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IS THE AMOUNT OF WEIGHT LOSS AFTER BARIATRIC SURGERY A FACTOR DETERMINING CARDIOMETABOLIC RISK REDUCTION?

BARİYATRİK CERRAHİ SONRASI KİLO KAYBI MİKTARI KARDİYOMETABOLİK RİSK AZALMASINI BELİRLEYEN BİR FAKTÖR MÜDÜR?

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ABSTRACT

Objective: This study aimed to investigate whether differential weight loss amount appropriately reflects improvements in cardiometabolic health in patients undergoing bariatric surgery.

Materials and Methods: Patients who underwent bariatric surgery (BS) and were followed up for six months were divided into three groups according to their weight loss (Group-1: Low weight loss; Group-2: Moderate weight loss; Group-3: High weight loss). Before and after surgery, patients were evaluated for metabolic syndrome (MetS) using waist circumference, blood pressure, glucose, HDL-C, and triglyceride data, and a clustered cardiometabolic risk (CMR) score was obtained for each patient using a calculator available in the literature online. Changes in each MetS criterion and CMR score in the groups before and after the operation, and their relations with each other were compared.

Results: Sixty-six patients were included in the study. It was observed that the prevalence of MetS, which was 74.2% before the operation, decreased to 25.8%. A significant difference was observed between the groups in the decrease in weight, waist circumference, fat mass, fasting blood sugar, and HOMA-IR values. However, no significant difference was found between the groups in the change in MetS parameters and CMR scores. While a significant negative correlation was found between the amount of weight loss and the difference in the CMR score, no relation was observed between each MetS parameter and the amount of weight loss. It was also found that each 1% increase in weight loss was associated with a 57% decrease in the CMR score.

Conclusion: Although there is a significant decrease in cardiometabolic risk parameters after bariatric surgery, the amount

ÖZET

Amaç: Bu çalışma, bariyatrik cerrahi geçiren hastalarda farklı miktarda kilo kaybının kardiyometabolik sağlıktaki gelişmeleri uygun şekilde yansıtıp yansıtmadığını araştırmayı amaçlamıştır.

Gereç ve Yöntem: Bariyatrik cerrahi (BC) geçiren ve altı ay takip edilen hastalar geriye dönük olarak kilo kayıplarına göre üç gruba ayrıldı (Grup-1:Düsük kilo kaybı; Grup-2:Orta kilo kaybı; Grup-3: Yüksek kilo kaybı). Cerrahi öncesinde ve sonrasında hastalar, bel çevresi, kan basıncı, glukoz, HDL-K ve trigliserid verileri kullanılarak hem metabolik sendrom (MetS) varlığı açısından değerlendirildi hem de literatürde mevcut bir hesaplayıcı kullanılarak, her hasta için kümelenmiş bir kardiyometabolik risk (KMR) skoru elde edildi. Her bir MetS kriteri ve KMR skorunun, operasyondan önce ve sonra gruplardaki değişimleri ve birbirleriyle ilişkileri karşılaştırıldı.

Bulgular: Çalışmaya 66 hasta dahil edildi. Operasyon öncesi %74,2 olan MetS sıklığının operasyondan sonra %25,8'e düştüğü görüldü. Gruplar arasında kilo, bel çevresi, yağ kütlesi, açlık kan şekeri ve HOMA-IR değerlerindeki düşüşte anlamlı farklılık gözlendi. Ancak hem MetS parametrelerindeki hem de KMR skorundaki değişimde gruplar arası anlamlı bir farklılık bulunamadı. Kilo kaybı miktarıyla KMR skorundaki değişim arasında anlamlı negatif korelasyon saptanırken, ayrı ayrı MetS parametreleriyle kilo kaybı miktarı arasında herhangi bir ilişki gözlenmedi. Ayrıca kilo kaybındaki her %1'lik artışın, KMR skorunda %57'lik bir azalma ile ilişkili olduğu tespit edildi.

Sonuç: Bariyatrik cerrahi sonrası kardiyometabolik risk parametrelerinde anlamlı azalma olmasına rağmen hastaların kilo kayıp miktarı, ayrı ayrı parametreleri etkilememektedir. Ancak hastaların kardiyometabolik küme risklerini değerlendirmek ve izlemek

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of weight loss of the patients does not affect the individual parameters. However, using a scoring system to evaluate and monitor patients' cardiometabolic cluster risks will make it possible to follow the gradual changes in patients after surgery, making interventions by physicians and nutritionists more targeted and efficient.

Keywords: Metabolic syndrome, bariatric surgery, cardiometabolic risk score, amount of weight loss, obesity

için bir skorlama sistemi kullanmak, hastalarda ameliyat sonrasındaki kademeli değişiklikleri takip etmeyi mümkün kılacak, hekim ve beslenme uzmanlarının müdahalelerini daha hedefe yönelik ve verimli hale getirecektir.

Anahtar Kelimeler: Metabolik sendrom, bariyatrik cerrahi, kardiyometabolik risk skoru, kilo kaybı miktarı, obezite

INTRODUCTION

The probability of developing cardiovascular disease (CVD) and type-2 diabetes (T2D) in an individual is known as the "cardiometabolic risk" (CMR) and many risk factors coexist. Metabolic syndrome (MetS) elevates CMR because the presence of MetS causes a five-fold increase in the risk of developing T2D and a two-fold increase in the risk of developing CVD over the next five to ten years (1,2).

