original article

Relative risk of metabolic syndrome among Iran Polyacryl Corporation shift workers: A retrospective cohort study

Mehri Rejali, Ali Hosseinzade, Mohammad Reza Maracy[1], Javad Sanati[2]

Department of Epidemiology and Biostatistics, School of Health, Isfahan University of Medical Science, Isfahan, Iran, [1]Department of Epidemiology and Biostatistics, School of Health, Isfahan University of Medical Sciences (IUMS), Isfahan, Iran; and Environment Research Center, IUMS, Isfahan, Iran, [2]Department of Industrial Health, Polyacryl Corporation, Mubareke, Isfahan, Iran

Address for correspondence:
Dr. Mohammad Reza Maracy, Department of Epidemiology and Biostatistics, Isfahan University of Medical Sciences, Hezar Jerib Avenue, Isfahan, Iran.
E-mail: maracy@med.mui.ac.ir

ABSTRACT

Aims: The aim of this study was to assess the effect of shift work on metabolic syndrome in Iran Polyacryl Corporation workers.

Materials and Methods: This retrospective cohort study was conducted on Iran Polyacryl Corporation workers for 10 years. The incidence of metabolic syndrome was assessed between shift workers and day workers. For analysis of the effects of shift work on six different combinations of metabolic syndrome, Logistic regression was used, and information was analyzed with using Statistical Package for Social Science-SPSS version 18.

Results: The mean triglyceride, body mass index, total cholesterol, and systolic blood pressure was higher in the day workers than rotating shift workers, but the difference was not significant (*P* value > 0.05). Logistic regression showed a significant inverse relationship between shift work and combination of three metabolic syndromes with a relative risk (RR) and %95 confidence interval (CI) of 0.24 and (0.06-0.94), respectively. Although shifts work increased risk of combination of numbers 2 (IFG, BP, and BMI) and 4 (IFG,TG, and BMI) metabolic syndrome 66% and 6%. These differences were not significant (RR = 1.66, %95 CI ; 0.81-3.37 and RR = 1.06, %95 CI ; 0.72-1.58 respectively). Other combinations of metabolic syndrome had a non-significant inverse relationship with shift work (*P* value > 0.05).

Conclusion: Our findings indicate that rotating shift work not increases the risk of metabolic syndrome and different combinations. However, significantly decreased risk for developing combination 3 (Impaired fasting glucose, hypertension, and positive micro albuminuria).

Key words: Metabolic syndrome, retrospective cohort study, shift work

INTRODUCTION

More than 20% of all employees in the industrialized countries work in rotating shifts or during the night.[1] There is much evidence to suggest that rotating shift work increases the cardiovascular diseases (CVD).[2,3] In a review 17 retrospective and prospective studies, indicated that rotating shift work raises the risk of CVD to 40%.[4] Disturbance of circadian rhythms, distressed sleep, and

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life-style alterations resulting changes in mood and stress are potential mechanisms that could clarify the relation of shift work with an increased risk of cardiovascular disorders.[5] Most studies have focused on life-style factors, but recent findings suggest that metabolic disorders can be induced as a result of circadian rhythms irregularity. An empirical study by Hampton *et al*., showed that postprandial glucose concentrations increases when the circadian rhythms phase is changed.[6] Moreover, a very complex set of daily metabolic is deeply related to sleep patterns and this suggests that the quality and sleep duration can affect the metabolic and endocrine function.[7,8] Theorell and Akerstedt[9] indicated that night work may lead to changes in glucose and serum lipids concentrations, which return to normal status when individual returns to daily work. Furthermore, other studies have shown the elevated triglyceride (TG) levels in shift workers.[4] Based on the findings of changes in glucose and lipid serum, it is necessary to investigate whether the work shift can lead to insulin resistance, which may lead to metabolic syndrome? Metabolic syndrome is a common disorder in Iran with prevalence of 30.1% and there is evidence to suggest that this syndrome is a risk factor for cardio-vascular diseases.[10] If shift work increases the risk of metabolic syndrome will be increased subsequently, this justifies association between shift work and CVD.

