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Comorbidity results of an obesity center

Müjgan Tuna[1], Şenay Kırlak[2], Seydahmet Akın[3], Özlem Çakır Madenci[4]

[1]Depatment of Family Medicine, Yapı Kredi Health Service, İstanbul, Türkiye; [2]Diabetes Policlinic Nurse, Kartal Dr. Lütfi Kırdar City Hospital, İstanbul, Türkiye; [3]Department of Internal Medicine, Kartal Dr. Lütfi Kırdar City Hospital, İstanbul, Türkiye; [4]Department of Biochemistry, Kartal Dr. Lütfi Kırdar City Hospital, İstanbul, Türkiye

ABSTRACT

Objectives: Obesity is linked to numerous severe health conditions, including type 2 diabetes mellitus, heart disease, hypertension, and stroke. This study aimed to compare metabolic parameters and anthropometric measurements between male and female patients with obesity to identify gender-based differences in obesity-related health markers.

Methods: This prospective study enrolled 393 obese patients (52 male, 341 female) from an outpatient clinic. After an overnight fast (8-10 hours), blood samples were collected to assess a range of parameters: complete blood count, fasting blood glucose, insulin, Hemoglobin A1c (HbA1c), Aspartate aminotransferase (AST), Alanine aminotransferase (ALT), Thyroid-stimulating hormone (TSH), total cholesterol, triglycerides, Low-density lipoprotein (LDL), High-density lipoprotein (HDL), 25-hydroxy vitamin D3 (25OHD3), ferritin, iron, and vitamin B12. Homeostatic Model Assessment of Insulin Resistance (HOMA-IR) and Body Mass Index (BMI) were calculated, while soft lean mass (SLM) and percent body fat (PBF) were also analyzed.

Results: Males with obesity had significantly higher levels of insulin, HOMA-IR, 25OHD3, ferritin, iron, hemoglobin, hematocrit, urea, and ALT compared to females ($P<0.05$ for all). Conversely, males had lower HDL and platelet levels ($P<0.05$). The prevalence of thyroid disease was significantly higher in females ($P=0.027$).

Conclusions: Thyroid disease prevalence was significantly higher in females compared to males. Additionally, metabolic parameters such as insulin, HOMA-IR, and urea were elevated in females, while HDL and platelet levels were lower in males.

Keywords: Obesity, insulin resistance, metabolic parameters, diabetes mellitus, body mass index

The obesity pandemic is expanding globally at an accelerating rate, affecting not only adults but also children and adolescents, irrespective of socioeconomic status. It is recognized as a significant health issue that strains healthcare systems and increases costs at every level [1]. According to a World Health Organization (WHO) report, it is estimated that 1 billion people worldwide will suffer from obesity by 2030, with one out of every five women and one out of every seven men [2]. The World Obesity Federation (WOF) forecasts that by 2035, 1.9 billion people will be obese, equating to one in four individuals [3]. Childhood obesity is expected to increase by 100%, and the global economic burden of obesity will reach 4.32 trillion dollars in the next decade [4].

Corresponding author: Müjgan Tuna, MD.,
Phone: +90 216 458 30 00, E-mail: mjgn-tn@hotmail.com

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This issue is also significant in our country, where 24.8% of women are obese, and 30.4% are classified as pre-obese. The obesity rate in men is 17.3%, with 39.7% in the pre-obese category [5]. Socioeconomic status, age, and gender are key factors contributing to the rise of obesity and related diseases.

In insulin resistance, the pancreas continues to produce and secrete insulin, but target cells fail to respond adequately to blood insulin concentrations [6]. This resistance primarily affects the liver, muscles, and adipose tissue, and is a common complication of obesity, forming a major criterion for metabolic syndrome [7]. Despite many studies aiming to clarify the mechanisms of insulin resistance, its exact etiology remains unclear. However, low-grade chronic inflammation in adipose tissue is believed to be a primary cause in the early stages of insulin resistance development [6-7]. Elevated C-reactive protein CRP) levels are used clinically to detect inflammation, and deactivating the genetic structures affecting insulin function has been shown to reduce inflammation and improve glucose metabolism. Inflammation in adipose tissue decreases as circulating insulin levels drop. Insulin resistance is present in 90% of patients with Type 2 Diabetes Mellitus (T2DM), and the risk of cardiovascular disease is doubled in these patients [8].

