ISSN- 2394-5125 VOL 7, ISSUE 04, 2020

METABOLIC SYNDROME AMONG SHIFT WORKERS IN MINIA MILLS, EGYPT.

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Abstract

Background: Twenty-four hour services are a growing part of modern society. Essential services are provided without interruption. As a result, companies and hospitals require employees to work continuously, creating a need for shift- and night-work schedules. The growing importance of shift and night work in meeting the demands of modern society creates an urgent need for research into the effects of such schedules on worker health. Shift work is associated with health problems, including metabolic syndrome. This study investigated the association between shift work and metabolic syndrome.

Aim of the study: to determine percentage of metabolic syndrome among workers Minia mills and to compare percentage of metabolic syndrome between day time and night shift workers in this mill.

Subjects and methods: This is a descriptive cross-sectional study which carried out in Minia mills, Egypt, during the period from September 2018 to March 2019. This study was conducted among 107 workers who were agreed to be interviewed and participate in this study. Data were collected by a questionnaire included demographic data, anthropometric measurements and laboratory tests are performed to determine metabolic syndrome.

Results: The percentage of metabolic syndrome was 61.7%. 72.7% of nightshift workers and 50% of daytime workers have metabolic syndrome (p=0.01). After adjusting for confounding factors, shift work was associated with metabolic syndrome (odds ratio, 3.2; 95% confidence interval, 1.2-8.5).

Conclusion: Shift work was associated with metabolic syndrome in Minia mills.

Recommendation: Applicable intervention strategies are needed for prevention of metabolic disorders for shift workers.

Key words: Metabolic Syndrome; Prevalence; shift work

I- Introduction:

Twenty-four hour services are a growing part of modern society. Essential services are provided without interruption, and several industries and business establishments operate on a 24 h basis so as to meet the constantly changing demands of the modern world **(Moreno et al., 2003)**. As a result, companies and hospitals require employees to work continuously, creating a need for shift- and night-work schedules. Shift schedules allow companies to operate on a continuous basis by ensuring that positions are always filled by rotating employees.

The growing importance of shift and night work in meeting the demands of modern society creates an urgent need for research into the effects of such schedules on worker health. Recent findings suggest that such schedules may affect glucose tolerance and induce obesity and systemic arterial hypertension **(Karlsson et al., 2001; Morikawa et al., 2005; Froy, 2007; Bacquer et al., 2009).**

Human natural body rhythms are called circadian rhythms which are regulated by a “circadian clock”; located in the hypothalamus. This biological clock is synchronized by receiving the photic information from light-sensitive ganglion cells in the retina, thereby entraining individuals’ physiology and behavior to the external day–night cycle **(Szosland, 2010; Golombek, 2010)**. Nearly all of the biological processes including the sleep-wake cycles, body temperature, energymetabolism, cell cycle and hormone secretion have a circadian rhythm and are controlled by this circadian clock **(Kohyama, 2009; Golombek, 2010).**

Shift work is recognized as a risk factor of many health outcomes by interrupting human circadian rhythm **(Bjorvatn et al., 2009; Hublin et al., 2010)**. Circadian rhythm can have effect on sleeping and feeding patterns, and also in patterns of core body temperature, brain wave activity, hormone production and other biological activities **(Gumenyuk et al., 2012)**. Recently, accumulating evidences have shown that shift work is related with cardiovascular diseases (**Hublin et al., 2010; Vyas et al., 2012)** and type 2 diabetes **(Pan et al., 2011; Ioja et al., 2012)** even in retired populations **(Guo et al., 2013).**

The metabolic syndrome is a common metabolic disorder that results from the increasing prevalence of obesity. The metabolic syndrome (MetS) or the insulin resistance syndrome constitutes a clustering of several interrelated abnormalities that increase the risk for cardiovascular events and progression to diabetes mellitus **(Isomaa et al., 2001; Malik et al., 2004).** It consists of a clustering of cardiovascular risk factors, such as central obesity, elevated blood

