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NIGHT SHIFT WORKING AND ITS IMPACT ON DEVELOPMENT AND CONTROL OF DIABETES MELLITUS IN WORKERS OF ABO KORKAS SUGAR FACTORY, EL-MINIA, EGYPT

By

Ghazawy ER, Kamel SM, Gamal HM and Ewis AA

Department of Public Health and Occupational Medicine, Minia University, Minia, Egypt

Abstract

Introduction: Rotating night shift work disrupts circadian rhythms and it has been associated with chronic conditions including cancers, cardiovascular diseases, obesity, metabolic syndrome and glucose dysregulation. **Aim of work:** the study aimed at determining the prevalence of glucose abnormalities among Abo-Korkas sugar factory workers and exploring the impact of rotating night shifts on glycemic state and control of diabetes. **Materials and Methods:** In a cross-sectional study a total of 330 male workers at Abo-Korkas sugar factory were randomly selected to fill out an interview questionnaire, have medical examination and be tested for fasting and post-prandial blood glucose level; with assessment of HbA1c (Hemoglobin A1c test) for those who were diagnosed as diabetics. **Results:** Our findings showed that 61 (18.4%) workers were diabetics, 7 of them were newly diagnosed diabetics. The prevalence of diabetes was significantly higher (p= 0.01) among former (33.3%) and current (15.7%) night shift than day-time workers (14.4%). The crude Odds Ratio (OR) for developing diabetes mellitus among the current and former shift workers were 1.1 (0.56-2.18) and 2.9 (1.39-6.31), respectively. Moreover, shift working significantly affected diabetes control (p= 0.04) with an OR= 3.83 (1.02-14.34). **Conclusion:** Rotating shift work especially night shifts have negative effects on health. It was found to be associated with developing type 2 diabetes mellitus and it hindered diabetes control among night shift diabetic workers. Preventive programs should be implemented for high risk employees. Occupational health practitioners should be aware of such associations that will help them in prevention and management of diabetic employees.

Keywords: Night shift work, Diabetes mellitus, Pre-diabetes, Abo-Korkas sugar factory, El-Minia

Introduction

Generally work schedules follow the sun. But working at nights or at irregular times has become a regular phenomenon in recent years. This phenomenon is known as shift work, which is the need and demand of modern society.

The International Labor Office (ILO) defines working in shifts as "a method of organization of working time in which workers succeed one another at the workplace so that the establishment can operate longer than the hours of work of individual workers" (ILO, 1990).

In general, the term 'shift work' is quite vague and includes any organization of working hours that differ from the traditional diurnal work period (Costa, 2003).

Shift work can be classified in one of two ways: 'rotating', where the employee's hours of work change (e.g., morning, afternoon, and night shift); and 'permanent', where the work pattern may be constant but occupy unusual hours of the day (Kivimäki et al., 2011).

Modern society is moving toward a pattern of working twenty-four hours a day and shift work that includes a night-time rotation has become an unavoidable attitude of today's 24-h society (Geliebter et al., 2000).

The past few decades have witnessed a tremendous growth in the population of shift workers, especially in developed and highly industrialized countries. Developing countries are also not free from experiencing this phenomenon (Kogi, 1985). Shift work is prevalent throughout the world. In 2007, US Bureau of Labor Statistics reported that 17.7% usually worked alternate shifts that fell at least partially outside the day-time shift range (McMenamin, 2007). Similar results have been reported from Europe and Japan (Paoli and Merllie, 2001; Suwazono et al., 2008a). Reliable data on the numbers of workers employed in shift work is not easy to collect due to the lack of robust statistics in many countries, and/or differences in methods of data collection are not always being comparable.

Despite the global spread of shift work, there is a growing concern over its adverse health effects. Shift work is considered to be disruptive of normal diurnal biological rhythms and has been associated with many health problems (NIOSH, 2014).

Shift working has been implicated as a risk factor for a number of chronic diseases, including cancer, cardiovascular disease (CVD), metabolic syndrome and diabetes (De Bacquer et al., 2009; Lin et al., 2009 and Wang et al., 2011).

