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Original Article

Relationship Between Shift Work and Lipid Profiles: A Prospective Cohort Study with Application of Ordinal Multilevel Modeling

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ABSTRACT

Introduction: A very limited evidences are available that considered the relationship between Shift Work (SW) and lipid variables.

Objectives: As the importance of this subject, this prospectively cohort study examines the association between SW and Body Mass Index (BMI) and lipid profiles among male workers using multilevel ordinal model

Methods: This five years prospective cohort study has been conducted in random selected workers (using cluster sampling) who work in Esfahan's Mobarakeh Steel Company (EMSC) (Iran) between 2011 and 2015.

Results: The study sample included 1626 male workers (mean age=41.5). Among these subjects, 652 (40.01%), 183 (11.3%) and 791 (48.6%) were day workers, weekly rotating shift workers and routinely rotating. After controlling for several confounding variables, except HDL and Cholesterol, the odds ratio for high HDL was decreased by 26% (OR=0.74, P<0.001) and increased for TG by 36% in weekly rotating shift workers compared to day workers.

Conclusion: Since weekly rotating shift workers had higher mean value of TG in their serum compared to day workers, they should limit eating high-fat diets in order to decrease risk of CVD.

Introduction

Cardiovascular disease (CVD) is a class of circulatory diseases that involves heart, blood vessel, arterial, brain and renal diseases [1]. It is a leading cause of mortality and morbidity among patients throughout the world. Therefore, identification and early diagnosis of risk factors involved in CVD is very important for health systems [2]. According to a report provided by WHO, about 3.41% of the deaths in Iran were occurred due to CVD in 2005; however, it is expected to be increased by 8.42% till 2030 [3]. Recent evidences have revealed that several factors such as overweight or obesity, unhealthy diets, higher blood glucose and cholesterol, smoking, and low physical activity are the major reasons for cardiovascular disease [4, 5]. Therefore, identification of factors that affect directly on blood fats can be helpful for the diagnosis and prognostic of CVD.

Shift work is now considered as one of the possible factors that may affect lipid profiles. However, there are conflicting results regarding the effect of shift work on lipid profiles. For example, previous studies considered relationship between shift-work with Low-density Lipoprotein (LDL) [6, 7] , High-density Lipoprotein (HDL) [6, 8, 9], Triglyceride (TG) [10, 11], Cholesterol [12, 13] levels, and blood pressure [9, 14-21]. Since CVD is now

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considered as one of the leading causes of death among people in a society, it is a very important controls it, for health system. Therefore, identification of affecting factors such as lipid profiles and Body Mass Index (BMI) among worker, especially those at the highest risk like steel company worker, is valuable.

Objective:

As the importance of this subject, this prospectively cohort study examines the association between SW and lipid profiles and BMI among male workers using multilevel ordinal model

Materials and methods

The data from this 5 years prospective cohort study, which was conducted on 1626 workers extracted from 2011 to 2015 in of Esfahan's Mobarakeh Steel Company (EMSC). EMSC is one of the biggest industrial companies in Iran that is located at the east of Mobarakeh city and the west of Zarrin Shahr in Esfahan's province. The sample size in this study using prevalence sample size formulation and considering α=5%, β=10% and d=27%, based on previous study has been calculated [19]**.** The inclusion criteria in this study were as follow:

(a) Official employment, (b) history of work experiences for at least 2 years, and (c) no history of specific medical diseases.

Individuals who met the following criteria were excluded from the study: (a) retirement, (b) death, and (c) unwillingness to participate in the study. From a total of 18140 employers, 1987 persons were examined before the study and eventually 1626 individuals were entered into the study based on inclusion and exclusion criteria (Flowchart 1). All participants filled a consent form and Medical Ethics Committee of Tarbiat Modares University Medical School approved the study (code number: 523817).

In this research, three types of shift works were considered that include: day workers, weekly rotating shift workers and routinely rotating workers. The routinely rotating work includes 2 days working at morning, 2 days working at evening, 2 days working at night and 2 days for resting. The weekly rotating shift works involve 3 days working at morning and 3 days working at evening. On a regulatory basis, individuals in this group rest every Friday and one additional day every two weeks. Day workers spend their time in the factory from every Saturday (7 am to 15 pm) to Wednesday (7 am to 15 pm). In this study the weight of all participants was assessed using a digital balance. Lipid profiles including HDL, LDL, TG, and Cholesterol were measured. The cut points for HDL were 40, 50, and 60, for LDL were 100, 120 and 140, for TG were 150 and 160, for BMI were 18.5 , 25 for Cholesterol were 200 and 240.

