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Overweight and Obesity in Saudi Patients with Schizophrenia Affects Cholesterol Concentration and Some Immune System Cells

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Introduction: Schizophrenia (SZ), a prevalent and highly debilitating mental disease, is associated with high rates of overweight and obesity and effects on different systems of the body including the immune system. There are very few studies worldwide on weight measured by the body mass index (BMI) in patients with SZ and its effect on blood parameters, while there are no such studies in Saudi Arabia.

Aims: This study is the first to determine the effects of weight, measured by the BMI, on the differential complete blood count in patients with SZ. Additionally, the serum lipid profile was determined.

Methodology: Blood samples were collected from 45 randomly chosen male inpatients with SZ with an age range of 28-47 years and a mean age of 37 years.

Results: BMI categorization of the patients showed that 6.7% were underweight, 53.3% were healthy, 24.4% were overweight, and 15.6% were obese. Compared with the healthy BMI, significantly lower cholesterol levels and neutrophil counts were found for the overweight BMI group, while significantly higher cholesterol levels and monocyte percents were found for the obese BMI group.

Conclusion: Most subjects had a healthy BMI while overweight and obese subjects showed effects on cholesterol levels and counts of innate immune system cells.

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1. INTRODUCTION

Schizophrenia (SZ) is a chronic and severe mental (psychotic) disorder characterized by auditory and visual hallucinations; delusions; paranoia; difficulties in perception, thinking, and emotions, and a lack of the sense of self [1]. SZ affects about 20 million people worldwide [1]. According to the Saudi National Health and Stress Survey for the Kingdom of Saudi Arabia [2], 34% of Saudis are diagnosed with a mental disorder sometime in their life and 40% of them are in an age range between 25-34 years.

There is no cure for SZ, but symptoms of the disorder are reduced by the use of antipsychotic drugs and behavioral and cognitive therapies. Diagnosis and treatment of the disorder can be complicated if accompanied by substance abuse since patients with SZ are more likely to use recreational drugs [3]. There are several factors that increase the risk of developing SZ, including malnutrition, drugs, alcohol, infectious diseases, and genetic factors [4].

SZ is linked to many biochemical and immunological changes in the body, and it is associated with an increased rate of overweight and obesity [5-13]. The higher prevalence of overweight and obesity in patients with mental disorder might be due to many factors, one of which is the medications that are used for their treatment [14,15]. According to the World Obesity Federation, Saudi Arabia ranked 17th in the world and 3rd in the Middle East for the prevalence of obesity in males [16]. In Saudi Arabia [17], 67.5% of males are overweight and 29.5% are obese. Overweight and obesity cause increased mortality, morbidity, and the incidence of many diseases, including dyslipidemia, metabolic disorders, heart diseases, high blood pressure, and psychological problems [18].

Overweight and obesity are measured by different measures, one of which is the body mass index (BMI) which is the most commonly used one [19]. It has been found that, compared to healthy weight BMI people, overweight and obese people usually have abnormal lipid levels, which leads to an increased risk of atherosclerosis and metabolic disorders [20-23]. Lipids are important biochemical nutrients that the body needs in many of its functions [24]. Changes in serum lipid levels can play a part in the pathophysiology of developmental and psychiatric disorders, such as depression, bipolar disorder, and SZ [25-27].

Studies [28-30] have shown an effect of overweight and obesity on general inflammation in the body and variable effects on the immune response. Obesity is linked with abnormal levels of pro-inflammatory cytokines [31], which enhance inflammation [32], that lead to an increase in the risk of development of diabetes, cardiovascular diseases, and other metabolic diseases [33]. The immune response is mediated by different types of white blood cell (WBC) that function in the innate immunity (such as monocytes, neutrophils, eosinophils, and basophils) and adaptive immunity (such as the lymphocytes), with some also being important mediators of inflammation [34,35]. The red blood cell (RBC) and platelet have important roles in immunity and inflammation [36,37]. The RBC has a role in the regulation of chemokines and prevents the recruitment of neutrophils [36]. The platelet has important functions in the immune system that include adhesion to vessel walls and WBC in the case of blood vessel injury [38,39], engulfing microbes, and stimulating the immune cells to target the site of inflammation [38,40].

There is some evidence that support the role of immunity and inflammation in patients with SZ. There is a relationship between SZ and abnormal levels of blood cells [41,42]. The counts of total WBC and neutrophils, which may be used as biomarkers for systemic inflammation [43], were found to be abnormal in patients with SZ [44]. In addition, the results of a previous study on patients with SZ [45] showed a high neutrophil-lymphocyte ratio (NLR), which indicates an inflammatory response [46]. Additionally, another study on patients with SZ compared to healthy subjects [47] found higher NLR, monocyte-lymphocyte ratio (MLR), and platelet-lymphocyte ratio (PLR); higher neutrophil counts; and lower lymphocyte counts. These findings support the presence of immunological differences in patients with SZ compared to healthy subjects.

