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Effect of Rotating Shift on Biomarkers of Metabolic Syndrome and Inflammation among Health Personnel in Gaza Governorate

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background: It's been suggested that shift employment is linked to an increased risk of metabolic syndrome (MetS). It is a complex syndrome that has been linked to the development of cardiovascular disease and/or type 2 diabetes mellitus. The goal of the study was to determine the prevalence of MetS among health-care workers and to investigate the impact of rotating shift work on MetS biomarkers and inflammation.

Methods: 100 current daytime workers were compared to 210 rotating shift workers in comparative analytical cross-sectional research involving 310 health care personnel. A questionnaire on socio-demographic (sex, age, marital status, job), health-related behaviors such as a physical activity) and occupational history about shift work, as well as a health examination with anthropometric and arterial blood pressure measurements, and laboratory investigations. For the diagnosis and determination of MetS, we used the Adult Treatment Protocol III National Cholesterol Education Program of America (ATPIII) indicators. SPSS version 20 was used for the statistical analysis.

Results: The overall prevalence of MetS among healthcare workers was 8.4% (9.0% among

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current daytime workers and 8.1% among rotating shift workers) with no significant difference between males and females, and shift category. Elevated C-reactive protein (44.5%) was the most commonly altered component among healthcare workers, followed by high triglyceride (35.5%), raised total cholesterol (24.8%), and elevated BMI>30 (20.6 %). In descending order, the following were the main risk factors for MetS in both sexes among rotating shift workers: high blood pressure (OR = 59.5; 95 percent CI, 16.4- 215.8), high fasting blood sugar (OR = 43.9; 95 percent CI, 12.9-149.1), high triglyceride (OR = 42.3; 95 percent CI, 5.5- 326.6), obesity (BMI >30) (OR = 11.8; 95 percent CI, 4- 34.6), and low HDL cholesterol (OR = 1.6; 95 percent CI, 0.3- 6.1)

Conclusion: MetS was prevalent amongst Gaza Strip healthcare workers, with a consistent increase in prevalence as people were older and had a higher BMI. There was no direct relationship between shift category and the occurrence of MetS and inflammation; however, other factors such as genetics, lifestyle factors, and the work itself may have a greater impact than shift category.

Keywords: Metabolic syndrome; current daytime workers; rotating shift workers; inflammation; risk factors.

1. INTRODUCTION

Metabolic syndrome (MetS) is a complicated disorder that affects the general public, the prevalence of which increases with age especially in adults over 50 years of age [1]. This syndrome has been described as a ‘‘clustering’’ of multiple risk factors for cardiovascular disease (CVD) [2,3] such as hypertension (HTN), dyslipidemia specifically high triglycerides (TG), low levels of high-density lipoprotein (HDL), and increased low-density lipoprotein (LDL), obesity (particularly central or abdominal obesity), insulin resistance, and impaired glucose tolerance (IGT) or diabetes mellitus (DM) [4]. Syndrome X, cardio metabolic syndrome, insulin resistance syndrome, Reaven's syndrome, and CHAOS were all terms used to describe MetS. (an abbreviation for coronary artery disease, hypertension, atherosclerosis, obesity, and stroke) [5,6]. Patients with MetS have a twofold greater risk of coronary heart disease-related death (CHD) [7].

The increased prevalence of MetS has been attributed to changes in lifestyle, particularly with regard to new eating patterns and sedentarism [8,9]. However, modern life has also brought changes to the work environment. Working hours that occurred during the daytime were extended in the last decades for a large number of services and production areas [10].

The internal cycle of physiological and metabolic events is the circadian system's primary purpose [11]. Many physiological systems, including lipid and glucose metabolism, as well as blood pressure (BP), have day–night cycles.

In rotating shift workers whose night activity is out of phase, the circadian rhythm and environmental conditions may become asynchronous, resulting in desynchronization of the usual phase relationships between biological rhythms within the circadian system [12].

Recent epidemiological investigations have found a link between inflammation and thrombogenesis as a cause of CVD in MetS patients [13].

Furthermore, multiple studies have found a link between increased leukocyte count and the risk of CHD, implying that leukocyte count is linked to metabolic and hemodynamic illnesses that are common in the MetS [14].

To that end, we aimed to determine the prevalence of MetS among rotating shift employees and to investigate the impact of the rotating shift work schedule on MetS biomarkers and inflammation among Palestinian medical professionals in Gaza-governorate hospitals. According to our knowledge and published literature, no studies have been conducted in Gaza to study the prevalence of MetS and its biomarkers among healthcare workers, as well as the impact of rotating shift work on MetS and inflammation biomarkers.

2. MATERIALS AND METHODS

2.1 Study Design

This is a quantitative study using a comparative analytical cross-sectional design to investigate the prevalence and impact of rotating shift work on MetS and inflammation biomarkers. A cross sectional study is typically quick, cheap, and simple to conduct. It is usually done at a point of time or over a short period of time. It also provides more information about the relationship between the study's variables. It is limited, however, by the fact that it is performed only once and provides no indication of the sequence of events, such as whether exposure happened before, after, or during the development of the illness outcome. As a result, inferring causality is impossible [15].

2.2 Study Setting

The research was carried out in two government hospitals, Al-Shifa Hospital (ASH) and Al-Nassir Pediatric Hospital (ANPH). The researchers chose these hospitals for a variety of reasons, including: The ASH hospital is the largest and general hospital in the Gaza strip, has the largest number of rotating shift health care workers (approximately 714), and is situated in Gaza city. ANPH hospital is one of the main general pediatric hospitals that located in the Gaza city with roughly 141 rotating shift health care employees.