Shift work has been hypothesized to contribute to development of CVD and other metabolic disorders through a number of pathways including circadian rhythm disruption, lifestyle changes, job strain and stress, and social stress (Green et al., 2008; Frost et al., 2009)

Information on the impact of rotating night shifts on glycemic state and control of diabetes in Egyptian workers is not available.

Aim of the study: The current study aimed at determining the prevalence of glucose abnormalities among Abo-Korkas sugar factory shift workers and exploring the impact of rotating night shifts on glycemic state and control of diabetes.

Materials and Methods:

This cross-sectional study was conducted in Abo-Korkas sugar factory, located 20 Km south to El-Minia city, El-Minia governorate, Egypt, during the period from March to September, 2013.

Study Population

The required sample size was estimated based on the following conditions: expected proportion of the population with diabetes mellitus in Egypt (P) = 20%; tolerated error/ margin of error (d) = 0.05; confidence interval (CI) = 95%. The following formula was used [n= p* (1-p)* (Zα/d) 2] (Lwanga and Lemeshow, 1991). The value for Z is found in statistical tables which contain the area under the normal curve. Accordingly, the sample size was estimated and additions of 20% of the sample were added to guard against non-respondent's rate. The final number was close to one fourth of the sugar factory's working force. Therefore, we used the list of employees to choose a systematic random sample "every 4th employees".

Finally, a total 330 male workers, employed in different sections of Abo Korkas sugar factory were included in the study. Male workers only were included since the number of females engaged in the work was considerably low.

Data were collected using an interview questionnaire that inquired about demographic data, working conditions, occupational history

and health-related behaviors. Waist circumference (in centimeters): was measured by using non stretchable measuring tape at midway between the 12th rib and the iliac crest, the person stand with abdomen relaxed, arms at sides, and feet together. Body weight and height were measured using the standard methods. Body mass index (BMI) was calculated as weight (kg) divided by height squared (m2) (Bray, 1993).

Diabetes Screening Protocol

Fasting finger prick blood glucose level was determined for workers, however, those who were not fasting on the test day were motivated to report in fasting state on the next day (fasting was defined as a minimum of 8 hours between the subject's last consumption of any calorie-containing food or drink and the time of the fasting plasma glucose (FPG) test. Participants with FPG levels ≥110 mg/dl were considered as abnormal (Expert Committee on the Diagnosis and Classification of Diabetes Mellitus, 2003). Next post-prandial blood glucose (PPG) level after two hours was measured by using Rightest ™ GM100 Glucose Test strips and Rightest ™ Blood Glucose Meter GM100 supplied by BIONIME Co., Taiwan.

Diabetes was considered if FPG value was >126 mg/dL and/or 2-hour PPG value was >200 mg/dL and/or the participant was a known diabetic. Pre-diabetes condition was diagnosed if FPG was 110-125 mg/dL and 2-hour PPG was <140 mg/dL in a person who was not a known diabetic (Expert Committee on the Diagnosis and Classification of Diabetes Mellitus, 2003).

For the diabetic workers, HbA1c was measured by using Nycocard HbA1c (AXIS-SHIELD PoC AS), to assess whether their diabetes is controlled or not. Those who had HbA1c ≥ 6.5% were considered to have uncontrolled diabetes (WHO, 2006).

Ethical consideration

The study was approved by the ethical committee of the Faculty of Medicine, El-Minia University. Prior to data collection, informed consents were obtained from all participants after supplying comprehensive information about the nature of the study and the procedural details of the blood sugar investigations.

Statistical analysis

The Statistical Program SPSS for Windows version 20 was used for data

entry and analysis. Quantitative data were presented by mean and standard deviation, while qualitative data were presented by frequency distribution. Chi Square test was used to compare between two or more proportions. Student t-test was used to compare two means and ANOVA was used to compare means of more than two groups. Risk ratios were estimated by calculating odds ratios (OR); and a regression analysis was performed. The lowest accepted level of significance was ≤ 0.05.

Results

This study included 330 male workers; whose ages ranged from 20 to 59 years with a mean of (43.2±8.6). Based on the work schedules, 111 (33.6%) were day-time workers, 60 (18.2%) and 159 (48.2%) were formerly and currently engaged in rotating night shift work, respectively.