Obesity is associated with numerous severe diseases, including T2DM, heart disease, hypertension, and stroke. A weight gain of 6-8 kg doubles the risk of developing T2DM compared to individuals who do not gain weight. Additionally, obesity is linked to several types of cancer (breast, endometrial, prostate, colon, and gallbladder), hypoxia, sleep apnea, hernias, and arthritis. Obesity-related disorders include insulin resistance (T2DM), lipoprotein metabolism disorders, cardiovascular issues (low high-density lipoprotein [HDL], hypertriglyceridemia, increased low-density lipoprotein [LDL], fibrinolytic anomalies, atherothrombosclerosis), hypertension (metabolic syndrome), and gastrointestinal disorders (reflux esophagitis, hiatal hernia, gallstones, hepatosteatosis, and steatohepatitis) [9].

The most effective long-term strategy for managing T2DM is weight loss. However, certain medications and physiological factors in the hypothalamus cause patients to regain weight, reducing feelings of satiety and increasing hunger. Early treatment of insulin resistance and reducing Body Mass Index (BMI) to near-normal levels can help prevent the progression of diabetes [10].

This study aims to provide a descriptive comparison of metabolic parameters and anthropometric measurements, such as BMI, Soft Lean Mass (SLM), and Percent Body Fat (PBF), with respect to gender.

METHODS

This prospective study enrolled 393 patients (52 male, 341 female) diagnosed with obesity at our institution's outpatient clinic. All procedures were conducted in accordance with the ethical standards of the responsible committee on human experimentation (both institutional and national) and in line with the Helsinki Declaration of 1975, as revised in 2008. Ethical approval was obtained from our institution's ethics committee (protocol number 2021/514/208/11), and informed consent was secured from all participants.

Baseline demographic information, including age, gender, and treatment regimens, was obtained from hospital records. After an 8-10 hour fasting period, blood samples were collected to assess complete blood count, fasting blood glucose, insulin, Hemoglobulin A1c (HbA1c), Aspartate aminotransferase (AST), Alanine aminotransferase (ALT), Thyroid-stimulating hormone (TSH), total cholesterol, triglycerides, LDL, HDL, 25-hydroxy vitamin D3 (25OHD3), ferritin, iron, and vitamin B12. Homeostatic Model Assessment of Insulin Resistance (HOMA-IR) was calculated using the formula: fasting blood glucose (mg/dL) × insulin (μIU/mL) / 405. BMI was calculated (kg/m²), and additional anthropometric measurements, such as SLM and PBF, were assessed using the Tanita MC-580 body composition analyzer (TANITA, MC-580, Japan).

Patients with a BMI > 30 kg/m² were included in the study, while individuals under 18 or over 80 years of age, pregnant women, and those who had undergone gastrointestinal obesity surgery were excluded.

Statistical Analysis

Patient data collected within the scope of the study were analyzed with the IBM Statistical Package for the Social Sciences (SPSS) for Windows 26.0 (IBM Corp., Armonk, NY) package program. Frequency and percentage for categorical data and mean and standard

deviation for continuous data were given as descriptive values. The distribution of the data was cheched using the Kolmogorov-Smirnov test. Parameters with normal distrıbution were presentedas mean and standard deviation, while those with non-parametric distribution were expressed as median and interquartile range. Categorical parameters were reported as count and percentage. AP <0.05 was accepted as significant. For comparisons between groups, the "Independent Sample T–test" was used for two groups, and the "Pearson Chi-Square Test" was used to compare categorical variables. The results were considered statistically significant when the P-value was less than 0.05.

