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Influence of Shift Work on Coronary High Risk Status among Natural Gas Field Workers

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Abstract

Background: The association between shift work and coronary high risk status (CHRS) is still unclear. The present work was designed to study the influence of shift work in a gas field petroleum company in Dakahlia on CHRS; as well as, to investigate its possible mechanisms. **Methods:** A cross-sectional approach was used and a systematic random technique was applied to select 200 shift workers and 200 non-shift workers. Both study groups were subjected to interview questionnaire about personal, social, smoking, occupational and medical histories. Clinical examination, including general and cardiovascular examinations, was done. Height, weight and waist circumference were measured and body mass index (BMI Kg/m^2) was calculated. Laboratory investigations included measurements of fasting blood glucose, lipid profile and uric acid; as well as, electrocardiographic examination (ECG). Coexistence of more than 2 conventional risk factors or diabetes mellitus (DM) or new and old coronary artery disease (CAD) defined CHRS. Vanillyl mandelic acid (VMA) was measured in 24 hours urine samples as a stress indicator for a randomly selected sub-sample from those with CHRS (25 shift and 25 non-shift workers). The R-R deep breathing variability test on the resting ECG as a measure for autonomic function was done for the same group. **Results:** The study revealed that 42.5% of shift workers were complaining of deterioration in performance and concentration during work. In addition, 35.5% of shift workers had the desire to change shift work. Among shift workers, 36% were smokers in comparison to 26.5% of non-shift workers with a statistically significant difference ($p = 0.04$). Rates of hypertension, hypercholesterolemia, high LDL-cholesterol, low HDL-cholesterol, hypertriglyceridemia, obesity and DM showed a statistically significant increase among shift workers than non-shift workers ($p < 0.05$). The overall rate of CHRS was significantly higher among shift workers ($p = 0.001$). Multiple logistic regression analysis of coronary high risk status as the dependant variable revealed that shift work kept a significant effect on CHRS even after adjustment for other confounders ($p= 0.002$). Mean level of urinary VMA was significantly higher for shift workers than non-shift workers ($p= 0.0001$); meanwhile, significantly lower R-R variability indices were recorded among shift workers than non-shift workers ($p < 0.05$).

Conclusion and Recommendations: The present study revealed that shift work has a significant impact on CHRS that might be related to sympathetic over-activity. It is recommended to screen for coronary risk factors in pre-placement and periodic medical examinations of shift workers with implementation of special preventive programs. Urinary VMA and R-R variability testing in ECG could be used as stress indicators among CHRS shift workers. Cases of CAD should be excluded from shift work.

Key words: Shift work, Coronary risk, Sympathetic over-activity, Natural gas and petroleum industry

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INTRODUCTION

Shift work is an employment practice designed to make use of the 24 hours of the clock, rather than a standard working day. The term shift work includes both long-term night shifts and work schedules in which employees change or rotate shifts to optimize technical and economic values.[1] Many types of shift work are described worldwide.[2] In Egypt, shift work in petroleum industry (oil and gas) generally goes monthly like that; a 12-hour night shift for one week followed by a vacation week, then a 12-hour day time shift for another week followed again by a vacation week.

An association between shift work and coronary artery disease (CAD) has been postulated since many years.[3] In a prospective cohort study among industrial workers in Finland, the relative risk for CAD was 1.4 for shift workers in comparison to day time workers. This relation kept significant after adjustment for life style factors, blood pressure and serum lipid levels.[4] In another follow up study; Furlan et al. 2000,[5] reported higher levels of blood pressure and sympathetic over-activity as measured by heart rate variability among shift workers than regular workers. These changes might partly explain the high incidence of CAD in shift workers. Concerning dyslipidemias, including hypercholesterolemia, hypertriglyceridemia and low concentration of HDL-cholesterol, results were contradictory. Some studies [6-8] revealed a positive relationship between shift work and dyslipidemias; while, others [9,10] denied this.

The exact mechanism by which shift work may impose a coronary high risk status (CHRS), as defined by existence of more than 2 of the conventional coronary risk factors, diabetes mellitus (DM) and/or established CAD is still unclear.[11] Also, it is of particular importance to investigate

this problem among workers in the strategic industry of natural gas production.