Recently, high prevalence of metabolic syndrome and its constituent components (abdominal obesity, hypertension, dyslipidemia, and impaired glucose tolerance) has been shown in shift workers.[11,12] Li *et al*. in 2011 showed that shift workers, compared to day workers are at increased risk of metabolic syndrome.[13] Similarly, a study conducted in 2008 by De Bacquer *et al*. showed that the cumulative incidence of metabolic syndrome among workers with rotating shifts is more than the day workers. The incidence of metabolic syndrome in workers with rotating shifts was 60.6 in 1000 person in year and in day workers were 37.2 in 1000 person in the year.[14] Another cross-sectional study was conducted by Esquirol *et al*. showed that the shift working is significantly associated with metabolic syndrome.[15] Furthermore, a population-based study conducted by Karlsson *et al*. showed that a combination of metabolic syndrome risk factors including, obesity, elevated TGs, and low high density lipoprotein cholesterol occur more among the shift workers than the day workers.[16] Other studies have shown that the metabolic syndrome occurs more in that works with rotating shifts.[11-15]

High prevalence of metabolic syndrome in Iran, which leads to increased risk of CVD, diabetes and stroke, imposes high cost on the health system in the country. Evaluation and proper management of the risk factors that increase the risk of metabolic syndrome are essential. Furthermore, the different combinations of the metabolic syndrome can be considered. Thus, in this study, the possible effects of shift work on each of the six different combinations of metabolic syndrome were evaluated separately.

MATERIALS AND METHODS

This study was performed as a retrospective cohort on the employees of Iran Polyacryl Corporation for 10 years from 2001 to 2011. In this study, the inclusion criteria was to be formally or informally employed in years between 2001 and 2011, lack of specific diseases history and having information medical records before employment including: Fasting glucose, TGs, body mass index (BMI), blood pressure (BP), and micro albuminuria. Incomplete information and lack of information before employment and having a specific disease were considered as exclusion criteria. Study was performed on all of Iran Polyacryl Corporation employees ($N = 2100$) who had been tested for fasting glucose, TGs, BMI, BP, and micro albuminuria. In this study, the metabolic syndrome was defined according to the World Health Organization criteria's (WHO).[17] Based on this definition, a person is affected with metabolic syndrome who has a fasting blood glucose ≥100 mg/dl plus two or more of the following four factors including BP ≥140/90 mm Hg, TGs ≥150 mg/dl, BMI ≥30, and have a positive urine micro albuminuria. Furthermore, in this study, different combinations of metabolic syndrome were considered and the effect of shift work on each of the compounds was evaluated. According to the WHO definition of the metabolic syndrome and since the presence of impaired glucose fasting is necessary to all compounds; hence, there were very few people who had the same five or four criteria of metabolic syndrome, the combination of the 4 and 5 sets were not included in the components. Ultimately, six different possible components for metabolic syndrome were defined as follows:[16] Combination 1 (Impaired fasting glucose [IFG], hypertension, and high TGs), Combination 2 (IFG, BP, and high BMI), Combination 3 (IFG, hypertension, and positive micro albuminuria), Combination 4 (IFG, high TGs, and high BMI), Combination 5 (IFG, high BMI, and positive micro albuminuria), Combination 6 (IFG, micro albuminuria positive, and high BMI).

Data collection was based on recorded information in the health system and industrial medicine unit of the Iran Polyacryl Corporation that was located at the company place. These data included the annual measurements of cholesterol, TGs, glucose, BP, height and weight, micro albuminuria, urea, age, education, and job (official-non-official). All measurements are taken in the fasting state. Based on the work plan, individuals in the Iran Polyacryl Corporation were employed as day workers, 2-rotation shift workers and 3-rotation shift workers. However, in this study due to the low number of people working in 2-rotation shift work, 2-rotation shift workers and 3-rotation shift workers were mixed and were considered as shift workers. Shift work was defined as work outside of the daily opening that

is hours from 7 am to 6 pm.[18] Data analysis of the study was performed using Statistical Package for Social Science (SPSS) software (version 18; SPSS Inc., Chicago IL). For analysis of distribution individual characteristics related to work between shift workers and day workers, the Chi-square test for categorical variables and independent *t*-test for continuous variables were used. Then, the effect of shift work in the onset of metabolic syndrome after controlling for age, gender, education level, marital status, employment status, work experience, and length of follow-up, was carried out using logistic regression model. A *P* value <0.05 was considered significant.

RESULTS

In this study, out of 2100 cases, 71 cases (38.3%) because their initial examinations had shown IFG (>100), 27 (29.1%) due to high BP (systolic BP >140 and diastolic BP >90 mm Hg), 46 cases (19.2%) due to high TG levels (>150) and 12 cases (57.0%) due to lack of the regular shift work schedule were excluded from the study. Finally, the study was conducted on 1944 participants. In the present study, the mean age of day workers and shift workers were 38.2 ± 9.4 and 34.5 ± 7.5 respectively. Each person on average had been followed every 4.3 ± 2.1 years. Because the number of women participating in the study was low (56 participants), they excluded from the final analysis and the analysis was conducted only on men. Evaluated variables during employment are separately described based on shifts in Table 1. Among the components of metabolic syndrome, initial analysis showed that the mean TG, BMI, total cholesterol, and systolic BP was higher in day workers than shift workers, but the difference of these variables between two groups was not significant. The mean fasting blood glucose, urea and diastolic BP was higher in shift workers than day workers, but the difference was not significant (*P* value > 0.05) [Table 1].