RESULTS

A total of 393 patients (52 male, 341 female) were enrolled in this prospective study. The general characteristics of the patients are shown in Table 1. The gender distribution was 86.8% female and 13.2% male. Male patients had significantly lower PBF levels, but significantly higher SLM and waist/hip ratios compared to females (P<0.001, P=0.004 and P<0.001, respectively). The distribution of diseases we detected together with obesity in patients are shown in Table 2. The prevalence of thyroid diseases was significantly higher in females than in males (P=0.027). There was

Table 1. Baseline demographics of the study population

			Gender		
		Total (n=393)	**Male (n=52))**	**Female (n=341)**	**P value***
Age (years)		46.8±12.2 (17-86)	48.3±12.8 (18-69)	46.6±12.1 (17-86)	0.356[#]
Education	0 (illiterate)	28 (7.1)	1 (1.9)	27 (7.9)	**<0.001**
	1 (primary)	240 (61.1)	22 (42.3)	218 (63.9)	
	2 (high school)	76 (19.3)	17 (32.7)	59 (17.3)	
	3 (universıty)	49 (12.5)	12 (23.1)	37 (10.9)	
Job	No	297 (75.6)	23 (44.2)	274 (80.4)	**<0.001**
	Yes	96 (24.4)	29 (55.8)	67 (19.6)	
Exercise	0 (no walk)	273 (69.5)	42 (80.8)	231 (67.7)	0.163
	1 (2day/w walk)	51 (13.0)	4 (7.7)	47 (13.8)	
	2 (5day/w walk)	69 (17.6)	6 (11.5)	63 (18.5)	
Weight (kg)		101.4 (91-113.8)	114.8 (103-130.3)	99.8 (89.8-111.7)	**<0.001[£]**
Height (cm)		160 (155-165)	172 (167.3-177)	159 (155-163.5)	**<0.001[£]**
BMI (kg/m^2)		39.1 (35.2-43.7)	39 (35.2-43.5)	39.2 (35-43.9)	0.560[£]
BMI	Obese	215 (54.7)	29 (55.8)	186 (54.5)	0.875
	Morbid obese	153 (38.9)	19 (36.5)	134 (39.3)	
	Super obese	25 (6.4)	4 (7.7)	21 (6.2)	
PBF		40.9 (36.3-44)	35.3 (32.6-39)	41.5 (37.6-44.5)	**<0.001**
SLM		50.2 (42.9-57.6)	61.5 (35.1-73.9)	50 (43-56)	**0.004**
Waist/Hip		0.96 (0.92-1)	1.01 (0.97-1.06)	0.95 (0.91-0.99)	**<0.001**
Cigarete		132 (33.6)	22 (42.3)	110 (32.3)	0.153

Data are shown as mean±standard deviation (minimum-maximum) or median (IQR) or n (%) where appropriate. BMI=Body mass index, PBF=Percentage of body fat, SLM=Smooth lean mass

[#]Student t Test *Chi Square Test

also a significant difference in the nutritional habits between the gender groups (P<0.001). The frequency of comorbidities according to gender is shown in Fig. 1.

Insulin, HOMA, 25OHD3, ferritin, iron, hemoglobin, hematocrit, urea, and ALT levels were significantly higher in males, while HDL and platelet levels were lower compared to females (P=0.003, P=0.007, P=0.022, P<0.001, P=0.007, P<0.001, P<0.001, P=0.042, P=0.004, P<0.001 and P=0.004, respectively). Additionally, insulin, HOMA-IR, ferritin, creatinine, ALT, and hemoglobulin levels were higher in males, while iron and hematoctit levels were normal, with higher rates of high HDL and low HDL in males than in females (P=0.021, P=0.029, P=0.023, P<0.001, P=0.001, P=0.007, P<0.001, P=0.012 and P=0.016, respectively). Laboratory results are shown in Table 3.

