

Relationship Between Rotating Night Shift Work and Anthropometric Markers of Overall and Central Adiposity

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Purpose: This study aimed to investigate possible association between rotating night shift (RNS) work and anthropometric markers of overall and central adiposity among male workers.

Methods: Medical records of workers who underwent medical examination at the Occupational Medicine Unit affiliated with Alexandria Faculty of Medicine were reviewed in December 2021 to extract data about RNS, overall adiposity [body mass index (BMI) from 25 to 29.9 kg/m² indicated overweight, while BMI \geq 30 kg/m² indicated obesity], central adiposity (waist circumference \geq 94 cm). Univariate and multivariate logistic regression were done to model adiposity as a function of potential demographic, lifestyle, and occupational factors.

Results: Data of 647 male workers, including daytime workers (26.9%) and RNS workers (73.1%) who spent 1–5 years, 6–9 years, or \geq 10 years working RNS, were analyzed. No association was found between RNS work and overall adiposity (BMI \geq 30 kg/m²). In multivariate regression, age, residence, and smoking status were predictors of an increased BMI. Compared with young workers (<30 years old), the odds of an increased BMI (BMI \geq 25 kg/m²) were 2.6 and 3.01 times higher among workers who were 30–<40, and 40–<50 years old, respectively [95% CI=(1.35, 5.05) and (1.19, 7.56), respectively]. Workers who lived in urban areas were less likely to have had an increased BMI (OR=0.34, 95% CI=0.16, 0.74). The odds of an increased BMI were 2.14 times higher in workers who never smoked compared with current smokers (95% CI=1.12, 4.11). No association was found between RNS and central adiposity. In multivariate regression, age was the sole predictor of central adiposity.

Conclusion: The study supports the idea that RNS work might not be associated with overall or central adiposity and highlights a possible association between central adiposity and age and association between BMI and age, residence, and smoking behavior. Longitudinal, larger studies are required to explore the relationship between RNS and adiposity.

Keywords: adiposity, body mass index, obesity, shift work, waist circumference

Introduction

Shift work is essential in today's 24/7 modern society including health care and emergency services, hospitality, transport, and manufacturing.¹ The International Labour Organization and European Foundation for the Improvement of Living and Working Conditions, compared exposure to shift work across 187 countries covering approximately 1.2 billion of the world's workers. According to the joint ILO-Eurofound report (2019), between 10% and 30% of workers were working night shifts at least once a month.² Working on a night-shift schedule was reported by 12% to 13% of the workforce in some countries.^{3,4} Other types of atypical shifts (split shifts, irregular shifts, on call) also occur, but more difficult to define and quantify.¹

Night shift work is accompanied by sleep restriction with concurrent deregulation of the circadian clock (due to desynchronization between sleep and the natural light-dark cycle). Prolonged sleep restriction and circadian disruption can induce metabolic adaptations including a decrease in the resting metabolic rate and an increase in the plasma glucose

concentration after a meal (due to inadequate pancreatic insulin secretion), to maintain blood glucose levels in a narrow constant range and ensure brain function. Those metabolic changes could lead to an increased body mass index (BMI).⁵ In addition, night shift work could influence health-related behaviors like eating and fasting patterns, smoking, physical activity, and alcohol consumption;^{6,7} and suppress the secretion of melatonin which regulates the levels of metabolism-related hormones (such as cortisol, insulin, and leptin).⁸ Such behavioral changes would promote weight gain and obesity among night shift workers.⁹

The Centers for Disease Control and Prevention (CDC) define overweight or obesity as weight that is higher than what is considered healthy for a given height.¹⁰ According to Liu et al meta-analysis, BMI has been used as a universally accepted anthropometric method to classify overweight and obesity.¹¹ Despite the fact that BMI measures excess weight rather than excess fat, it is found to be moderately correlated with more direct measures of body fat, such as skinfold thickness measurements, underwater weighing, and dual energy x-ray absorptiometry. In addition, BMI was found to be strongly correlated with various adverse health outcomes consistent with these more direct measures of body fatness.^{12–14} The CDC concludes that BMI is a reasonable indicator of body fat for adults, and should be used as a measure to track weight status in populations, and is considered a screening tool to identify potential weight problems in individuals.^{10,15} However, in order to diagnose overweight or obesity with greater accuracy, it is recommended to use BMI along with waist circumference, skin fold thickness, and body composition analysis.¹⁶