2.3 Study Population

The study population comprised of 1474 healthcare personnel who worked in the aforementioned selected hospitals (1268 from ASH and 206 from ANPH) including physicians (470 from ASH, 55 from ANPH), nurses (680 from ASH, 120 from ANPH), medical technologists, radiologists, and radiologic technologists (118 from ASH, 31 from ANPH).

2.4 Eligibility Criteria

2.4.1 Inclusion criteria

In ASH and ANPH hospitals, it included rotating night shift and daytime health care employees (male and female) aged from 20 to 60 years.

2.4.2 Exclusion criteria

1- Permanent night shift health care professionals at the hospitals that have been chosen.
2- Health-care professionals having a history of T2DM, CVD, or inflammatory illness.
3- Health-care personnel who have type 1 diabetes.

Health-care workers who have a family history of hyperlipidemia.

2.5 Period of the Study

The study took ten months in execution; it began in April 2016 and ended in February 2017. In May 2016, the research proposal was presented to and argued in front of the SOPH appointed committee. The research proposal outlined the complete process and offered information and design of data collection and data analysis methodologies and tools. Following the approval, the researchers prepared the study's essential equipment, as well as the demographic question. Before finalizing the instrument, the researchers consulted a group of 12 specialists at the arbitration stage. The arbitration stage lasted two weeks and included tool refinement in light of feedback from reviewers and the academic supervisor.
The tool was ready for data collecting in October 2016. Pilot study was conducted between 2nd to 6th October 2016. The actual data collecting began on October 16th and ended on November 30th, 2016. To improve the possibility of giving the questionnaires to as many participants as possible, the researchers set daily work hours to begin at 07.15 a.m. and end at 01.00 p.m.

Between December 2016 and January 2017, statistical analysis of quantitative data was completed. The study's findings were extracted, descriptive tables were constructed, and inferential statistical analysis was performed.

2.6 Sampling

The governmental hospitals were used as the sampling frame (Al- Shifa Hospital and Al- Nassir Pediatric Hospital).

Because the selected hospitals are the main and largest hospitals, and have the largest number of health care employees, a convenient sample approach was provided.

2.7 Sample Size and Sample Process

The researchers gathered the necessary data in order to calculate the required sample size. The sample size was calculated using Epi-Info version 7. At ASH and ANPH, there are roughly 1474 healthcare personnel (physicians, nurses, radiologists, radiologic technologists, and medical technicians). The highest estimate of sample size was when both exposed and non-exposed groups reported the outcome with 50%, the confidence interval was 95 percent, and the power was 80, so the sample size was 305 health care workers. To overcome non-respondents, 310 health care workers were including in the study. The self-administering questionnaire was sampled from two governmental hospitals in Gaza (ASH and ANPH), and a proportional sample was chosen from each health care worker in the two hospitals based on their number.2.8 Research instrument.

2.8 The Researchers Employed Two Types of Instruments in this Study

2.8.1 Direct instrument

Self-administering questionnaire: Data was collected from health care professionals in the selected hospitals using a self-administering questionnaire. The majority of the questions were yes/no questions, which provide dichotomous choice. The questionnaire includes questions about personal information (sex, age, marital status, job). The questions covered social data, demographic data to determine the existence of disorders as HTN, CHD, DM and inflammation, lifestyle variables such as (physical activity, and occupational history including questions concerning shift work.

2.8.2 Clinical tests and laboratory investigations

• The biochemical parameters selected to study were measured in serum sample with spectrophotometer using commercially available reagent kits:

1- Triglyceride
2- High-density lipoprotein (HDL), low-density lipoprotein (LDL), and total cholesterol
3- Fasting Blood sugar
4- C-reactive protein (CRP)

• Complete Blood Count (CBC)
• Anthropometric measurements include:

- Length
- Weight

• Blood pressure levels (BP)

2.9 Data and Sample Collection

The exact, systematic gathering of information linked to the research aim or specific objectives, questions, or hypothesis of the study is referred to as data collection [16]. The questionnaire included helath related behaviours, information regarding the nature of work such as years of work, either shift or day work, duration of work, past medical history. The anthropometric measurements were done and recorded in questionnaire along with laboratory results including biochemical parameters, BP and CBC. Prior to blood sampling, all participants who accepted to participate in the study had to fast for at least 10 hours the night before. Venous blood samples (5 mL) were obtained in serum vacutainer tubes without anticoagulant, and EDTA tubes for CBC test under strict quality control and safety procedures. The serum was separated from blood samples by centrifugation at 3500-4000 rpm for 10 min. The serum was then transferred to new plain tubes and used for biochemical testing (on the same day of sample collection). The leukocyte count and differential count were determined using blood in an EDTA tube.

2.10 Criteria for Diagnosis MetS

We used the NCEP/ATPIII standard for MetS diagnostic criteria. If a person met three or more of the following criteria, they were diagnosed with the syndrome:

1- Men's waist circumference is >102cm, and women's waist circumference is >88cm.
2- Fasting plasma glucose level is equal or higher than110mg/dl.
3- Blood pressure of equal or higher than 130/85 mmHg
4- Serum triglycerides are equal or higher than 150mg/dl
5- Serum HDL cholesterol <40mg/dl in male and <50 mg/dl in female.

We chose the BMI instead of the WC because the participants refused to measure it for obesity, with a BMI more than 30 being considered obese.

2.11 Administrative and Ethical Considerations

The researchers agreed to follow all ethical guidelines for conducting study, including:

- An official letter of approval was obtained from public health school at Al Quds University.
- An official letter of request was obtained from the general director of Ministry of Health in Gaza Strip.

- An official letter of approval to conduct this study was obtained from the Helsinki Committee in the Gaza Strip.
- A covering letter stating that participation is optional and that the ability to refuse was included to protect participants' rights.
- The confidentiality of the respondents' responses was ensured by describing how the data will be recorded and used.