Table 2. Distribution of diseases in study group

Diseases, n (%)	Total (n=393)	Male (n=52)	Female (n=341)	P value*
Diabetes mellitus	127 (36.1)	14 (31.8)	113 (36.7)	0.529
Pre-diabetes mellitus	94 (23.9)	11 (21.2)	83 (24.3)	0.616
Hypertension	137 (34.9)	22 (42.3)	115 (33.7)	0.226
Thyroid disease	102 (26.0)	7 (13.5)	95 (27.9)	**0.027**
Anemia	26 (6.6)	1 (1.9)	25 (7.3)	0.228
Cardiovascular disease	36 (9.2)	6 (11.5)	30 (8.8)	0.604
Asthma	50 (12.7)	9 (17.3)	41 (120.0)	0.287
Hyperlipidemia	29 (7.4)	2 (3.8)	27 (7.9)	0.401
Depression	29 (7.4)	1 (1.9)	28 (8.2)	0.152
Polycystic over syndrome	15 (3.8)	0 (0.0)	15 (4.4)	0.237
Cancer	7 (1.8)	1 (1.9)	6 (1.8)	1.000
Rheumatic disease	18 (4.6)	1 (1,9)	17 (5.0)	0.488
Epilepsy	3 (0.8)	0 (0.0)	3 (0.9)	1.000
Sleep apnea syndrome	16 (4.1)	4 (7.7)	12 (3.5)	0.246
Osteoporosis	10 (2.5)	1 (1.9)	9 (2.6)	1.000
Venous insufficency	3 (0.8)	0 (0.0)	3 (0.9)	1.000
Gastroesophageal reflux	2 (0.5)	0 (0.0)	2 (0.6)	1.000
Renal diseases	10 (2.5)	0 (0.0)	10 (2.9)	0.371
Gout	2 (0.5)	0 (0.0)	2 (0.6)	1.000
Glocom	1 (0.3)	0 (0.0)	1 (0.3)	1.000
Amputated leg	5 (1.3)	0 (0.0)	5 (1.5)	1.000
Gallbladder diseases	3 (0.8)	0 (0.0)	3 (0.9)	1.000
Cirrhosis	1 (0.3)	0 (0.0)	1 (0.3)	1.000
Psychiatric disease (bipolar)	1 (0.3)	0 (0.0)	1 (0.3)	1.000
Herniated disc	7 (1.8)	1 (1.9)	6 (1.8)	1.000
COVID-19	393 (100)	52(100)	341 (100)	-
Obesity history	110 (28.2)	17 (32.7)	93 (27.5)	0.440
Family history	270 (68.7)	33 (63.5)	237 (69.5)	0.382

Data are shown as n (%).