After an extensive search in the internet, worldwide very few studies categorized patients with SZ into BMI groups, while there are no such

studies in Saudi Arabia. Of the studies done on patients with SZ categorized into BMI groups, a study [12] correlated the BMI with the lipid levels, and another study [13] correlated the lipids with P-selectin. The remaining studies [5-8,48-51] compared the BMIs of the patients with those of the general population but not determining any blood parameters. Therefore, only one study determined the lipid profile in patients with SZ and none studied the differential complete blood count (CBC). In addition, there are no studies in Saudi Arabia on the relationship between the BMI and the lipid profile and differential CBC in patients with SZ.

Therefore, the aim of this study was to determine the BMI, lipid profile, and the differential CBC in patients with SZ and to determine the association between the BMI and these parameters. This is the first study to determine the differential CBC for patients with SZ categorized into the BMI groups. This would help in determining the effects of SZ in Saudi Arabian patients in order to provide better treatments, and to avoid or reduce the development of future health problems in these patients.

2. MATERIALS AND METHODS

2.1 Subjects and BMI Categorization

In this study, 45 randomly chosen male inpatients with chronic SZ, with an age range of 28-47 years, were recruited from the Eradah Complex Mental Health Services, Jeddah, Saudi Arabia. None of the subjects had any immune diseases, thyroid diseases, renal dysfunction, hepatic dysfunction, cancers, or urinary tract infections. Additionally, none of the subjects were taking any anti-inflammatory or antibiotic medications for the two weeks prior to blood collection. Each of the subjects signed a consent form and filled a questionnaire to evaluate their health status and any variables that may influence the studied parameters. In addition, some information about the patients was collected from their hospital files.

The subjects were categorized based on their BMI's. Subjects that had a BMI below 18.5 kg/m^2 were considered underweight, subjects with a BMI in the range of 18.5-24.9 kg/m^2 were considered as having a healthy weight, subjects with a BMI in the range of 25-29.9 kg/m^2 were considered overweight, and, finally, obese subjects had a BMI in the range of 30-39.9 kg/m^2 [19].

2.2 Blood Collection

Overnight fasting blood samples were collected from the subjects into vacutainer tubes. Ethylene diamine tetra acetic acid (EDTA) vacutainer tubes were used for the differential CBC analysis and gel serum separator vacutainer tubes were used for the lipid profile [cholesterol, triglyceride (TG), high-density lipoprotein (HDL), and low-density lipoprotein (LDL)]. Serum was separated from the blood clot by centrifugation for three minutes at a speed of 4400 rpm.

2.3 Determination of the Differential CBC and Lipid Profile

The differential CBC was done on a DxH 500 instrument (Beckman Coulter Inc., Brea, CA, USA), while the lipid profile was done on an UniCel DxC 600 instrument (Beckman Coulter Inc., Brea, CA, USA), using the chemicals approved for the instruments, at the Eradah Complex Mental Health Services, Jeddah, Saudi Arabia.

2.4 Statistical Analysis

Statistical analysis of the data was done using the MegaStat program (Version 9.4, Butler University, Indianapolis, Indiana, USA). Descriptive statistics was done for all the data (mean, standard deviation (± SD), standard error of the mean (± SE), maximum value, and minimum value). The *P* value was used to determine the statistical differences between the BMI groups for each parameter. The one-way ANOVA test was used for the normally distributed parameters, whereas the Kruskal-Wallis test was used for the non-normally distributed parameters. For the comparisons between the groups, the post hoc testing was done using the t-test for the normally distributed parameters (TG and HDL concentrations; neutrophil, basophil, and platelet counts; NLR, MLR, and basophil-lymphocyte ratio (BLR) for counts and percents; and eosinophil-lymphocyte ratio (ELR) and PLR for counts), while the Mann-Whitney U test was used for the non-normally distributed parameters (BMI; age; cholesterol, LDL, and hemoglobin concentrations; WBC and RBC counts; lymphocyte, monocyte, and eosinophil counts and percents; neutrophil and basophil percents; and ELR percents).

3. RESULTS

3.1 Subjects BMI Categorization and Characteristics

The subjects were categorized according to their BMI values. As shown in Table 1 and Fig. 1, the BMI for the subjects had a range of 16.1-37.2 kg/m^2 (mean ± SD = 24.6 ± 5.1). Most subjects had a healthy weight BMI, followed by overweight and obese BMI, while the BMI with the fewest subjects was the underweight BMI. Since the underweight subjects were only 3, this BMI group was not included in any statistical analysis. As shown in Fig. 1, most subjects had an age between 36 to 42 years and there was a weakly positive liner correlation between the age and BMI.