Table 1: Baseline characteristics of the studied different shift workers in Abo-Korkas sugar factory, El-Minia, Egypt, during March-September, 2013

Characteristics	Current shift workers (n=159)	Former shift workers (n=60)	Day-time workers (n=111)	P value
Age*	42.1±9.1	44.3±8.2	44.1±8.0	0.1
Total duration of occupation (years)*	16.1±8.2	17.2±8.5	16.1±7.8	0.5
Total duration of night shift working (years)*	15.4±8.4	10.6±7.5	-- --	0.0001
Body mass index**				
~ 24.9kg/m^2	27 (17.0%)	10 (16.7%)	18 (16.2%)	0.9
≥ 25kg/m^2	132 (83.0%)	50 (83.3%)	93 (83.8%)	
Waist circumference (cm)*	97.7±12.6	100.3±13.6	96.7±14.9	0.2
Smoking status**				
Current smoker	54 (34.0%)	27 (45.0%)	38 (34.2%)	0.2
Never/former smoker	105 (66.0%)	33 (55.0%)	73 (65.8%)	
History of hypertension**				
Hypertensive	9 (5.7%)	12 (20%)	5 (4.5%)	0.001
Normal	150 (94.3%)	48 (80%)	106 (95.5%)	

* Quantitative data is represented by means± SD,
**Qualitative data is represented by numbers and percentages.

There was a significant difference between the current and former shift workers regarding the duration of night shifts throughout their job experience (p= 0.0001), where mean duration was (15.3±8.4) in current shift workers compared to (10.6±7.6) in former shift workers. Regarding the history of hypertension, the former and current night shift workers reported significantly higher prevalence of hypertension (20%) and (5.7%), respectively, than the day-time ones (4.5%). No statistical significant differences were observed between study groups regarding BMI, waist circumference and smoking status (Table 1).

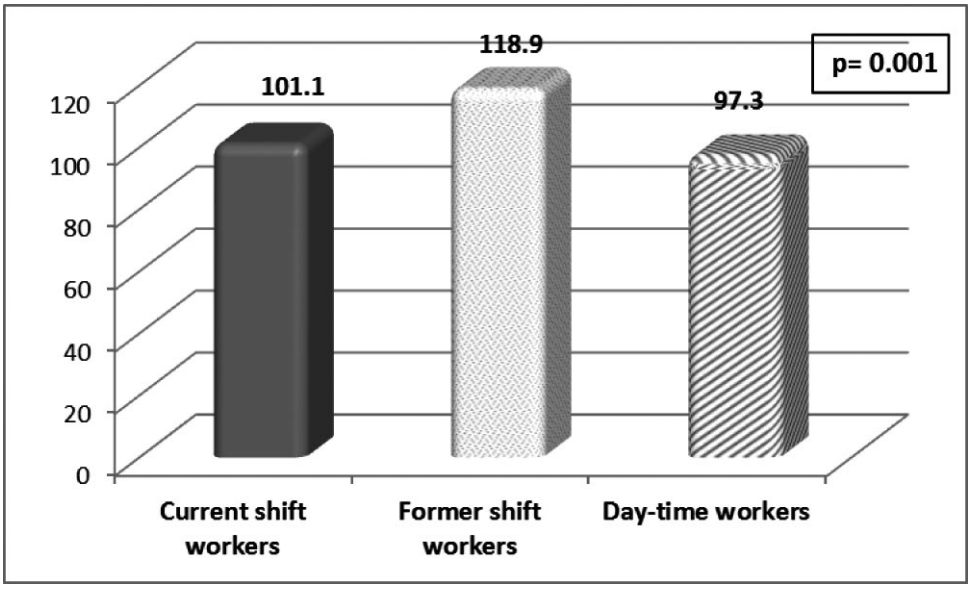

Figure 1: Serum fasting blood glucose level of different shift workers in Abo-Korkas sugar factory, El-Minia, Egypt, during March-September, 2013

Serum fasting blood glucose level was significantly higher among current and former night shift workers (101.1±38.5) and (118.9±48.8), respectively compared to day-time workers (97.3±26.5) (Figure 1).

