THE ASSOCIATION OF SHIFT WORK AND CORONARY HEART DISEASE RISK FACTORS AMONG MALE FACTORY WORKERS IN KOTA BHARU, KELANTAN

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ABSTRACT

INTRODUCTION: *Shift work is one of the work hour systems in which a relay of employees extends the period of production beyond the conventional 8-hour working day. It has been found to be associated with various health problems and there is concern that shift workers are at higher risk to develop risk factors for coronary heart disease (CHD). The study was undertaken to examine relationships between shift work and CHD risk factors, namely hypertension, dyslipidaemia (either hypercholesterolaemia, hyper-low density lipoprotein-cholesterolaemia, hypo-high density lipoprotein-cholesterolaemia or hypertriglyceridaemia), high body mass index (BMI), hyperglycemia and physical inactivity among male factory workers in a factory in Kota Bharu, Kelantan.* ***METHODS:*** *This study was a contrived cross-sectional study of 76 shift and 72 day workers from one of the factories in Kota Bharu, Kelantan. Data was collected through a questionnaire on psychosocial and life-style factors, anthropometric and blood pressure measurement, fasting blood sugar and fasting lipid profiles analyses.* ***RESULTS:*** *The prevalence of hypertension, hypercholesterolaemia, hypertriglyceridaemia and high body mass index (BMI) were significantly higher among shift workers compared to day workers. There was no difference in the prevalence of hyperglycemia, hypo-high-density lipoprotein-cholesterolaemia, hyper-high-density lipoprotein-cholesterolaemia and physical inactivity. When the shift workers were compared with the day workers, the adjusted odds ratio (OR) for hypertension, high BMI andphysical inactivity were 9.1 (95% CI 1.4-56.8), 2.9 (95% CI 1.3-6.1) and 7.7 (95% CI 2.1-27.5) respectively. There was neither association of shift work with dyslipidaemia, nor with hyperglycemia.* ***CONCLUSIONS:*** *There were positive association between shift work and hypertension, high BMI andphysical inactivity which denotes a higher risk of CHD risk factors among shift workers compared to day workers.*

Keywords: shift work, risk factors, coronary heart disease, prevalence, odds ratio

INTRODUCTION

Shift work is one of the work hour systems in which a relay of employees extends the period of production beyond the conventional 8-hour working day and that potentially disrupts workers' normal biological or social diurnal rhythms or both (Akerstedt, T. *et al.*, 1984, Harrington, J.M., 2001). Today, about one in five workers in Europe (Harrington, J.M., 2001) and in the United States (U.S. Congress, 1991, Scott, A.J. and LaDou, J., 1994) are employed on shift work. Some sectors have a considerably higher percentage of employees on shift work. For example, capital-intensive industries and continuous-process operations may have 50% of employees working on shift and over 38% of those in service occupations are shift workers (U.S. Congress, 1991). 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 to those employed in traditionally known as "white collar" occupations like doctors and nurses (Harrington, J.M., 2001).

Shift work has been found to be associated with various health problems which do not only affect the workers but also the economic and industrial sectors. Health problems of shift workers are caused by disturbance of the biologic rhythms. It is well-established that most human functions have a rhythm, the peaks and troughs of which occur in approximately a 24-hour period, known as circadian rhythms. They 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. These circadian rhythms, which are geared towards activities during the day and rest at night, are persistent and rigid and therefore do not adapt immediately to new working patterns (Taylor, E. *et al.*, 1997).

As association of risk of coronary heart disease (CHD) and shift work is concerned, most of the studies on cardiovascular disease (CVD) among shift workers were supported by the hypothesis