The subjects with the underweight BMI had a mean age of 35 years (SD: ± 7), healthy weight BMI subjects had a mean age of 38 years (± 4), overweight BMI subjects had a mean age of 38 years (± 5), and obese BMI subjects had a mean age of 39 years (± 4) (Table 2). There were no significant differences between the mean ages for the BMI groups. As shown in Table 2, most of the subjects had a duration of illness of 1 to 10 years, versus 10 to 20 years. In addition, most had a healthy BMI, were more educated, unemployed, single, smokers, and substance abusers.

3.2 Lipid Profile

Using the Kruskal-Wallis test (Table 3), there were no significant differences between the BMI groups for the mean cholesterol and LDL concentrations. For the mean TG and HDL concentrations, using the one-way ANOVA test (Table 3), there were no significant differences between the groups. As for the post hoc analysis,

Table 1. Descriptive statistic for the BMI groups

BMI groups	N (%)	Min	Max	Mean	± SD	± SE
Underweight	3 (6.7)	16.1	18.3	17.5	1.2	1
Healthy	24 (53.3)	18.7	24.4	21.6	1.8	0.4
Overweight	11 (24.4)	25.9	29.8	27.2	1.3	0.4
Obese	7 (15.6)	30.0	37.2	33.6	2.9	1
Mean BMI	45 (100)	16.1	37.2	24.6	5.1	1

N: number of subjects, Min: minimum value, Max: maximum value, SD: standard deviation, SE: standard error of the mean

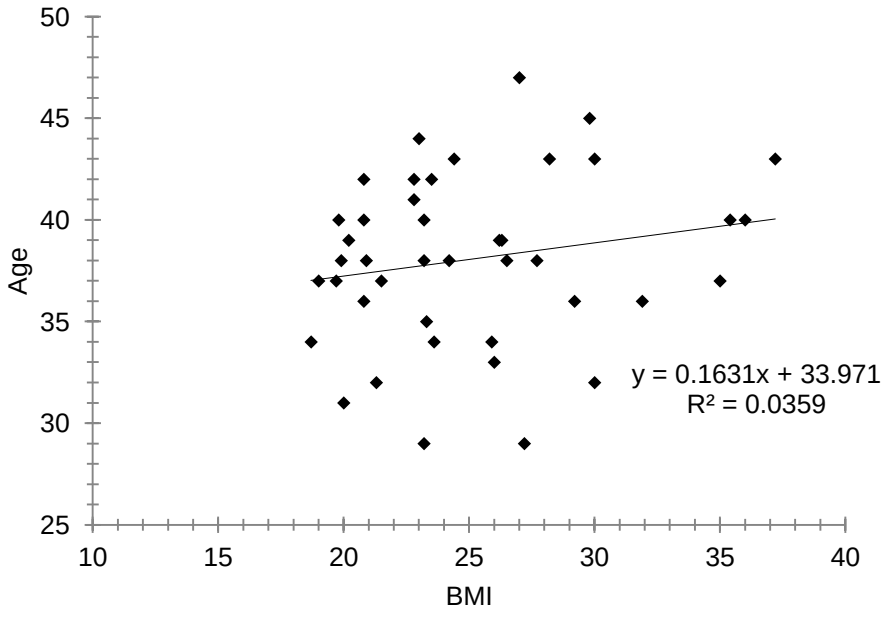

Fig. 1. The correlation between the age and BMI. R is the correlation coefficient and the straight-line equation is shown

Table 2. Subject's characteristics

Factor	BMI groups N (%)			
	Underweight (n = 3)	Healthy (n = 24)	Overweight (n = 11)	Obese (n = 7)
Mean age ± SD	35± 7	38 ± 4	38 ± 5	39 ± 4
Duration of illness				
1-10 years	2 (6)	11 (34)	6 (19)	4 (13)
10-20 years	1 (3)	5 (16)	1 (3)	2 (6)
Education				
Elementary/middle	-	9 (20)	2 (4)	3 (7)
High school	3 (7)	11 (24)	5 (11)	-
College/diploma	-	4 (9)	4 (9)	4 (9)
Employment status				
Unemployed	3 (7)	16 (36)	7 (16)	5 (11)
Employed	-	4 (9)	1 (2)	2 (4)
Retired	-	4 (9)	3 (7)	-
Marital status				
Single	2 (4)	19 (42)	8 (18)	5 (11)
Married	1 (2)	1 (2)	1 (2)	2 (4)
Divorced	-	4 (9)	2 (4)	-
Smoking				
Yes	3 (7)	20 (4)	9 (20)	4 (9)
No	-	4 (9)	2 (4)	3 (7)
Substance abuse				
Yes	2 (4)	17 (38)	7 (16)	3 (7)
No	1 (2)	7 (16)	4 (9)	4 (9)

N: number of subjects, SD: standard deviation

shown in Table 4, only the mean cholesterol concentrations showed differences between the groups. Using the Mann–Whitney U test and comparing the cholesterol levels for the BMI groups with those of the healthy BMI group, the overweight BMI group had a significantly lower level, while the obese group was significantly higher. There was no significant difference, using the Mann–Whitney U test, between the overweight and obese groups for the mean cholesterol levels.