2.12 Pilot Study

A pilot study of 20 health care professionals outside of the selected clinics was conducted prior to the commencement of data collection to evaluate applicability and identify faults in the research questionnaire of data collection for validity and reliability. Before the data collection process began, a pilot study was conducted to assess the clarity and ambiguity, length, and applicability of questions. [17].

2.13 Data Entry

Data was entered into the computer using SPSS (Statistical Package for Social Science) software version 20 to be analyzed after all filled questionnaires were checked and reviewed in the same way. Check codes were used to avoid double entries after the data entering process was completed. The tools were pretested to reduce inconsistencies and ensure that the questions were relevant to the local context. Data cleaning were done to adjust for missing values in a bid to assure integrity and reliability.

2.14 Statistical Analysis

- For data processing and analysis, the Statistical Package for the Social Sciences (SPSS, version 20) was utilized.
- The following is a list of variables and their descriptions:
- Data were normally distributed, as determined using Kolmogorox-Smirnov test.
- Description of quantitative variables were presented as the following: Normally distributed data were expressed as mean ± SD.
- Description of qualitative variables was in the form of numbers (No.) and percent (%).
- Comparison between quantitative variables was carried out by student t-test of two independent samples. Results were expressed in the form of P-values, and the significance level of $p<0.05$.
- Comparison between qualitative variables was carried out by Chi-Square test (χ^2). Fisher exact test was used instead of Chi-square test when one expected cell or more were ≤ 5.
- Binary correlation was carried out by Spearman correlation test. Results were expressed in the form of correlation coefficient (r) and P-values. The following points are the accepted guidelines for interpreting the correlation coefficient:
- 0 indicates no linear relationship.
- +1 indicates a perfect positive linear relationship: as one variable increases in its values, the other variable also increases in its values via an exact linear rule.

3. RESULTS

As indicated in Table 1, the represented sample of health care professionals included in the study was 310 healthcare employees who were distributed according to selected hospitals and socio-demographic variables such as gender, marital status, age, employment, and governorate. The study sample comprised of 310 healthcare employees from the Gaza Strip's ASH and ANPH, including (100) currently daytime workers (32.3%), the majority of whom were at senior levels, and (210) rotating shift workers (67.7%), the majority of whom were at junior levels.

With percent (56.0 percent vs. 74.3 percent), (81.0 percent vs. 77.1 percent), respectively, the majority of daytime and rotating shift workers were men and married. A greater part of daytime workers were 41 years and above (52.0 percent), however 47.1 percent of rotating shift workers were 30 years and younger.According to the profession, 51.0 percent of daytime workers were practical nurses, 31.0 percent were physicians, and 18.0 percent were radiologists, radiologic technologists, and medical technologists. 50.0 percent of rotating shift workers were practical nurses, 43.3 percent were physicians, and 6.7 percent were radiologists, radiologic technologists, and medical technologists. The majority of daytime and rotating shift workers are from Gaza (72.0 percent vs. 70.0 percent), with (13.0 percent vs. 14.3 percent) from the North and (14.0 percent vs. 13.8 percent) from the Middle Zone, respectively. Khan Younis accounted for only (1.0 percent vs.1.4 percent).

Our findings revealed that 8.4% of health care workers had MetS, with a higher prevalence among day workers (9%) than rotating shift workers (8.1%), with no statistical relationship (x2= 0.07, P-value>0.05) between MetS and shift category, implying that daytime and rotating shift workers had the same chance of developing MetS. In our study, the most common abnormalities were elevated CRP, high TG, high TC, increased BMI >30, high LDL-C, increased FBS and BP, and low HDL-C, increased WBC count, increased neutrophil count, and decreased lymphocyte count, with 44.5 percent, 35.5 percent, 24.8 percent, 20.6 percent, 18.7 percent, 12.6 percent, and 11.3 percent, 3.2 percent, 2.3 percent, 0.3 percent, respectively. This was the first study to look into the prevalence and the effect of rotating shift on biomarkers of MetS and inflammation among health personnel in the Mediterranean countries.

The association between shift category and the risk factors associated with it was investigated. Table 2 shows that 27.0 percent of daytime workers are obese (BMI > 30) compared to 17.6 percent of rotating shift workers, with no statistical relationship (x2= 3.64, P-value> 0.05). For FBS, 17.0 percent of daytime workers had elevated FBS compared to 10.5 percent of rotating shift workers without statistical relationship ($\mathbf{x^2}$= 2.62, *P*-value>0.05). Also16.0 percent of the daytime workers had elevated BP vs. 11.0 percent of rotating shift workers without statistical relationship (x2= 1.57, P-value > 0.05).Furthermore, the study found that 33.0 percent of daytime workers had high cholesterol, compared to 21.0 percent of rotating shift workers, with statistically significant difference (OR=1.9, 95 percent CI= 1.1-3.2). For TG, 41.0 percent of daytime workers had increased TG compared to 32.9 percent of rotating shift workers with no statistical relationship ($\mathbf{x^2}$= 1.96, *P*-value>0.05). In addition, 18.0 percent of daytime workers had low HDL levels compared to 8.1 percent of rotating shift workers, with a statistically significant difference (P = 0.010). About 30.0 percent of daytime workers had high LDL, while 13.3 percent of rotating shift workers had raised LDL with statistical association, (OR= 2.8, 95 percent CI=1.6-5.0). Finally, 52.0 percent of daytime workers had increased CRP compared to 41.0 percent of rotating shift workers with no statistically significant difference (P-value>0.05). Furthermore, there were no statistical differences in the CBC results which included WBC and its differential counts between daytime and rotating shift workers. According to our findings, obesity was shown to be higher among daytime workers than in current shift workers.