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that they were at increased risk of developing the disease (Akerstedt, T. *et* al., 1984, Kawachi, I. *et al.*, 1995, Nakamura, K. *et al.*, 1997, Karlsson, B. *et* al., 2001). Few studies have reported that shift work might have an impact on metabolic variables and also be a risk factor for diabetes, although the evidence is not conclusive (Knutsson, **A.,** 2003). **A** recent study by Nagaya, T. *et al.* (2002) found that all markers of insulin resistance (IR) which include hypertension, hyperglycemia, hypertriglyceridemia and hypo-High Density Lipoprotein-cholesterolemia were more common in shift workers than in day workers in the age group less than 50 years. **A** higher prevalence of obesity, hypertension, high triglyceride and low High Density Lipoprotein (HDL) but not hyperglycemia in shift workers than in day workers was also found in a population study (Karlsson, B. et *al.*, 200 I). In Malaysia, shift work system is receiving priority attention as it has been practiced in United States and Europe. There are about 8.6 million labor forces in Malaysia which represents approximately 38.7% of the total population (Rampal, K.G. *et al.*, 2002). It is estimated that one-third of the present Malaysian workforce work abnormal hours of some type such as shift work, some form of regulated scheme and staggered working hours (Chee, H.L. and Rampal, K.G., 2003). This study is designed to determine whether there are relationships between shift work and risk factors to coronary heart disease which are dyslipidaemia (either hypercholesterolaemia, hyper-low density lipoprotein-cholesterolaemia, hypo-high density lipoprotein-cholesterolaemia or hypertriglyceridaemia), high body mass index (BMI), hypertension, impaired fasting glycemia (labeled as "hyperglycemia") and physical inactivity among male shift workers as compared to male day workers in a factory in Kota Bharu, Kelantan.

METHODOLOGY

A contrived cross-sectional study was carried out in a factory located in Pengkalan Chepa, Kota Bharu, Kelantan. The factory specializes in the manufacturing of semiconductors and related components. It has a total of 980 employees, running 24-hours with two shifts. The shift system is as follows: first shift workers work from 0800H to 2000H whereas the second shift workers from 2000H to 0800H. Shift rotation was as follows: MMMM-00-NNNN-00- and so on (M= morning, N= night, O= off from working). Subjects for each group of workers were selected through a simple random sampling method. We could not run a screening to exclude those who do not fulfill the inclusion criteria due to the factory's rules and regulations. In view of the possibilities of having those who do not fulfill the criteria, we over-sampled the workers. The over-sampling was based on the overall prevalence of hypertension in Kelantan which was 14%. Those who did not fulfill the inclusion criteria were not included in the analysis. The sample size was calculated for each objective and the largest sample size for each group including 20% non-response and 14% over-sampling was 80. A worker was selected as a study subject when he fulfilled the following criteria: Malaysian with age ranges from 19 to 50 years and has been working for more than a year. On the other hand, a subject was excluded to be a sample if he has 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, dyslipidaemia or any cardiovascular diseases (to minimize healthy worker effect since employer tend to put those 'unhealthy' workers into day work). The study was conducted from 1st December 2003 to 31" May 2004.

Research instruments used during the study were:

1. Self-administered questionnaire

Each subject answered a questionnaire which consisted of demographic data, smoking habit and physical activity. Shift workers were determined if he answered his type of work as "shift work" in the questionnaire. Physical activity was graded as active if a subject engaged himself in a sporting activity for at least three times a week; and each activity should be lasting for at least 15 minutes. Otherwise, physical activity was graded as inactive. It was based on one of our local studies (Lim, T.O. *et* al., 2000).

2. WHO Standard Physical Examination

Height and weight of the subjects were measured 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 which was attached to a rigid wall. High body mass index was defined by BMI $\geq$ 25 kg/m^2. Systolic and diastolic blood pressures were measured twice on the day of interview using an 8 X 14 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 mean systolic blood pressure (SBP) ≥ 140 mmHg or mean diastolic blood pressure (DBP) ≥ 90 mmHg.

3. Blood collection

For each subject, a ten hours overnight-fasting blood specimen was drawn from antecubital vein between 0800-0900H. Blood for fasting lipid profile (FLP) was analyzed using chemistry analyzer (Hitachi 912) at USM laboratory. Fasting blood sugar was obtained through a capillary puncture using a glucometer (Accutrend). Hypercholesterolaemia was defined by a fasting serum total cholesterol level ≥ 6.22 mmol/l, hypertriglyceridaemia if fasting serum triglyceride level ≥ 1.70 mmol/l, hypo-HDL-cholesterolaemia if fasting serum HDL level ≤ 1.04 mmol/l and hyper-LDL-cholesterolaemia if fasting serum LDL level ≥ 4.14 mmol/l. All the cut-off point levels were based on the Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation and Treatment of High Blood Cholesterol in Adults. Hyperglycemia determination was based on WHO criteria. The capillary fasting blood sugar level of more than 6.10 mmol/l was regarded as abnormal (hyperglycemia). All data was analyzed using Statistical Package for Social Science version 11.0 and Statistics/Data analysis version 7. Independent t-test was performed to compare the mean differences of each numerical risk factor which had normal distribution between shift and non-shift workers. Chi square test or Fisher Exact test were used to determine the differences of the categorical variables between the two groups of workers. In multivariable analysis, multiple logistic regression was used to detect an association between shift work and each CHD risk factor after adjustment for other variables such as age, education levels, duration of employment, income, smoking status and nature of job. The adjusted odds ratio was estimated with 95% confidence interval (95% CI) and a p-value of less than 0.05 was judged to be statistically significant. Each CHD risk factor was tested separately.

