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Shift work and risk factors for coronary heart disease in Japanese blue-collar workers: Serum lipids and anthropometric characteristics

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This study was conducted to determine if there is an association between shift work and risk factors for coronary heart disease (CHD) in Japanese male blue-collar shift workers. Health check-up data on serum lipid concentration and anthropometric indices of 33 three-shift workers and 27 two-shift workers were compared with those of day workers. The average years in age of the shift workers and day workers were 34 5 (SD = 7.1) and 32.7 (SD = 7.6), respectively. Serum total cholesterol levels of three-shift, two-shift and day workers were 5.70 (SD = 1.19) mmol/l, 4.81 (SD = 1.01) mmol/l, 4.98 (SD = 0.95) mmol/l, respectively, and the cholesterol levels of three-shift workers were significantly higher than the other workers ($p < 0.05$). In addition, the abdominal to hip circumference ratios were 0.905 (SD = 0.060) for three-shift workers and 0.877 (SD = 0.054) for day workers, with a significant difference ($p < 0.05$). In the present Japanese population, three-shift workers had higher risks of CHD than day workers, which was characterized by higher levels of serum total cholesterol and tendency to central obesity. These findings held when lifestyle factors were taken into account.

Key words: Central obesity; cholesterol; coronary heart disease (CHD); lifestyle; risk factors; shift work.

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INTRODUCTION

Shift work has become common in many kinds of services, such as food, health, safety and transportation, and industries in developed countries, where the proportion of shift workers is estimated to be greater than 20% of the working population.[1–3] Shift work is associated with various health problems caused by disturbance of the biological rhythms. Research on the health effects of shift work had mainly been aimed at sleep disorders and gastrointestinal disturbances.[4–6] In recent years, an increasing risk of coronary heart disease (CHD) in shift workers has been pointed out and investigated by several researchers.[4,7–11] High levels of serum triglyceride[8,12] and serum total cholesterol[12,13] were found in shift workers.

On the other hand, a recent study[14] using a nested case–control design has shown no association between shift work and mortality from CHD. In such a study, there potentially exits a confounder like a healthy shift

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worker effect. Therefore, further research is needed to clarify shift workers' risk for CHD.

Since the above reports were mostly from Western countries, we investigated risk factors for CHD in Japan where few studies have been published. The present study was designed to compare serum total cholesterol, serum triglyceride, body fat distribution, blood pressure and ways of living of shift workers with those of day workers. In addition to the serum lipids, we investigated anthropometric indices which gave us further information in relation to the risk of CHD. The goal of this study was to determine if there is an association between shift work and risk factors for CHD in Japanese shift workers.

METHODS

Study design and sample design

This study used a cross-sectional design for an industrial male, blue-collar population. Health examinations were conducted as an annual health check-up of workers at a personal computer and printer manufacturing company. Of 812 male workers, 752 participated in the health check-up. We restricted eligible subjects to blue-collar workers because all shift workers were such workers. Blue-collar workers in this company did many kinds of works (except for desk jobs) including assembly of personal computers and printers, manufacture of printer parts, machine operation and maintenance, *etc.* Of those people, shift workers tended to do the machine operation and maintenance. In this paper, a shift worker is defined as a male shift worker with a shift career of three years or longer. Sixty shift workers and 239 day workers, as a control group, were eligible. Workers who had a current serious illness did not participate in the study. Subjects ranged in age from 19–55 years. The average career of shift work of the subjects was 9.2 (SD = 5.2) years. Educational levels were almost equivalent between day and shift blue-collar workers as more than 98% of workers in both groups were educated to high school level.

Shift work in this company consisted of two types of shift schedule, rotating three-shift ($n = 33$) and rotating two-shift ($n = 27$). Typical shift schedules of three-shift, two-shift and day work were as follows:

three-shift:	MMMM-AAAA-NNNN--MMMM-
two-shift:	ddDdd--nn-nn--ddDdd--
day work:	DDDDD--DDDDD-DDDDD-

M = morning shift (8.15–15.15), A = afternoon shift (15.15–22.30), N = night shift (22.30–8.15), d = day work (8.15–18.15), D = day work (8.15–17.15), n = night shift (19.15–8.05), - = off).