Objective: The present work was designed to study the influence of shift work in a gas field petroleum company in Dakahlia on CHRS; as well as, to investigate its possible mechanism.

SUBJECTS AND METHODS

Study design and setting:

A cross-sectional approach was used. This study was carried out at a natural gas field belonging to a petroleum company located in Dakahlia governorate.

Study population:

Using an arbitrary prevalence of CAD from previous studies [4, 12, 13] among shift and non-shift workers of 27% and 15% respectively with 95% confidence and 80% power, the minimum required sample size is 200 for each group by Epi-Info 2003. Systematic random technique was applied to select a group of 200 shift workers. Another group of 200 non-shift workers was similarly selected. Both groups were males and were matched in socio-demographic characteristics.

Methods:

After ethical considerations; including getting approval from the concerned authorities and detailed explanations about the study, safety of the procedure and confidentiality of collected data; a written consent was obtained from each participant in the study.

Each individual in the two studied groups (shift and non-shift) was subjected to the following:

- Interview questionnaire, about personal, social and medical histories was applied according to the guidelines of WHO.[14] Smoking history was obtained and smoking index was calculated as the number of cigarettes smoked / day multiplied by years of smoking.[15] Occupational history; including present job, duration of employment in years, desire to change shift work as well as effect of work on performance and

concentration; was inquired about. Physical activity at work was graded into regular activity, limited activity and sedentary work according to Cassel et al. 1971.[16]

- Clinical examination was performed including general and cardiovascular examinations. Measurements of resting heart rate (HR), systolic (SBP) and diastolic (DBP) blood pressure were done in sitting position according to standard methods. [10] Height (Ht), weight (Wt) and waist circumference were measured and body mass index (BMI Kg/m^2) was calculated and classified where obesity was considered at ≥ 30 Kg/m^2.[17]
- Laboratory investigations: A fasting venous blood sample was obtained by vein-puncture and was left to clot. Serum was separated to measure levels of blood glucose, lipid profile (total cholesterol (TC), LDL-cholesterol, HDL-cholesterol and triglycerides TG) and uric acid according to the standard methods.[18]
- Electro-cardio-graphic examination was done by the standard resting 12 leads techniques and signs of ischemia were defined according to standard criteria.[19]
- Diagnostic criteria were considered according to the guidelines of ESH and ESC 2007.[11] Conventional risk factors were considered to be age ≥ 55 years, family history of CAD first relative below the age 55 years, hypercholesterolemia (TC ≥200mg/dl or LDL-cholesterol ≥ 130 mg/dl) and hypertension (BP ≥ 140/90 mmHg or past history of hypertension). Diabetes mellitus was diagnosed based on past history of DM or fasting blood glucose ≥ 126 mg/dl. Coexistence of more than 2 conventional risk factors or DM or new and old CAD defined CHRS.[11, 20]

- A sub-sample was randomly selected from those with CHRS free from diabetes mellitus, new or old CAD and other diseases that may affect autonomic function [21] (25 shift and 25 non-shift workers). Vanillyl mandelic acid (VMA) was measured in 24 hours urine samples as a stress indicator and the R-R deep breathing variability test on resting ECG as a measure for autonomic function [22] were done for each worker in the sub-group. The indices of R-R variability were calculated including the minimum (R-R min), maximum (R-R max), mean (Mean R-R), standard deviation (SD of R-R) and coefficient of variation (CV of R-R).

Statistical Analysis:

Data were analyzed using SPSS (Statistical Package for Social Sciences) version 17. Continuous variables were expressed as means and standard deviations; meanwhile, qualitative data were defined as numbers and percentages. The appropriate test of significance (t-test and chi-square) was computed. Variables that were statistically significant were chosen for the next stage of analysis. Logistic regression analysis with coronary high risk status as a dependant variable was performed to test the independent effect of shift work after adjustment for the confounders. The 0.05 level of significance was used as a cut-off point for statistical significance.