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pressure, glucose intolerance, and dyslipidemia **(Szosland, 2010).** Individuals with this condition have an elevated risk of developing cardiovascular diseases **(Wannamethee et al., 2005; Ninomiya et al., 2007)** and T2D in different ethnic populations **(Wannamethee et al., 2005; Meigs et al., 2007; Cameron et al., 2008; Mannucci et al., 2008).**Clinical identification of the metabolic syndrome according to National Cholesterol Education Program – Third Adult Treatment Panel (NCEP ATP III) **(UKPDS Group, 1996; Dunstan et al, 2002):**

Three or more of the following five risk factors:

- Central obesity:

• Men Waist circumference > 102 cm (> 40 in)

• Women Waist circumference> 88 cm (> 35 in)

- TG ≥ 150 mg/dL (1.7 mmol/L)
- HDL cholesterol:

• Men < 40 mg/dL (1.03 mmol/L)

• Women< 50 mg/dL (1.29 mmol/L)

- Blood pressure ≥ 130/ ≥ 85 mm Hg
- Fasting glucose ≥ 110 mg/dL (6.1 mmol/L)

II- Aim of the study:

Aim of the study: to determine percentage of metabolic syndrome among workers Minia mills and to compare percentage of metabolic syndrome between day time and night shift workers in this mill.

III- Research design and methods:

- **Study design:** This is a descriptive cross-sectional study which carried out in Minia mills during the period from September 2018 to March 2019.

Administrative and ethical consideration: The study was approved by the ethical committee of the Faculty of Medicine, Minia University. Prior to data collection, informed consent was obtained from all participants after supplying comprehensive information about the nature of the study and the procedural details of the blood investigations. An approval was taken from the mills administration to interview and examine the workers.

- **Study population and sample size:**

All workers of Minia mills who aged 18-60 years old.

- **Daytime workers and shift workers:**

Daytime workers were defined as those individuals who worked from 9am to 2pm only, while the rest - those who worked 3 shifts of 8 hours, from 7am to 3pm, from 3pm to 11pm and from 11pm to 7am- were considered shift workers.

- **Collection of data:**

Data were collected by a structured interview questionnaire, included demographic data, working conditions, occupational history and health related behaviors.

- **Anthropometric measurements**

Body weight (in kilograms): was measured by a standardized balanced scale with the participant stand on the center without touching anything else, bare feeted and in light clothing. Reading recorded to the nearest kg, adjust the scale to zero after each weighting.

Height (in centimeters): was measured by a standardized measuring tape, during the procedure the participants were bare feeted and were instructed to be fixed tightly to the wall at shoulders, back of knees and heels, the external auditory meatus and the lower border of the orbit in the plane parallel to the floor.

BMI was calculated by the use of the following equation:

BMI = weight (kg) / height (m^2) **(Bray, 1993)**.

● Waist circumference (in centimeters): was measured by using non stretchable measuring tape at the midway between the 12^{th} rib and the iliac crest, the person stands with abdomen relaxed, arms at sides, and feet together (**Han et al., 1995**).

Central obesity was diagnosed for waist circumference ≥ 94cm for men and ≥ 80cm for women according to the IDF recommendations for Mediterranean **(IDF, 2006).**

● Waist to hip ratio (WHR) (in centimeters): was measured by using non stretchable measuring tape to measure waist circumference and measure the distance around the largest part of hips (hip circumference) then calculated by dividing waist circumference by hip circumference **(WHO,2008)**.

- **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 **(ADA,2013).** Next post-prandial blood glucose (PPG) level after two hours was measured by using Rightest

ISSN- 2394-5125 VOL 7, ISSUE 04, 2020

™ 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 **(ADA, 2013).**

- **Blood pressure Screening Protocol**

BP measurements were obtained on the right arm, with the participant in a seated posture with feet on the floor and arm supported at heart level, after at least 15 min of rest. An appropriate size of cuff and a standard mercury sphygmomanometer were used. All the sphygmomanometers were checked and calibrated before use.