Table 3. Statistical analysis of the lipid profile for the BMI groups

Parameters (mg/dL)	BMI groups	N	Mean	± SD	± SE	*P* value
Cholesterol**	Healthy	22	162	39	8	0.276^{NS}
	Overweight	11	148	44	13	
	Obese	7	178	38	14	
TG*	Healthy	24	103	58	13	0.735^{NS}
	Overweight	11	123	116	33	
	Obese	7	124	57	22	
HDL*	Healthy	12	47.8	12.7	3.7	0.936^{NS}
	Overweight	3	45.2	14.5	8.3	
	Obese	3	49.1	15.5	8.9	
LDL**	Healthy	11	89.1	36.8	11.1	0.910^{NS}
	Overweight	3	93.3	50.2	28.9	
	Obese	3	97.1	31.1	8.9	

The one-way ANOVA test was used for the significance testing The Kruskal-Wallis test was used for the significance testing*

SD: standard deviation, SE: standard error of the mean, TG: triglycerides HDL: high-density lipoprotein, and LDL: low-density lipoprotein, N: number of subjects

NS: None significant (P> 0.05)

Table 4. Post hoc comparisons between the BMI groups for the lipid profile

Parameters (mg/dL)	G1	G2	Mean difference (G1 – G2)	±SD	*P* value
Cholesterol**	Healthy	Overweight	14	26	0.000^{HS}
		Obese	-16	20	0.000^{HS}
	Overweight	Obese	-30	11	0.122^{NS}
TG*	Healthy	Overweight	-19	82	0.528^{NS}
		Obese	-20	58	0.429^{NS}
	Overweight	Obese	58	98	0.985^{NS}
HDL*	Healthy	Overweight	2.5	13.0	0.762^{NS}
		Obese	-1.2	13.1	0.888^{NS}
	Overweight	Obese	-1.0	15.0	0.771^{NS}
LDL**	Healthy	Overweight	-4.2	6.4	0.876^{NS}
		Obese	-8.0	6.4	0.755^{NS}
	Overweight	Obese	19.1	2.3	1.000^{NS}

The t-test was used for the significance testing The Mann–Whitney U test was used for the significance testing*

G: group, SD: standard deviation, TG: triglycerides HDL: high-density lipoprotein, and LDL: low-density lipoprotein

NS: None significant (P > 0.05) and HS: Highly significant (P < 0.01)

3.3 Total and Differential Blood Counts

Using the Kruskal-Wallis test (Tables 5 and 6), there were no significant differences between the BMI groups for the total mean WBC and RBC counts; lymphocyte, monocyte, and eosinophil counts and percents; neutrophil and basophil percents; and hemoglobin concentrations. Additionally, using the one-way ANOVA test, there were no significant differences between the BMI groups for the mean neutrophil, basophil, and platelet counts.

Table 5. Statistical analysis for the mean total and differential WBC counts and percents for the BMI groups

Parameters	BMI groups	Cell count (×10^3/µL)				Cell %		
		N	Mean	± SD	*P* value	Mean	± SD	*P* value
WBC**	Healthy	24	7.68	1.99	0.380^{NS}			
	Overweight	11	6.5	2.03				
	Obese	7	7.46	2.26				
Lymphocyte**	Healthy	24	2.70	0.64	0.618^{NS}	36.09	8.27	0.172^{NS}
	Overweight	11	2.79	1.13		42.42	11.52	
	Obese	7	2.55	0.84		35.37	12.76	
Monocyte**	Healthy	24	0.65	0.19	0.141^{NS}	8.53	2.11	0.069^{NS}
	Overweight	11	0.63	0.21		9.74	2.11	
	Obese	7	0.85	0.27		11.75	3.94	
Neutrophil*,**	Healthy	24	4.06	1.62	0.086^{NS}	51.64	9.58	0.141^{NS}
	Overweight	11	2.81	0.98		43.78	12.23	
	Obese	7	3.87	1.70		50.21	11.98	
Eosinophil**	Healthy	22	0.27	0.16	0.769^{NS}	3.77	2.05	0.634^{NS}
	Overweight	11	0.26	0.18		3.73	2.23	
	Obese	6	0.21	0.12		2.85	1.92	
Basophil*,**	Healthy	22	0.02	0.01	0.750^{NS}	0.28	0.07	0.313^{NS}
	Overweight	11	0.02	0.01		0.32	0.14	
	Obese	6	0.02	0.00		0.24	0.08	