Today, the global pandemic of obesity presents a major challenge to public health.^{17,18} Researchers have attributed rising obesity rates to lifestyle factors rather than gene mutations.⁵ According to the World Health Organization (WHO), Egypt ranks 18th with the highest prevalence of obesity worldwide.¹⁹ In Egypt 2019, the “100 million health” National Survey screened 49.7 million adult Egyptians (≥ 18 years old), and found 39.8% of adult Egyptians suffered from obesity ($\text{BMI} \geq 30 \text{ kg/m}^2$) that was more prevalent in women (49.5%) than men (29.5%).²⁰ In Egypt 2020, the estimated total number of deaths due to obesity was around 113 thousand (19% of the total estimated number of deaths in 2020);²¹ and ischemic heart disease had the greatest share among obesity comorbidities causing mortalities.²⁰ Identifying the modifiable predictors of obesity would be crucial for the prevention of obesity-related comorbidities and mortalities.

In the literature, studies have examined the association between shift work and adiposity; however, several limitations have been reported.^{11,22–27} For example, many studies were conducted among women only,^{22–25} some relied on self-reported weight and height, which might have resulted in imprecision in BMI assessment;^{25,26} and some were conducted in certain working populations such as health professionals,¹⁷ or military personnel.²⁷ In many studies, assessment of obesity relied solely on measuring BMI which does not differentiate between body fat and muscle mass;^{11,22,24,26} whereas few studies measured waist circumference together with BMI to minimize this technical limitation.^{9,28}

To our knowledge, no studies have been conducted to examine the association between shift work and adiposity among Egyptian workers. Given the worldwide increasing prevalence of shift work,³ major impact of obesity on health,²⁰ and limitations of previous studies,^{11,22–27} the current study was conducted to investigate the association between rotating night shift (RNS) work and anthropometric markers of overall and central adiposity (BMI and waist circumference, respectively) among men workers in Egypt 2021.

Materials and Methods

Research Design and Setting

A retrospective study was conducted at the Occupational Medicine Unit (OMU) affiliated with the Alexandria Faculty of Medicine, in December 2021. Medical records of workers who underwent medical examination at OMU from May through October 2021 were reviewed.

Participants

The OMU is mostly visited by male workers who are currently employed in Alexandria's primary and secondary industries in order to get their periodic medical examinations. The OMU kept medical records for 812 workers. Workers between the ages of 20 and 60 who were actively employed and had held their current position for more than two years were eligible for this study. The above-mentioned inclusion criteria were set based on the minimum legal age for work

and retirement age; in addition, adiposity was assumed to be the result of long-term biological effects associated with displacing the sleep/awake cycle and circadian misalignment. Workers with conditions deemed to be adiposity confounders were excluded. Accordingly, 165 workers were excluded because they had a job duration of less than two years ($n = 98$), joined a weight loss program ($n = 19$), or received medications to control body weight ($n = 9$). In addition, women workers were excluded since their total number would be insufficient for the statistical analysis ($n = 26$). Incomplete medical records with more than 10% missing data ($n = 13$) were also excluded. In this study, the data of 647 eligible workers was included in the analysis.

Sample Size

Using the Open-Epi calculator, the sample size was calculated (Open-Epi online calculator, Version 3.3a, OpenEpi, Atlanta, GA, USA). The minimum required sample size would be 369 employees at a confidence level of 95% ($\alpha=0.05$), absolute precision of 5%, and an assumed prevalence of overall adiposity (overweight or obesity) among shift workers of 40%.⁹ The minimum required sample size would be 338 workers with the same confidence level and absolute precision and an expected prevalence of central adiposity of 32.6% among shift workers.⁹

Extraction of Data from the Records

Assessment of Shift Work

The eligible workers ($n=647$) were distributed according to their work schedule into: daytime workers ($n=174$): referring to workers who never work at night; and RNS workers ($n=473$): referring to workers whose work schedule involved at least three night shifts per month in addition to day and evening shifts in that month, with a rotating pattern of shifts (for example, morning shift followed by evening shift, then night shift which is then repeated).²⁸ For some workers, exposure to night work might have started after a period of time (months to years) of having daytime work; therefore, RNS workers in the current study were categorized according to the number of years spent working RNS into three subgroups: 1–5 years of RNS ($n = 169$), 6–9 years of RNS ($n = 213$), and ≥ 10 years of RNS ($n = 91$).²⁸