#Student t Test*Ki Square Test

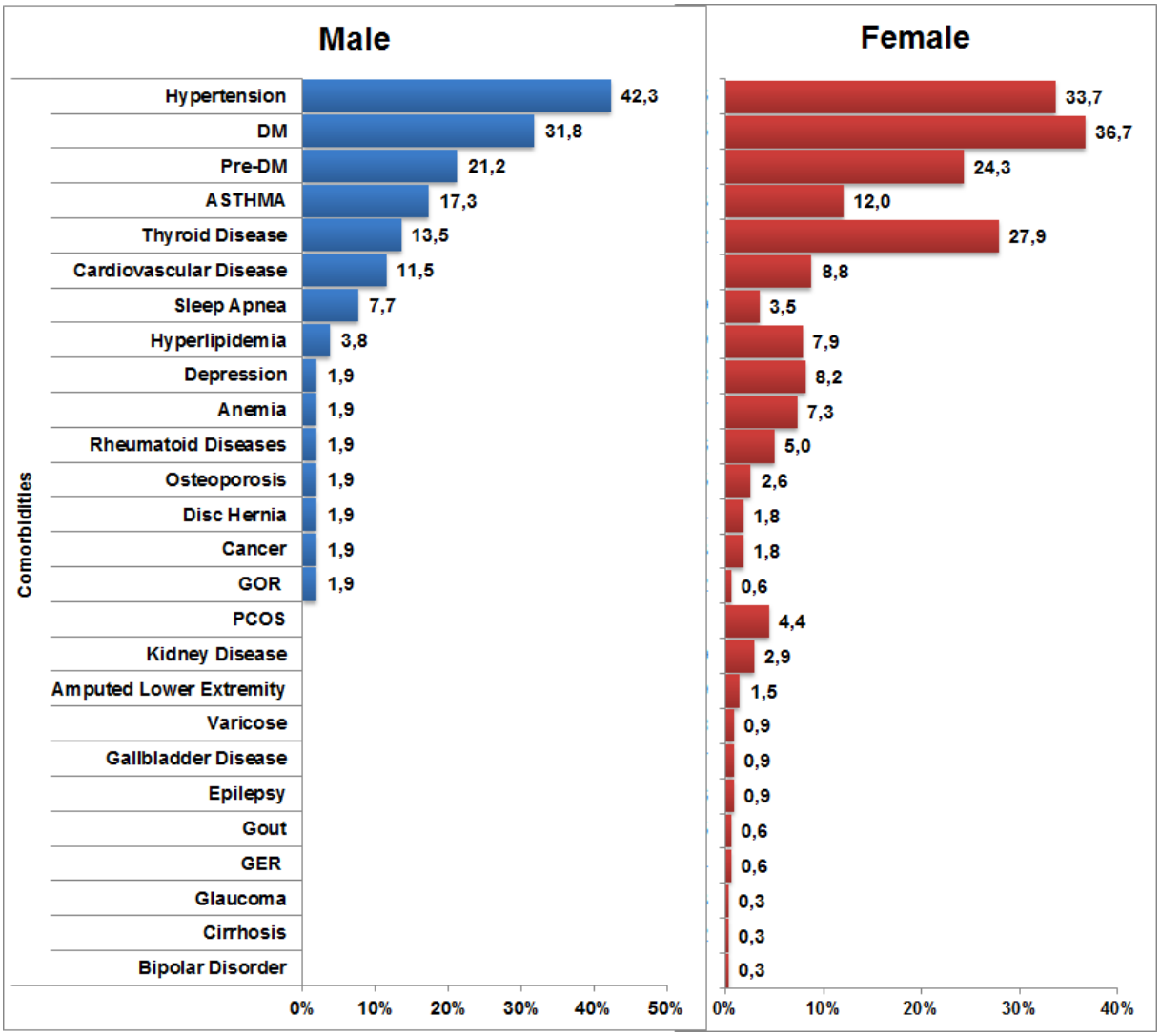

Fig. 1. Tabulated list of diseases according to frequency.

DISCUSSION

The World Health Organization (WHO) European Regional Obesity Report (2022) highlighted that Turkey has the highest rate of overweight and obesity among all European countries. The obesity rate in Turkey stands at 32.1%, compared to the European average of 23.3%. Furthermore, the rate of obesity in Turkish women is 39.2%, higher than the European average of 24.5%, and the rate in men is 24.4%, higher than the European male average of 21.8% [2]. In line with these statistics, our study demonstrated a gender distribution of 86.8% female and 13.2% male, consistent with the higher prevalence of obesity in women as reported in the literature.

Obesity has evolved into a complex issue influenced by biological, genetic, and environmental factors. Recent studies suggest that obesity is not merely the result of personal lifestyle choices, but a biological condition that stems from dysfunction within fatty tissue. The dysregulation of adipose tissue contributes to chronic low-grade inflammation, a primary mechanism in the development of insulin resistance (IR). Obesity, through inflammatory cytokines and metabolic disruptions, leads to insulin resistance, which is strongly associated with a variety of comorbidities such as diabetes, hypertension, heart disease, stroke, and certain cancers [5]. Early identification of insulin resistance and achieving a normal BMI can help prevent the onset of diabetes [11].

