ 100 (mg/dl)	78(7.8)/43(7.4)	1.06(0.72,1.56)	1.13(0.77,1.68)	1.13(0.76,1.67)
BP ≥ 130/85 (mmHg)	275(27.6)/167(28.9)	0.94(0.75,1.18)	0.98(0.78,1.24)	0.98(0.78,1.23)
TG ≥ 150 (mg/dl)	536(53.8)/268(46.4)	1.35(1.10,1.65) **	1.38(1.13,1.70) **	1.40(1.12,1.74) **
BMI ≥ 30 (kg/m^2)	167(16.8)/86(14.9)	1.15(0.87,1.53)	1.18(0.89,1.57)	1.16(0.87,1.56)
HDL< 40 (mg/dl)	529(53.1)/239(41.3)	1.60(1.30,1.97)**	1.59(1.29,1.96) **	1.64(1.33,2.03) **
Metabolic syndrome ≥ 3/5	196(19.7)/94(16.3)	1.26(0.96,1.65) *	1.34(1.02,1.76) **	1.34(1.01,1.76) **

Abbreviation: FBS, Fasting blood sugar; BP, blood pressure; TG, Triglyceride; BMI, body mass index; HDL, high-density lipoprotein; OR, odd ratio; CI, confidence interval.
*$p < 0.10$.
**$P < 0.05$.
[a] Adjusted for Age.
[b] Adjusted for Age, smoking habit, and TC.

work and MetS has not fully understood, several possible mechanisms which likely play the significant role in this association were suggested in the previous studies. The main mechanism refers to the circadian rhythm disturbance among shift workers [31]. Several studies reported the effects of circadian rhythm disturbance on the neuroendocrine and cardiometabolic stresses [1,32,33]. Apart from, other studies implicated the role of Melatonin hormone on the prevalence of MetS. Melatonin is an indolic hormone splashed by the pineal gland in response to darkness and in mammals introduced as the key regulator of the circadian rhythm [34]. Therefore, night shift work can inhibit the secretion of melatonin [22]. An animal study reported the associations between MetS components and decreased secretion of melatonin [35]. In addition, it is observed that artificially providing melatonin can reduce the risk of MetS among rats [36,37]. In addition, the levels of 6-sulfatoxymelationin as a urinary biomarker of melatonin was significantly observed lower in the night in comparison to fixed day shift workers [38]. In addition to circadian rhythm and Melatonin disturbances, in other studies emphasized on irregular eating habits as an important mechanism. Redistribution of food consumption among night shift workers caused these workers in comparison to fixed day shift workers consume higher foods at night [39]. The desynchronization of food intake and internal metabolic rhythm may affect the rhythmicity of glucose and triglycerides [40,41]; As a result, abdominal fat deposits and dyslipidemias increase [42]. The other mechanism is related to quantity and quality of sleep among shift workers. Considerable studies have reported night shift workers or two and three rotating shift work including night are the more risk of sleep disorders. In addition, some studies have stated two-rotating shift workers compared to three rotating shift workers are the more risk of sleep disturbances. This is, because extended night shift work hours and the frequency of it among two-rotating shift workers. Short sleep duration and poor quality can have adverse impacts in psychological and physical health [43]. Accumulating evidence indicated that chronic short or long sleep duration can be associated with variety adverse health outcomes. Several meta-analysis studies stated that short sleep duration significantly increases the risk of MetS [44,45] and its components such as hypertension [46], type 2 diabetes [47] and obesity [48]. Besides, a recent meta-analysis indicated a significant higher risk of MetS among subjects with poor sleep quality compared to normal subjects [49]. Finally, insufficiency and deficiency of vitamin D levels among night shift workers can consider as another potential mechanism. Several studies have reported night shift workers had a lower vitamin D levels in comparison to fixed day workers [50,51]. It can be due to lower exposure to sunlight among night shift workers [22]. Some meta-analysis studies indicated the significantly the higher risk of MetS in subjects with vitamin D deficiency or insufficiency [52,53].

This study was attempted to determine the association between 12-hr rotating night shift work schedule and the risk of MetS and its components which have not been well-defined. We carried out the current study in a homogeneous population of male petrochemical workers with an age range of 22–64 years. However, our study accompanied with several limitations that must be mentioned. This study had cross-sectional design. The design has the limitation to indicate cause-effect relationships. Thus, the results of it should be interrupted with caution. Second, the effect of quality and quaintly of sleep on the association between shift work and MetS was not adjusted. Third, the diet pattern of the participants was not determined. However, it is worth noting that all participants had a same diet plan during work time (the three weeks of a month). Forth, physical activity of subjects in working and out of working time was not assessed. Finally, we did not able to investigate the effects of exposure to other physical and chemical risk factors in the working and rest time.

5. Conclusion

In the present study, we compared the prevalence of MetS among the petrochemical workers who employed in 12-hr rotating night and 12-hr fixed day shift work schedules. Our study indicated the 12-hr rotating night in comparison to 12-hr fixed day shift workers significantly had the higher risk of MetS. More studies are needed to confirm our findings and to overcome the mentioned limitations.

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Declaration of competing interestCOI

The authors declare they have no actual or potential conflicting of Interests.

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