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ORIGINAL ARTICLE

Rotating Night Shift Work and Glycemic Control among Diabetic Nursing Staff in a University Hospital

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ABSTRACT

Background: Night shift work negatively affect human health by disturbing circadian rhythm & altering biological functions, due to poor sleep quality. These disturbances have been linked to insulin resistance & poor glycemic control in type 2 diabetic patients (T2DM).
Objectives: to investigate the association between rotating night-shift work and glycemic control among type 2 diabetic nursing staff**. Materials and Methods**: case-control study included 104 T2DM nursing staff (65 of them on rotating night shift work & the other 39 on fixed day work) in addition to 104 healthy control subjects at Menoufia University hospitals, Egypt. They were subjected to a pre-designed self-administered questionnaire & blood samples for assessment of glycemic control were withdrawn as fasting, two-hour post prandial blood glucose and glycated hemoglobin.
Results: overnight work (62.5%) had significantly worse glycemic control assessed by glucose parameters (FBG, 2Hppg and HbA1c) than those performing day work (37.5%). There was significant association between unhealthy diet, physical inactivity, obesity and night-shift working and DM ($p<0.05$). Multiple regression analysis revealed factors like positive family history, unhealthy diet, obesity and night-shift working were significant predictors for poor diabetic control.**Conclusion**: This study revealed that T2DM nurses working rotating night shifts had poor glycemic control due to chronic circadian misalignment and several factors associated with night shift working as bad dietary foods habits, weight gain, less exercise, night light exposure and endocrinal disturbances. Occupational diabetic health practitioners should be aware of modifying mealtimes, adjusting insulin dosing schedule avoiding factors triggering hypoglycemia episodes by consulting diabetic specialists.

Keywords: Night shift work ; Circadian rhythm ; Glycemic control ; Diabetes mellitus ; Nursing staff

INTRODUCTION

The circadian rhythm's homeostatic physiology regulates sleep regulation and plays a role in controlling tissue metabolism and hormonal secretion. [1]. Circadian rhythm (sleep/wake cycle) is the 24-hour internal clock in brain that regulates cycles of alertness and sleepiness and deeply interacts with environmental factors to maintain the internal balance including light changes

temperature, meal timing and exercise play a role in entraining the circadian system [2].

The hypothalamus contains the central clock that is synchronized with the light/dark cycle and sends information to other organs containing peripheral clocks to adjust daily rhythms of sleep/wake [3].

Periodic fluctuations are observed in hormonal homeostasis; it has become evident that endocrine rhythms and circadian rhythms are tightly connected [4].

Working in shifts often involves various non-standard alternating work schedules and/or working in the evening, overnight or at weekends that abrupt changes in sleeping time and light-dark exposure [3].

Night work is defined as at least three hours of continuous work from the period of 11 pm to 6 am according to United Kingdom government. Rotating night shifts are defined asthree nights/month in addition to days and evenings in that monthat least[1].

Rotating night shift work disrupts circadian rhythm with alterations to sleep activity patterns, altering biological functions and can negatively affect physical, psychological well-being and work performance [5].

This misalignment between circadian systemand the external light-dark cycle is resistant to adaptation from a day to a night-oriented schedule due to a lack of substantial phase shifts over several days in centrally controlled rhythms as those of cortisol and melatonin [6].

Night shift has been associated with obesity, metabolic syndrome, an increased risk of cardiovascular disease, and glucose dysregulation [7, 8].

Type 2 diabetes mellitus (T2DM) constitutes 90% of all diabetes is complex metabolic disease with genetic predisposition and environmental triggers[9]. While, type 1 diabetes (T1D) is caused by autoimmune destruction of pancreatic beta-cells resulting in insulin deficiency. Patients with T1D typically have less insulin resistance with poor metabolic control than patients with T2D [10].

Circadian misalignment shown to be a risk factor for incident diabetes and have been linked to reduced glucose tolerance with poorer glycemic control in T2DM patients is associated with in reduced insulin sensitivity without adequate insulin response. Insufficient sleep, intermittent hypoxiaand disruption to circadian rhythms increase the susceptibility of beta cells in the pancreas to damage and death leading to the development of diabetes[11].