Although, compared to shift workers a greater percentage of the day workers had metabolic syndrome components [Table 2], but the relative risk (RR) of day workers on any of the components of the metabolic syndrome was not significant (*P* value > 0.05). Based on the logistic regression model, combination 3 of the shift work showed a significant reveres relation with the metabolic syndrome (*P* value = 0.04). Furthermore, based on this model, shift work increases combination 2 and 4 of metabolic syndrome 66% and 6% respectively, but this increase was not significant (RR = 1.66, 95%CI; 0.81-3.37 and RR = 1.06, 95%CI; 0.72-1.58, respectively). Other components of metabolic syndrome had an inverse relationship with shift work, but the relationship was not significant [Table 3].

DISCUSSION

After controlling for confounding variables including age, gender, education level, marital status, employment status, work experience, and length of follow-up, current study showed that shift working is not a predictive factor for the development of the metabolic syndrome.

There was no significant correlation between the hypertension and shift work in our study. This result is consistent with the Bacquer's study and some cross-sectional studies that have shown no association between shift work and hypertension.[11-19]

Table 1: Baseline characteristics of the study population according to shift work

Variables	Shift workers	Day workers	*P* value
Total	1224	720	
Age (years)	34.4 ± 7.5	38.2 ± 9.4	
Sex (%)			
Male	1224 (100)	664 (92.2)	
Female	—	56 (7.8)	
Educational level (%)			
Diploma and lower	845 (69)	265 (36.8)	0.001
Associated degree and above	379 (31)	455 (63.2)	
Marital status (%)			
Married	662 (54.1)	474 (65.8)	0.001
Unmarried	562 (49.9)	246 (34.2)	
Job (%)			
Official	32 (2.6)	86 (11.9)	
Non-official	1192 (97.4)	634 (88.1)	
IFG	86.1 ± 13.5	85/2 ± 11.4	0.18
TG (mg/dl)	135.5 ± 63.3	136.6 ± 64.1	0.71
BMI	25.8 ± 4.1	26.5 ± 13.6	0.10
Systolic BP (mmHg)	120.2 ± 9.8	120.2 ± 9.1	0.95
Diastolic BP (mmHg)	79.1 ± 6.5	78.6 ± 6.1	0.25
Urea (mg/dl)	26.9 ± 5.6	26.6 ± 5.1	
Cholesterol (mg/dl)	163.3 ± 31	164.2 ± 30.7	0.53

IFG: Impaired fasting glucose, TG: Triglyceride, BMI: Body mass index, BP: Blood pressure

Table 2: Relative risk of shift work on components of the metabolic syndrome using logistic regression with control variables, age, sex, educational level, marital status, job status, work experience, and length of follow

Variables	Day workers no. (%)	Shift workers no. (%)	*P* value	Relative risk	Confidence interval (%95 CI)
IFG	207 (28.8)	312 (25.5)	0.31	0.88	0.7-1.13
TG	382 (53.1)	661 (53)	0.93	1.01	0.81-1.25
BMI	189 (26.3)	307 (25.1)	0.81	0.97	0.76-1.25
BP	121 (16.8)	217 (17.7)	0.91	1.01	0.76-1.35
Micro-albuminuria	75 (10.4)	118 (9.6)	0.38	0.85	0.6-1.22
Cholesterol	209 (29)	315 (25.7)	0.63	0.94	0.73-1.2

IFG: Impaired fasting glucose, TG: Triglyceride, BMI: Body mass index, BP: Blood pressure

Table 3: Relative risk of shift work on different combinations of the metabolic syndrome using logistic regression with control variables, age, sex, educational level, marital status, job status, work experience, and length of follow

Metabolic syndrome combination*	Day workers no. (%)	Shift workers no. (%)	*P* value	Relative risk	Confidence interval (%95 CI)
Combination (1)	34 (4.7)	38 (3.1)	0.3	0.74	0.42-1.29
Combination (2)	14 (1.9)	40 (3.3)	0.16	1.66	0.81-3.37
Combination (3)	9 (1.3)	4 (0.3)	0.04	0.24	0.06-0.94
Combination (4)	60 (8.3)	102 (8.3)	0.75	1.06	0.72-1.57
Combination (5)	9 (1.3)	6 (0.5)	0.21	0.46	0.14-1.57
Combination (6)	12 (1.7)	14 (1.1)	0.85	0.91	0.36-2.23
Metabolic syndrome	138 (19.2)	202 (16.5)	0.55	0.92	0.70-1.22