Assessment of Overall and Central Adiposity

The overall adiposity was measured by calculating the BMI (weight in kilograms divided by the square of height in meters). During the medical examination at OMU, the body weight and height of workers are obtained using standard balance and procedures.²⁹ Every worker is weighed barefoot and in light clothes; the weight is recorded to the nearest kilogram, and the balance is calibrated for accuracy before each session using standard weights. For the measurement of the body height, a vertical measuring scale is used; the worker stands barefooted on the flat floor with parallel feet and with heels, buttocks, shoulders, and the back of the head all touching the wall. The head is erect, with the lower border of the orbit in the same horizontal plane as the external auditory meatus. Height is recorded to the nearest centimeter (cm), then converted to meters.²⁹ In this study, according to the WHO, overweight and obesity were defined as a BMI of 25 to 29.9 kg/m² and a BMI equal to or greater than 30 kg/m², respectively. Workers with a BMI less than 25 kg/m² were classified as either normal weight (18.5 to 24.9 kg/m²) or underweight (less than 18.5 kg/m²).³⁰

The central adiposity was assessed by measuring the waist circumference (cm). At OMU, waist circumference is measured in a standard way using constant tension tape. It is taken over a light clothing at the end of a normal expiration with the arms relaxed at the sides. It is measured at the midpoint between the lower border of the costal arch and the iliac crest at the midaxillary line.³¹ In this study, according to the international guidelines, central adiposity was defined as an increased waist circumference of 94 cm or more for men.^{32–34}

Assessment of Covariates

The medical records were reviewed for workers' sociodemographic data including age, residence, education, and marital status. In addition, health-related behaviors including smoking status and physical activity were reported. As for smoking, a worker was classified as: i) never been smoker (has never smoked or smoked less than 100 cigarettes in his lifetime; ii) current smoker (has smoked more than 100 cigarettes in his lifetime and who currently smokes cigarettes); and iii) ex-smoker (had quit smoking at the time of examination).³⁵

Physical activity was reported (yes or no) according to the WHO recommendation of at least 150–300 minutes of moderate-intensity, or 75–150 minutes of vigorous-intensity physical activity each week.³⁶ In order to determine whether the worker's physical activity fulfils the WHO recommendation or not, a number of questions are asked to pinpoint the type of physical activity, degree (intensity), and overall duration per week. Moreover, self-rated health was reported as very good, good, fair, or poor.

Occupational characteristics including job duration (the whole duration of employment), work schedule (daytime work vs RNS work), and years of RNS were also reported. In addition, workers' jobs were classified according to the nature of the job into white-collar jobs, including supervisory and managerial, professional or semiprofessional, and business owner roles; pink-collar jobs, including hospitality and administration roles, retail workers, office clerks, and salesperson roles; and blue-collar jobs, including laborer and skilled trade roles.³⁷

Statistical Analysis

The SPSS v.22 (IBM Corp. Released 2011. IBM SPSS Statistics for Mac, Armonk, NY, USA) was used for analysis. Descriptive statistics were presented for qualitative data as frequencies, percentages, and 95% confidence interval (CI) of the percent, to demonstrate sociodemographic data, occupational characteristics, and health-related behaviors of the studied workers. Cross-tabulation analysis was used to present markers of overall and central adiposity in terms of RNS categories. In cross tabulations, data were demonstrated as frequencies with their respective 95% CIs, and the Monte Carlo test was used to examine a possible association. A univariate logistic regression was conducted to compute the odds ratio (OR) and assign a 95% CI to quantify the probability of overall or central adiposity (a dependent variable) associated with the RNS work (an independent variable).

Two multivariate logistic regression models were conducted among the studied workers ($n = 647$). The first one was done to model the increased BMI ($\geq 25 \text{ kg/m}^2$) (a dependent variable) associated with potential sociodemographic, lifestyle, and occupational factors, namely; age, education, residence, smoking, physical activity, job nature and work schedule, to investigate for independent associations. The second one was done to model the increased waist circumference ($\geq 94 \text{ cm}$) (a dependent variable) associated with the above-mentioned potential factors. The adequacy of the regression models in data fitting was determined by Nagelkerke's R^2 and Hosmer and Lemeshow goodness-of-fit test. The first and second models were significant and correctly classified 89.3% of workers with and without increased BMI and 64.8% of workers with and without increased waist circumference, respectively. All statistical analyses in this study were judged at the level of significance of 5% ($\alpha = 0.05$).