Statistical Analysis

For better description of model, considered an ordinal response (Y) with K category and one explanatory variable (x). Considered $\gamma_i^k = p(y_i \le k) = p_{i1} + p_{i2} + \cdots + p_{ik}$ and defined logit function as $\text{Logit}\,\gamma_i^k = \text{logit}\,p(y_i \le k) = \log\frac{p(y_i \le k)}{1-p(y_i \le k)}$ $k = 1,2,\dots,K-1$. The ordinal logistic defined as $\text{Logit}\gamma_i^k = \alpha_k - \beta x_i$, $k = 1,2,\dots,K-1$. In cohort data because the repetition exist the data is not independent. Such independency in model formulated like below. Repetition and workers considered as level 1 and level 2 respectively.

$$\text{logit}(\gamma_{ij}^k) = \alpha_k + \beta_{0i}^k - \beta_{1i}x_{ij}$$
$$\beta_{0i}^k = \beta_0^k + u_{0i},\ u_{0i} \sim N(0, \sigma_u^2)$$

In multilevel modeling Inter Class Correlation (ICC) [22] which is a measurement of dependency calculated by $\sigma_u^2/(\sigma_u^2 + \frac{\pi^2}{3})$ and whatever close to one showed more power of multilevel ordinal regression in compare with ordinal regression.

For estimation above formula Penalized (Predictive) Quasi-Likelihood (PQL) and Marginal Quasi-Likelihood (MQL) [23] and MLWIN (version 2.1) has been used. In this study for preparing data and describing data the SPSS (version 21). In this study, the variables presented with mean ±SD and n(%) for continues and categorical data respectively.

Results

The mean age of all participants at the beginning of study was 41.5 ±7.37 year. 240 employers (14.7%) were smoker. Regarding the educational background, 262 employers (16.11%) had higher educational degree (higher than a diploma). 791

persons (48.6%) were shift workers, 652 employers (40.1%) were day workers, and 183 employers (11.25%) were weekly shift workers. The mean ±SD of age, work experience, as well as TG, LDL, HDL and Cholesterol levels at the beginning of study is summarized in Table 1. Day workers had higher mean age and work experiences compared to the shift workers. There was no significant difference in mean values of HDL, LDL, TG and Cholesterol at the beginning of the study between the groups.

Since the age and work experiences were not similar in three groups, the age was further analyzed to find any relationships with other variables. Furthermore, BMI was further considered as a factor affecting lipid profiles. The relationships between age and BMI with the blood HDL, LDL, TG, FBS and Cho levels were evaluated using Multilevel Logistic Regression (Table 2). There was no significant difference in mean of blood HDL, FBS and Cholesterol contents between three groups. However, a significant reduction was observed in odds ratio of LDL by 26% in weekly shift workers compared to day workers (OR=0.74), while the odds ratio for TG was enhanced by 36% (OR=1.36). A negative and significant correlation was observed between BMI and HDL values, while a positive and significant correlation was found between BMI with TG, FBS and Cho. We couldn't find a significant correlation between BMI and LDL levels. There was also a significant and positive relationship between age and FBS value. Increased mean age was associated with increased levels of blood FBS.

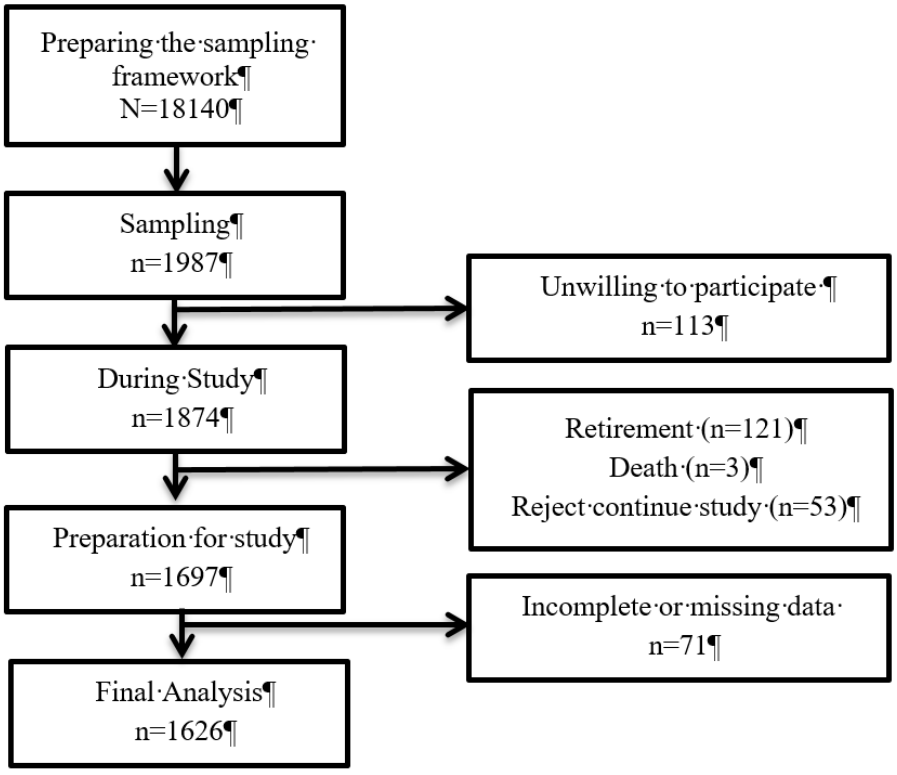

Figure 1. Follow up study

Table 1. Demographic variables of the participants in the study by the pattern of work in the first observation period