Conventional diagnosis of metabolic syndrome does not make it possible to follow the gradual changes after treatment in the diagnosed patients. This limitation seems to have been overcome with the continuous cardiometabolic risk (cCMR) index, which was used to estimate CMRs of patients diagnosed with MetS, especially in the pediatric age group, in previous studies (3). This index shows the continuous risk that the individual is exposed to and gives information about the severity of the risk (1,2). An article published in Diabetes Care in 2006 argued that CVR is a progressive function of various MetS risk factors and that separating variables into "metabolic risk" and "cardiovascular risk" would reduce statistical power; therefore, separate evaluation was suggested as not being necessary. It has been suggested that the continuous MetS risk score developed using the MetS risk factors of the International Diabetes Federation (IDF) is a more appropriate and valid alternative for epidemiological analyses (4). Similar indices have recently been developed for continuous cardiometabolic risk (cCMR) measurement. Although they contain the same components of the MetS, they were created using different methodologies (1,2).

In observational and randomized controlled studies with long-term follow-up of patients such as Surgical Treatment and Medications Potentially Eradicate Diabetes Efficiently (STAMPEDE) and Gastric Bypass to Treat Obese Patients With Steady Hypertension (GATEWAY) and with shorter follow-up periods, it has been shown that bariatric surgical interventions not only reduce weight, but also reduce glycemic and cardiometabolic risk, and are superior to intensive medical and lifestyle change treatments alone (5,6).

The most important indicator of treatment success and superiority of bariatric surgery is considered to be the amount of weight lost after surgery (7). However, in addition to patients who could not reach the target weight or regain weight after surgery, there are also studies showing improvements in MetS and CMR factors independent of weight loss with lifestyle changes such as diet and/or exercise without surgery (8,9). The findings of these studies highlight the necessity of considering other markers in managing obesity apart from weight loss alone. At this point, it comes to mind whether the amount of weight loss provided by bariatric surgery can be a treatment success on its own. This study evaluated the relationship between the amount of weight loss in obese individuals who underwent bariatric surgery and decreased CMR.

MATERIALS AND METHODS

In the study, the data of the patients who underwent bariatric surgery at Istanbul University, Istanbul Faculty of Medicine between the dates 2013-2017 and followed up afterward were used by scanning their files retrospectively. The study was approved by the local ethics committee (Date: 24.06.2022, No:12), and written informed consent was obtained from all patients.

Study population

The characteristics of the patients who were pre-evaluated for the study were as follows: Men and women aged between 18-60 years who had Roux-en-Y gastric bypass (RYGB) surgery by the same surgeon at Istanbul University, Istanbul Faculty of Medicine hospital, whose blood tests were performed at Istanbul Faculty of Medicine Clinical Biochemistry Laboratory, and who followed up in Istanbul Faculty of Medicine Endocrinology and Metabolic Diseases department.

Patients with the following characteristics were not included in the evaluation: Those diagnosed with cancer, kidney and liver failure, stroke, coronary artery disease, myocardial infarction or angina, coronary bypass surgery, and Percutaneous Coronary Angioplasty and stent placement.

Evaluated data: height (cm), weight (kg), fat mass (kg and %), fat-free mass (kg), waist and hip circumference (cm), systolic and diastolic blood pressure (mmHg), fasting blood sugar (FBG, mg/dl), fasting insulin (μU/mL), glycated hemoglobin (HbA1c, %), low-density lipoprotein cholesterol (LDL-C, mg/dl), high-density lipoprotein cholesterol (HDL-C, mg/dl), triglycerides (TG, mg/dl), and C -reactive protein (CRP) measurements.

Patients were divided into tertiles according to the magnitude of percent weight loss; 1st tertile, Group-1: "mild weight loss; 2nd tertile, Group-2: "moderate weight loss"; 3rd tertile, Group-3: "high weight loss".

Metabolic syndrome criteria and cardiometabolic risk assessment

The following were accepted as diagnostic criteria for metabolic syndrome (MetS): Presence of at least one of these: insulin resistance (IR), diabetes mellitus (DM), or impaired glucose tolerance (IGT); Presence of any two of these: Hypertension (SBP≥130, DBP≥85 mmHg or antihypertensive use), Dyslipidemia (TG≥150 mg/dl or HDL-C <40 mg/dl in men, <50 mg/dl in women), presence of abdominal obesity (BMI)≥30 kg/m^2 or waist circumference ≥96 cm in men, ≥90 cm in women (based on TURDEP-II data) (10,11).

The Homeostasis Model Assessment (HOMA) formula, the most commonly used method in clinical practice, was used to detect the presence of insulin resistance. It has been reported that the HOMA value is lower than 2.7 in normal individuals, and a value above 2.7 reflects varying degrees of insulin resistance [HOMA: Fasting insulin (μU/mL) x Fasting plasma glucose (mg/dl)/405)] (11).