Ethical Considerations

The study received ethical approval from the Research Ethics Committee at the Alexandria Faculty of Medicine on March 18, 2021 (Serial Number: 0305090; IRB NO: 00012098; FWA NO: 00018699). Prior to the start of the study, informed consent was obtained from the workers. The confidentiality of the collected data was ensured. This study was performed in compliance with the Declaration of Helsinki.

Results

Sociodemographic and Occupational Data, and Health-Related Behaviors

Seventy three percent of the studied workers were below 40 years old, with mean age of 36.4 ± 7 years. The majority of workers lived in urban areas (74.2%), attained high school (61.2%) or higher (university) education (30.4%), and were married (82.4%). Seventy eight percent of workers rated their health as good or very good.

Regarding health-related behaviors, 55.8% of workers were current smokers and 8.7% were ex-smokers. Current smokers ($n=361$) were categorized according to smoking intensity into light (48.5%), moderate (31.6%), and heavy smokers (19.9%). Only seven percent of the studied workers were physically active, while 93.0% did not meet the WHO recommendations on physical activity (Table 1).

As for occupational characteristics, the mean job duration of the studied workers was 8.1 ± 6.0 years. The majority of workers had job duration less than 10 years (78.4%), and were blue collars (81.3%). The study included 473 RNS

Table 1 Sociodemographic Characteristics and Health-Related Behaviors of the Studied Workers (n=647)

Characteristic	Frequency		95% CI [^]
	No.	%	
Age (years)			
<30	97	15.0	(12.1, 17.8)
30-<40	376	58.1	(54.4, 62.1)
40-<50	131	20.2	(17.2, 23.5)
≥ 50	43	6.6	(4.7, 8.6)
Residence			
Urban	480	74.2	(70.8, 77.5)
Rural	167	25.8	(22.5, 29.2)
Level of education			
Never been to school	9	1.4	(0.6, 2.3)
Basic primary education	45	7.0	(5.0, 8.9)
High school	396	61.2	(57.4, 65.0)
Higher education	197	30.4	(26.8, 33.9)
Marital status			
Never married	93	14.4	(11.6, 17.3)
Married	533	82.4	(79.5, 85.3)
Divorced	21	3.2	(2.0, 4.7)
Smoking status			
Never been smoker	230	35.5	(31.8, 39.5)
Ex-smoker	56	8.7	(6.5, 10.8)
Current smoker	361	55.8	(51.7, 59.9)
Smoking intensity [#]			
Light	175	48.5	(43.5, 53.2)
Moderate	114	31.6	(26.6, 36.2)
Heavy	72	19.9	(15.9, 24.6)
Physical activity			
No	602	93.0	(90.9, 94.9)
Yes	45	7.0	(5.1, 9.1)
Self-rated health			
Poor	7	1.1	(0.3, 2.0)
Fair	136	21.0	(17.8, 24.3)
Good	482	74.5	(71.0, 77.8)
Very good	22	3.4	(2.1, 4.8)

Notes: [^]CI, confidence interval of the percent, [#]Intensity of smoking was determined by calculating the smoking index (SI) among current smokers (n=361), by multiplying the number of cigarettes smoked per day by the number of smoking years, then, categorized into: light (SI <200), moderate (SI: 200–400), and heavy (SI >400).

workers (73.1%) who spent 1–5 years, 6–9 years, or 10 years or more working RNS work (35.7%, 45.0, or 19.2% respectively) (Table 2).

Relation Between RNS Work and Overall Adiposity

According to BMI, the studied workers (n=647) were classified into obese (45.4%), overweight (43.7%), normal weight (10.5%), and underweight (0.3%) (Table 2). The frequency of overall adiposity (BMI ≥ 30 kg/m²) was higher in workers

Table 2 Occupational Characteristics and Anthropometric Markers of Overall and Central Adiposity Among the Studied Workers (n=647)

Characteristic	Frequency		95% CI [^]
	No.	%	
Occupational characteristics			
Job duration (years) [#]			
<10	507	78.4	(75.2, 81.6)
10-<20	97	15.0	(12.3, 18.1)
≥20	43	6.6	(4.8, 8.5)
Job nature			
Blue collar	526	81.3	(78.4, 84.5)
White collar	111	17.2	(14.0, 20.1)
Pink collar	10	1.5	(0.6, 2.6)
Work schedule			
Daytime work	174	26.9	(23.3, 30.4)
RNS	473	73.1	(69.6, 76.7)
Years of RNS			
0	174	26.9	(23.5, 30.7)
1–5	169	35.7	(31.5, 40.0)
6–9	213	45.0	(40.7, 49.5)
≥ 10	91	19.2	(15.7, 22.9)
Anthropometric markers of adiposity			
BMI (kg/m ²)			
Underweight (<18.5)	2	0.3	(0.0, 0.8)
Normal (18.5 to 24.9)	68	10.5	(8.1, 12.8)
Overweight (25 to 29.9)	283	43.7	(39.9, 47.2)
Obese (≥ 30)	294	45.4	(41.7, 49.3)
Waist circumference (cm)			
Adequate	255	39.4	(35.8, 43.4)
Increased ^{\$}	392	60.6	(56.6, 64.2)