Variable		Shift work Pattern			p-value
		day workers	rotating weekly	routinely rotating	
BMI	Mean	26.00	26.17	25.74	
	SD	3.51	3.26	3.39	0.268
HDL	Mean	46.0	46.8	46.3	
	SD	9.5	9.2	9.0	0.128
LDL	Mean	114.3	110.7	113.8	
	SD	27.2	27.3	26.3	0.904
TG	Mean	162.2	147.4	159.4	
	SD	98.9	98.4	83.7	0.257
Cholesterol	Mean	193.2	189.6	27.2	
	SD	37.4	37.2	35.2	0.085
Age	Mean	42.6	42.1	42.1	
	SD	6.6	6.0	6.0	<0.001
work experience	Mean	8.34	7.03	5.35	
	SD	8.67	8.23	7.53	<0.001

BMI: Body Mass Index, LDL: Low-density Lipoprotein, HDL: High-density Lipoprotein, TG: Triglyceride
The P-value calculated by Analysis of Variance (ANOVA) or Kruskal–Wallis

Table 2. Multilevel ordinal regression in the study of the relationship between Shift Work (SW) and lipid variables

Response Variable ICC	Independent variables	β	Se	P-value	OR, 95% CI
HDL ICC=8.2%	rotating routinely | Working day	0.013	0.124	0.917	1.01 (0.79-1.29)
	rotating weekly | Working day	0.311	0.194	0.109	1.36 (0.93-2)
	Age	0.017	0.009	0.059	1.02 (1-1.04)
	BMI	-0.085	0.017	<0.001	0.92 (0.89-0.95)
LDL ICC=40.3%	rotating routinely | Working day	-0.319	0.182	0.08	0.73 (0.51-1.04)
	rotating weekly | Working day	-0.304	0.013	<0.001	0.74 (0.72-0.76)
	Age	0.019	0.013	0.144	1.02 (0.99-1.05)
	BMI	0.035	0.024	0.145	1.04 (0.99-1.09)
TG ICC=4%	rotating routinely | Working day	-0.009	0.087	0.918	0.99 (0.84-1.18)
	rotating weekly | Working day	-0.283	0.138	0.04	1.36 (0.57-0.99)
	Age	-0.008	0.006	0.182	0.99 (0.98-1)
	BMI	0.124	0.012	<0.001	1.13 (1.11-1.16)
Cholesterol ICC=3%	rotating routinely | Working day	-0.137	0.105	0.192	0.87 (0.71-1.07)
	rotating weekly | Working day	-0/249	0.171	0.145	0.78 (0.56-1.09)
	Age	0.003	0.008	0.708	1.00 (0.99-1.02)
	BMI	0.05	0.014	<0.001	1.05 (1.02-1.08)

BMI: Body Mass Index, LDL: Low-density Lipoprotein, HDL: High-density Lipoprotein, TG: Triglyceride, SE: standard Error.
The P-value calculated by multilevel ordinal regression

Discussion

Shift working is a social phenomenon that has been designed to increase the output of factories and equipment's [24]. In this research we couldn't find a significant relationship between

shift work with blood HDL, LDL, FBS and Cho levels. This is may be because of the principle of "healthy worker" [25], which suggests healthy individuals are often shift worker and weaker persons are usually day workers. It also means that day workers are often older, having lower physical activity and health compared to shift workers.

Our data have revealed decreasing of odds ratio for LDL by 26% and increasing of odds ratio for TG by 36% in weekly rotating shift workers compared to day workers. Circulating TG will be increased after a high-fat meal, indicating weekly rotating shift workers eat high-fat diets rather than to day workers. Since weekly rotating shift workers have higher physical activity compared to day workers, they have lower mean value of blood LDL. Regarding the TG, LDL, HDL and Cholesterol levels our findings were in accordance with the results obtained from previous studies [6, 9, 10, 26-30] while these data were inconsistent with the results provided by other works [7, 11, 31-34]. The presence of these contradiction results may be related to lack of unit definition for shift work in various environments [35], various rotation times, and type of sample collection in different study [36].

The strength of the present study is related to use of multilevel logistic regression to evaluate any possible significant relationships between variables, being a cohort study, large sample size with homogeneous population, laboratory examinations, and calculation of BMI by a well-experienced physician. The weak points of the study are as follow: (i) lack of information about previous work experiences, (ii) physical activity, (iii) nutritional habitat, (iv) sleep quality measurement, (v) income, and (vi) job satisfactory score.

Conclusion

Since weekly rotating shift workers had higher mean value of TG in their serum compared to day workers, they should limit eating high-fat diets in order to decrease risk of CVD.

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