According to our findings, among the daytime workers and shift workers, MetS increased from 0 percent and 5.9 percent within less than 30-year-old group to 66.7 percent and 47.1 percent respectively, in the participants older 41 years of age. Among rotating shift workers, there was a statistically significant association (p-value<0.05) between MetS and age (30 years and less, 31-40 years, 41 years and above). Furthermore, for rotating shift workers the results showed that the ratio of having MetS for 41 years and above equals 4.5 times that of other age groups, with their percent of susceptible ranging from 1.6 to 12.9 times.

Table (4) showed that 66.7 percent of daytime workers with MetS had previously worked night shifts for more than 5 years without statistical significance vs. 82.4 percent of rotating shift workers with statistical significance (P-value= 0.026 OR= 3.9, 95 percent CI= 1.1-14). This means that rotating shift workers who have worked night shifts for more than 5 years are four times more likely to have MetS than workers who have worked night shifts for less than 5 years, while 22.2 percent of daytime workers with MetS had previously been exposed to night shifts from one year to five years without statistical relationship vs. 17.6 percent of rotating shift workers, the difference was statistically significant (P-value= 0.042) between MetS and the exposed night shifts among rotating shift workers.

According to the findings in Table (5), the majority of daytime and rotating shift workers who have elevated CRP have worked night shifts for more than 5 years (75.0 percent and 59.3 percent, respectively), with a statistically significant relationship among day workers (OR=3.26, 95 percent CI =1.4-7.6), but the differences did not reach statistical significance among rotating shift workers (P =0.572), which could be due to their ages (the average was 33.2), as CRP is known to be affected by age beyond 40 years.

Table 1. Sociodemographic features of the study population (N = 310)

Variable	Category	Current daytime workers (N=100, 32.3%)		Rotating shift workers (N=210, 67.7%)		Total (N=310, 100%)	
		N	%	N	%	N	%
Gender	Male	56	56.0%	156	74.3%	212	68.4%
	Female	44	44.0%	54	25.7%	98	31.6%
Marital status	Single	19	19.0%	48	22.9%	67	21.6%
	Married	81	81.0%	162	77.1%	243	78.4%
Age	30 years & less	17	17.0%	99	47.1%	116	37.4%
	31-40 years	31	31.0%	68	32.4%	99	31.9%
	41years and above	52	52.0%	43	20.5%	95	30.6%
Job	physicians	31	31.0%	91	43.3%	122	39.4%
	Practical nursing	51	51.0%	105	50.0%	156	50.3%
	Radiologists, radiologic technologists, and medical technologists	18	18.0%	14	6.7%	32	10.3%
Governorate	North	13	13.0%	30	14.3%	43	13.9%
	Gaza Strip	72	72.0%	147	70.0%	219	70.6%
	Middle zone	14	14.0%	29	13.8%	43	13.9%
	Khan Younis	1	1.0%	3	1.4%	4	1.3%
	Rafah	0	0.0%	1	.5%	1	.3%

Table 2. Relationship between various risk factors and shift category among daytime and rotating shift healthcare workers (N = 310)

Risk factors	Level	Current daytime workers (N=100, 32.3%)		Rotating shift workers (N=210, 67.7%)		Total (N=310, 100%)		Chi-Square (x^2)	OR	95% CI	*P*-value
		N	%	N	%	N	%				
BMI >30 (Obese)	No	73	73.0%	173	82.4%	245	79.4%	3.64	0.6	0.3-1.0	0.056
	Yes	27	27.0%	37	17.6%	64	20.6%		0.7	0.4-1.2	0.172
Blood pressure (BP) (mmHg)	<130/85	84	84.0%	187	89.0%	271	87.4%	1.57	0.7	0.3-1.3	0.210
	≥130/85	16	16.0%	23	11.0%	39	12.6%		1.6	0.8-3.1	0.210
Fasting blood sugar (FBS) (mg/dl)	<110	83	83.0%	188	89.5%	271	87.4%	2.62	1.8	0.9-3.5	0.105
	≥110	17	17.0%	22	10.5%	39	12.6%		0.6	0.3-1.1	0.105
T. Cholesterol (TC) (mg/dl)	< 200	67	67.0%	166	79.0%	233	75.2%	5.27	0.5	0.3-0.9	0.022*
	≥200	33	33.0%	44	21.0%	77	24.8%		1.9	1.1-3.2	0.022*
Triglyceride (TG) (mg/dl)	Normal	59	59.0%	141	67.1%	200	64.5%	1.96	0.7	0.4-1.2	0.161
	Abnormal	41	41.0%	69	32.9%	110	35.5%		1.4	0.9-2.3	0.161
High density lipoprotein (HDL-C) (mg/dl)	Normal	82	82.0%	193	91.9%	275	88.7%	6.64	0.4	0.2-0.8	0.010*
	Abnormal (decreased)	18	18.0%	17	8.1%	35	11.3%		2.5	1.2-5.1	0.010*
low density lipoprotein (LDL-C) (mg/dl)	Normal	70	70.0%	182	86.7%	252	81.3%	12.37	0.4	0.2-0.6	0.001*
	Abnormal (increased)	30	30.0%	28	13.3%	58	18.7%		2.8	1.6-5.0	0.001*
C- Reactive Protein (CRP)	Normal	48	48.0%	124	59.0%	172	55.5%	3.35	0.6	0.4-1.0	0.067
	Abnormal	52	52.0%	86	41.0%	138	44.5%		1.6	1.0-2.5	0.067
Leukocyte count	Normal	51	100.0%	249	96.1%	300	96.8%	0.99	-	-	0.321
	Increased	0	0.0%	10	3.9%	10	3.2%		-	-	
Neutrophil count	Normal	50	98.0%	253	97.7%	303	97.7%	0.13	-	-	0.719
	Increased	1	2.0%	6	2.3%	7	2.3%		-	-	
Lymphocyte count	Decreased	0	0.0%	1	0.4%	1	0.3%	0.82	-	-	0.365
	Normal	51	100.0%	258	99.6%	309	99.7%		-	-	
Metabolic syndrome	Absent	91	91.0%	193	91.9%	284	91.6%	0.07	0.9	0.4-2.1	0.788
	Present	9	9.0%	17	8.1%	26	8.4%		1.1	0.5-2.6	0.788