Shift work has been associated with an increased risk of dyslipidemia with high triglyceride levels, and low high-density lipoprotein (HDL) cholesterol concentrations seem to cluster together more often in shift workers than in day workers [5].

Circadian misalignment also resulted in alterations in appetite regulating hormones suppression of melatonin production, elevated inflammatory markers, increased blood pressure, and decreased energy expenditure [1].

While shift workers are a significant part of the health workforce, there are few studies on shiftwork and health hazards, particularly among nurses, that have been conducted. This is the initiative which motivates us to propose this study to investigate the association between shift work and glycemic control among T2DM nursing staff working in Menoufia University Hospitals, Egypt.

PATIENTS AND METHODS

A case-control study, conducted at Menoufia university hospitals in Shebin El kom city, Menoufia governorate, Egypt from October 2022 to February 2023. 208 male and female nurses were enrolled in this study after exclusion of non-responders and were categorized into 2 groups:

- Group 1 (Study group): Included 104 T2DM nursing staff (65 of them on rotating night shift work and the other 39 on fixed day work) diagnosed with diabetes more than one year recruited from the in-patient departments of the Menoufia University hospitals. The shift system in these hospitals consisted of 2 shifts (night and day) each about 12-hour for three times/week. Night shift (from 8 pm to 8

am the following day) and day shift (from 8 am to 8 pm).

- Group 2 (Control group): This group involved 104 healthy control subjects (age and sex-matched) recruited from the in-patient departments in the same period.

Study sample:

The total number of nursing staff at the in-patient departments in this hospital was 1053 nurse. Sample size was calculated using Open-epi; an open source software for epidemiological statistics, assuming hypothesized percentage of the prevalence of uncontrolled DM among employees with anti-clockwise rotating shift work was 92.9% on the basis of a previous study as [12] and 95% confidence limits. The minimum calculated sample size to achieve study objectives was 104 DM patients.

Study methods:

We took permission of the authorities to help us conduct the study without any obligation any of the nursing staff to participate. All workers are freely to participate and they have the right to be in or out. The enrolled participants were subjected to I- **A pre designed self-administered questionnaire that include data about**personal data (age, sex, education, occupation, SES, smoking, drug abuse), employment status (duration of recent employment and number of working hours per week, working shifts, the duration of the shift work), health status through history especially use of anti-anxiety/antidepressant or any medications interfere with sleep/circadian functions as antihistaminic drugs) and diabetes-related questions (diabetes medication use were asked, including insulin, number of non-insulin medications and latest HbA1c test outcome), Daily healthy diet is considered, based on WHO recommendations, as consuming more than 400 grams of vegetables and fruits excluding potatoes, sweet potatoes and other starchy roots, total fat intake not exceed 30% of daily energy intake, and <10% free sugar of total energy intake and consuming <5 grams salt per day (equivalent to sodium intake of less than 2 g per day) [13].

II- **general and local examination:** The participants were subjected to general examination and Local examination mainly to abdomen**,** body mass index (BMI) was calculated by using formula [weight (kg)/height (meter) ^{2}] withBMI between 18.5 – 24.9 kg/m^2 was considered non obese, 25 - 29.9 kg/m^2 was overweight and BMI ≥ 30.00 kg /m^2 was obese [14].**III- Laboratory investigations:** Glycemic control as assessed by glucose parameters including FBG, 2hPPG and HbA1c. Glycemic level was described as controlled if FBG 70-130 mg/dL, 2hPPG ≤180 mg/dl and HbA1c level <7% and uncontrolled if one and/or all of these parameters measured as FBG >130 mg/dl, 2hPG >180 mg/dl and HbA1c level ≥7%. After an overnight fast, 5 ml venous blood sample were withdrawn by sterile venipuncture from a peripheral vein using a sterile plastic syringe and divided as follows: 2.5 ml was added to a fluoride tube to evaluate FBG level using the colorimetric method by Spinreact kit. 2.5 ml of blood was collected into a tube containing EDTA (disodium Ethylene Diamine Tetra Acetate) for HbA1C by Teco Diagnostic kit, USA. Then, second samples of 2.5 ml blood were taken 2 hours post-prandial and put in a fluoride tube to measure 2hPPG.