Notes: [^]CI, confidence interval of the percent, [#]job duration refers to the whole duration of employment. ^{\$}Waist circumference ≥ 94 cm for men.

Abbreviation: RNS, rotating night shift.

with 6–9 years of RNS (50.7%) followed by workers with 10 years or more of RNS (48.4%), daytime workers (43.7%), and workers with 1–5 years of RNS (39.1%); yet, the difference between the groups was statistically insignificant ($p=0.125$) (Table 3). The univariate logistic regression revealed no association between overall adiposity ($\text{BMI} \geq 30 \text{ kg/m}^2$) and RNS work (Table 4).

In multivariate logistic regression, age, residence, and smoking status were found to be independent predictors of an increased BMI ($\text{BMI} \geq 25 \text{ kg/m}^2$). Compared with younger workers who aged less than 30 years old, the odds of an increased BMI were 2.6 and 3.01 times higher among workers in the age groups 30 to less than 40 and 40 to less than 50 years old, respectively (95% CI = 1.35, 5.05, and 1.19, 7.56, respectively). Workers who lived in urban areas were less likely to have had an increased BMI compared with workers who lived in rural areas (OR = 0.34, 95% CI = 0.16, 0.74). The odds of an increased BMI were 2.14 times higher among workers who have never smoked compared with current smokers (95% CI = 1.12, 4.11) (Table 5).

Table 3 Anthropometric Markers of Overall and Central Adiposity Among the Studied Workers Stratified by the Work Schedule (n=647)

Adiposity Markers	Work Schedule								P-value ^a
	Daytime Workers (n=174)		RNS Workers (n=473) ^{&}						
			1–5 Years of RNS (n= 169)		6–9 Years of RNS (n= 213)		≥10 Years of RNS (n= 91)		
	No.	% (95% CI)	No.	% (95% CI)	No.	% (95% CI)	No.	% (95% CI)	
BMI (kg/m ²)									
<30	98	56.3 (49.5, 64.4)	103	60.9 (53.3, 68.2)	105	49.3 (42.9, 56.0)	47	51.6 (41.0, 61.4)	0.125
≥ 30	76	43.7 (35.6, 50.5)	66	39.1 (31.8, 46.7)	108	50.7 (44.0, 57.1)	44	48.4 (38.6, 59.0)	
Waist circumference									
Adequate	65	37.4 (30.0, 44.1)	81	47.9 (40.6, 56.0)	77	36.2 (30.0, 42.9)	32	35.2 (25.3, 44.7)	0.068
Increased [#]	109	62.6 (55.9, 70.0)	88	52.1 (44.0, 59.4)	136	63.8 (57.1, 70.0)	59	64.8 (55.3, 74.7)	

Notes: [#]Waist circumference ≥ 94 cm for men. ^{*}RNS workers (n=473) were classified according to the total number of years of RNS during career into three groups: 1–5 years; 6–9 years; and 10 years or more of working RNS. ^aMonte Carlo test.

Abbreviations: RNS, rotating night shifts; BMI, body mass index; CI, confidence interval of the percent.

Table 4 Univariate Logistic Regression of Overall Adiposity (BMI ≥ 30 Kg/m²) Associated with the Work Schedule Among the Studied Workers (n=647)

Work Schedule	Overall Adiposity				OR# (95% CI)	P-value
	Yes (n=577)		No (n=70)			
	No.	%	No.	%		
Daytime work [^]	76	25.9	98	27.8	Ref.	-
1–5 years of RNS	66	22.4	103	29.2	0.82 (0.53, 1.27)	0.385
6–9 years of RNS	108	36.7	105	29.7	1.32 (0.88, 1.98)	0.169
≥ 10 years of RNS	44	15.0	47	13.3	1.20 (0.72, 2.01)	0.468

Notes: [#]Univariate logistic regression was conducted to compute the odds of overall adiposity (BMI ≥ 30 kg/m²) (dependent variable) associated with the work schedule (independent variable).