RESULTS

The total subject in this study was 148. Table 1 shows the main characteristics of shift and day workers in the factory studied. Their ages ranged from 20.1 to 49.2 years and their working duration was from one to fourteen years. The income of shift workers was significantly lower than that of day workers. There was no worker who did not have any formal education nor had only finished primary education. Many of the day workers (66.7%) had tertiary education, while only about 12% of the shift workers had. Majority of the workers in both worker groups were currently married. Majority of them were among ex-smokers or non-smokers which comprise about 63% and 61% for the shift and day workers respectively. Most of the shift workers were doing machine assisted jobs while on the other hand, more than half of day workers were doing supervisory jobs. The proportion of workers who did manual jobs were almost equal (15%) for both groups. Crude prevalence (n and %) for each risk factor by worker group is presented in Table 2 below. Shift workers had a significantly higher prevalent of hypertension, hypercholesterolaemia, hyper-LDL-cholesterolaemia and hypertriglyceridaemia as compared to day workers. On the other hand, the prevalence of hypo-HDL-cholesterolaemia, diabetes mellitus, obesity and physical inactivity were not significantly different between the two worker groups. To exclude the effects of other controlling variables, we calculated both crude and adjusted odds ratios (ORs) for each CHD risk factor. Simpie and multiple logistic regression analyses were conducted separately for each risk factor parameter with each risk factor as a dependent variable and type of work (shift work or day work) and other controlling variables as independent variables. Variable selection was done with type of work remained in the model in each analysis. There was no multicollinearity detected since result showed that all the variables have VIF of less than 10. All possible two-way or first order interactions, between type of work and other independent variables were checked by LR test and none was significant. All models were reasonably fit, proven by Hosmer-Lemeshow test. The model fitness was also supported by the Classification table and ROC curve. The identified outliers were not omitted as there was no obvious justification for them when the individual data was checked. Table 3 shows a summary of the final model for each CHD risk factor with their independent and/or important variable/s. There were a significant association between shift work and hypertension, high BMI and being physically inactive. The risk of shift workers having hypertension was 9.1 times, high BMI 2.9 times and being physically inactive 7.7 times more compared to day workers.

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

Variable	Shift workers n = 76		Day workers n = 72		P value*
	Mean (sd)	No. (%)	Mean (sd)	No. (%)	
Age	31.6 (4.73)		32.32 (4.61)		0.369[t]
Working duration	8.8 (4.00)		8.12 (4.38)		0.350[t]
Income	982 (394.15)		1753 (624.82)		<0.001
Level of education:					
Secondary		67 (88.16)		24 (33.33)	<0.001
Tertiary		9 (11.84)		48 (66.67)	
Marital status:					
Married		59 (77.63)		64 (88.89)	0.068
Unmarried		17 (22.37)		8 (11.11)	
Nature of job:					
Machine assisted		61 (80.26)		11 (15.28)	<0.001
Manual		12 (15.79)		11 (15.28)	
Supervisory		3 (3.95)		50 (69.44)	
Working hour:					
≤48 hours/week		47 (61.84)		47 (65.28)	0.664
>48 hours/week		29 (38.16)		25 (34.72)	
Smoking habit:					
Current smoker		28 (36.84)		28 (38.89)	0.613
Ex-smoker		12 (15.79)		15 (20.83)	
Never smoked		36 (47.37)		29 (40.28)	
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
*Chi-square test (Pearson)
[t]Independent t test

Table 2:Prevalence of risk factors for CHD in shift and day workers (using chi-square test)