Exclusion Criteria: Any nurse who showed refusal or hesitation even after being signing the consent. The nurse had the all right to withdraw at any time and that was treated by increase in the sample size to compensate for non-response rate.Also, nurses who were diagnosed with T2DM less than one year and their night shifts less than 3 per month were excluded, patient on medication affecting circadian rhythm as hypnotics and antidepressants.

Ethical Considerationsand consent to participate: This study was approved by Institutional Review Boards (IRB) of the Menoufia faculty of medicine, Egypt, with approval code 11/2022INT28. An informed consent was taken from each participant and has been informed of all aspects of the study and has the right to give up as he wanted.

Statistical Analysis: Statistical analysis was done using Statistical Package for Social Sciences (SPSS) version 28 (SPSS Inc., Chicago, IL, USA). Data analysis involved descriptive statistics and inferential statistical techniques. Descriptive statistics e.g. was expressed in: Number (No), percentage (%) mean ($\bar{x}$) and standard deviation (SD).Analytic statistics included t-test was be used for quantitative data. Chi-square test (χ^2) was used to study association between qualitative variables. Odds ratio (OR) was used to assess risk of exposure. Regression analysis was used to detect the predictors of developing poor glycemic control. P- Value of < 0.05 was considered statistically significant.

RESULTS

The current study was carried out enrolling 208 participants with an overall response rate of 96.4%. Group 1 included 104 diabetic nurses while group II included 104 controls.

There was no statistically significant difference between the studied groups as regards most of studied demographic characteristics (P>0.05). However, significant more participants from diabetic group showed comorbidities like hypertension and chronic kidney diseases (CKD) 29.8% versus only 18.3% of control group (p=0.051).Also obese participants were more frequent among this diabetic group 37.5% versus only 18.3% of control group (p=0.002). Diabetic patients had higher mean arterial blood pressure (MAP) (100.52±21.33 mmHg) in comparison with control group (82.91±12.59 mmHg) (p <0.001) **(Table 1)**.

Compared diabetic nurses worked rotating night shifts and those with fixed daytime ones. Obesity and unhealthy diet were more frequent among those with rotating night shifts 44.7% and 32.3% versus only 25.6% and 20.5% of fixed daytime workers (p=0.011 and <0.001, respectively). Shift work patients had higher MAP (102.35±19.21 mmHg) in comparison with fixed daytime workers (92.91±17.59 mmHg) (p=0.019). Uncontrolled glycemic level was reported in 83.1% of those working rotating night shifts compared to only 56.4% fixed daytime workers with DM (p=0.002) (**Table 2) (Figure 1)**.

Diabetic nurses with uncontrolled glycemic level were compared with those with controlled one. Obesity and unhealthy diet were more frequent among those with uncontrolled level 40.8% and 30.3% versus only 28.6% and 21.4% of those with controlled one (p=0.002 and <0.001, respectively). Physical inactivity was more prevalent among those with uncontrolled levels 89.5% versus 60.7% of controlled (p=0.007). Also, patients with uncontrolled level had higher MAP (103.35±22.41 mmHg) in comparison with those with controlled one (91.63±17.59 mmHg) (p =0.015) **(Table 3)**.

Multiple regression analyzed the effects of factors like positive family history, unhealthy diet, obesity, working at night shift factors were significantly affected diabetic control (p values are < 0.029, 0.041, 0.041, and 0.003; respectively) **(Table 4)**.

Table 1: Socio-demographic and basic clinical data among the studied participants

	Studied groups				χ^2 test	P value
	Diabetic nurses (n=104)		Controls (n=104)			
	No.	%	No.	%		
Age (years): Mean±SD Range	43.06±9.61 34– 55		41.91±4.19 31– 48		**t-test =** 1.12	0.264
Sex: Male Female	28 76	26.9 73.1	19 85	18.3 81.7	2.23	0.135