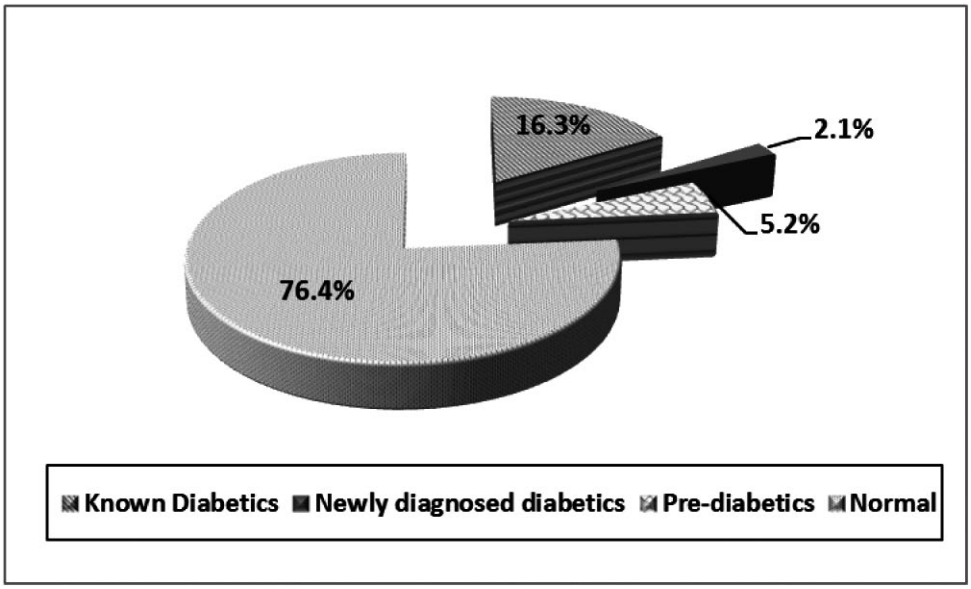

Figure 2: Glycemic state of the studied workers in Abo-Korkas sugar factory, El-Minia, Egypt, during March-September, 2013

It is observed from the current study that 16.3% of studied workers known to have diabetes mellitus, 2.1% of them newly diagnosed as diabetics and 5.2% were pre-diabetics (Figure 2).

Table 2: Glycemic state of the studied workers distributed by type of shift working in Abo-Korkas sugar factory, El-Minia, Egypt, during March-September, 2013

Diabetes mellitus	Shift working			Total	X^2	P value
	Current shift workers No (%)	Former shift workers No (%)	Day-time workers No (%)			
Normal	127 (79.9)	35 (58.3)	90 (81.1)	252 (76.4)	13.4	0.01
Pre-diabetic	7 (4.4)	5 (8.3)	5 (4.5)	17 (5.2)		
Diabetic	25 (15.7)	20 (33.3)	16 (14.4)	61 (18.4)		
Total	159 (100)	60 (100)	111 (100)	330 (100)		

From all the studied workers, 61 had diabetes mellitus; and out of them seven (11.5%) were newly diagnosed as diabetics. The percentage of workers with abnormal glycemic state was significantly higher among former shift workers, where 8.3% and 33.3% of them were pre-diabetics and diabetics, respectively, compared to 4.4%; 15.7% and 4.5%; 14.4% of current shift workers and day-time workers, respectively (p= 0.01) (Table 2).

Table 3: Serum fasting and postprandial glucose levels with HbA1c in diabetic workers of different shifts in Abo-Korkas sugar factory, El-Minia, Egypt, during March-September, 2013

Variables	Current shift workers (n=25)	Former shift workers (n=20)	Day-time workers (n=16)	P-value
FBS	157.4±72.2	172.8±50.8	135.7±52.2	0.2
PPBS	219.3±83.0	257.8±108.4	179.1±53.0	0.03
HbA1c	7.8±1.9	8.4±2.6	6.3±1.1	0.01

FBS: Fasting Blood Sugar PPBS: Post Prandial Blood Sugar
HbA1c: Hemoglobin A1c test

Laboratory investigations showed significant higher levels of mean postprandial blood glucose and HbA1c among diabetic shift workers compared to diabetic day-time workers (Table 3).