Table 3. The metabolic parameters and laboratory tests of the study population

	Total (n=393)	Gender		P value[£]
		Male (n=52)	Female (n=341)	
Glucose (mg/dL)	113.1±44.5	111.1±36.6	113.4±45.6	0.760
HbA1C (%)	6.29±1.36	6.27±1.18	6.29±1.39	0.640
Insulin (µU/mL)	20.0±20.2	29.7±44.2	18.6±13.1	**0.003**
HOMA-IR	5.61±6.06	8.01±12.23	5.26±4.43	**0.007**
25-OHD3 (ng/mL)	17.8±11.6	20.1±10.3	17.4±11.8	**0.022**
TSH (µU/mL)	2.55±2.76	2.57±2.76	2.54±2.76	0.447
Total cholesterol (mg/dL)	199.8±40.7	194.3±34.9	200.7±41.5	0.312[#]
LDL (mg/dL)	124.1±42.2	123.4±49.6	124.2±41.0	0.522
HDL (mg/dL)	50.1±11.1	45.0±9.9	50.9±11.1	**<0.001**
Triglyceride (mg/dL)	153.0±81.1	170.2±91.8	150.3±79.1	0.166
Vitamin B12 (pg/dL)	308.1±252.6	365.3±559.1	299.3±160.6	0.740
Ferritin (ng/dL)	60.1±89.8	116.0±102.4	51.4±84.6	**<0.001**
Iron (µg/dL)	67.8±33.6	81.5±36.4	65.7±32.7	**0.007**
Urea (mg/dL)	28.0±11.6	29.8±4.1	27.7±12.3	**0.042**
Creatinine (mg/dL)	1.55±7.91	0.74±0.27	1.67±8.47	0.071
ALT (U/L)	22.8±13.8	36.9±23.5	20.7±10.4	**0.004**
AST (U/L)	22.0±13.2	24.7±8.7	21.6±13.7	0.091
Hemoglobulin (g/dL)	13.3±4.9	14.2±1.7	13.2±5.3	**<0.001**
Hematocrit (%)	42.2±24.7	43.0±4.5	42.1±26.5	**<0.001**
Platelets (×10^9/L)	287.2±74.2	258.6±75.7	291.7±73.1	**0.004**[#]

Data are shown as mean±standard deviation. HbA1c=Hemoglobin A1c, HOMA-IR= Homeostatic Model Assessment for Insulin Resistance, 25-OHD3=25-hydroxy vitamin D3, TSH=Thyroid-stimulating hormone, LDL=Low-density lipoprotein, HDL=High-density lipoprotein, ALT=Alanine aminotransferase, AST=Aspartate aminotransferase

[#]Student t Testi [£]Mann Whitney U testi

Adipose tissue, particularly visceral fat, plays a key role in the clinical manifestation of obesity-related diseases. Visceral fat is more closely linked to insulin resistance, cardiovascular risk, and metabolic disorders than subcutaneous fat. In our study, males had significantly lower PBF and higher SLM and waist/hip ratios compared to females. This finding supports the idea that male and female adipose tissue distributions differ, with males generally having more visceral fat, which is more detrimental to metabolic health. Visceral fat cells, especially macrophages and immune cells, secrete inflammatory cytokines and adipokines, which in turn modulate immune responses and contribute to obesity-related diseases [12].

The persistent inflammation associated with hypertrophic adipose tissue leads to impaired insulin sensitivity, increased circulating free fatty acids, and dysfunctional fat storage in organs such as the liver and pancreas. This condition, characterized by elevated CRP and other inflammatory markers, further exacerbates metabolic dysfunction. [13, 14].

Our findings showed that insulin, HOMA, ferritin, iron, hemoglobin, hematocrit, and ALT levels were significantly higher in males, while HDL and platelet levels were lower than in females. Additionally, male patients exhibited higher rates of insulin resistance (HOMA-IR) and ferritin, creatinine, ALT, and hemoglobin. These findings suggest that male obesity is as-

sociated with more severe metabolic disturbances compared to female obesity. The blunted leptin response and the hyperleptinemia observed in obesity further complicate the regulation of energy balance, increasing the difficulty in managing obesity and its comorbidities [15].

