THE ASSOCIATION OF SHIFT WORK AND HYPERTENSION AMONG MALE FACTORY WORKERS IN KOTA BHARU, KELANTAN, MALAYSIA

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Abstract. Shift work associated with various health problems and there is concern that shift workers are at higher risk to develop hypertension. A cross-sectional study was conducted from December 2003 to May 2004 to compare the prevalence of hypertension and to examine the relationship between shift work and hypertension among 148 randomly selected male workers from one of the factories in Kota Bharu, Kelantan. Information on psychosocial and life-style factors, anthropometric and blood pressure measurements, and fasting blood sugar and lipid profiles analyses were obtained. The prevalence of hypertension was significantly higher among shift workers (22.4%) compared to day workers (4.2%), with p-value of 0.001. Shift work was significantly associated with hypertension (adjusted odds ratio 9.1; 95% CI 1.4-56.7).

INTRODUCTION

Modern society is changing rapidly both in terms of economic and productive strategies such as new technologies, market globalization, and information processes. The changes have occurred also in terms of social organizational and individual behaviors. Time constraints no longer limit human activities. People want and are able to do everything at any hour of the day or night. Therefore, the arrangement of working hours has become a crucial factor in work organization and acquires different values according to economic and social consequences that can arise at different periods of the company's and worker's lives (Costa, 2003).

Various types of work schedules have been adopted by organizations and companies in which working hours are extended to evenings and night hours, as well as to weekends. Shift work is one work-hour system in which a relay of employees extends the period of production beyond the conventional eight-hour working day (Akerstedt *et al*, 1984; Harrington, 2001). Today, about one in five workers in Europe (Harrington, 2001) and in the United States (US Congress, 1991; Scott and LaDou, 1994) are employed on shift work. Although the shift workers of fifty years ago were likely to be factory-based workers, increasing demand for services (both business and pleasure) has extended shift work practice to those employed in what are traditionally known as "white collar" occupations, such as doctors and nurses (Harrington, 2001).

Because it has been practiced in United States and Europe, the shift work system is receiving priority attention in Malaysia. It is because of concerns about productivity, health, and safety. Rapid industrialization has introduced various types of working schedules and working hours as opposed to the conventional dawn-to-dusk practice. There are a reported 8.6 million workers in Malaysia who represent approximately 38.7% of the

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total population (Rampal *et al*, 2002). An estimated one-third of the present Malaysian workforce work abnormal hours of some type, such as shift work, some form of regulated scheme, or staggered working hours (Chee and Rampal, 2003).

Shift work has been found to be associated with various health problems that not only affect workers but also economic and industrial sectors. Disturbance of workers' normal biological or social diurnal rhythms, or both, cause health problems of shift workers (Akerstedt *et al*, 1984; Akerstedt, 2003). Most human functions have a rhythm, the peaks and troughs of which occur over approximately a 24-hour period, known as circadian rhythms. These rhythms are determined partly by endogenous factors, the internal body clock, and partly by environmental cues, such as daylight, noise, and the social habits of the individual (Spurgeon, 2003). Multiple physiologic, psychologic, and behavioral parameters, such as body temperature, serum and urinary corticosteroids and electrolytes, cardiovascular functions, gastric enzyme secretion, blood leukocyte count, muscle strength, alertness, mood, and immediate and long-term memory follow circadian rhythms (Scott and LaDou, 1994). These circadian rhythms, which are related to activities during the day and rest at night, are persistent and rigid and therefore do not adapt immediately to new working patterns (Taylor *et al*, 1997).

A recent study found that all markers of insulin resistance (IR), including hypertension, hyperglycemia, hypertriglyceridemia, and hypo-high density lipoprotein-cholesterolemia, were more common among shift workers than day workers in the age group of less than 50 years (Nagaya *et al*, 2002). A higher prevalence of hypertension among shift workers compared with day workers was also found in a population study (Karlsson *et al*, 2001). Causal mechanisms are not well defined, but contributing factors include disruption of circadian rhythm, disturbed socio-temporal patterns and social support, stress, smoking, poor diet, and lack of exercise (Harrington, 2001).

Because no related study has been undertaken in Malaysia and there is a lack of data on the effect of shift work, particularly on blood pressure changes, this study was designed to compare the prevalence of hypertension between shift and day factory workers and to investigate whether shift work is associated with hypertension.

There are almost 10 million of manual workers in Malaysia, among whom, most do shift work, and they tend to be exposed to various health problems. These workers contribute considerably to supporting our economic growth. Hence, the risks of hypertension should be studied, and efforts should be administered to minimize such risks. The results of this study could provide potentially useful information for the prevention of hypertension among shift workers.