Table 4: Odds' ratio for diabetes mellitus associated with shift working among the studied workers in Abo-Korkas sugar factory, El-Minia, Egypt, during March-September, 2013

	Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 3 OR (95% CI)
Day-time workers (n=111)	1.00 Reference group	1.00 Reference group	1.00 Reference group
Current shift workers (n=159)	1.11 (0.56-2.18)	1.24 (0.61-2.48)	1.24 (0.61-2.48)
Former shift workers (n=60)	2.96 (1.39-6.31)	3.09 (1.41-6.71)	3.08 (1.04-1.2)

N.B. dependent variable is work schedule. OR: odds ratio; CI: confidence interval.

Model 1: Crude model. Model 2: Adjusted for age. Model 3: Adjusted for age and smoking status. Day-time workers were used as a reference.

Table 4 listed the ORs and 95% confidence intervals (95% CI) for developing diabetes mellitus among shift workers compared to the day-time ones. The crude ORs for developing diabetes mellitus among the 159 current shift workers and the 60 former shift workers were 1.1 (0.56-2.18) and 2.9 (1.39-6.31), respectively, (Model 1). When we adjusted for age in Model 2, the OR for diabetes mellitus increased. In Model 3, after adjustment for both age and smoking status, the point estimate of OR for diabetes mellitus among both former and current shift workers was similar to that of Model 2.

Table 5: Factors affecting the control of diabetes mellitus among the studied different shift workers in Abo-Korkas sugar factory, El-Minia, Egypt, during March-September, 2013

Variables	OR	95% CI	P-value
Shift working	3.83	1.02-14.34	0.04
Body Mass Index	1.17	0.99-1.38	0.06
Duration of diabetes mellitus	1.14	0.98-1.32	0.08
Waist circumference	1.00	0.95-1.05	0.9
Age	1.00	0.92-1.09	0.9

Dependent factor: Uncontrolled DM (HbA1c≥6.5)

Table 5 shows that shift work itself has a significant effect on control of diabetes (P= 0.04), with an OR = 3.83 (1.02-14.34) whereas age, duration of diabetes, BMI and waist circumference had no significant effect.

Discussion

Type 2 diabetes is a modern worldwide epidemic. Its complications are a significant cause of morbidity and mortality and the consequences of its explosive growth are an intolerable burden both to the individual and to healthcare systems. The work environment, such as shift work employment, is known to play an important role in the onset and control of DM (Mikuni et al., 1983; Wang et al., 2011; Kobayashi et al., 2012).

Some studies reported an impairment of glucose tolerance in shift workers, with increased insulin resistance at night (Nagaya et al., 2002; Suwazono et al., 2009) and a higher (almost double) prevalence of type 2 diabetes in relation to rotating shift work (Morikawa et al., 2005).

In the present study, from the 330 studied workers, 54 (16.3%) were known to have diabetes mellitus, 7 (2.1%) were newly diagnosed as diabetics and 5.2% were pre-diabetics (Figure 2). These result was slightly higher than that reported by Zaghloul et al. (2014) who conducted a study on all work force (4800 workers) in factory for cigarettes production, Giza, Egypt to evaluate the impact of work and family stress on workers' health and reported that 14.8% of the working population were diabetic (Zaghloul et al., 2014). This is in accordance with a cross sectional study performed by Al Zurba and Al Mansour, (2003) among health care workers in El-Bahrain, they detected that about 16.9% of the total sample had diabetes mellitus (Al Zurba and Al Mansour, 2003).

In the current study, distribution of diabetic cases according to shift working showed significant difference between the three shift categories, where 33.3% and 15.7% were former and current night shift workers compared to 14.4% of day-time workers ($p= 0.01$), (Table 2). These results were consistent with the findings of Suwazono and his colleagues (2006), who evaluated the relationship between shift work and the onset of diabetes among male workers in a Japanese steel company and found that the risk of developing diabetes was significantly higher for workers on rotating shifts than it was for regular day workers (Suwazono et al., 2006).