The examination was conducted in September 1993. A questionnaire on lifestyle was distributed to each worker a week before the check-up and collected on the day of the examination.

Anthropometric measurements

Height and weight were measured to the nearest millimetre and 100g, respectively. Body mass index (BMI) was calculated by weight (kg)/height $(m)^2$. Circumferences of the body were measured with a nonelastic tape. Abdominal circumference was measured at the level of the umbilicus. Hip circumference was measured at their maximum girth. Since we did not measure waists, waist to hip girth ratio was not obtained. Instead, abdominal to hip girth ratio (AHR) was calculated by the abdominal circumference divided by the hip circumference. Skinfold thickness was measured at the sites of the triceps and subscapular muscles with a constant pressure calliper by a single trained observer according to the standardized procedures.[15]

Blood collection and blood pressure

An overnight-fasting blood specimen was drawn from the cubital vein between 8.00 a.m. and 9.00 a.m. Blood collection of three-shift workers were conducted in the morning shift, and two-shift in the day shift. Blood samples were drawn as immediately as possible by trained nurses while each subject was sitting on a chair. They were measured by an autoanalyser in the Clinical Laboratory Division of Nakano Hospital (Fukushima, Japan). Enzymatic methods were used to measure serum total cholesterol[16,17] and serum triglyceride.[18]

Systolic and diastolic blood pressures were measured with the oscillometric method using a sphygmomanometer (Nippon Colin: BP-203I, Tokyo, Japan). Each subject was sitting on a chair during the measurement after at least a 5 min rest.

Questionnaire

A self-administered questionnaire elicited information about demographic characteristics such as age, sex and lifestyle. Questions about lifestyle consisted of snacking, exercise habit and use of tobacco and alcohol. A habit was asked about with simple expressions like 'Do you have breakfast?', 'Do you snack?', *etc.* Answers were placed in three to five categories to ascertain frequency of the habits.

Data analyses

Normality was assessed for all continuous variables. Since distributions of total cholesterol, triceps and subscapular skinfold thickness were skewed to the right, natural logarithmic transformation was applied to them. One-way analysis of variance was used to compare mean values of three groups with Scheffe's multiple comparisons for any two groups. The chi-square test was used to test independence of categorical data. Multivariate analyses were used to identify multiple factors associated with total cholesterol as a dependent variable. Multiple regression analysis was used to detect associations between total cholesterol

and age, type of work (three-shift or not), lifestyle parameters such as exercise habits, snacking habits, drinking and smoking. A p-value less than 0.05 was judged to be statistically significant. Data were analyzed by using an SAS statistical package.[19]

RESULTS

The serum cholesterol measurement from the three-shift and two-shift workers were not amalgamated as the difference between them was statistically significant. Demographic and anthropometric characteristics of the subjects are shown in Table 1. There were no statistically significant differences among three-shift workers, two-shift workers and day workers.

Table 2 shows the mean values of anthropometric variables and concentrations of serum lipids. Three-shift and two-shift workers had greater values of AHR and subscapular skinfold thickness than day workers, with statistically significant differences in AHR between three-shift and day workers. There were no statistically significant differences in BMI. The total cholesterol level was significantly higher for three-shift workers than the other two groups. On the other hand, there were no significant differences in triglyceride levels among the three groups though three-shift workers had the highest level.

Table 3 shows characteristics of lifestyles of the workers. About 69% of shift workers did not exercise at all, while 50% of the day workers did ($p < 0.05$). In addition, only about 10% of the shift workers exercised at least once a week. Snacking did not seem to be a usual behaviour, as only 7–14% of the workers snacked. No less than 70% of all groups of workers smoked every day, and the differences among the three groups were not statistically significant. Concerning alcohol consumption, 54% of the three-shift workers drank alcohol every day, the highest of the three groups, whereas around 40% was the figure for the other two groups. Frequency of no drinking habit also tended to be greater in the three-shift workers, but the differences were not statistically significant.