[^]Reference category.

Abbreviations: BMI, body mass index; RNS, rotating night shifts; OR, odds ratio; CI, confidence interval.

Table 5 Multivariate Logistic Regression of Independent Predictors of Increased BMI (≥ 25 Kg/m²) Among the Studied Workers (n=647)

Variables	Coefficient	Adjusted OR [†]	95% CI	P-value
Work schedule				
Daytime work [^]	Ref.	Ref.	Ref.	Ref.
1–5 years of RNS	−0.181	0.835	(0.38, 1.82)	0.650
6–9 years of RNS	−0.585	0.557	(0.26, 1.17)	0.126
≥ 10 years of RNS	2.016	7.512	(0.93, 60.67)	0.059
Age (years)				
<30 [^]	Ref.	Ref.	Ref.	Ref.
30–40	0.961	2.613	(1.35, 5.05)	0.004**
40–50	1.102	3.011	(1.19, 7.56)	0.019*
≥ 50	0.861	2.366	(0.57, 9.82)	0.236

(Continued)

Table 5 (Continued).

Variables	Coefficient	Adjusted OR [†]	95% CI	P-value
Education				
Unschooling or basic education	−0.376	0.687	(0.28, 1.76)	0.435
High school or higher education [^]	Ref.	Ref.	Ref.	Ref.
Residence				
Urban area	−1.063	0.346	(0.16, 0.74)	0.007**
Rural area [^]	Ref.	Ref.	Ref.	Ref.
Physical activity [#]				
No	−0.421	0.656	(0.23, 1.86)	0.430
Yes [^]	Ref.	Ref.	Ref.	Ref.
Smoking				
Never been smoker	0.765	2.149	(1.12, 4.11)	0.021*
Ex-smoker	−0.665	0.514	(0.22, 1.15)	0.107
Current smoker [^]	Ref.	Ref.	Ref.	Ref.
Job nature ^{&}				
Pink-collar	−0.596	0.551	(0.08, 3.6)	0.538
Blue-collar	0.538	1.712	(0.81, 3.59)	0.156
White-collar [^]	Ref.	Ref.	Ref.	Ref.

Notes: Model $\chi^2 = 47.15$ ($p < 0.001$). Nagelkerke's $R^2 = 0.14$; Cox & Snell $R^2 = 0.07$; Hosmer & Lemeshow $\chi^2 = 7.433$ ($p = 0.491$). [#]Physical activity was reported according to the WHO recommendation of at least 150–300 minutes of moderate-intensity, or 75–150 minutes of vigorous-intensity physical activity each week. [&]White-collar jobs, including supervisory and managerial, professional or semiprofessional, and business owner roles; pink-collar jobs, including hospitality and administration roles, retail workers, office clerks, and salesperson roles; and blue-collar jobs, including laborer and skilled trade roles. [†]OR adjusted for all variables in the above table [^]Reference category. * p value ≤ 0.05 . ** p value ≤ 0.01 .

Abbreviations: RNS, rotating night shifts; OR, odds ratio; CI, confidence interval.

Relation Between RNS Work and Central Adiposity

The frequency of central adiposity was 62.9% in daytime workers, 52.1%, 63.8%, and 64.8% in RNS workers who spent 1–5 years, 6–9 years, and 10 years or more of RNS, respectively (Table 3). Cross tabulation and univariate logistic regression analyses revealed no association between RNS work and central adiposity (waist circumference ≥ 94 cm) (Table 3 and Table 6).

Table 6 Univariate Logistic Regression of Central Adiposity (Waist Circumference ≥ 94 Cm) Associated with the Work Schedule Among the Studied Workers (n=647)

Work Schedule	Central Adiposity				OR [#] (95% CI)	P-value
	Yes (n=392)		No (n=255)			
	No.	%	No.	%		
Daytime work [^]	109	27.8	65	25.5	Ref.	-
1–5 years of RNS	88	22.4	81	31.8	0.64 (0.42, 0.99)	0.048
6–9 years of RNS	136	34.7	77	30.2	1.05 (0.69, 1.59)	0.807
≥ 10 years of RNS	59	15.1	32	12.5	1.09 (0.64, 1.86)	0.725

Notes: [#]Univariate logistic regression was conducted to compute the odds of central adiposity (waist circumference ≥ 94 cm) (dependent variable) associated with the work schedule (independent variable). [^]Reference category.