The one-way ANOVA test was used for the significance testing The Kruskal-Wallis test was used for the significance testing*

N: number of subjects, SD: standard deviation, WBC: white blood cell, NS: None significant (P > 0.05)

Table 6. Statistical analysis for the mean RBC count, hemoglobin concentration, and platelet count for the BMI groups

Parameters	BMI groups	N	Mean	± SD	± SE	*P* value
RBC**	Healthy	24	4.98	0.56	0.11	0.993^{NS}
($\times 10^6$/µL)	Overweight	11	4.91	0.42	0.12	
	Obese	7	5.00	0.43	0.16	
Hemoglobin**	Healthy	24	14.19	1.24	0.25	0.222^{NS}
(g/dL)	Overweight	11	13.50	1.58	0.47	
	Obese	7	14.65	1.24	0.46	
Platelet*	Healthy	24	276.9	87.8	17.92	0.484^{NS}
($\times 10^3$/µL)	Overweight	11	256.6	84.0	25.33	
	Obese	7	308.7	98.9	37.36	

The one-way ANOVA test was used for the significance testing The Kruskal-Wallis test was used for the significance testing N: number of subjects, SD: standard deviation, RBC: red blood cell NS: None significant (P > 0.05)*

For the post hoc analysis (Table 7), using the t-test, comparing between the overweight and healthy subjects for the total and differential WBC, the overweight BMI group had a significantly lower mean neutrophil count, while there was no significant difference for the mean basophil count. Using the Mann–Whitney U test, there were no significant differences for the WBC counts; lymphocyte, monocyte, and eosinophil counts and presents; and neutrophil and basophil percents between the healthy and overweight BMI subjects.

The obese weight BMI group, compared to the healthy BMI (Table 7), using the Mann–Whitney U test, had significantly higher mean monocyte percent, while there were no significant differences for the WBC count; lymphocyte and eosinophil counts and presents; neutrophil and basophil percents; and monocyte count. On the other hand, using the t-test, there were no significant differences in the mean neutrophil and basophil counts between the healthy and obese BMI subjects.

For the post hoc comparison, using the Mann–Whitney U test (Table 8), the mean RBC counts and hemoglobin concentrations for the BMI groups were not significantly different. In addition, using the t-test, the mean platelet counts for the overweight and obese BMI groups were not significantly different compared to the mean platelet count for the healthy BMI group. Finally, the post hoc comparisons (Tables 7 and 8) between the overweight and obese BMI subjects showed no significant differences between the means for all cells counts and percents, hemoglobin concentrations, and platelet counts.

3.4 Differential WBC and Platelet Ratios

As shown in Table 9, the t-test was used for the counts and percents for NLR, MLR, BLR, and counts for ELR and PLR. Compared to the healthy weight subjects, the MLR counts and percents were significantly higher for the obese BMI subjects. Whereas, there were no significant differences between the BMI groups for the other cell ratios counts and percents.

4. DISCUSSION

As mentioned previously, very few research studies categorized patients with SZ into BMI groups [5-13] and only one study [12] determined the lipid profile for the BMI groups, while none determined the total and differential CBC for the BMI categorized patients with SZ. Therefore, this is the first study to determine the total and differential CBC, and lipid profile in Saudi male patients and the first worldwide to find the relationship between weight, as categorized by the BMI, and the measured parameters.

Most of the patients (n = 24) had a BMI in the healthy range (mean ± SD = 21.6 ± 1.8) while only 3 patients had an underweight BMI (17.5 ± 1.2). The second highest BMI group for the number of subjects (n = 11) is the overweight BMI group (27.2 ± 1.3), while the obese (n = 7) were the second lowest (33.6 ± 2.9). These findings disagree with previous findings [5-8,10,12,13] that found a prevalence of overweight and obese BMI among patients with SZ and compared to the general population. On the other hand, the current findings agree with the previous studies [48-51] that showed that from 53.9% to 72% of patients with SZ had a healthy weight BMI making this BMI category the

most common in these studies. Of special interest is one study [49] done in Japan on patients with SZ that found that 53% of them had a healthy weight BMI, which is exactly as found in the present study.