Results

Table 1 describes the socio-demographic and occupational data of the studied population. There were no statistically significant differences between both studied groups (shift versus non-shift) regarding age, marital status, residence, educational level and duration of employment. The age of the studied population ranged between 30-55 years in shift workers and 27-57 in non-shift workers. Deterioration in performance and

concentration during work was more common among shift workers than non-shift workers with a statistically significant difference (p = 0.001). In addition, 35.5% of shift workers had the desire to change shift work.

Table 2 shows the mean values for hemo-dynamic, anthropometric and laboratory measurements among the studied population. Statistically significant higher values for resting HR, SBP, DBP, WT, waist circumference, total cholesterol, LDL-cholesterol, triglycerides and uric acid were reported for shift workers than non-shift workers (p = 0.001, 0.03, 0.029, 0.026, 0.041, 0.001, 0.0001, 0.001 & 0.002 respectively). Meanwhile, HDL-cholesterol showed a statistically significant decrease among shift workers than non-shift workers (p = 0.027), but there was no statistically significant difference for height between both groups.

Table 3 demonstrates the prevalence of coronary risk factors expressed as qualitative variables among the studied groups. Among shift workers, 36% were smokers in comparison to 26.5% of non-shift workers with a statistically significant difference (p = 0.04). On the other hand, no statistically significant difference regarding smoking index was observed between shift and non-shift groups. Rates of hypertension (23% vs 11%), high TC (30.5% vs 18.5%), high LDL-cholesterol (35% vs 10%), low HDL-cholesterol (27% vs 13%), hypertriglyceridemia (24% vs 14.5%), obesity (40% vs 30%) and DM (8.5% vs 2%) were statistically significantly higher among shift workers than non-shift workers. On the other hand, regular physical activity was more common among shift workers than non-shift workers (34.5% vs 27.5%); meanwhile, physical inactivity was more prevalent among non-shift workers than shift workers (32.5% vs 26%) with statistically significant differences. There was no statistically significant difference for family history of premature

CAD between both groups of the study.

Table 4 and figure 1 describe coronary risk status among the studied population. Only 23% of shift workers had no risk factors in comparison to 43.5% of non-shift workers. Co-existence of more than 2 coronary risk factors and/or DM was significantly more prevalent among shift workers than non-shift workers (29.5% vs 21.5%). Also, evidence for new and old CAD was more significantly reported in shift workers than in non-shift workers (11.5% vs 4%). The overall rate of CHRS was highly significantly prevalent among shift workers (p = 0.001).

Table 5 shows multiple logistic regression analysis of Coronary High Risk Status as the dependant variable in the studied groups. The model revealed that shift work kept a significant effect on CHRS even after adjustment for other confounders (p = 0.002), including obesity, physical inactivity and triglycerides level that were also significant variables in the model (p= 0.041, 0.013 & 0.045 respectively); meanwhile, HDL-cholesterol was not significant.

Table 6 reveals results of urinary VMA and R-R variability test among the sub-sample of CHRS participants to investigate the possible risk mechanisms for shift work. Mean level of urinary VMA was significantly higher for shift workers than non-shift workers (p = 0.0001). Meanwhile, significantly lower R-R variability indices; namely R-R min, R-R max, mean R-R, CV of R-R and SD of R-R; were recorded among shift workers compared to non-shift workers (p= .001, 0.0001, 0.021, 0.01 and 0.001 respectively).

Table 1: Socio-demographic and occupational data of the studied population.