The data was analyzed by multiple regression analysis to determine if three-shift (three-shift or not) work was associated with serum total cholesterol concentration, together with age and lifestyle parameters. Three-shift work was only linked to serum cholesterol levels ($p = 0.0047$) after adjusting for age, exercise, smoking, drinking and snacking.

DISCUSSION

Our results showed that three-shift workers had higher levels of serum total cholesterol than the other workers, after adjusting for age and lifestyle parameters. This means that the three-shift work is independently associated with serum total cholesterol levels. Our findings were in line with previous studies,[12,13,20] and this association might be partly explained by stress-induced hypercholesterolemia.[21,22] Another explanation for the

Table 1. Mean values with standard deviations (in parentheses) of demographic and anthropometric characteristics of the blue-collar shift workers and day workers

	Shift workers (n = 60)				*Day workers (n = 239)*	
	3-shift (n = 33)		*2-shift (n = 27)*			
Age (yrs)	34.2	(6.8)	34.8	(7.6)	32.7	(7.6)
Weight (kg)	66.1	(10.0)	64.9	(8.5)	65.5	(9.7)
Height (cm)	167.9	(6.6)	167.2	(6.0)	168.9	(5.9)
Abdominal circumference (cm)	82.1	(8.5)	79.5	(7.3)	80.0	(8.6)
Hip circumference (cm)	90.6	(5.4)	90.1	(4.5)	91.0	(5.5)

Table 2. Mean values with standard deviations (in parentheses) of anthropometric indices, blood pressure and serum lipid concentrations of shift workers and day workers

Variable	*Shift workers (n = 60)*				*Day workers (n = 239)*	
	3-shift (n = 33)		*2-shift (n = 27)*			
Body mass index (kg/m^2)	23.4	(2.6)	23.2	(2.6)	23.0	(3.2)
Abdominal to hip girth ratio (AHR)*	0.905	(0.060)	0.882	(0.055)	0.877	(0.054)
Triceps skinfold thickness (mm)	9.4	(4.6)	8.8	(3.6)	8.9	(4.6)
Subscapular skinfold thickness (mm)	17.2	(7.2)	15.2	(6.6)	14.4	(7.6)
Systolic blood pressure (mmHg)	127.5	(11.7)	124.6	(11.2)	129.4	(12.4)
Diastolic blood pressure (mmHg)	76.7	(8.3)	72.9	(8.5)	75.5	(10.0)
Total cholesterol (mmol/l)†	5.70	(1.19)	4.81	(1.01)	4.98	(0.95)
Triglyceride (mmol/l)	1.71	(0.90)	1.37	(0.70)	1.58	(1.08)

* Statistically significant difference between three-shift workers and day workers ($p < 0.05$)

† Statistically significant difference between three-shift workers and day workers ($p < 0.05$), and between three-shift workers and two-shift workers ($p < 0.05$)

Table 3. Per cent frequency of lifestyle habits in shift workers and day workers

	Per cent frequency (%)		
	Shift workers (n = 60)		Day workers (n = 239)
	3-shift (n = 26)	2-shift (n = 22)	
Exercise habit			
Never	69.2	68.2	50.2
1–3 (per month)	19.2	18.2	22.6
1–2 (per week)	11.5	9.1	20.9
> 2 (per week)	0	0	5.0
Every day	0	4.6	1.3
Snacking			
Never	42.3	45.5	45.6
Sometimes	50.0	40.9	47.7
Every day	7.7	13.6	6.7
Smoking			
Never	15.4	23.8	25.9
Ex-smoker	7.7	0	2.1
Sometimes	0	4.8	0.4
Every day	76.9	71.4	71.6
Drinking			
Never	26.9	22.7	15.5
Sometimes	19.2	36.4	40.6
Every day	53.9	40.9	43.9

higher cholesterol levels could be given by the dietary intake of shift workers.[23,24] Lennernäs's intensive work[25] suggested that redistribution of food intake from day to night in three-shift workers, not the daily consumption of nutrients, was responsible for the increase in cholesterol level or disturbance of lipid metabolism. Because few studies have been conducted in this field, further research is needed.