Most of the patients had a duration of illness from 1 to 10 years, with the healthy weight BMI subjects having the highest number and percent of patients (N, %: 11, 34%), followed by the overweight (6, 19%), obese (4, 13%), and finally the underweight BMI subjects (2, 6%). As for the patients with the 10-20 years duration, most of them had a healthy BMI (5, 16%), followed by the obese BMI (2, 6%), then both the overweight and underweight BMI patients (1, 3%). For the level of education, the healthy BMI subjects had the highest numbers of educated patients with all patients having some form of education. Most of the healthy BMI patients had education at the high school levels (11, 24%), followed by the elementary/middle school level (9, 20%). The next most educated group of patients were the overweight, where 11 of them had some form of education. Most of the overweight BMI subjects had a high school level education (5, 11%), followed by college/diploma (4, 9%) and then elementary/middle school level education (2, 4%). The obese BMI subjects were nearly equally at the college/diploma level (4, 9%) and the elementary/middle school level education (3, 7%).

Table 7. Post hoc comparisons between the BMI groups for the mean total and differential WBC counts and percents

Parameters	G1	G2	Mean difference (G1 – G2)	± SD	*P* value
WBC**	Healthy	Overweight	1.18	28.14	0.182^{NS}
($\times10^3$/µL)		Obese	0.22	21.16	0.670^{NS}
	Overweight	Obese	-0.96	11.04	0.468^{NS}
Lymphocyte**	Healthy	Overweight	-6.33	28.14	0.062^{NS}
(%)		Obese	0.72	21.17	0.831^{NS}
	Overweight	Obese	7.05	11.04	0.277^{NS}
Monocyte**	Healthy	Overweight	-1.22	28.14	0.155^{NS}
(%)		Obese	-3.22	21.16	0.049^{S}
	Overweight	Obese	-2.01	11.04	0.204^{NS}
Neutrophil**	Healthy	Overweight	7.86	10.45	0.062^{NS}
(%)		Obese	1.46	10.12	0.906^{NS}
	Overweight	Obese	-6.43	12.13	0.277^{NS}
Eosinophil**	Healthy	Overweight	0.04	26.19	0.954^{NS}
(%)		Obese	0.92	17.86	0.313^{NS}
	Overweight	Obese	0.91	9.95	0.580^{NS}
Basophil**	Healthy	Overweight	-0.04	26.15	0.632^{NS}
(%)		Obese	0.04	17.81	0.261^{NS}
	Overweight	Obese	0.08	9.93	0.118^{NS}
Lymphocyte**	Healthy	Overweight	-0.09	28.14	0.413^{NS}
($\times10^3$/µL)		Obese	0.15	21.16	0.813^{NS}
	Overweight	Obese	0.24	11.04	0.414^{NS}
Monocyte**	Healthy	Overweight	0.02	28.13	0.776^{NS}
($\times10^3$/µL)		Obese	-0.20	21.16	0.068^{NS}
	Overweight	Obese	-0.22	11.04	0.093^{NS}
Neutrophil*	Healthy	Overweight	1.24	1.46	0.025^{S}
($\times10^3$/µL)		Obese	0.19	1.65	0.789^{NS}
	Overweight	Obese	-1.06	1.33	0.121^{NS}
Eosinophil**	Healthy	Overweight	0.01	26.17	0.848^{NS}
($\times10^3$/µL)		Obese	0.06	17.85	0.519^{NS}
	Overweight	Obese	0.05	9.91	0.579^{NS}
Basophil*	Healthy	Overweight	0.00	0.01	0.522^{NS}
($\times10^3$/µL)		Obese	0.00	0.01	0.610^{NS}
	Overweight	Obese	0	0.00	1.000^{NS}

**The t-test was used for the significance testing; **The Mann–Whitney U test was used for the significance testing; G: group, SD: standard deviation, WBC: white blood cell; NS: None significant (P > 0.05), S: Significant (P ≤ 0.05)*

Table 8. Post hoc comparisons between the BMI groups for the mean RBC count, hemoglobin concentration, and platelet count

Parameters	G1	G2	Mean difference (G1 – G2)	± SD	*P* value
RBC**	Healthy	Overweight	0.07	28.14	0.985^{NS}
($\times10^6$/µL)		Obese	-0.02	21.16	0.924^{NS}
	Overweight	Obese	-0.09	11.04	0.751^{NS}
Hemoglobin**	Healthy	Overweight	0.69	28.14	0.213^{NS}
(g/dL)		Obese	-0.46	21.16	0.395^{NS}
	Overweight	Obese	-1.15	11.04	0.123^{NS}
Platelet*	Healthy	Overweight	-31.9	28.1	0.526^{NS}
($\times10^3$/µL)		Obese	20.2	21.2	0.417^{NS}
	Overweight	Obese	-52.1	11.0	0.248^{NS}

**The t-test was used for the significance testing*
***The Mann–Whitney U test was used for the significance testing*
G: group, SD: standard deviation, RBC: red blood cell
NS: None significant (P > 0.05)