- **Supplies:**

Stethoscope and Sphygmomanometer blood pressure cuffs.

Classification according to Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure Classification (JNC-7) 2017:

- **Normal:** Less than 120 (mm Hg) **Systolicand** Less than 80(mm Hg) **Diastolic**
- **Prehypertensive:** 120 - 139(mm Hg) **Systolic and** 80-89 (mm Hg) **Diastolic**
- **Stage 1 Hypertension:** 140 - 159 (mm Hg) **Systolic or** 90 – 99 (mm Hg) **Diastolic**
- **Stage 2 Hypertension:** 160 or higher (mm Hg) **Systolicor** 100 or higher (mm Hg) **Diastolic**

- **Lipid profile Screening Protocol**

A serum lipid profile, including total cholesterol, high-density lipoprotein (HDL) cholesterol, low-density lipoprotein (LDL) cholesterol and triglyceride (TG), was ordered for subjects after fasting for 12 hours, and the laboratory results were assessed.

- **According to ATP III (2003), normal ranges of lipid profile are:**

Lipid Guidelines 2018: Updates from ACC/AHA Guidelines 2013

- **Total cholesterol: <200**
- **LDL cholesterol: <100**
- **HDL cholesterol: >40**
- **Triglycerides: <150**

All the laboratory tests were taken by laboratory technician and were done in Minia University Hospital lab.

Criteria of metabolic syndrome:

After an overnight fast, all participants got physical examinations by trained physicians, nurses and technicians. In this study, we defined MetS according to the diagnostic criteria proposed by the Adult Treatment Program III of the National Cholesterol Education Program (NCEP ATP III, 2002), participants were recognized as MetS patients if they met three or more of the following variables and cutoff points: (1) Fasting triglyceride_1.69 mmol/L (150 mg/dL); (2) HDL cholesterol:Men<1.04 mmol/L (40 mg/dL), Women<1.29 mmol/L (50 mg/dL); (3) Fasting glucose: _5.5 mmol/L (100 mg/dL); (4)Waist circumference: men >102 cm, women >88 cm; (5) Systolic blood pressure _130 mmHg and/or diastolic blood pressure_85 mmHg.

IV- Statistical analysis:

The Statistical Program SPSS for Windows version 19 was used for data entry and analysis. Graphics were done by Excel Microsoft office 2013.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. Risk ratios were estimated by calculating odds ratios (OR); and a regression analysis was performed. The lowest accepted level of significance was less than 0.05.

V- Results:

Table 1: General characteristics of the studied workers in Minia mills, Egypt, during the period from September 2018 to March 2019.

General characteristics	N=107
Age: Mean ± SD	24 - 60 (46.8±11.01)
Residence • Urban • Rural	 60 (56.1%) 47 (43.9%)
Marital status • Married • Widow	 100(93.5%) 7 (6.5%)
Total duration of occupation (years)	23.3 ± 13.1

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Total duration of rotating shifts (years)	14.2 ± 10.8

N.B. Quantitative data were expressed as range (mean±SD) and qualitative data were expressed as No (%).
This study included 107 workers; whose ages ranged from 24 to 60 years with mean ± SD (46.8±11.01) years (table1). The majority (93.5%) of the participants were married, and 56.1% were urban inhabitants. The mean duration of occupation was 23.3 ± 13.1, while mean duration of night shifts throughout their job experience was 14.2 ± 10.8. In this study, 51% of studied workers were shift workers and 49% were daytime workers.