* Significant (P<0.05)
BMI: underweight <18.5 kg/m^2; Normal 18.5–24.9 kg/m^2; Overweight 25 - 29.9 kg/m^2; Obesity ≥ 30 kg/m^2
BP: Ideal blood pressure 90/60mmHg-120/80mmHg; High blood pressure ≥140/90mmHg
FBS: Normal 70-99mg/dl; Prediabetes100-125mg/dl; Diabetes ≥ 126mg/dl
TC: Normal <200 mg/dl; Borderline High 200-239 mg/dl; High >240 mg/dl
TG: Desirable <200 mg/dl; Borderline High 200-400 mg/dl; Elevated >400 mg/dl
HDL: 40-80 mg/dl
LDL: Desirable <130 mg/d; Borderline High risk 130-160mg/dl; High risk >160 mg/dl
CRP: Up to 5.0 mg/L
Leukocyte count: 4-12 x 10^3 μl, Neutrophil count:2-8 x 10^3 μl, Lymphocyte count:1-5 x 10^3 μl

Table 3. MetS prevalence by age and work category (N = 310)

Work category	variable	Category	Metabolic syndrome						OR	95% CI	*P*- value
			Present		Absent		Total				
			N	%	N	%	N	%			
Daytime workers	Age	30 years & less	0	0.0%	17	18.7%	17	17.0%	-	-	-
		31-40 years	3	33.3%	28	30.8%	31	31.0%	1.1	0.3-4.8	0.874
		41 years & above	6	66.7%	46	50.5%	52	52.0%	2.0	0.5-8.3	0.356
		Total	9	9.0%	91	91.0%	100	100.0%	(Fisher-exact x^2=1.78, *p*-value=0.512)		
Rotating shift workers	Age	31 years & less	1	5.9%	98	50.8%	99	47.1%	0.1	0-0.5	0.001*
		31-40 years	8	47.1%	60	31.1%	68	32.4%	2.4	0.8-62	0.117
		41 years & above	8	47.1%	35	18.1%	43	20.5%	4.5	1.6-12.9	0.002*
		Total	17	8.1%	193	91.9%	210	100.0%	(Fisher-exact x^2=15.53, *p*-value=0.001*)		

** Significant (P<0.05)*

Table 4. Relationship between metabolic syndrome and previous night shift exposure in both groups (N = 310)

Work category	Variable	Category	Metabolic syndrome						OR	95% CI	*P*- value
			Present		Absent		Total				
			N	%	N	%	N	%			
Daytime workers	Years	not exposed	1	11.1%	16	17.6%	17	17.0%	0.6	0.1-5.0	0.622
		1-5 years	2	22.2%	19	20.9%	21	21.0%	1.1	0.2-5.6	0.925
		more than 5 years	6	66.7%	56	61.5%	62	62.0%	1.3	0.3-5.3	0.762
		Total	9	100.0%	91	100.0%	100	100.0%	(Fisher-exact x^2=0.25, *p*-value=0.999)		
Rotating shift workers	Years	not exposed	0	0.0%	5	2.6%	5	2.4%	-	-	-
		1-5 years	3	17.6%	83	43.0%	86	41.0%	0.3	0.1-1.0	0.042*
		more than 5 years	14	82.4%	105	54.4%	119	56.7%	3.9	1.1-14.0	0.026*
		Total	17	100.0%	193	100.0%	210	100.0%	((Fisher-exact x^2=4.57, *p*-value=0.099)		

** Significant (P<0.05)*

Table 5. Relationship between elevated CRP and prior night shift exposure night in day and shift workers (N=310)

Work category	Variable	Category	CRP						OR	95% CI	*P*- value
			Elevated		Normal		Total				
			N	%	N	%	N	%			
Daytime workers	Years	not exposed	5	9.6%	12	25.0%	17	17.0%	0.3	0.1-1.0	0.040*
		1-5 years	8	15.4%	13	27.1%	21	21.0%	0.5	0.2-1.3	0.151
		more than 5 years	39	75.0%	23	47.9%	62	62.0%	3.26	1.4-7.6	0.005*
		Total	52	100.0%	48	100.0%	100	100.0%	(Fisher-exact x^2=7.95,*p*-value=0.018*)		
Rotating shift workers	Years	not exposed	1	1.2%	4	3.2%	5	2.4%	0.4	0-3.2	0.335
		1-5 years	34	39.5%	52	41.9%	86	41.0%	0.9	0.5-1.6	0.728
		more than 5 years	51	59.3%	68	54.8%	119	56.7%	1.2	0.7-2.1	0.572
		Total	86	100.0%	124	100.0%	210	100.0%	(Fisher-exact x^2=1.01,*p*-value=0.598)		

** Significant (P<0.05)*

Table 6. Prevalence of various factors that indicate metabolic syndrome (as defined by ATPШ) and inflammation among present daytime employees (N= 100)