	Studied groups				χ^2 test	P value
	Diabetic nurses (n=104)		Diabetic nurses (n=104)			
	No.	No.	No.	No.		
Residence: Urban Rural	 56 48	 53.8 46.2	 43 61	 41.3 58.7	3.26	0.071
Marital status: Unmarried Married	 19 85	 18.3 81.7	 11 93	 10.6 89.4	2.49	0.114
Level of education: Diploma Institute Bachelorate	 45 38 21	 43.3 36.5 20.2	 53 34 17	 51.0 32.7 16.3	1.30	0.523
Working unit at hospital: Medical Surgical	 47 57	 45.2 54.8	 40 64	 38.5 61.5	0.97	0.325
Years of work experience: ≤ 10 years 10– 20 years > 20 years	 29 43 32	 27.9 41.3 30.8	 22 37 45	 21.1 35.6 43.3	3.61	0.165
Working hours Day: ≤ 8 hours > 8 hours	 65 39	 62.5 37.5	 67 37	 64.4 35.6	0.08	0.773
Smoking: Yes No	 18 86	 17.3 82.7	 13 91	 12.5 87.5	0.95	0.330
Physical activity: Yes No	 19 85	 18.3 81.7	 25 79	 24.0 76.0	1.04	0.308
Diet: Healthy Less healthy Unhealthy	 24 51 29	 23.1 49.0 27.9	 31 56 17	 29.8 53.9 16.3	4.25	0.119
Comorbidities: Yes No	 31 73	 29.8 70.2	 19 85	 18.3 81.7	3.79	0.051
Family history of DM: Yes No	 48 56	 46.2 53.8	 17 87	 16.3 83.7	21.50	< 0.001
BMI (kg/m²) *: Normal Overweight Obese	 18 47 39	 17.3 45.2 37.5	 36 49 19	 34.6 47.1 18.3	12.94	0.002
MAP (mmHg)#: Mean±SD Range	 100.52±21.33 70.0–150.0		 82.91±12.59 70.0–110.0		**t-test =** 7.25	< 0.001
FBG(mg/dL): Mean±SD Range	 160.76±19.84 120.0–190.0		 91.88±7.52 80.0–100.0		**t-test =** 33.11	< 0.001
2hPG (mg/dL): Mean±SD Range	 202.45±24.36 170.0–250.0		 110.94±11.18 100.0–130.0		**t-test =** 34.06	< 0.001
HbA1c %: Mean±SD Range	 7.92±1.95 6.30–9.80		 5.19±1.06 4.90–5.60		**t-test =** 12.54	< 0.001

χ^2: Chi square test* BMI: Body Mass Index #MAP: mean arterial blood pressure

Table 2: Distribution of diabetic participants according to work shift

	Work status				χ^2 test	P value
	Shift work (n=65)		Daytime work (n=39)			
	No.	%	No.	%		
Age (years): Mean±SD Range	41.96±5.88 34–46		44.47±8.41 38– 55		**t-test** = 1.79	0.086
Sex: Male Female	18 47	27.7 72.3	10 29	25.6 74.4	0.05	0.819
Residence: Urban Rural	34 31	52.3 47.7	22 17	56.4 43.6	0.17	0.684
Marital status: Unmarried Married	13 52	20.0 80.0	6 33	15.4 84.6	0.35	0.556
Level of education : Diploma Institute Bachelorate	31 25 9	47.7 38.5 13.8	14 13 12	35.9 33.3 30.8	4.42	0.119
Working unit at hospital : Medical Surgical	32 33	49.2 50.8	15 24	38.5 61.5	1.14	0.285
Years of work experience: ≤ 10 years 10– 20 years > 20 years	20 32 13	30.8 49.2 20.0	9 11 19	23.1 28.2 48.7	9.66	0.008
Working hours| Day: ≤ 8 hours > 8 hours	47 18	72.3 27.7	18 21	46.2 53.8	7.11	0.007
Smoking: Yes No	11 54	16.9 83.1	7 32	17.9 82.1	0.02	0.894
Physical activity : Yes No	9 56	13.8 86.2	10 29	25.6 74.4	2.27	0.132
Diet: Healthy Less healthy Unhealthy	5 39 21	7.7 60.0 32.3	19 12 8	48.7 30.8 20.5	23.24	< 0.001
Comorbidities: Yes No	16 49	24.6 75.4	15 24	38.5 61.5	2.23	0.135
Family history of DM: Yes No	27 38	41.5 58.5	21 18	53.8 46.2	1.49	0.223
BMI (kg/m²): Normal Overweight Obese	6 30 29	9.2 46.1 44.7	12 17 10	30.8 43.6 25.6	8.91	0.011
MAP (mmHg): Mean±SD Range	102.35±19.21 80.0–150.0		92.91±17.59 70.0–130.0		**t-test** = 2.50	0.019