MATERIALS AND METHODS

Study design

We conducted a cross-sectional study in a factory with 980 employees located in Pengkalan Chepa, Kota Bharu, Kelantan, from December 2003 to May 2004. The factory manufactures semiconductors and related components. It runs for 24 hours with two shifts. The first-shift workers work from 8:00 AM to 8:00 PM (considered as daytime), whereas the second shift workers work from 8:00 PM to 8:00 AM (considered as nighttime). Shift rotation was as follows: DD-NN-OOO-DD-NN-OOO- and so on (D = daytime, N= nighttime, O= off from work).

Selection of participants

We selected the participants through simple random sampling. The list of workers obtained from the factory's manager was the sampling frame, and we used a random num-

ber table to identify the participants. Workers were eligible when they fulfilled the following criteria: Malaysian nationality, age ranging from 19 to 50 years, and had been working in the factory for more than a year. Subjects were excluded if they had been changing working schedules, for example, from shift work to day work, or vice versa, or having any known chronic illnesses, such as diabetes mellitus, hypertension, dyslipidemia, or any cardiovascular disease. We excluded those participants to minimize healthy worker effect, because employers tend to put "unhealthy" workers in the daytime work shift. These inclusion/exclusion factors were determined from the subjects' information sheets.

Sample size

The largest and feasible sample size was determined from the high triglyceride (> 1.7 mmol/l) variable (Karlsson *et al*, 2001) with the specified level of significance (α) at 0.05 and power of the study (1-β) as 80%. The proportion of high triglyceride among day workers was 0.1, and the proportion of high triglyceride among shift workers was specified as 0.3 (with detectable difference of 20%). The ratio of day to shift workers was taken as one.

Total sample size for each group, including 20% non-response and 14% over-sampling, was 80. Cases of non-response included refusing to give blood sample and dropping out before end of study. A total of 160 subjects were selected. However, seven subjects were dropped from the study because they did not fulfill the inclusion criteria, and five did not finish the study. Those who did not fulfill the inclusion criteria were not included in the analysis.

Ethical approval

The study protocol was reviewed and presented to the Research Ethics Committee, School of Medical Sciences, Universiti Sains Malaysia on 24 September 2003 and was approved on 5th November 2003 (Ref No: USM/PPSP®/Ethics Com./2003(113.3[1]).

Subjects information sheet

Each subject answered a Malay-language Subjects Information Sheet that consisted of three parts, including demographic data, smoking habits, and physical activity. Shift workers were self-identified based on an answer about the type of work given as "shift work." Based on one of our local studies (Lim *et al*, 2000), physical activity was graded as "active," if a subject engaged himself in a sporting activity for at least three times a week; each activity should last for at least 15 minutes. Otherwise, physical activity was graded as "inactive."

WHO standard physical examination

Height and weight of the subjects were measured to the nearest tenth of a centimeter and nearest tenth of a kilogram, respectively. These were done with the participants wearing light clothing and their shoes removed. Their weight was measured using a validated and calibrated bathroom spring balance. Their height was measured using a measuring tape that was attached to a rigid wall. During height measurement, their heels were close together, and the subjects were asked to look straight ahead. Body mass index (BMI) was calculated, and high body mass index was defined as BMI ≥ 25 kg/m^2.

Systolic and diastolic blood pressures were measured twice, using an 8x14 cm cuff of a standard mercury sphygmomanometer. The average of the two readings for both systolic and diastolic pressures was recorded for data analysis. The measurement was taken with each subject sitting on a chair after at least five minutes of rest. Hypertension was defined as the mean systolic blood pressure (SBP) ≥ 140 mmHg or mean diastolic blood pressure (DBP) ≥ 90 mmHg.

Blood collection

For each subject, a ten-hour overnight-

fasting blood specimen was drawn from the antecubital vein, between 8:00 AM and 9:00 AM of the day after. Blood for fasting lipid profile (FLP) was analyzed using a calibrated chemistry analyzer (Hitachi 912™, Roche Diagnostics, Switzerland) at USM laboratory. Fasting blood sugar was obtained using a calibrated glucometer (Accutrend™, Bochringer, Germany).

Hypercholesterolemia was defined as a fasting serum total cholesterol level ≥ 6.22 mmol/l; hypertriglyceridemia, if fasting serum triglyceride level ≥ 1.70 mmol/l. Hypo-HDL-cholesterolemia was defined as a fasting serum HDL level ≤ 1.04 mmol/l; hyper-LDL-cholesterolemia, if fasting serum LDL level ≥ 4.14 mmol/l, based on the Expert Panel on Detection, Evaluation and Treatment of High Blood Cholesterol in Adults (National Institutes of Health, 2002). The presence of any abnormality above was regarded as having dyslipidemia. Hyperglycemia determination was based on WHO criteria; a fasting blood sugar level of > 6.10 mmol/l was regarded as abnormal (hyperglycemia).