Components of MetS	Level	Metabolic syndrome						OR	95% CI	*P*- value
		Present		Absent		Total				
		N	MetS%	N	%	N	%			
FBS (mg/dl)	≥110	5	55.6%	12	13.2%	17	17.0%	8.2	1.9-35.0	0.001*
	<110	4	44.4%	79	86.8%	83	83.0%	0.1	0-0.5	0.001*
BP (mmHg)	≥130/85	6	66.7%	10	11.0%	16	16.0%	16.2	3.5-75.1	0.001*
	<130/85	3	33.3%	81	89.0%	84	84.0%	0.1	0-0.3	0.001*
Obesity (BMI > 30)	Yes	6	66.7%	21	23.1%	27	27.0%	6.7	1.5-29.0	0.005*
	No	3	33.3%	70	76.9%	73	73.0%	0.2	0-0.7	0.005*
TG (mg/dl)	≥150	8	88.9%	33	36.3%	41	41.0%	14.1	1.7-117.4	0.002*
	<150	1	11.1%	58	63.7%	59	59.0%	0.1	0-0.6	0.002*
HDL-C (mg/dl)	<50 for women < 40 for men (Abnormal)	4	44.4%	14	15.4%	18	18.0%	4.4	1.1-18.4	0.030*
	> 50 for women > 40 for men (Normal)	5	55.6%	77	84.6%	82	82.0%	0.2	0.1-1.0	0.030*
CRP (mg/L)	Abnormal	4	44.4%	48	52.7%	52	52.0%	0.7	0.2-2.8	0.634
	Normal	5	55.6%	43	47.3%	48	48.0%	1.4	0.4-5.5	0.634

** Significant (P<0.05)*

From Table (6) the researchers calculated the odds ratio and confidence interval for daytime workers with MetS, by comparing the measurement of each MetS component for the normal and abnormal levels In our analysis, 55.6 percent of participants with high FBS developed MetS compared to 44.4 percent of those with normal FBS, with statistically significant difference (OR = 8.2, 95 percent CI =1.9-35.0). In terms of Bp, 66.7 percent of daytime workers with high Bp had MetS compared to 33.3 percent of those with normal Bp, with statistically significant difference (OR= 16.2, 95 percent CI = 3.5-75.1).

Furthermore, 66.7 percent of daytime workers with BMI>30 had MetS vs. 33.3 percent with BMI <30, and the difference was statistically significant OR 6.7 CI 95 percent (1.5-29.0). Eventually, the study found that 88.9% of daytime workers with high TG had MetS vs. 11.1 percent with normal TG OR (95 percent CI) 14.1 (1.7-117.4). Furthermore, 44.4 percent of those with low HDL cholesterol developed MetS, compared to 55.6 percent of those with normal levels, and the difference was statistically significant (P= 0.030). Finally, 44.4 percent of participants with elevated CRP had MetS compared to 55.6 percent of participants with normal CRP levels, but the difference was not statistically significant (P= 0.634).

Based on the value of OR in our sample, we concluded that the following risk factors for MetS among daytime workers were in descending order: high blood pressure, high TG, high FBS, raised BMI >30, and low HDL cholesterol level.

By comparing the measurements of each component of MetS for the normal and abnormal level, the researchers calculated the odds ratio and confidence interval for rotating shift workers with MetS Table (7). In our study, 70.6 percent of those with a high level of FBS developed MetS, compared to 29.4 percent of those with a normal level of FBS. This difference was found to be statistically significant (P= 0.001, OR = 43.9, 95 percent confidence interval: 12.9-149.1). In terms of Bp, 76.5 percent of rotating shift workers with high Bp had MetS, compared to 23.5 percent of those with normal Bp. (P= 0.001, OR=59.5, 95 percent CI=16.4-215.8) the difference was statistically significant. Furthermore, 64.7 percent of shift workers with a BMI greater than 30 had MetS, compared to 35.3 percent of shift workers with a BMI less than 30, and the difference was statistically significant (P= 0.001, OR= 11.8, 95 percent CI= 4.0-34.6). The study then revealed that 94.1 percent of shift workers with high TG developed MetS, compared to only 5.9% of those with normal TG levels. (P= 0.001, OR= 42.3, 95 percent CI=5.5-326.6) These differences were statistically significant once again Furthermore, 11.8 percent of rotating shift workers with low HDL cholesterol had MetS, compared to 88.2 percent of those with normal HDL cholesterol, and the difference was not statistically significant. Finally, 58.8% of participants with elevated CRP had MetS compared to 41.2 percent of participants with normal CRP levels, but the difference was not statistically significant (P= 0.118).

Based on the value of OR in our sample, we concluded that the following risk factors for MetS among rotating shift workers were in descending order: high blood pressure, high FBS, high TG, raised BMI >30, and low HDL cholesterol level. Except for FBS and TG, all were in the order of risk variables in daytime workers (Tables 6& 7).

4. DISCUSSION

Metabolic syndrome (MetS) is multifaceted syndrome that usually occurs in general population, mainly in adults over 50 years of age [1]. Patients with MetS have a twofold increased risk of mortality from coronary heart disease (CHD) [7]. Studies have shown that various lifestyle factors influence MetS. A sedentary lifestyle and physical inactivity are factors that have been shown to contribute to the development of MetS and its components [18,19]. Smoking and alcohol consumption have also shown to have variable influences on MetS and its components [20,21]. In this study, we investigate the prevalence of MetS among rotating shift workers and the link between shift work and MetS, focusing on inflammatory markers.