Risk factor	Shift workers *n* = 76	Day workers *n* = 72	P value
	No. (%)	No. (%)	
Hypertension[a]	17 (22.37)	3 (4.17)	0.001
Hypercholesterolaemia[b]	36 (47.37)	20 (27.78)	0.014
Hyper-LDL-cholesterolaemia[c]	29 (38.16)	22 (30.56)	0.331
Hypo-HDL-cholesterolaemia[d]	7 (9.21)	10 (13.89)	0.372
Hypertriglyceridaemia[e]	32 (42.10)	19 (26.39)	0.044
Hyperglycemia[f]	7 (9.21)	5 (6.94)	0.610
Obesity[g]	32 (42.10)	16 (22.22)	0.010
Physical inactivity[h]	64 (84.21)	55 (76.39)	0.231

[a]Systolic blood pressure ≥ 140 mmHg or diastolic blood pressure ≥ 90 mmHg
[b]Fasting serum total cholesterol ≥ 6.22 mmol/l
[c]Fasting serum LDL cholesterol ≥ 4.14 mmol/l
[d]Fasting serum HDL cholesterol ≤ 1.04 mmol/l
[e]Fasting serum triglyceride ≥ 1.70 mmol/l
[f]Fasting blood sugar ≥ 6.10 mmol/l
[g]BMI ≥ 25 kg/m^2
[h]Not engaging in a sporting activity of at least three times a week and each lasting at least 15 minutes

Table **3:** Summary of final model for each **CHD** risk factor (from multiple logistic regression analysis)

CHD risk factor	Significant / important independent variable/s	Adjusted ORs	95% CI
Hypertension	Type of work		
	Shift work	9.07	1.45-56.75
	Day work	1.00	
	Nature of job		
	Manual	6.55	1.43-30.08
	Supervisory	3.00	0.45-20.18
	Machine assisted	1.00	
	Body mass index		
	High	11.90	3.21-44.08
	Normal	1.00	
Dyslipidaemia	Type of work		
	Shift work	1.27	0.63-2.57
	Day work	1.00	
	Age	1.10	1.01-1.19
	Body mass index		
	High	2.41	1.08-5.34
	Normal	1.00	
Hyperglycemia	Type of work		
	Shift work	1.36	0.41-4.49
	Day work	1.00	
High body mass index	Type of work		
	Shift work	2.86	1.34-6.10
	Day work	1.00	
	Physical activity		
	Inactive	1.42	0.53-3.82
	Active	1.00	
	Age	1.13	1.04-1.23
Physical inactivity	Type of work		
	Shif? work	7.67	2.14-27.47
	Day work	1.00	
	Working duration	1.25	1.07-1.46
	Level of education		
	Tertiary	16.53	2.63-103.94
	Secondary	1.00	
	Nature of job		
	Manual	0.88	0.26-2.98
	Supervisory	5.66	1.18-27.11
	Machine assisted	1.00	
	Income	0.99	0.99-1.00

DISCUSSION

Many studies on the prevalence of CHD risk factors have been published in the occupational health literature over the last 30 years, with correspondingly wide range of results. Some of the discrepancies could be attributed to the methods of studies used. In our study, we found that the prevalence of all risk factors is generally higher among shift workers except for the prevalence of hyper-HDL-cholesterolaemia. However, the significant or possible positive relationships between shift work and CHD risk factors were in term of hypertension, hypercholesterolaemia, hypertriglyceridaemia and high body mass index. Our finding was similar to the study by Karlsson, B. *et al.* (2001) who reported a higher prevalence of hypertension, hypertriglyceridaemia and high body mass index (but not hypercholesterolaemia) among shift workers than day workers.

Among shif? workers, we had found a higher prevalence of hypertension which was 22.37% (95% CI 13.6-33.4%) compared to studies by Karlsson, B. *et al.* (2001) and Nagaya, T. *et al.* (2002) which was reported as 17.8% and 18.6%