	Work status				Work status	P value
	Shift work (n=65)		Shift work (n=65)			
FBG(mg/dL): Mean±SD Range	168.32±22.73 120.0–190.0		152.71±17.89 120.0–170.0		**t-test** = 3.66	0.003
2hPG (mg/dL): Mean±SD Range	213.66±26.15 170.0–250.0		191.83±21.27 170.0–230.0		**t-test** = 4.41	0.002
HbA1c %: Mean±SD Range	8.54±1.95 6.50–9.80		7.48±1.87 6.30–8.60		**t-test** = 2.72	0.007
Glycemic level*: Controlled Uncontrolled	11 54	16.9 83.1	17 22	43.6 56.4	8.81	0.002

*Glycemic leveldetermined by 3 glucose parameters (FBG, 2HPPG and HbA1c).

Table 3: Distribution of diabetic participants according to glycemic control

	Diabetic status				χ^2 test	P value
	Controlled (n=28)		Uncontrolled (n=76)			
	No.	%	No.	%		
Age (years): Mean±SD Range	44.05±6.37 39– 55		41.88±5.19 34– 48		**t-test** = 1.78	0.078
Sex: Male Female	11 17	39.3 60.7	17 59	22.4 77.6	2.98	0.084
Residence: Urban Rural	12 16	42.9 57.1	44 32	57.9 42.1	1.86	0.173
Marital status: Unmarried Married	7 21	25.0 75.0	12 64	15.8 84.2	1.16	0.281
Level of education : Diploma Institute Bachelorate	13 9 6	46.5 32.1 21.4	32 29 15	42.1 38.2 19.7	0.32	0.852
Working unit at hospital : Medical Surgical	16 12	57.1 42.9	31 45	40.8 59.2	2.21	0.137
Years of work experience: ≤ 10 years 10– 20 years > 20 years	11 10 7	39.3 35.7 25.0	18 33 25	23.7 43.4 32.9	2.49	0.287
Working hours| Day: ≤ 8 hours > 8 hours	22 6	78.6 21.4	43 33	56.6 43.4	4.22	0.039
Smoking: Yes No	7 21	25.0 75.0	11 65	14.5 85.5	1.58	0.208
Diet: Healthy Less healthy Unhealthy	15 7 6	53.6 25.0 21.4	9 44 23	11.8 57.9 30.3	20.53	< 0.001

Comorbidities: Yes No	9 19	32.1 67.9	22 54	28.9 71.1	0.10	0.751
Family history of DM: Yes No	12 16	42.9 57.1	36 40	47.4 52.6	0.17	0.682
Physical activity : Yes No	11 17	39.3 60.7	8 68	10.5 89.5	11.33	0.007
BMI (kg/m²)*: Normal Overweight Obese	11 9 8	39.3 32.1 28.6	7 38 31	9.2 50.0 40.8	12.95	0.002
MAP (mmHg): Mean±SD Range	91.63±17.59 70.0–140.0		103.35±22.41 90.0–150.0		**t-test =** 2.65	0.015

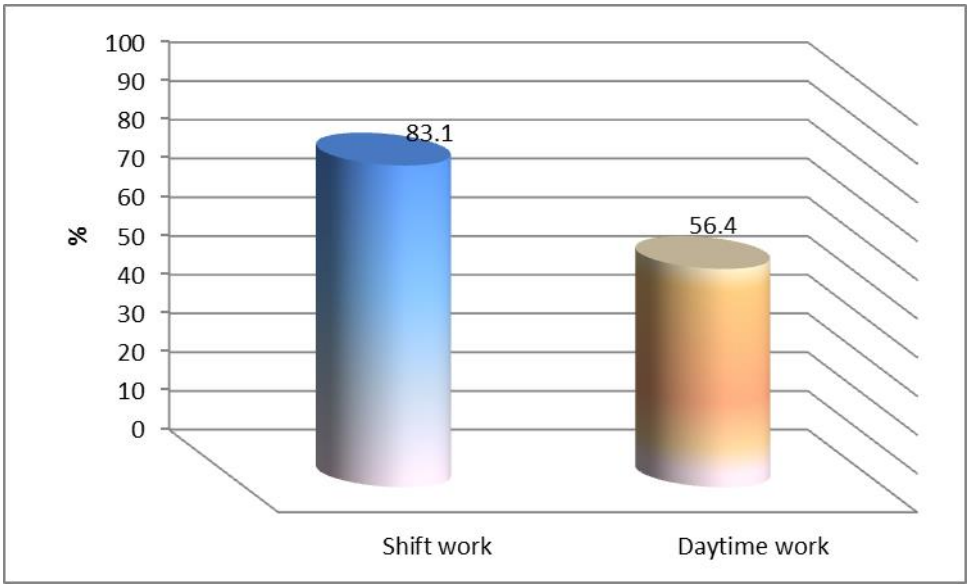
* BMI: Body Mass Index #MAP: mean arterial blood pressure