Our results show that 8.4% of healthcare workers have MetS, which has a higher prevalence of day workers, 9.0% than 8.1% of shift workers, with no statistical relationship (P >0.05), implying that daytime and rotating shift workers had the same chance of developing MetS. The results of this study showed that according to the NCEPATPШ standard, the prevalence of MetS in healthcare workers working at ASH and ANPH in Gaza was 8.4%,

Table 7. Prevalence of various factors that define metabolic syndrome (as defined by АТРШ) and inflammation among rotating shift workers (N=210)

Components of MetS	Level	Metabolic syndrome						OR	95% CI	*P*- value
		Present		Absent		Total				
		N	MetS %	N	MetS%	N	%			
FBS (mg/dl)	≥110	12	70.6%	10	5.2%	22	10.5%	43.9	12.9-149.1	0.001*
	<110	5	29.4%	183	94.8%	188	89.5%	0.02	0-0.1	0.001*
BP	≥130/85	13	76.5%	10	5.2%	23	11.0%	59.5	16.4-215.8	0.001*
(mmHg)	<130/85	4	23.5%	183	94.8%	187	89.0%	0.01	0-0.1	0.001*
Obesity (BMI >30)	Yes	11	64.7%	26	13.5%	37	17.6%	11.8	4.0-34.6	0.001*
	No	6	35.3%	167	86.5%	173	82.4%	0.1	0-0.3	0.001*
TG (mg/dl)	≥ 150	16	94.1%	53	27.5%	69	32.9%	42.3	5.5-326.6	0.001*
	<150	1	5.9%	140	72.5%	141	67.1%	0.02	0-0.2	0.001*
HDL-C (mg/dl)	<50 for women < 40 for men (Abnormal)	2	11.8%	15	7.8%	17	8.1%	1.6	0.3-6.1	0.562
	> 50 for women > 40 for men (Normal)	15	88.2%	178	92.2%	193	91.9%	0.6	0.1-3.0	0.562
CRP (mg/L)	Abnormal	10	58.8%	76	39.4%	86	41.0%	2.2	0.8-6.0	0.118
	Normal	7	41.2%	117	60.6%	124	59.0%	0.5	0.2-1.2	0.118

** Significant (P<0.05)*

and the prevalence increased with age. Studies in Pakistan [22] and Lampang Hospital [23] showed prevalence rates of 14.95 and 9.5 percent, respectively, higher than the prevalence in this study. In another Ethiopian study [24] using NCEPAPT III, the overall prevalence of MetS was 12.5 percent, which is higher than our prevalence 8.4 percent in this study.

In this study, the researchers observed that there was no statistical difference between shift work rotation and MetS versus current workers. This result was consistent with a study [25] conducted on male workers working in three shifts and a study by Shafei [26]. This can be explained by the positive value that healthcare professionals had more physical activity during the shift and outside the work as well as fast forward rotation shift schedule practice among rotating shift workers.

Fast forward rotation is currently thought to be the most effective in reducing sleep loss and fatigue among shift workers [27] thereby reducing other health effects associated with circadian rhythm disruption. Additionally, daytime workers were not only involved with their job, but some of them also had administrative jobs, which increased the stress that may be involved in the MetS mechanism. Furthermore, environmental and genetic variables have been linked to the development of this condition. MetS prevalence can be increased by advanced age, sedentary lifestyle, and a high-fat diet [28]. According to this study, 27.0 percent of daytime employees were obese (BMI >30) compared to 17.6 percent of rotating shift workers, without statistical relationship (P-value >0.05). Our findings were comparable with research done on 9,989 female nurses in Korea, which found that obesity rates for shift workers and non-shift employees were 5.8 percent and 9.1 percent, respectively [29]. However, it contradicted a cross-sectional research from Australia, which found that nurses who worked shifts were 1.15 times more likely to be overweight or obese than day workers [30]. BMI of daytime workers was greater than that of shift workers, which might be impacted by the daytime workers' older age, as well as other potential confounding factors.

Furthermore, 16.0 percent of daytime employees had increased blood pressure compared to 11.0 percent of rotating shift workers with no significant association (P-value >0.05). In terms of elevated blood pressure, our findings were consistent with a cross-sectional study of 493 nursing staff from a large general hospital in (Hospital São Vicente de Paulo). Passo Fundo, Brazil [31]. Their findings revealed that 17.7% of day workers had HTN, whereas 13.9 and 17% of morning and evening night shift workers had HTN, respectively. Their data showed that there was no relationship between shift workers and HTN. Some studies have found a tendency toward increased blood pressure among shift workers. Ye [32] discovered that shift worker had higher HTN than day workers (50.3 percent vs. 28.2 percent). This was clarified by the researchers due to their advanced age. In this survey, 32.2 percent of shift workers were over 50, whereas just 11.3 percent of day workers were over 50.

In terms of FBS, 17.0 percent of daytime workers had high FBS compared to 10.5 percent of rotating shift workers, with no significant association (P-value >0.05). Similar findings were obtained in research conducted in Brazil by Canuto [33] who discovered that high FBS was more prevalent in day employees than in night shift workers (4.9 percent vs. 3.8 percent). However, according to research by Ye [32] FBS was higher among shift employees (24.6 percent) than day workers (4.2 percent) (P <0.001). This may be explained by the fact that the majority of shift workers (55 percent) were between the ages of 40 and 49, whilst the majority of day workers were between the ages of 18 and 39 (64.8 percent).

Our findings revealed a significant difference in cholesterol, HDL-C, and LDL-C levels between shift workers and day employees, with day workers having higher levels (P <0.05), while no such difference was seen for TG (P >0.05). A research done by Nazri [26] for the estimate of HDL-C in day and shift workers revealed a consistent finding that day workers had lower HDL-C levels than shift workers (13.89 percent , 9.21 percent respectively). However [33], their data revealed no statistically significant difference between the two groups, but our findings revealed a substantial difference in HDL-C levels of daytime and shift workers.

The fact that the result of HDL-C was statistically significant between the two groups in this study indicates that the majority of daytime workers were older, and historically, HDL levels below the reference value have been related with increasing age, particularly among women [34]. The TG result obtained in this study was similar to a cross-sectional study on 12 shift workers and 13 day workers using pre and posttest over a six-month period that demonstrated the prevalence of TG among day workers and shift workers was (28 percent, 25 percent respectively) with no significant difference between the two groups (P>0.05) [35].