Comparison of the fasting blood sugar (FBS) levels among the studied three shift work categories revealed significant higher levels in current and former night shift workers (101.1±38.6

and 118.9±48.8), respectively, than the day-time ones (97.3±26.6), (Figure 1). Such results were similar to that of Di Lorenzo et al. (2003) who examined the influence of shift work on metabolic and cardiovascular risk factors among subjects working in a chemical industry in southern Italy and found that shift workers had higher glucose levels (Di Lorenzo et al., 2003). In another cross-sectional study of Japanese male blue collar workers, Nagaya et al. (2002) reported that shift workers were more likely than day-time workers to have high fasting serum glucose (Nagaya et al., 2002). Additionally, a study by Ye et al. (2013) reported similar associations between shift work and the metabolic syndrome in female workers from the Daegu area Dyeing Industrial Complex, Korea, and found that the shift work group had significantly higher FBS levels.

Additionally, the crude and adjusted OR showed that night shift workers were 3 fold increases for developing diabetes mellitus than day time workers. Odds of having diabetes was 1.11 and 2.96 times among current and previous shift workers, respectively, compared to a reference group of day time workers. The OR for diabetes mellitus increased after adjustment for age alone and for age smoking status together (Table 4). These results were consistent with the findings of Ika and his colleagues (2013), who studied the association between shift work and diabetes mellitus among male workers in Japan and found that the continuous shift workers had approximately double the odds of developing diabetes mellitus compared to the non-shift workers (Ika et al., 2013).

Shift work adversely affects diabetes control. Our findings confirmed that in the studied group, FBS and PPBS levels were higher among night shift workers than in day-time workers. Moreover, the mean HbA1c levels were significantly higher among current and former night shift workers (7.89±1.92 and 8.47±2.63), respectively, than day-time workers (6.38±1.19), (Table 3). Such results were similar to that of Chalernvanichakorn et al. (2008) who conducted a study on type 2 diabetic patients from the Social Security Clinic in five hospitals in Bangkok doing day work and shift work and found that good glycemic control was significantly higher in day workers versus shift workers (Chalernvanichakorn et al., 2008)

Instantly, when logistic regression analysis was done it showed that shift working was a significant predictor in control of diabetes (P= 0.04), with an OR = 3.83 (1.02-14.34), (Table 5). This could be explained by, shift workers having less sleep time than day workers so circadian rhythm of shift workers was interfered. Disruption of circadian rhythm may influence cortisol secretion (Spiegel et al., 1999) and dose-response patterns of oral hypoglycemic agents (Knutsson, 2003).

As people work irregular hours, their daily routine is interrupted. Regular eating and exercise habits are difficult to maintain (Geliebter et al., 2000). Consequently, shift workers have a higher prevalence of being overweight (Chee et al., 2004; Sudo and Ohtsuka, 2001).

Several studies have suggested that rotating night shift work is associated with an increased risk of obesity and metabolic syndrome, conditions closely related to type 2 diabetes (De Bacquer et al., 2009; Lin et al., 2009; Antunes et al., 2010). In the current study, although high prevalence rate of overweight and obesity was reported, there were no significant differences in BMI and waist circumference between the three shift work categories (Table 1). Consistent results from previous studies that were summarized in a review article by Bøggild and Knutsson (1999), confirmed our findings (Bøggild and Knutsson, 1999). The dietary intake and quality are similar in day-time workers as well as shift workers, no differences in eating habits and physical inactivity may explain these findings.

The present study showed that, the formerly and currently engaged in rotating work reported significantly higher prevalence of hypertension (20%) and (5.7%), respectively, than the day-time workers (Table 1). This is in agreement with Suwazono and his colleagues (2008b) who conducted a 14-year historical cohort study in Japanese Steel Company workers to clarify the effect of shift work on blood pressure and revealed that alternating shift work was a significant independent risk factor for an increase in blood pressure.

In conclusion, our study suggests that rotating shift work especially night shifts has negative effects on health as it contributes in developing of type2 diabetes mellitus and may adversely affect diabetic control. So prevention programs should be implemented for high risk persons. Occupational health practitioners should be aware of this

association and be able to advice on management strategies to improve diabetic control while working shifts.

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