Statistical analysis

Data was entered, cleaned, and analyzed using SPSS (version 11.0). STATA (version 7) was used to determine the model fitness during logistic modeling. Descriptive analysis determined the comparability between the two groups. In multivariable analysis, multiple logistic regression was used to detect an association between shift work and hypertension after adjusting for other variables. Fitness of the model was assessed using Hosmer-Lemeshow goodness-of-fit test, classification table, and Receiver Operating Characteristics (ROC) curve. The model was further checked for model diagnostics by influential statistics with residuals plotted against predicted probability. The adjusted odds ratio (OR_{adj}) was estimated with a 95% confidence interval (95% CI). A p-value of less than 0.05 was judged statistically significant.

RESULTS

A total of 148 subjects were selected for our study, with 76 (51.4%) shift workers and 72 (48.6%) day workers. Table 1 shows the main characteristics of shift and day workers. The ages of the workers who participated in the study ranged from 20.1 years to 49.2 years, and their duration of employment ranged from 1 to 14 years. There were no significant differences in the mean age and duration of employment between the two groups (p = 0.369). Ex-smokers or non-smokers comprised about 63% and 61% of the shift and day workers, respectively. There was no significant difference in the proportion of smokers among shift workers (36.8%) as compared to the day workers (38.9%). For the proportion of physical inactivity, there was no significant difference between shift workers and day workers, which were 84.2% and 76.4%, respectively.

Table 2 shows the characteristics of the physical examinations and fasting blood profiles of the workers in relation to type of work. There were no significant differences in mean serum total cholesterol, LDL, triglyceride, glucose, and body mass index between the shift and day workers. Although there were no significant differences in the mean values of the fasting serum indices and body mass index, except for the HDL level, the values were higher among shift workers when compared to day workers. Shift workers had a significantly higher prevalence of hypertension as compared to day workers which was 22.4% and 4.2% respectively with p-value of 0.001.

Table 3 shows a final model for hypertension with the independent variables. Simple and multiple logistic regression analysis were conducted with presence or absence of hypertension as a dependent variable, and type of work (shift work or day work) and other controlling variables as independent variables. We examined all possible confounders in the

Table 1
Characteristics of 76 shift workers and 72 day workers.

Variable	Shift workers		Day workers		p-value[a]
	Mean (SD) *n* = 76	No. (%)	Mean (SD) *n* = 72	No. (%)	
Age	31.6 (4.73)		32.32 (4.61)		0.369[b]
Working duration	8.8 (4.00)		8.12 (4.38)		0.350[b]
Income	982 (394.2)		1,753 (624.8)		<0.001
Level of education					
Secondary		67 (88.2)		24 (33.3)	<0.001
Tertiary		9 (11.8)		48 (66.7)	
Marital status					
Married		59 (77.6)		64 (88.9)	0.068
Unmarried		17 (22.4)		8 (11.1)	
Nature of job					
Machine assisted		61 (80.3)		11 (15.3)	<0.001
Manual		12 (15.8)		11 (15.3)	
Supervisory		3 (3.9)		50 (69.4)	
Smoking habit					
Current smoker		28 (36.8)		28 (38.9)	0.613
Ex-smoker		12 (15.8)		15 (20.8)	
Never smoked		36 (47.4)		29 (40.3)	
Smoking duration among smokers (year)	12.1 (4.86)		10.6 (4.23)		0.234
Tobacco smoked per day among smokers	8.21 (3.28)		9.2 (4.68)		0.376

(SD): standard deviation; [a]Pearson Chi-square test; [b]Independent *t* test

Table 2
Characteristics of physical examination and fasting blood profiles of 76 shift workers and 72 day workers.

Measurements	Mean (SD)			Min	Max
	Shift workers *n* = 76	Day workers *n* = 72	Total *n* = 148		
Body mass index (kg/m^2)	23.6 (3.82)	23.6 (2.86)	23.6 (3.38)	14.5	31.8
Fasting serum indices (mmol/l):					
Total cholesterol	6.2 (1.70)	5.9 (0.85)	6.1 (1.36)	2.5	16.2
LDL-cholesterol	4.0 (1.36)	3.8 (0.82)	3.9 (1.14)	1.2	10.0
HDL-cholesterol	1.4 (0.34)	1.4 (0.55)	1.4 (0.45)	0.8	5.2
Triglyceride	1.8 (1.47)	1.5 (0.97)	1.7 (1.25)	0.4	10.8
Glucose	5.0 (0.89)	4.8 (0.89)	4.9 (0.90)	3.2	7.2

(SD): standard deviation; Min: Minimum value; Max: Maximum value

model during variable selection process. Those variables were age, working duration, education level, marital status, nature of job, working hours (either 48 hours per week, or less or more than 48 hours per week), smoking habit, BMI (either high or normal), and physical activity (either active or inactive). After controlling for possible confounders, we

Table 3
Association of shift work and hypertension among 148 factory workers.