*Combination 1 (IFG, high BP, high TG), Combination 2 (IFG, high BP, high BMI), Combination 3 (IFG, high BP, micro-albominurea+), Combination 4 (IFG, high TG, high BMI), Combination 5 (IFG, high BMI, micro-albominurea+), Combination 6 (IFG, micro-albominurea+, high BMI), IFG: Impaired fasting glucose, TG: Triglyceride, BMI: Body mass index, BP: Blood pressure

A majority of studies in the Japanese have shown that compared to day workers, shift workers have a 10% higher BP over a period of 10 years.[20] However, the results of different studies are contradictory in relation to BP and shift work.[21] The results of current study is consistent with study of Karlsson *et al*., which was conducted among 27485 participant in Sweden and other studies that result indicated no statistically significant differences in the both mean systolic and diastolic BP.[16,22,23]

In case of TGs, some studies have shown that TG levels were not statistically different among shift workers and day workers.[16-24] This is consistent with our study, however, some population-based studies have shown that shift work could cause the high prevalence of elevated TGs.[11-19] It is also revealed that the shift work independent of the diet is associated with increased levels of TGs,[25] this is in contrast to the results of our study. One reason for this inconsistency in the results of the studies in comparison with our study could be due to variation in circadian rhythms for TGs and blood sampling from individuals measured at different times.[26]

This study also showed that the presence of obesity is not significantly different between shift workers and day workers that is not consistent with the results of two recent cohort studies.[27,28]

In addition, a cohort study conducted on men aged 40-59 in Denmark indicated that there is a relation between shift work and increased body weight after controlling for socio-economic status.[29] Although these findings is not consistent with the results of the study conducted by Nakamura *et al*. that revealed there was not statistically significant difference between body weights of shift workers and day workers.[24] For justification of this matter can infer to insufficient matches of potentially confounder variables such as socioeconomic factor. Furthermore, it can be noted about the follow-up period that affect the body weight changes, this has been shown by Amelsvoort who noted that the early reaction to shift is body weight loss, but the next reaction in the long period is high body weight. In general, contradictory results of previous studies can be due to different follow-up durations.

Although defect in spreading fats and abdominal obesity have been frequently displayed in shift workers, there are few studies, which have shown glucose metabolism disorders associated with shift work. In the current study, blood fasting sugar in the shift workers was not less than day workers; this result is not consistent with results from a 14 year cohort study in Japan male workers, which revealed that shift work is an independent risk factor for abnormality in metabolism of glucose.[30] This should be kept in mind that the definitions of shift work are different in different studies. Likewise, the type of work that shift workers engaged in can affect these results 3-rotation shift work personnel in Polyacryl that experience night shift work have a more comfort service and lack of inspection as equal as with day shifts that could be a justification for reducing the components of metabolic syndrome in these individuals. On the other hand, 2-rotation shift workers fully perform their works in the day time. Furthermore, Shift workers in some studies have a higher age than the day workers.[31,32] In this study, we combined the 2-rotation and 3-rotation shift workers as a shift work personnel. Therefore, this new definition of shift work and also differences in characteristics between shift workers and day workers could be explained the relation between metabolic syndrome and shift work.

One of the advantages of this study is that for metabolic syndrome, different combinations were considered. Collectively, six different triple combinations of components of metabolic syndrome were evaluated. Relation of shift work with these six components was analyzed and roughly no study similar to this study in the world has been performed. These results show that shift work has a negative relation with combination 3 (IFG, High BP, Micro-albominurea+) Furthermore, in some studies relation of the shift work have been shown with incidence of diabetes disease, although this relation had been very weak and have not been independent of BMI and life-style subjects study.[33,34] Working as a shift worker especially during the night affects the quality and quantity of sleeping and based on the recent studies sleep

problems may be related to the development of metabolic syndrome and some of its components.[35,36] In current study, although more percentage of the shift workers had components of metabolic syndrome than the day workers, but RR of shift workers was not significant for all components of metabolic syndrome. This result is not consistent with other performed studies.[14] It should emphasis that the results of the present study may be affected by health workers effect. This may affect the power of relationship between shift work and the metabolic syndrome. In addition, about the limitations of our study can refer to lack of information such as smoking status, body activity, and diet.

CONCLUSION

Basis on the findings of this study, shift work cannot to be the cause of high incidence of the metabolic syndrome; however, significantly decreased risk for developing combination 3.

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