Table 4: Multiple regression analysis of variables controlling diabeteswith glycaemic level as an outcome

Variables	Wald	P value	OR	95% CI	
				Upper	Lower
Family history (Positive)	4.79	0.029	2.73	1.06	7.66
Working hours (> 8 hours)	1.79	0.17	0.38	0.21	0.83
Years of experience (> 20 years)	1.76	0.189	0.37	0.19	0.75
Diet (unhealthy)	2.86	0.041	2.53	0.86	7.39
Physical activity (No)	2.72	0.099	0.35	0.12	1.22
BMI (obese)	4.16	0.041	3.29	2.04	10.33
Night Shift	4.95	0.003	4.25	2.18	9.71
Constant	-5.54	0.037	3.11		

OR: Odds Ratio CI: Confidence Interval

Figure (1): Uncontrolled glycemic level among diabetic participantsaccording to work status.



DISCUSSION

A set of biological processes including sleep-wake cycles, metabolism, body temperature, and endocrinal secretions are regulated by the circadian rhythms. Chronic misalignment between the endogenous circadian timing system and the behavior cycles is usually linked to rotating night shift work [1].

This study investigates the relation between shift work and glycemic control, and it shows that T2DM nurses who worked overnight (62.5%) had a significantly worse glycemic control, assessed by glucose parameters including FBG, 2HPPG and HbA1c, than those performing day work (37.5%).

These findings had a similar agreement with Albishri et al. [12] evaluating diabetic healthcare workers glycemic control and shift working in Saudi Arabia, reporting that health care shift workers (39.4%) had worsened glycemic control among diabetic employees when compared to daytime workers (60.6%).

These findings also supported by Her et al. [15] that revealed circadian rhythm disruption is associated with impaired glucose metabolism and type 2 diabetics and Manodpitipong et al. [11] found that night shift workers had a significantly higher HbA1c % levels compared with day time workers. This may be due to sleep restriction and disruption, intermittent hypoxia and circadian misalignment, which resulted in reduced insulin sensitivity without adequate insulin response and the increase in glucose level usually owing to be the result of an exaggerated postprandial glucose response.

There was a significant association between longer duration of rotating night shift work and increasing risk of diabetes (Table 2). Similarly, Pan et al. [7] supported this dose-response relationship as with increased years of night shift work, there was increase in the risk for diabetes which indicated a dose-response manner: increased risk of developing of DM by 20% for 3 to 9 years of shift work; increased risk by 40% for 10 to 19 years; and for equal or more than 20 years, by 58%.

The current study reported that increased overweight and obesity rates in shift workers 46.1% and 44.7% respectively. These findings agreed with El Tayeb et al. [16] survey that showed that group of rotating shifts had significantly higher BMI compared to the other group of daytime work.

Regarding the association between shift work and weight gain and consistent with the current study (Table 2), supported by Zitting et al. [17] who stated that about 14% of Americans shift workers exposed to chronic circadian disruption due to increasing their risk of obesity, diabetes and different cardiometabolic disorders.

Weight gain in shift workers not only due to different food availability (less and unhealthy diet as high-fat food, frequent snacking and more carb containing diet with its deleterious effect on DM control as shown in Young et al. [18] but also, bad exercise activity than daytime workers.

This in accordance with Peplonska et al. [19] study revealed that nurses working in rotating night shift regime had considerably lower physical activity than those of daytime work.

Assessing BMI and weight gain in shift workers was of great interest for many studies as in Manodpitipong et al. [11] which revealed that night shift workers consumed a greater daily calorie than other groups, also Sooriyaarachchi et al. [20] showed night shift workers had the highest calorie intake leading at a long term to a higher BMI.