Characteristics	Shift (n:200)		Non-Shift (n:200)		X^2	p
	No.	%	No.	%		
Age (years)						
< 40	78	39.0	84	42.0		
40-50	63	31.5	72	36.0		
> 50-60	59	29.5	44	22.0	3.01	0.223
Marital status						
Single	20	10.0	17	8.5		
Married	177	88.5	182	91.0		
Divorced	3	1.5	1	0.5	0.58	0.68
Residence						
Urban	110	55.0	119	59.5		
Semi-urban	75	37.5	68	34.0		
Rural	15	7.5	13	6.5	1.08	0.32
Educational level						
Read and Write	4	2.0	0	0.0		
Preparatory or secondary	130	65.0	125	62.5		
High education	66	33.0	75	37.5	0.98	0.41
Duration of employment (years):						
i- < 5	52	26.0	40	20.0		
ii- 5-15	70	35.0	90	45.0		
iii- > 15	78	39.0	70	35.0	1.33	0.136
Complaining deterioration in performance & concentration during work:						
i. No	115	57.5	180	90.0		
ii. Yes	85	42.5	20	10.0	3.12	0.001*
Desire to change shift work:						
i. No	129	64.5	-	-	-	-
ii. Yes	71	35.5				

*Difference is significant at 0.05 level

Table 2: Hemo-dynamic, anthropometric and laboratory measurements among the studied population

Measurements	Shift (n:200)		Non-Shift (n:200)		t	p
	Mean	S.D	Mean	S.D		
Resting Heart Rate (beat/minute)	73	5.11	69.60	3.21	4.65	0.001*
Systolic Blood Pressure (mmHg)	134.68	12.74	122.30	9.10	1.98	0.03*
Diastolic Blood Pressure (mmHg)	89.11	10.60	79.33	6.07	2.11	0.029*
Height (cm)	172.86	5.107	172.74	5.177	0.056	0.814
Wight (Kg)	89.7	11.47	82.4	8.33	2.06	0.026*
Waist circumference (cm)	108.83	7.501	97.35	6.2	1.89	0.041*
Total Cholesterol (mg/dl)	214.30	39.80	196.40	40.00	9.98	0.001*
LDL-cholesterol (mg/dl)	137.00	16.21	110.11	7.50	15.65	0.0001*
HDL-cholesterol (mg/dl)	43.81	6.61	46.21	6.59	2.51	0.027*
Triglycerides (mg/dl)	162.40	80.41	151.00	82.40	5.65	0.001*
Uric acid (mg/dl)	6.01	1.69	4.53	3.09	4.25	0.002*

Table 3: Coronary risk factors expressed as qualitative variables among the studied population.

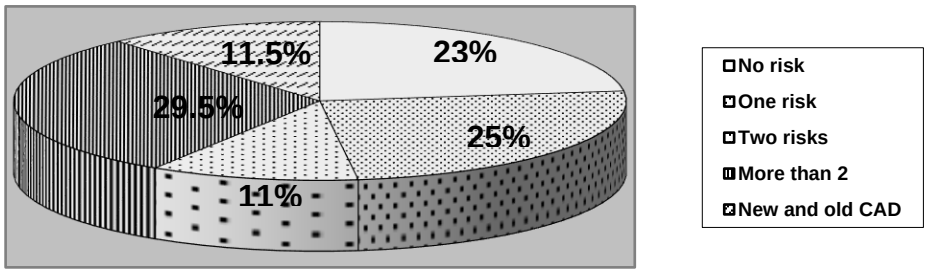
Characteristics	Shift (n:200)		Non-Shift (n:200)		X^2	p
	No.	%	No.	%		
1-Smoking:						
i. Non smoker	128	64.0	147	73.5		
ii. Smoker	72	36.0	53	26.5	4.20	0.040*
iii. Smoking index:						
(Daily cigarettes*years)						
< 200 (Mild)	25	34.7	22	41.5		
200 – 400 (Moderate)	30	41.7	20	37.7		
> 400 (Heavy)	17	23.6	11	20.8	0.60	0.73
2-Hypertension :						
hypertension ≥ 140/90	46	23.0	22	11.0	6.98	0.001*
3-Dyslipidemia:						
High TC (≥200mg/dl)	61	30.5	37	18.5	19.98	0.001*
High LDL-C (≤40mg/dl)	70	35.0	20	10.0	25.61	0.000 1*
Low HDL-C (≥130mg/dl)	54	27.0	26	13.0	11.51	0.002*
Hypertriglyceridemia (≥150mg/dl)	48	24.0	29	14.5	12.81	0.001*
4-Obesity:						
BMI ≥ 30 kg/m^2	80	40.0	60	30.0	4.40	0.036*
5-Family history of premature CAD	14	7.0	7	3.5	2.46	0.117
6-Physical activity:						
i. Physical in-activity	52	26.0	65	32.5		
ii. Limited activity	79	39.5	80	40.0		
iii. Regular activity	69	34.5	55	27.5	6.98	0.013*
7-Diabetes mellitus	17	8.5	4	2	3.69	0.043*