respectively. For the prevalence of hypercholesterolaemia, it was higher among the shift workers (47.7%) than day workers (27.8%). Our finding was in contrast with a prospective study by Kawachi, I. *et al.* (1995) who showed that the prevalence of hypercholesterolaemia between the two groups is almost similar which was about 23%. In our study, there was a higher prevalence of hypertriglyceridaemia among shift workers than in day workers. This finding was in line with two previous cross-sectional studies (Karlsson, B. *et al.*, 2001, Nagaya, T. *et al.*, 2002). However, the prevalence of hypertriglyceridaemia (42.1%) among shift workers in our study was higher compared to those previous studies which were 30.8% and 31.3% respectively. There was no adverse health effect of shift work found on the prevalence of hypo-HDL-cholesterolemia in our study. This finding was consistent with the result from the studies by Romon, M. *et al.* (1992), Nakamura, K. *et al.* (1997) and Nagaya, T. *et al.* (2002). On the other hand, in a population study by Karlsson, B. *et al.* (2001), shift workers had a higher prevalence of hypo-HDL-cholesterolaemia than day workers which was significant among workers in 30-39 years and 50-59 years old. However, the results were not adjusted either for nature of jobs or for lifestyle such as smoking. Effects of shift work on serum HDL-cholesterol should be reanalyzed, with more detail being used to take account of lifestyle and the nature of their jobs. We did not also find any significant difference in its prevalence of hyper-LDL-cholesterolaemia between the two workers group. In the present study, we found no difference in the prevalence of hyperglycemia when comparing shift workers and day workers. This result is consistent with a previous study by Karlsson, B. *et al.* (2001). However, Kawachi, I. *et al.* (1995) found a clear relation between duration of shift work and diabetes in a cohort study of 79,109 female nurses. Nagaya, T. *et al.* (2002) also reported a significantly higher prevalence of hyperglycemia among people age 30-39 years old working in shift than among day workers of the same age group. A recent review article summarizing previous studies have yielded inconsistent results on BMI in day and shift workers (Knutsson, A., 2003). We had classified BMI into either high or normal with a cut-off BMI value of 25 kg/m^2. In our study, we found a significant difference in the prevalence of high BMI between the two groups. The prevalence was higher among shift workers (42.1%) than day workers (22.2%). This finding was consistent with a previous study by Karlsson, B. *et al.* (2001). The prevalence of high-BMI among shift workers in our study was higher compared to that found in the previous study.

From our analysis, there was no difference in the prevalence of physical inactivity between the two groups. The result is consistent with a study by Johansson, G. *et al.* (1991) who explored the possible influences of work organization, work-related stress and work-related adult socialization on level of physical activity. They found that shift work was entirely unrelated to sedentary behaviour. In view of confounders' effect, we calculated both crude and adjusted odds ratio (ORs) for each of the CHD risk factor. There was about 36% change in odds ratio of shift work in association with hypertension after we adjusted for significant possible confounders which are BMI and nature of their jobs. The risk of having hypertension is 9.07 times more among shift workers compared to day workers. In their prospective study, Kawachi, I. *et al.* (1995) had proven that longer durations of shift work were associated with higher age-adjusted prevalence of hypertension. In our study, there was no association between type of work and dyslipidaemia. As the prevalences of hyperglycemia were similar between the two groups, there was also no association between shift work and risk of having hyperglycemia after adjusting for all possible confounders in the multivariable analysis. Study design could be one of the reasons why we found no difference in association of type of work with dyslipidemia, nor with hyperglycemia. This is because cross-sectional study will underestimate chronic diseases due to selection effects. Usually managers will tend to transfer those shift workers with any chronic illnesses to day work (Karlsson, B. *et al.*, 2001). This observation could also be due to no effects on lipid profile and glucose level at the current exposure, very minimal or subtle change in their profiles or due to inadequate sample size to produce enough study power. For the association between shift work and high BMI, we found that the risk was higher among shift workers which were 2.86 times more compared to day workers. Our finding was in line with a cohort study of 377 shift workers and day workers as controls (Amelsvoort, L.G.P.M.v. *et al.*, 1999). In contrast to no difference in the prevalence of low physical activity, we found that there was an association between shift work and risk of being physically inactive after adjusting for all possible confounders. The risk of being physically inactive among shift workers was 7.67 times more compared to day workers.

The results from our study suggest that in the present factory male workers population, shift work may affect the workers health that may induce development of CHD in the future. It is characterized by a higher prevalence of hypercholesterolaemia, hypertriglyceridaemia and high body mass index that seems to cluster together more often in shift workers than in day workers. However after adjustment, shift work is persistently highly associated with higher risk of having hypertension and high body mass index. Our study also proved that shift workers may be associated with a higher risk of being physically inactive. On the other hand, there are no adverse health effects of shift work on serum LDL, HDL and glucose. No matter what advances there are in high-technology medicine, the fundamental message is that any major reduction in deaths and disability from CHD will come from prevention, not cure. This must involve robust reduction of risk factors.

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