These results indicate that chronic circadian disruption has a deleterious effect on metabolism even in the absence of significant sleep loss. Also, exercise improves insulin sensitivity, glucose uptake in skeletal muscle and respectively glucose control

The present study reported that increased MAP among rotating shift workers in comparison with day shift ones. This finding was agreed by Ho et al. [3] who found that shift workers had a higher risk of incident and fatal cardiovascular disease (CVD) and mediated by modifiable risk factors including sleep duration and quality that affected by shift work, adiposity and metabolic status.Gao et al.[1] also reported an increase in MAP among rotating shift employee.

There are also other factors that may play a vital role in glucose metabolism in shift workers, including exposure to light at night,

sleep disturbances and alterations in meal timing [15].

Sleep parameters including both sleep duration and sleep quality are considered to be risk factors for developing diabetes and often reduced in shift workers [21]. Also sleep disturbances have been shown to be associated with insulin resistance (IR) and poor glycemic control type 2 diabetics consistent with Boivin et al. [5] founded that sleep deprivation and improper physical activity among night time workers were more when compared with daytime ones as sleep deprivation occurs owing to night shift, the homeostatic drive for sleep increases. Chontong et al. [8] studied the sleep patterns in diabetic patients working in rotating shifts using an overnight polysomnography, diabetic patients with alterations in sleep spent less time in slow-wave sleep and more time in stage 2 along with an increase in growth hormone, adrenocorticotropic hormone and epinephrine levels, diabetic patients reported also significantly longer sleep duration on weekdays than healthy controls.

Light is a potent effector of the circadian rhythm and can affect the circadian gene expression [22]. Increased ambient light exposure at night equal or more than 3 lux was associated with a 51.2% increase in developing diabetes especially in the elderly and with increases in BMI [23].

Light is known to be a suppressor of melatonin production and detected by lower urinary melatonin level and associated with increased incidence of diabetes [24].

Food exposure at night could lead to circadian misalignment, resulting in altered metabolism. In night workers, possibly due to worsen insulin sensitivity is more in the evening; night eating is associated with poor glycemic control [25]. Collectively, these factors may contribute to abnormal glucose metabolism in night-shift workers. Also, Wirth et al. [26] supported this finding by declaring that rotating shift workers consumed an unhealthier diet with higher daily calories more than fixed day time workers.

All of these factors were contributors to disturbed glucose metabolism and poor glycemic control in night-shift workers, some studies supported these findings [5, 11, 12, and 15]. Regarding the effect of sex differences in increased risk of uncontrolled DM, There was a non-significant association between them (Table 3). In contrast to Chontong et al. [8] who found an increased risk in male shift workers 37% compared by females 9%.

There was a significant association between unhealthy diet, physical inactivity, obesity, working at night shift and DM (Table 3). Also, factors as positive family history, unhealthy diet, obesity, working at night shift were considered significant risk predictors for poor diabetic control for night shift workers especially those with DM (Table 4).

CONCLUSION

This study revealed that type 2 diabetic nurses working rotating night shifts had poor glycemic control that may be due to chronic circadian misalignment. Circadian misalignment can lead to many negative metabolic consequences, including an increase in blood glucose, IR and increased MAP. Night shift working also associated with bad dietary foods habits, weight gain, less exercise, bad psychological mood, inverted sleep rhythm, night light exposure and endocrinal disturbance, all had a negative impact on their glycemic control. According to the study findings, a reasonable diabetic control was associated with fixed daytime work, a healthy diet and exercise. Occupational health practitioners diagnosed with DM should therefore be aware of modifying mealtimes, adjusting insulin dosing schedule avoiding factors triggering hypoglycemia episodes by consulting diabetic specialists who should be available at the hospital employee clinic.

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Author contribution: All persons who meet authorship criteria are listed as authors, and all authors certify that they have participated sufficiently in the work. Asmaa A. Abdel Latif has the role of getting the idea, sharing in statistical analysis, writing the methodology and results sections, final revision. Zeinab A. Kasemy has the role of

revising the idea and protocol from its beginning passing to revision of the final manuscript. Moustafa B. Ata has the role of getting the idea, collecting the data, writing discussion and revision of the final manuscript.

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