*Difference is significant at 0.05 level

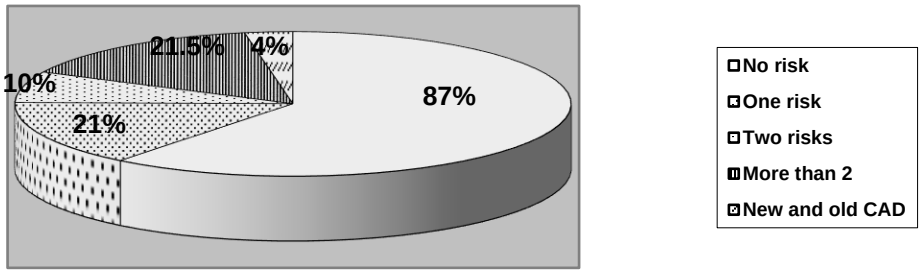
Table 4: Coronary risk status among studied population

coronary risk status	Shift (n:200)		Non-Shift (n:200)		X^2	p
	No.	%	No.	%		
i. No risk factor	46	23.0	134	87.0		
ii. One risk factor	50	25.0	42	21.0		
iii. Two risk factors	22	11.0	20	10.0		
iv. More than 2 risk factors and/or DM	59	29.5	43	21.5		
v. New and old CAD	23	11.5	8.0	4.0	6.52	0.013*
CHRS (iv + v)	82	41.0	51	25.5	10.82	0.001*

*Difference is significant at 0.05 level



Shift Workers



Non-Shift Workers

Figure 1: Coronary risk status among the studied population

Table 5: Multiple logistic regression analysis of Coronary High Risk Status as dependent variable in the studied groups

Variables	Unstandardized Coefficients		Standardized Coefficients	t	p
	B	Std. Error	Beta		
(Constant)	0.122	0.635		3.11	0.0001*
Obesity (BMI ≥ 30 kg/m^2)	0.211	0.109	0.003	2.16	0.041*
Physical inactivity	0.109	0.063	0.365	2.99	0.013*
HDL-cholesterol (mg/dl)	0.088	0.1099	0.244	1.07	0.109
Triglycerides (mg/dl)	0.175	0.108	0.109	2.11	0.045*
Shift work	0.85	0.106	0.782	2.98	0.002*

*Difference is significant at 0.05 level

Table 6: Results of urinary VMA and R-R variability test among the sub-sample of CHRS participants

Test result	Shift (n:25)		Non-Shift (n:25)		t	p
	Mean	S.D	Mean	S.D		
Urinary VMA (mg/ day)	8.51	5.16	5.64	2.75	12.98	0.0001*
R-R min (msec)	69.85	11.55	73.70	12.12	6.69	0.001*
R-R max (msec)	97.35	13.40	107.80	14.75	11.33	0.0001*
Mean R-R (msec)	82.30	12.19	85.63	13.10	2.65	0.021*
CV of R-R (%)	2.70	0.15	3.40	0.22	3.01	0.01*
SD of R-R(msec)	22.00	12.78	34.65	14.99	6.58	0.001*

*Difference is significant at 0.05 level

DISCUSSION

Shift work represents an increasing burden on workers mode of life with its possible consequences on their health status especially from cardio-vascular point of view. There are limited data about the prevalence of shift work health related disorders. In the present study, two groups of shift and non-shift workers with matched socio-demographic characteristics were examined. High percent of the current shift workers were found to complain of deterioration in performance and concentration, and to have the desire to change shift work. These findings go in harmony with the shift work reported intolerance. It was stated that approximately