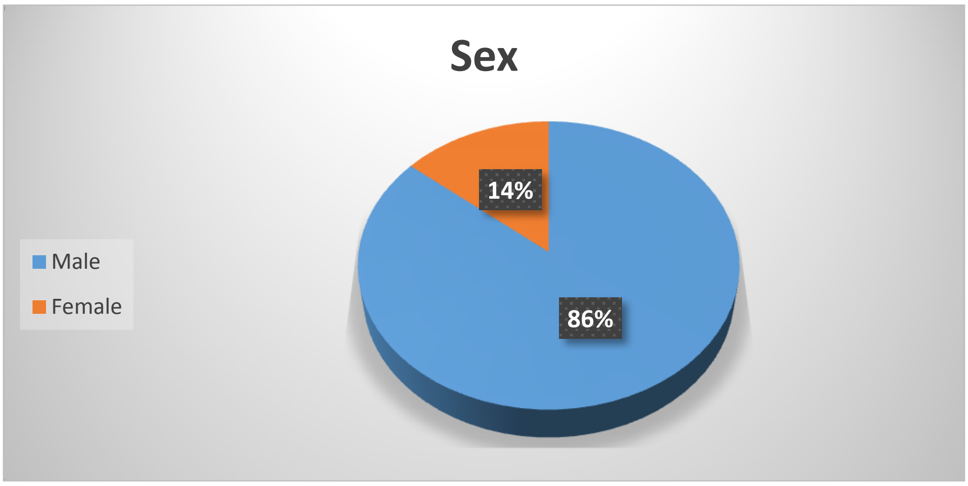

Figure 1 Gender distribution among the studied workers in Minia mills, Egypt, during the period from September 2018 to March 2019.

In this study, 86% of the studied workers were males and 14% were females.

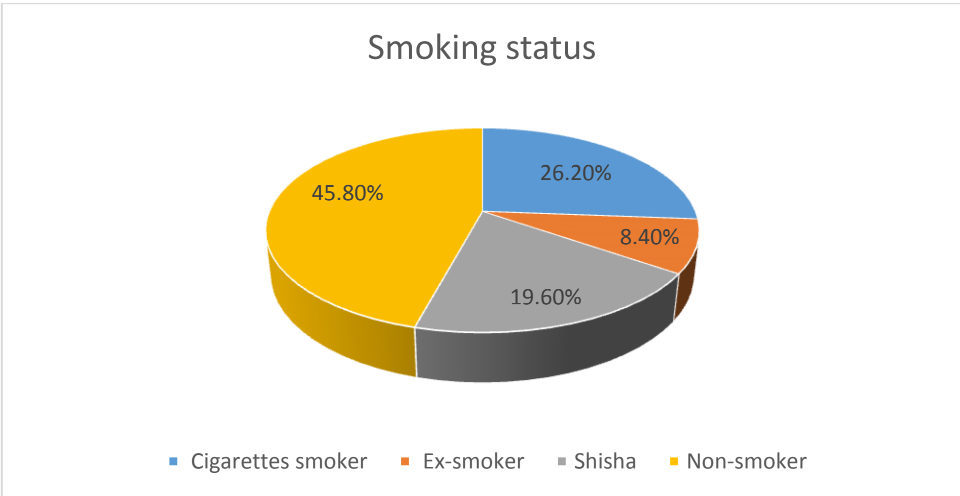

Figure 2 Smoking status of the studied workers in Minia mills, Egypt, during the period from September 2018 to March 2019.

As regard smoking status, 26.2% were cigarettes smoker and 19.6% were shisha smoker.

Table 2: Smoking status in the studied workers according to work schedules in Minia mills, Egypt, during the period from September 2018 to March 2019.

	Rotating shifts n=55	**Day time work n=52**	**P**
Smoking status			**<0.0001**
• Smoker	36(65.4%)	13(25%)	
• Ex-smoker	1(1.8%)	8(15.4%)	
• Non-smoker	18(32.7%)	31(59.6%)	

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Smoking index of cigarette	740.7 ± 801.3	576.2±324.9	0.5
Duration of smoking (years)	23.4±13.8	20±8.5	0.6

There was significant difference between the shift workers and daytime workers regarding smoking status, (34.5% and 17.3%) cigarette smoker in both groups respectively. Regarding Shisha smoking there was significant difference between the shift workers and daytime workers as the prevalence of Shisha smoking was higher in nightshift workers than in daytime workers (30.9% and 7.7%) respectively (table 2).