Abbreviations: RNS, rotating night shifts; OR, odds ratio; CI, confidence interval.

Table 7 Multivariate Logistic Regression of Independent Predictors of Increased Waist Circumference (≥ 94 Cm) Among the Studied Workers (n=647)

Variables	Coefficient	Adjusted OR [†]	95% CI	P-value
Work schedule				
Daytime work [^]	Ref.	Ref.	Ref.	Ref.
1–5 years of RNS	0.045	1.046	(0.64, 1.70)	0.856
6–9 years of RNS	0.288	1.334	(0.83, 2.14)	0.233
≥ 10 years of RNS	−0.070	0.932	(0.51, 1.68)	0.816
Age (years)				
<30 [^]	Ref.	Ref.	Ref.	Ref.
30–<40	1.084	2.955	(1.80, 4.83)	<0.001***
40–<50	1.598	4.945	(2.64, 9.25)	<0.001***
≥ 50	1.905	6.718	(2.73, 16.48)	<0.001***
Education				
Unschooling or basic education	0.243	1.275	(0.66, 2.46)	0.469
High school or higher education [^]	Ref.	Ref.	Ref.	Ref.
Residence				
Urban area	0.134	1.144	(0.78, 1.67)	0.491
Rural urea [^]	Ref.	Ref.	Ref.	Ref.
Physical activity [#]				
No	−0.232	0.793	(0.40, 1.54)	0.497
Yes [^]	Ref.	Ref.	Ref.	Ref.
Smoking				
Never been smoker	0.198	1.219	(0.84, 1.75)	0.286
Ex-smoker	0.049	1.050	(0.57, 1.91)	0.873
Current smoker [^]	Ref.	Ref.	Ref.	Ref.
Job nature ^{&}				
Pink-collar	−0.555	0.574	(0.13, 2.37)	0.443
Blue-collar	−0.361	0.697	(0.42, 1.14)	0.157
White-collar [^]	Ref.	Ref.	Ref.	Ref.

Notes: Model $\chi^2 = 43.396$ ($p < 0.001$). Nagelkerke's $R^2 = 0.08$; Cox & Snell $R^2 = 0.06$; Hosmer & Lemeshow $\chi^2 = 5.99$ ($p = 0.541$). [#]Physical activity was reported according to the WHO recommendation of at least 150–300 minutes of moderate-intensity, or 75–150 minutes of vigorous-intensity physical activity each week. [&]White-collar jobs, including supervisory and managerial, professional or semiprofessional, and business owner roles; pink-collar jobs, including hospitality and administration roles, retail workers, office clerks, and salesperson roles; and blue-collar jobs, including laborer and skilled trade roles. [†]OR adjusted for all variables in the above table [^]Reference category. ***p value ≤ 0.001 .

Abbreviations: RNS, rotating night shifts; OR, odds ratio; CI, confidence interval.

In multivariate logistic regression, age was found to be the sole predictor of increased waist circumference (≥ 94 cm). Compared with younger workers who were less than 30 years old, the odds of increased waist circumference were 2.9, 4.9, and 6.7 times higher among workers in the age groups 30 to less than 40, 40 to less than 50, and ≥ 50 years, respectively [95% CI = (1.80, 4.83), (2.64, 9.25), and (2.73, 16.48), respectively] (Table 7).

Discussion

Egypt is one of the leading countries in the prevalence of obesity worldwide.¹⁹ The frequency of obesity (BMI ≥ 30 kg/m²) among the studied workers (45.4%) was one and half times higher than that reported among adult Egyptian men (29.5%) in the “100 million health” National Survey in 2019.²⁰ The current study is relatively small and included currently employed men only, yet, this alarming figure needs further evaluation to assess whether there is a substantial rise in obesity trend among Egyptian men.

The present study revealed no association between RNS work and overall or central adiposity. Regarding overall adiposity, findings of the present study are consistent with findings in Saulle et al meta-analysis, which did not produce significant results on the prevalence of obesity among night shift workers.¹⁷ On the other hand, Liu et al meta-analysis, indicated that shift work might be associated with an increased risk of overweight and obesity; however, there was a substantial heterogeneity in the studies included in the meta-analysis since there was a great variation in the cut-off points of overweight and obesity. For example, among 26 studies included in the meta-analysis, only eight studies defined overweight as BMI ≥ 25 Kg/m², and 11 studies defined obesity as BMI ≥ 30 Kg/m². Moreover, any type of shift work was considered as an exposure variable.¹¹ This might provide an explanation to the contradictory results.