20% of shift workers report falling asleep during work due to disruption of body circadian rhythms and mal-adaptation.[23] Most conventional and other novel coronary risk factors were more significantly prevalent among shift workers than non-shift workers in the present study. These include smoking, hypertension, obesity, different patterns of atherogenic dyslipidemias, diabetes mellitus and hyperuricemia. These results go with the findings of many other studies reporting similar increases in coronary risk profile.[6-8, 24-26]

Smoking was reported as a common unhealthy behavior response among shift workers.[25] Moreover, Su et al. 2008,[26] observed a consistent elevation of SBP and DBP during ambulatory BP monitoring of shift workers in comparison to day workers. They attributed such finding to the possible effect of shift work in disruption of circadian rhythm which is modulating BP and in preventing the normal dipping pattern of BP at night.

Both general and central obesity were more prevalent in shift workers than in non-shift group in the present study. Nakamura et al. 1997,[27] and Suwazona et al. 2008,[28] reported similar observation among blue collar shift workers in comparison to day workers, attributing this finding to the possibility of increased activity of hypothalamic pituitary axis and insulin resistance by stress. Alternations in lipid parameters in terms of significant increase in total cholesterol, LDL-cholesterol and triglycerides; and reduction in HDL-cholesterol were similarly reported by other investigators among shift versus non-shift workers.[6,7] They explained it by a possible interaction between changes in dietary habits with tendency for overeating among shift workers and a stress mediated mechanism among them.

Other metabolic changes that were reported in the current study included higher prevalence rate of diabetes mellitus and greater mean level of serum uric acid in shift workers than non-shift workers. This

is going with the findings of Joseph 2001,[29] who reported that shift work is associated with increased risk of diabetes and other metabolic changes.

On the other hand, Mina and Jungsun 2005,[30] and Hublin et al. 2010,[31] denied the association between coronary risk and shift work. This discrepancy may be attributed to differences in methodological design and poor control for the known healthy workers' effect. However, the only observed positive risk reducing factor in the present study is the higher rate of physical activity among shift workers than non-shift workers; possibly as related to their specific occupational duties.

The most important finding of the current study is the higher rate of co-existence of coronary risk factors in shift workers than non-shift workers. Clustering of more than 2 coronary risk factors, diabetes mellitus and/or CAD resulted in a CHRS which maintained a consistent significant association with shift work even after adjustment for other confounders. These results are going with the finding of Knutsson et al. 2000,[13] who highlighted the association between increased coronary risk profile and shift work independent from other risk factors.

In a trial to understand the exact risk mechanism of shift work in the present study, a subsample of CHRS shift workers and a similar subgroup of CHRS non-shift workers were tested for urinary VMA and resting heart rate (R-R) variability. The outcome indicated a possible status of increased sympathetic activity as measured by high urinary VMA and reduced R-R variability. Similar findings were reported by Furlan et al. 2000.[5] They demonstrated reduced heart rate (R-R) variability indices during 24-hour Holter ECG monitoring of shift workers. In another study, Fujiwara et al. 1992,[32] stated that the increased rates of excretion of urinary catecholamines are possible markers not only for increased sympathetic drive; but

also, disruption of circadian rhythm among shift workers. Therefore, a multi-factorial mechanism characterized by autonomic dysfunction with predominating sympathetic over-activity is possibly responsible for the currently observed CHRS in relation to shift work.

CONCLUSION AND RECOMMENDATIONS

Shift work was significantly related to CHRS even after control for other confounders. Sympathetic over-activity might be a possible mechanism for CHRS among shift workers. Therefore, it is recommended, in pre-placement and periodic medical examinations of shift workers, to screen for coronary risk factors including smoking, obesity, (general and abdominal), blood pressure, heart rate, lipid profile, diabetes mellitus and uric acid. Simple markers of sympathetic over-activity such as 24 hour urinary VMA and R-R variability testing in ECG could be used as stress indicators among CHRS shift workers. Cases of CAD should be prevented from shift work. Special control programs for coronary risk factors promoting healthy life-style should be designed and implemented among shift workers. Further studies for shift work system modification are needed to reduce the stress mediated sympathetic over-activity.

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