Recent studies have demonstrated that elevated serum triglyceride concentration is an important risk factor for CHD[28–31] in relation to serum HDL-cholesterol levels.[28,31] Several studies suggested the increased levels of triglycerides in shift workers.[8,12,26,27] In the present study, triglyceride levels were also higher in three-shift workers than other workers, but the difference was not statistically significant. The lack of significance can be explained by large standard deviations of triglyceride concentrations and the relatively small sample size of this study.

Central obesity increases the risk of CHD, independently of BMI,[32] and the waist-to-hip girth ratio (WHR) is well known to reflect central deposition of fat or abdominal obesity.[33,34] In the present study on the assessment of abdominal fat, we used the AHR which is an equally valid estimate of intra-abdominal fat distribution, as well as WHR.[35] Skinfold thickness is well correlated with total body fat.[36] In particular, subscapular skinfold thickness is a good estimator of central fat.[32] Our anthropometric findings clearly demonstrated that three-shift workers were not different in overall body size from day workers but were centrally obese, indicating greater values of AHR and subscapular skinfold thickness. It has been known that deposition of visceral fat is regulated by cortisol, sex steroid hormones and other hormones.[37,38] Tendency to central obesity might possibly be explained by increased activation of the hypothalamic-pituitary-adrenal axis and insulin resistance by stress.[38] It is more likely that shift work and shift work-related behaviours may lead to desynchronization of hormonal circadian rhythms and imbalance of the hormonal regulation of lipids. Furthermore, abnormal food intake pattern for shift workers and subsequent disturbance of lipid metabolism[25] may also contribute to that phenomenon. Since those hypotheses are speculative, they should be examined further.

Why did three-shift workers, not two-shift, have higher cholesterol levels and a tendency to central obesity? We speculate that stress levels of the workers in this study who suffered from the three-shift schedule may be higher than those of two-shift workers. As is shown in the shift schedules, night shifts in the two-shift schedule appear every second week and workers had a day off in the middle of the night shift week. This is apparently advantageous to the two-shift rather than the three shift workers, in terms of desynchronization of circadian rhythms in shift workers.[39]

Socioeconomic class could be a confounding factor associated with shift workers which increases their risk of CHD in this study. However, socioeconomic classes of the shift workers and day workers appeared to be equivalent since salaries of both workers were basically the same with additional shift allowance for the shift workers. Furthermore, disparity in wealth among people of low and middle socioeconomic classes in the local population in Japan is thought to be smaller than in other developed countries.

Our study found a significant difference in frequency of exercise between shift workers and day workers. In addition, addictive habits of daily smoking and drinking were more prevalent in three-shift workers (although the difference was not statistically significant). Previous reports[2,8,12] also referred to this trend, the reasons for which are still indefinite. Some suggested that the shift schedule was associated with not only smoking or drinking, but also more minor psychiatric disorders,[40] higher levels of sleeping pill and tranquilizer use, more frequent indigestion aids and a poor social network.[2] Moreover, disturbance of family life could exist in shift workers. These characteristics of shift work may be common in any situation and may be due in part to the stress of the shift. In the present study, shift workers did not exercise very often. Shift workers might prefer sleeping to exercising on their day off. Another reason may be that they do not have companions for sports since they have to take a day off irregularly, unlike day workers. Unfortunately we were not able to obtain sufficient data to discuss this point. In any case, smoking habits and lower levels of physical activity are adverse and promote the risk of CHD.

In conclusion, in the present Japanese industrial population, three-shift workers had higher risks of coronary heart disease than other blue-collar workers,

which was characterized by higher levels of serum total cholesterol and tendency to central obesity. The association held when lifestyles were taken into account. Further studies should be needed to clarify the eating behaviours in shift workers.

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