Long-term management of T2DM heavily relies on weight loss, yet the weight-increasing effect of some medications and the physiological pressure exerted by the hypothalamus makes it challenging to maintain weight loss over time. This leads to a cycle of hunger and satiety that undermines the effectiveness of weight management strategies [16]. The risk of developing T2DM increases with each kilogram of weight gain, and the presence of insulin resistance in 90% of T2DM patients doubles the risk of cardiovascular disease [17].

The Framingham Study has shown that obesity leads to a shorter life expectancy, with obese women and men living 5.8 and 7.1 years less, respectively, than their non-obese counterparts [18]. Furthermore, obesity significantly increases the risk of hypertension and ischemic heart disease. The Framingham and Nurses Health Studies also showed that obesity increases the risk of both fatal and nonfatal myocardial infarction [18-20]. This reinforces the critical need for early intervention in managing obesity to prevent cardiovascular diseases and improve long-term health outcomes.

A meta-analysis by Guh *et al*. [21] also highlighted that the relative risks for conditions like T2DM and coronary artery disease (CAD) are higher in obese patients compared to those who are overweight. While some studies, such as those by Faeh *et al*. [23] and Chu *et al*. [24], report lower cut points for obesity-related comorbidities in different populations, the overall association between obesity and comorbidities is well-established across various ethnic groups.

The relationship between obesity and hypertension is influenced by sex, as demonstrated by a large cohort study evaluating the incidence of hypertension in Japanese adults with obesity. The study found that female patients had a greater risk of developing hypertension compared to males with similar BMI values. This supports the notion that women may be more vulnerable to certain obesity-related comorbidities, such as hypertension, than men. This finding is consistent with our study, where females exhibited a higher prevalence of thyroid diseases and other obesity-related complications, reinforcing the need for gender-specific interventions in the management of obesity and its associated health risks [25].

National Health and Nutrition Examination Survey (NHANES I, II, III) studies also support this data, with findings suggesting that the risk of developing Type 2 diabetes is significantly higher in individuals with high BMI. Specifically, the age-adjusted relative risk of developing diabetes was reported to be 100 times higher in women with a BMI >35 kg/m² compared to women with a BMI <22.4 kg/m² over 14 years. Similarly, the relative risk was 50.7 times higher in men with a BMI ≥35 kg/m² compared to those with a BMI <23 kg/m². Furthermore, the Framingham Heart Study found that the risk of heart failure was doubled in obese individuals, emphasizing the serious long-term consequences of obesity on cardiovascular health [19, 20].

In our study, we observed a significantly higher rate of thyroid disease in females compared to males, consistent with previous literature indicating that obesity is associated with various endocrine disorders. Additionally, the metabolic consequences of obesity, including its effect on cardiovascular risk, highlight the need for early intervention to prevent the onset of complications such as diabetes, hypertension, and cardiovascular disease [26]. In Turkey, obesity-related diseases, particularly ischemic heart disease and diabetes, contribute to a substantial burden on healthcare, with 57,143 deaths annually attributed to obesity-related conditions [27].

CONCLUSION

This study reveals significant gender differences in obesity-related health risks, with women showing higher thyroid disease prevalence and men experiencing more severe metabolic disturbances. Obesity is strongly linked to increased risks of Type 2 diabetes, cardiovascular disease, and hypertension. Given Turkey's high obesity rates, particularly among women, urgent action is needed to address these health threats and prevent long-term complications.

Ethical Statement

This study was approved by the Kartal Dr. Lütfi

Kırdar City Hospital Clinical Research Ethics Committee (Decision no: 2021/514/208/11 and date: 25.08.2021). All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Informed consent was obtained from all participants.

Authors' Contribution

Study Conception: MT, SA; Study Design: MT; Supervision: MT, ŞK; Funding: MT; Materials: MT; Data Collection and/or Processing: MT, ŞK; Statistical Analysis and/or Data Interpretation: ÖÇM; Literature Review: ÖÇM; Manuscript Preparation: MT; and Critical Review: ÖÇM.

Conflict of interest

The authors disclosed no conflict of interest during the preparation or publication of this manuscript.

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