Table 3: Physical activity of the studied workers according to work schedules in Minia mills, Egypt, during the period from September 2018 to March 2019.

	Rotating shifts n=55	**Day time work n=52**	**P**
Physical activity • ≥0.5 hour /day • <0.5 hour /day	 43(78.2%) 12(21.8%)	 27(51.9%) 25(48.1%)	**0.004**

It was shown that 78.2% of night shift workers are physically active while 51.9% of day time workers are physically active which was statistically significant (table3).

Table 4: Anthropometric measurements in the studied workers according to work schedules in Minia mills, Egypt, during the period from September 2018 to March 2019.

	Rotating shifts n=55	**Day time work n=52**	**P**	**t**
Waist circumference (cm)	102.4±9.9	100.9±9.4	0.4	0.7
Hip circumference (cm)	103.6±8.5	113.8±14.1	**<0.001**	4.6
W / H Ratio	0.99±0.06	0.89±0.06	**<0.0001**	6.9
BMI • ≥25 • <25	 47(85.5%) 8(14.5%)	 44(84.6%) 8(15.4%)	0.9	**X^2** 0.01

In table 4, the mean of W/H ratio was significantly higher among shift workers compared to day workers (0.99±0.06 compared to 0.89 ±0.06) with p<0.0001. Also, the mean of waist circumference was significantly higher among shift workers compared to day workers (102.4±9.9 and 100.9±9.4) but without statistical significance. The percentage of persons had BMI ≥25 was higher among night shift workers than among daytime workers (85.5% compared to 84.6%) but without statistical significance.

Table 5: Blood pressure measurements of the studied workers in Minia mills, Egypt, during the period from September 2018 to March 2019.

Characteristics	**Rotating shifts n=55**	**Day time work n=52**	**P**	**t**
Systolic BP	125.6±14.8	129.4±14.5	0.2	1.3

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Diastolic BP	86.3±9.2	85.3±9.6	0.6	0.5

As shown in table 5, the mean of systolic BP was higher among day time workers compared to shift workers (129.4±14.5 compared to 125.6±14.8). On the other hand, the mean of diastolic BP was higher among shift workers compared to day workers but without statistical significance.

Table 6: Metabolic syndrome status of the studied workers in Minia mills, Egypt, during the period from September 2018 to March 2019.

Characteristics	**Rotating shifts n=55**	**Day time work n=52**	**P**
ATP III criteria • Yes • No	 40(72.7%) 15(27.3%)	 26(50%) 26(50%)	**0.01**
TG • ≥150mg/dl • <150mg/dl	 50(90.9%) 5(9.1%)	 33(62.3%) 20(37.7%)	**0.001**
HDL • Men ≤ 40 mg/dL Women≤50 mg/dL • Men >40 mg/dL Women>50 mg/dL	 40(74.1%) 14(25.9%)	 37(69.8%) 16(30.2%)	0.6
BP • ≥130/85mmHg • <130/85mmHg	 27(49.1%) 28(50.9%)	 31(59.6%) 21(40.4%)	0.3
Waist circumference • Men ≥102 cm Women ≥88 cm • Men<102 cm Women <88 cm	 29(52.7%) 26(47.3%)	 22(42.3%) 30(57.7%)	0.3
FBG • ≥110 mg/dl • < 110mg/dl	 20(36.4%) 35(63.6%)	 22(42.3%) 30(57.7%)	0.5

In table 6, regarding the ATP III criteria, the rotating shift workers reported significantly higher prevalence of metabolic syndrome (72.7%) than the day-time ones (50%) with P=0.01. The percentage of persons had TG ≥ 150mg/dl was significantly higher among shift workers, where 90.9% of them had TG ≥ 150mg/dl compared to 62.3% of day time workers (p=0.001).