Table 9. Differential WBC and platelet ratios

Parameters	G1	G2	Mean differences (G1-G2)	± SD	*P* value
NLR*	Healthy	Overweight	0.37	0.72	0.172^{NS}
(%)		Obese	-0.11	0.76	0.739^{NS}
	Overweight	Obese	-0.48	0.82	0.245^{NS}
MLR*	Healthy	Overweight	0	0.11	0.956^{NS}
(%)		Obese	-0.13	0.14	0.033^{S}
	Overweight	Obese	-0.14	0.16	0.115^{NS}
BLR*	Healthy	Overweight	0	0.00	0.597^{NS}
(%)		Obese	0	0.00	0.859^{NS}
	Overweight	Obese	0	0.00	0.855^{NS}
ELR**	Healthy	Overweight	0.02	26.19	0.390^{NS}
(%)		Obese	0	17.86	0.715^{NS}
	Overweight	Obese	-0.02	9.95	0.959^{NS}
NLR*	Healthy	Overweight	0.37	0.73	0.168^{NS}
($\times10^3$/µL)		Obese	-0.11	0.76	0.737^{NS}
	Overweight	Obese	-0.48	0.82	0.240^{NS}
MLR*	Healthy	Overweight	0	0.11	0.987^{NS}
($\times10^3$/µL)		Obese	-0.14	0.14	0.034^{S}
	Overweight	Obese	-0.14	0.16	0.113^{NS}
BLR*	Healthy	Overweight	0	0.00	0.952^{NS}
($\times10^3$/µL)		Obese	0	0.00	0.929^{NS}
	Overweight	Obese	0	0.00	0.980^{NS}
ELR*	Healthy	Overweight	0.02	0.05	0.952^{NS}
($\times10^3$/µL)		Obese	-0.01	0.06	0.860^{NS}
	Overweight	Obese	-0.03	0.07	0.574^{NS}
PLR*	Healthy	Overweight	7.64	45.04	0.644^{NS}
($\times10^3$/µL)		Obese	-31.93	52.62	0.168^{NS}
	Overweight	Obese	-39.57	58.24	0.179^{NS}

The t-test was used for the significance testing The Mann–Whitney U test was used for the significance testing*
G: group, SD: standard deviation, NLR: neutrophil-lymphocyte ratio, MLR: monocyte-lymphocyte ratio
BLR: basophil-lymphocyte ratio, ELR: eosinophil-lymphocyte ratio, PLR: platelet-lymphocyte ratio
NS: None significant (P > 0.05), S: Significant (P ≤ 0.05)

Most subjects were unemployed, with 16 (36%) of them having a healthy weight BMI, 7 (16%) were overweight, 5 (11%) were obese, and 3 (7%) were underweight BMI. This is followed by equal overall percents of employed (underweight 0; healthy 4, 9%; overweight 1, 2%; and obese 2, 4%) and retired patients (underweight and obese 0; healthy 4, 9%; and overweight 3, 7%). Additionally, most of the patients were single and at a healthy weight (19, 42%), followed by patients with an overweight (8, 18%), obese (5, 11%), and, finally, underweight BMI (2, 4%). Married patients were more obese (2, 4%) compared to equal numbers (1, 2%) for all the other BMI groups. Divorced patients were mainly healthy (4, 9%) and overweight (2, 4%) and none for the remaining two groups. Most patients were smokers (underweight 3, 7%; healthy 20, 4%; overweight 9, 20%; and obese 4, 9%) compared to non-smokers (underweight 0; healthy 4, 9%; overweight 2, 4%; and obese 3, 7%). Finally, most subjects were substance abusers (underweight 2, 4%; healthy 17, 38%; overweight 7, 16%, and obese 3, 7%) compared to non-substance abusers (underweight 1, 2%; healthy 7, 16%; and overweight and obese 4, 9%).

Compared to the mean cholesterol levels for the healthy BMI group, the mean cholesterol level for the overweight BMI group was significantly lower (P = 0.000) and the mean cholesterol level for the obese BMI group was significantly higher (P = 0.000). On the other hand, the TG, HDL, and LDL mean concentrations were not significantly different (P > 0.05) between the groups.

The current study findings for the cholesterol, TG, and HDL levels for the BMI groups are inconsistent with the findings of a study [12] that showed no significant differences for the cholesterol level, a significantly higher level of TG, and a significantly lower level of HDL in patients with SZ who had an overweight or obese BMI compared to the normal weight patients. On the other hand, both the current study and the above study [12] agree in the lack of significant differences between the BMI groups for the LDL levels. There were no other studies to compare our findings with, as mentioned above.