According to Sookoian [36] shift workers had a considerably higher leukocyte count than daytime workers (6530 ± 1,216 , 5556 ± 1,123, cells/μL, respectively, *P*= <0.001), Puttonen [37] also found an increase in hs-CRP in 3-shift workers and an increase in leukocyte count in 2-shift and 3-shift workers, and Lu [38] found that increased total and differential leukocyte counts (neutrophil, monocyte, and lymphocyte) were associated with shift work (P < 0.05), thus contradicting with our findings. The researchers explained that this could be attributable to the sort of job and the fact that most day employees were over 40 years old, with CRP levels being affected by age.

According to our findings, in the daytime workers and shift workers, respectively, MetS increased from 0 percent and 5.9 percent within less than 30-year-old group to 66.7 percent and 47.1 percent in the participants over 41 years of age. Among rotating shift workers, there was a statistically significant relationship (p-value<0.05) between MetS and age (30 years and less, 31-40 years, 41 years and above). Furthermore, the results showed that for rotating shift workers, the ratio of having MetS for 41 years and above is 4.5 times that of other age groups, with their percent of susceptible ranging from 1.6 to 12.9 times. Our findings are consistent with two prior studies on shift workers, both of which found a direct relationship between age and MetS [39-41].

According to the findings, 66.7 percent of daytime workers with MetS had previously worked night shifts for more than 5 years without a statistically significant relationship, compared to 82.4 percent of rotating shift workers with a statistically significant relationship (P-value= 0.026 OR= 3.9, 95 percent CI= 1.1-14), this means that rotating shift workers who have worked night shifts for more than five years are four times more likely to develop MetS than employees who have worked night shifts for less than five years. Our findings are in line with those of Guo [42] who found that the odds of developing MetS increased with the extension of shift work duration. In the unadjusted model, every ten years of shift work was associated with a 17 percent increase in OR. Another study by Shafei [26] corroborated our findings, showing that nurses who worked 10 years more than others were twice more likely to have MetS.

5. CONCLUSIONS

The total prevalence of MetS among health employees was 8.4 percent (9 percent among daytime workers, which was higher than the 8.1 percent among rotating shift workers), with no statistically significant difference between the two categories, and the prevalence increases with age. According to the findings of the study, MetS is more prevalent amongst male daytime and rotating shift workers than in females. Daytime professionals were 27.0 percent obese (BMI > 30), whereas rotating shift workers were 17.6 percent obese. In terms of FBS, 17.0% of daytime workers had increased FBS compared to 10.5 percent of rotating shift workers, and 16.0 percent of daytime workers had raised BP compared to 11.0 percent of rotating shift workers without statistical significance. There was a statistically significant difference between cholesterol levels and shift category, with daytime employees having a higher prevalence. With no statistical association, 41.0 percent of daytime workers had increased TG compared to 32.9 percent of rotating shift workers. Forty one percent of daytime workers had increased TG compared to 32.9 percent of rotating shift workers with no statistical association. Furthermore, there is a statistical difference between a low HDL level and a high LDL level, as well as the shift category. From our results, there were no statistical variations in the CBC values, including WBC and its differential count, and CRP levels, between daytime and rotating shift workers. CRP levels were increased in 52.0 percent of daytime employees, with males (53.8%) having a higher percentage than females (46.2%). In addition, 41.0 percent of rotating shift employees had a high level of CRP, with males (75.6%) having a higher level than females (24.4%). Approximately 82.4 percent of rotating shift employees with MetS had previously worked night shifts for more than five years. Our findings revealed that the majority of daytime and rotating shift workers with increased CRP levels had worked night shifts for more than 5 years (75.0% and 59.3%, respectively). The current study additionally looks into the risk factors that cause MetS in current daytime workers, which are listed below in descending order depending on the value of the OR: a high blood pressure, a high TG level, a high FBS level, a BMI >30, and a low HDL cholesterol level. High BP, high FBS, high level of TG, increased BMI >30, and low HDL cholesterol level were the risk factors that defined MetS among rotating shift workers, based on the value of OR in descending order. Except for high FBS and increased TG, they were in the order of risk variables among daytime workers.

6. LIMITATIONS

1- Time limit due to the working and living conditions of the researcher.
2- Non-governmental organizations (NGOs) and the private sector were excluded from the study.
3- Matching was not achievable because the age of currently day shift healthcare personnel differs from that of rotating shift.
4- The refusal of study subjects for measuring waist and hip circumference and thereby not including the WHR as measure of obesity

DISCLAIMER

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FUTURE CLINICAL IMPLICATIONS

1- A national prevention programs need to be implemented to combat hypertension, diabetes, obesity, dyslipidemia, and related co morbidity and change in lifestyle, especially with respect to physical activity and nutrition.
2- As blood pressure was the main risk factor of MetS, conducting regular check-up of BP health settings is very important.
3- As age was one of the main determinants of MetS, Ministry of Health need to develop policies to regulate the work schedule of employees, particularly of those who are over 40.
4- Future prospective longitudinal studies should be carried out for identifying the prevalence and the effect of shift work on biomarkers of MetS and inflammation on a large sample to include all healthcare workers in all governmental and private hospitals in the Gaza Strip.
5- It is recommended to conduct other studies that involve selection of comparative groups from places other than the hospitals.

CONSENT

Informed consent was taken from all participants who accepted to participate in the study after well explanation of the procedures and objectives and considerations beyond the study.

ETHICAL APPROVAL

An approval to perform the study was taken from the Palestinian Ethical Committee (Helsinki Ethics Committee) (PHRC/HC/154/16).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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