Regarding central adiposity, unlike the current study, some studies found central adiposity had a significant (but sometimes marginal) association with night shift work.^{9,28,38,39} Conflicting results could be due to variation in the methods of studies, for example, Antunes et al study included a considerably small sample size (14 shift workers and 13 daytime workers).³⁸ In Sun et al study, the cut-off point of central adiposity was set according to the recommended criteria for Chinese populations (waist circumference ≥ 85 cm for men).²⁸ Correia et al study had a different study design,⁹ and Ulacia et al study evaluated adiposity in a specific working population (nursing workers).³⁹

In the current study, the worker's age was found to be an independent predictor of an increased waist circumference, whereas the worker's age, residence, and smoking status were independently associated with BMI. Similarly, a significant independent association and positive correlation was found between age and BMI among men.⁴⁰ In Al-Raddadi et al study, the prevalence of obesity in adult men increased after the age of 30 years, then decreased in the older age groups.⁴¹ Likewise, in the current study, compared with younger workers aged less than 30 years old, the odds of overall adiposity were 2.6 and 3.01 times higher among workers in the age group 30 to less than 40, and 40 to less than 50 years old, respectively.

Regarding residence, over the last few decades, the urban environment has included vast changes in lifestyle and dietary patterns such as more shift work, more meals outside the home and more irregular eating patterns like breakfast skipping and late-night eating; all of which would have an impact on public health.⁴² Studies that explored the role of geographic environment on obesity revealed inconsistent results.^{43,44} In the present study, workers who lived in urban areas were less likely to be overweight or obese compared with workers lived in rural areas. This contradicts the results of Angkurawaranon et al systematic review,⁴³ however, it supports findings in Leal et al systematic review which found that living in a rural environment is associated with higher BMI. The review identified environmental characteristics associated with obesity including: low area socioeconomic position; low urbanization degree; low street intersection, service availability and residential density; high noise pollution; low accessibility to supermarkets and high density of convenience stores.⁴⁴

Findings in the present study support the idea that smoking might be associated with weight loss;⁴⁵⁻⁴⁷ the odds of overall adiposity were 2.14 times higher among workers who have never smoked compared with current smokers in the current study. Similarly, smoking was negatively associated with the risk of obesity in adult males in Zhao et al longitudinal study (2021),⁴⁵ and in Watanabe et al study where current smokers had lower OR for obesity (OR=0.80; 95% CI=0.72, 0.88) compared with non smokers.⁴⁶ In addition, in Wang Q study (2015), smoking resulted in an increase of being underweight and healthy weight, and decrease of being overweight and obese.⁴⁷ On the contrary, a conflicting effect of significantly increased BMI among smokers was reported in some studies.^{48,49} Biologically, nicotine affects brain's regulation of appetite and energy expenditure; thus, smoking would decrease appetite and calorie intake, enhance metabolism, and reduce fat accumulation.⁵⁰ On the other hand, smoking decreases exercise by constraining respiratory functions.⁵¹ The exact nature and net effect of smoking on body weight remains unclear and requires further research.

Limitations of the Study

In our study, it would have been better to include, in addition to BMI and waist circumference, information about skin fold thickness measurements and body composition analysis for a more accurate diagnosis of adiposity. Moreover, the retrospective record review design might have resulted in some selection bias, such as under-coverage bias, since women workers were not represented; consequently, the potential variation in the association between RNS work and adiposity due to sex could not be examined in this study. Another potential limitation that might have resulted in an

underestimation or a lack of association between shift work and adiposity would be the “survivorship bias” and “healthy worker effect”, which means that only workers who tolerate work well continued working, thus having records at the OMU, whereas workers with chronic diseases at advanced stages (in which obesity might have played a role) were probably excluded from work, had no records at the OMU, and accordingly were not included in the study. In addition, assessment of potential covariates such as eating habits, eating time, sleep pattern, and alcohol consumption was not possible in the current study since such information was not reported in the medical records.

Conclusion

The study supports the idea that RNS work might not be associated with overall or central adiposity and points out possible association between increased waist circumference and age, as well as possible association between increased BMI and age, residence, and smoking status among male workers. Longitudinal, larger studies that include both males and females would be required to address the relation between RNS and overall and central adiposity.

List of Abbreviations

BMI, Body mass index, OMU, Occupational Medicine Unit, RNS, Rotating night shift, WHO, World Health Organization.

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