Variables (*n*)	Crude OR (95% CI)	p-value	Adjusted OR (95% CI)[a]	LR Stat	p-value
Type of work					
Shift work (76)	6.63 (1.85, 23.73)	0.004	9.07 (1.45-56.75)	7.19	0.018
Day work (72)	1.00	-	1.00	-	-
Nature of job					
Manual (72)	2.19 (0.70-6.88)	0.180	6.55 (1.43-30.08)	6.40	0.016
Supervisory (23)	0.51 (0.15-1.71)	0.273	3.00 (0.45-20.18)	-	0.257
Machine assisted (53)	1.00	-	1.00	-	-
Body mass index					
High (48)	12.00 (3.74-38.52)	0.000	11.90 (3.21-44.08)	17.78	<0.001
Normal (100)	1.00	-	1.00	-	-

Crude OR: Crude odds ratio; Adj OR: Adjusted odds ratio; LR Stat: Likelihood ratio statistic

found that there was a significant association between shift work and hypertension, with an adjusted odds ratio of 9.1 (95% CI 1.4-56.7).

There was no multicollinearity detected. All possible two-way or first-order interactions between type of work and other independent variables were checked, with none of them being significant in our model. The model had reasonable fit, with Hosmer-Lemeshow test being insignificant (chi-square = 7.17, df = 6, p-value = 0.306) and 86.5% of area was under the ROC curve.

DISCUSSION

Studies on the prevalence of hypertension published in the occupational health literature over the last 30 years have had inconclusive findings, probably attributable to the methods of studies used. Our results indicated that the prevalence of hypertension among shift workers was significantly higher when compared to day workers. This result was consistent with a previous study in another population of shift workers (in Japan) (Nagaya *et al*, 2002). However, we found a higher prevalence of hypertension among shift workers, which was 22.37% (95% CI 13.6-33.4%), compared to their study, which reported 18.6%. The difference in the findings could be explained by a lower prevalence of hypertension in their general population if compared with that in our country.

A previous prospective study (Kawachi *et al*, 1995) suggested that longer durations of shift work are associated with higher age-adjusted prevalence rates of hypertension, and they found that the prevalence of hypertension among those who never did shift work was 25.7%, which was much higher compared to our finding of 4.17%. The difference in the finding could be explained by the difference of subjects recruited into their study.

Studies on the relationship between shift work and hypertension are few, and they have been investigated with different groups and outcome measurements. The results, therefore, were inconsistent. In the present study, we found that there is an association between shift work and hypertension. The odds of having hypertension is almost nine times more among shift workers compared to day workers. In contrast, there was no evidence of an association between shift work and hypertension found by a study of Singapore factory workers (Chan *et al*, 1993).

An increased susceptibility of shift

workers to develop hypertension can be explained by the fact that shift work triggers the effects of other lifestyle-related factors, such as disruption of circadian rhythms, stress, and behavior modification. Behavior modification includes increase in smoking, unhealthy diet, and decrease in physical activity. In this study, the proportions of smokers and being physically inactive were similar in the two groups. However, we did not study the effect of shift work on the dietary intake of those workers.

An important limitation of our study was that we did not collect detailed work histories of the subjects. The participants were defined as "shift" or "day" workers after answering their type of work as "shift work" in the information sheet distributed on the day of examination. Therefore, selection bias might affect the findings of our study by which the designation of workers as shift workers may operate through certain procedures or through the workers' estimate of their own ability to withstand shift work. If less healthy workers tend to be assigned to day work, this would bias the association with hypertension towards the null. On the other hand, a positive association with hypertension might arise if those less healthy workers choose to do shift work.

Another limitation of this study was a cross-sectional design, which gives inconclusive results. This type of study design could not reflect the true causal effect or any temporal relationship. Furthermore, this study was looking at health problems that develop over long periods of exposure. Our study design was similar to other studies (Karlsson *et al*, 2001; Nagaya *et al*, 2002).

The main strength of this study is that we had access to socioeconomic variables. In our study, "level of education" acted as a proxy for the socioeconomic status. Low socioeconomic status is a potential confounder when studying the association between shift work and hypertension. We found that day workers were more educated as compared to shift workers, probably due to the selection of the subjects in our study. Day workers were selected from operators as well as from white collar and administrative work. We included the variable in our multivariable analysis, but it gave an insignificant association with hypertension.

In conclusion, the present study has strengthened the evidence of a relation between shift work and hypertension. As shift work practice is common in industrialized countries as well as in developing countries, interventions to minimize such risk among workers need to be introduced. In addition, further research on disease mechanisms is needed if we want to reduce the increased risk of hypertension among shift workers.

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