The percentages of persons had HDL (≤ 40 mg/dL in men and ≤50 mg/dL in Women) and waist circumference (≥102 cm in men and ≥88 cm in women) were higher among shift workers, where 74.1% of them had HDL (≤ 40 mg/dL in men and ≤50 mg/dL in Women) and 52.7% of them had waist circumference (≥102 cm in men and ≥88 cm in women) respectively compared to 69.8% and 42.3% of day time workers, respectively but without statistical significance.

On the other hand,the percentages of persons hadFBG ≥110 mg/dl and BP ≥130/85mmHg were higher among day time workers, where 42.3% of them had FBG ≥110 mg/dl and 59.6% of them had BP ≥130/85mmHg respectively compared to 36.4% and 49.1% of shift time workers, respectively but without statistical significance.

Table 7: Binary logistic analysis for factors associated with metabolic syndrome in the studied workers (n=107) in Minia mills, Egypt, during the period from September 2018 to March 2019.

Independent factors	**Model I[a] OR (95% CI)**	**Model II[b] OR (95%CI)**
Age	1.01 (0.9-1.05)	1.1 (0.9-1.1)
Waist/hip ratio	2.5 (0.9-6.7)	2.4 (0.8-6.9)
Shift working Day time	 1.0 (reference)	 1.0 (reference)

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Rotating shifts	2.7 (1.2-5.9)*	3.4 (1.3-8.5)*
Smoking status		
Non-smoker	1.0 (reference)	1.0 (reference)
Smoker	1.8 (0.8-4.1)	1.1 (0.8-1.7)
Physical activity		
Physically active	1.0 (reference)	1.0 (reference)
Physically inactive	1.7 (0.7-4.1)	2.9 (1.1-7.9)*

a Model 1 presents odds ratios (95% confidence intervals) from a crude model which contains only one variable at the time

b Model 2 presents odds ratios (95% confidence intervals) from a multivariable-adjusted model adjusted for age, waist/hip ratio, shift working, smoking status and physical activity.

Table 7 shows the crude and multivariable-adjusted ORs (95% CIs) for factors associated with metabolic syndrome. Rotating shifts and physical inactivity are significant predictors of metabolic syndrome. Worker in rotating shifts are about three and half times more likely to have metabolic syndrome than day-time workers; the multivariable-adjusted OR (95% CI) is 3.4 (1.3-8.5). Being physically inactive has higher odds to have metabolic syndrome; the multivariable-adjusted OR (95% CI) is 2.9 (1.1-7.9).

VI- Discussion

As a result of the rapidly evolving 24-h society, about 15–30% of the workforce works outside normal business hours, with about half of them working rotating shifts **(Puttonen, 2010).**

In the present study, the total percentage of workers who have metabolic syndrome are 61.7%. 72.7% of rotating shift workers and 50% of daytime workers have metabolic syndrome (p=0.01) with odds ratio 3.4 (95% CI 1.3-8.5) (table 6 &7). These results are similar to that of **ALY et al., 2018** who conducted a comparative study in an Electricity Distribution Company in Ismailia city, Egypt. 100 shift workers and 100 non shift workers were chosen by systematic random method to clarify the relation between rotating shift work and metabolic syndrome components. This study found that 53% of shift workers had metabolic syndrome compared to 39% of day workers (p=0.04) with odds ratio 1.8 (**ALY et al., 2018**). These results higher than that reported with**Nikpour et al., 2019** who evaluated the association between shift work and metabolic syndrome [based on the National Cholesterol Education Program Adult Treatment Panel III guidelines (ATP III)] during reproductive age in 419 female shift and day workers in Mazandaran, Iran and found that the total prevalence of metabolic syndrome was 16.3%, and its prevalence among shift workers and day workers was 17.3 and 14.9%, respectively with odds ratio 1.83 (95% CI, 0.09-3.8). These results come in accordance with the findings of **Ye et al.2013** who study associations between shift work and the metabolic syndrome in female workers from the Daegu area Dyeing Industrial Complex, Korea, and found that the prevalence rates of the metabolic syndrome for the total group of study subjects was 11.8%, for daytime workers was 2.8%, and for shift workers was 15.3% with odds ratio 6.30 (95% CI 1.24-32.15).