The mean total WBC counts and lymphocyte, monocyte, neutrophil, eosinophil, and basophil counts and percents were not significantly different (P > 0.05) between the BMI groups. The mean neutrophil count for the overweight BMI group was significantly lower (P = 0.025) compared to that for the healthy weight subjects. The mean monocyte percent for the obese BMI group was significantly higher (P = 0.049) compared to the healthy weight subjects.

The present findings are consistent with the results of a previous study [52] where it was found that WBC counts were not correlated with anthropometric measurements (including BMI) of obese men. Published studies [53,54] found that there was a relationship between higher WBC counts and obesity due to inflammatory mechanisms in obese people. Our findings support this relationship in obese people since the percent of monocytes was high, which is also in agreement with the findings of studies [55,56] that found an association of the BMI with elevated monocytes. On the other hand, the findings did not support the presence of inflammation in the overweight subjects due to the low neutrophil count.

Low counts of neutrophil have been found in some conditions, such as taking some medications (anti-inflammatory, antipsychotic, antidepressant, and anxiolytic medications), alcohol consumption, infections, and inflammatory and immune diseases [57]. In addition, these medications also may cause high monocyte counts [57]. Previous studies give a probable explanation for the high monocyte count found for the obese BMI in the current study, where it has been previously found [55,56] that obese people have a high count of monocyte cells in peripheral blood. This was explained by the finding that the accumulation of adipose tissue macrophages in adipose tissue [58] releases IL-1β and that stimulates the production of monocytes from the bone marrow [59]. Therefore, the obese may show high levels of inflammation due to higher monocyte counts. In the current study the obese patients may have inflammation although it probably is not major since no other WBC counts nor platelets counts (as shown below) were higher in the obese compared to the healthy BMI patients.

No significant differences (P > 0.05) were found for the mean RBC counts, hemoglobin concentrations, and platelet counts when comparing the healthy BMI group with each of the overweight and obese BMI groups. There are no studies to compare the present findings with, although an interesting previous finding [60] is the none significantly different RBC counts found in patients with psychosis compared to patients with other types of mental disorders. On the

other hand, the levels of hemoglobin are in contrast with the results of a research study [60] that found that there is a prevalence of anemia among patients with psychosis. It is expected that people with overweight and obese BMI have higher hemoglobin levels since, in general, previous researchers [61] have shown a positive correlation between the concentration of hemoglobin with BMI.

The current findings showed no significant differences between the platelet counts for the obese and healthy subjects, which agrees with the findings of previous studies [52,61] where no association was found between high platelet counts and obesity among men. The current results are contradictory to a previous study [62] where an association of high platelet levels with obese BMI was found. Platelet counts may be an indicator of inflammation in overweight and obese people [28].

The current results showed a significantly higher MLR for counts and percents (P= 0.034 and P = 0.033) for the obese BMI subjects compared to the healthy weight subjects. On the other hand, there were no significant differences (P> 0.05) between the BMI groups for the other cells counts and percents ratios. The NLR, MLR, and PLR are used as indicators of an inflammatory response [46,63]. These results partially agree with previous results [47] that found a higher MLR in patients with SZ compared to healthy (none SZ) subjects. While, on the other hand, their findings of significantly higher NLR and PLR in patients SZ disagree with the present results of no significant differences. In addition, the result of a high NLR in healthy weight SZ patients compared with healthy (none SZ) subjects found previously [45] disagrees with the current result. Other than our study, no other studies compared the differential WBC and platelet ratios between the BMI groups for SZ patients. The above current findings support the presence of immunological differences and inflammation in obese patients with SZ due to the high MLR.

Therefore, in summary, cholesterol concentrations were significantly lower for the overweight BMI and significantly higher for the obese BMI group. In addition, significant differences were found for the neutrophil count for the overweight BMI, and for the mean monocyte percent and MLR for the counts and percents for the obese BMI. The remaining lipids and WBC, and the RBC, platelet, and hemoglobin were all not different between the groups.

5. CONCLUSION

The results showed no prevalence of overweight and obesity in the studied group of patients with SZ. In fact, most had a healthy weight BMI. On the other hand, there were significant changes in some inflammatory immune system WBC counts, MLR, and cholesterol levels for the overweight and obese subjects. Therefore, cholesterol levels and the immune system are affected in SZ patients.

It is recommended that overweight and obese patients with SZ follow a healthy lifestyle and eat a healthy diet to prevent possible complications from abnormal cholesterol levels, increased inflammation and effects on the immune system. It is also recommended that further research be done using various anthropometric measurements to determine the prevalence of obesity and to find the best measure of obesity in patients with SZ.

DISCLAIMER

The products used for this research are the commonly and predominantly used products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

CONSENT

As per international standard or university standard, patient's written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

Ethical approval was granted by the local Institutional Review Board in Jeddah Health Affairs, approval number: A00857.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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