Comparison of the TG levels among the shift workers and daytime workers revealed significant higher percentage of workers with TG ≥150 mg/dl in shift workers 90.9% compared with 62.3% of day-time ones, (table 6). Such results were similar to that of **Karlsson et al., 2003** who investigate the relationship between metabolic risk factors for coronary heart disease (CHD) and type 2 diabetes in shift workers and day workers and found t0hat high levels of triglycerides were significantly associated with shift work (OR: 1.40, 95% CI: 1.08–1.83). These results were consistent with the finding of **Biggi et al., 2008** who examined the relationship between permanent night work and metabolic and cardiovascular risk factors in a retrospective longitudinal study of workers employed in a large municipal enterprise in charge of street cleaning and domestic waste collection and found that night workers smoked more and had significantly higher triglycerides than day workers.

Comparison of the waist to hip ratio levels among the studied categories revealed significant higher levels in shift workers (0.99±0.06), than the day-time ones (0.89±0.06), (table 4). Such results were similar to that of **Sookoian et al. (2007)** who examined the effects of rotating shift work on biomarkers of metabolic syndrome and inflammation and found that rotating shift workers had elevated waist-hip ratio (0.95 ± 0.01 vs. 0.93 ± 0.01) in daytime workers. These results were consistent with the findings of **Ghanbaryet al., 2016** who investigated the relationship between shift work, and body mass index and waist-hip ratio among military personnel in 2016 and found that mean body weight, waist circumference, hip circumference, BMI, and WHR were higher in shift workers than day workers. The findings showed that 80.3% of shift workers had a WHR of higher than 0.90. Another cross-sectional study was conducted among 724 female nurses and midwives, aged 40-60 years (354 rotating night shift and 370 daytime workers) in Poland, revealed both current and cumulative night work was associated with higher WHR **(Peplonska et al., 2015).**

The current study showed that there were no significant differences in BMI and waist circumference between shift workers and daytime workers (table 4). Consistent results from previous studies that were summarized in a review article by **(Bøggild and Knutsson, 1999),** who showed no significant difference in BMI among shift and daytime workers. **Ghiasvand et al., (2006)** evaluated the association between shift work and biochemical variables and blood pressure, in a total of 424 Iranian rail road workers. This study found that no differences were seen in obesity prevalence among shift workers **(Ghiasvand et al., 2006).**

Regarding to physical activity, in the present study, there were 78.2% and 51.9% of shift workers and daytime workers respectively, physically active (table 12), this can be explained by the shift workers are manual workers while the daytime workers are clerk. These results come in accordance with the findings of **Gadallah et al., 2017** who evaluated the relationship between rotatory shift and lipid profile and studied factors associated with dyslipidemia among nurses in an Egyptian tertiary university hospital (Ain Shams University hospital) and found that 31.4% of shift nurses and 26.6% of day shift nurses reported moderate intensity exercise. Additionally, a study by **Cathy et al. (2017)** reported similar results that the shift workers more physically active than daytime workers in UK Biobank study with 277,168 employed participants.

In the current study, the percentage of smokers was higher in shift workers than in daytime workers (65.4% compared to 25%) (table 2).These results are similar to that of **Buchvold et al., 2015** who found that smoking was more prevalent in shift Norwegian nurses. Another study concluded that cigarette smoking also appears to disrupt lipid and lipoprotein metabolism, leading to elevated plasma Cholesterol, Triglycerides and LDL-cholesterol, and lower HDL-cholesterol levels as compared to non-smokers **(He B.M, 2013).**

VII- Conclusion and recommendation:

Our study revealed that rotating shift work especially night shifts has negative effects on health as it contributes in developing of metabolic syndrome. 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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