The definition of mean arterial pressure (MAP) is the average arterial pressure throughout one cardiac cycle; systole, and diastole. To perfuse vital organs requires 70-100 mmHg (minimum 60 mmHg) MAP. If the MAP drops below this point for an extended period, end-organ manifestations such as ischemia and infarction can occur. A standard method to estimate the MAP is the following formula: "MAP=DP+1/3(SP–DP)". This method is often more conducive to measuring MAP in most clinical settings as it offers a quick means of calculation if the blood pressure is known (14).

The metabolic syndrome z-score (MetS z-score)

To date, approximately 90% of the indices used in many studies for calculating cardiometabolic risk have been calculated using the sum or average of the statistical z-scores of the 5 MetS components. This analysis produces a score based on the individual's measurements of these components. This score behaves like a z-score in that it has a normal distribution with a mean of "0" and a standard deviation of "1". Technically, a z-score is the number of standard deviations from the mean of a given value. A z-score=0 for a given individual indicates that the value of that individual is equal to the population mean. Z-score=2 implies that the subject's population mean is two standard deviations above the mean, that is, "well above the mean", indicating MetS diagnosis. The components most frequently included were waist circumference (52%), triglycerides (87%), high-density lipoprotein cholesterol (67%), glucose (43%), and systolic blood pressure (52%) (12).

It cannot be excluded that there are different genetic and environmental controls on the expression of cardiometabolic risk factors, both in different racial/ethnic communities and in different genders. From this point of view, Gurka MJ et al. developed a gender and race/ethnic-specific equation to calculate the severity of MetS: MetS z-score (13). This calculator uses gender, ethnicity, height, weight, waist circumference, SBP, HDL-C, TG, and FBG parameters and is available online at https://metscalc.org/metscalc/. The calculator score is calculated in 2 different ways based on BMI (MetS z-score BMI) and waist circumference (MetS z-score waist). Both were calculated for each patient and used for this study.

This calculator, which uses IDF criteria, does not have a cut-offs value for the MetS z-score, and the CMR increases as the score value increases. Receiver operating characteristic (ROC) analysis has been used in studies to evaluate the differences of this score from the traditional definition of MetS, and cut-offs values were determined for the evaluated populations and interpreted (13).

In this study, the MetS z-score was evaluated by plotting receiver operating characteristic-(ROC) curves from which sensitivity and specificity were obtained to accurately classify patients at high and low cardiometabolic risk (CMR). The optimal thresholds for the MetS z-score to distinguish between low or high CMR were determined by calculating the Youden index.

Statistical analysis

Statistical analyses were performed in the SPSS 21 package program with an odds ratio (OR) and 95% confidence intervals (CI) and a significance level of p<0.050. Normality control was done by drawing Shapiro Wilk and single sample Kolmogorov Smirnov tests, box plot, Q-Q, and histogram graphs. Data were presented as mean and standard deviation (SD), frequency, and percentage. Normally distributed variables in the comparison of tertiles were compared using one-way ANOVA and t-test in independent groups and the others with the Mann-Whitney U test. Nominal variables were compared with Yates corrected chi-square and Fisher exact probability tests. Variables with a "p" value below 0.30 were included in the Binary Logistic Regression analysis.

The association of weight loss percentages with MetS z-score and cardiometabolic risk parameters: age, gender, HbA1c, FBG, HOMA, waist circumference, HDL-C, TG, and CRP were evaluated by Pearson's and Spearman's correlation. Statistical significance was accepted at p<0.050.

RESULTS

Sixty-six patients were included in the study. According to the conventional MetS criteria (10.11), the number of patients diagnosed with MetS was n=49 (74.2%) in the preoperative period and n=17 (25.8%) in the 6th postoperative month. The characteristics of the patients in the preoperative period are presented in Table 1.

In general, bariatric surgery provided a large and significant reduction in all parameters of the patients, regardless of the amount of weight loss (Table 2).

ΔWeight (kg) (p=0.000), ΔWeight (%) (p=0.000), ΔFM% (p=0.000), ΔEWL% (p=0.000), ΔWaist circumference (p=0.031), ΔFBG (p=0.038) and ΔHOMA (p=0.039) values were significantly different between groups with mild (Group-1), moderate (Group-2) and high (Group-3) weight loss. ΔFBG and ΔHOMA values were found to be significantly lower at sixth months in the "High Weight Loss, Group-3", which had the lowest FBG and HOMA values before the operation. Changes in other CMR factors at 0-6 months did not differ significantly between groups (ΔMAP (p=0.752), ΔHbA1c (p=0.446), ΔTG (p=0.886), ΔHDL-C (p= 0.893), and ΔCRP (p=0.572), ΔMetS z-BMI (p=0.527) and ΔMetS z-bel (p=0.638)). The changes in Group-1, Group-2, and Group-3 over the period of 0-6 months are presented in Table 2 and Figure 1.

MetS z-score receiver-operating characteristic curve (ROC) was used to reflect Cardiometabolic risk assessed by conventional MetS criteria. The most appropriate thresholds for MetS z-score to distinguish the presence or absence of CMR were: Baseline: "1.282, p=0.003" and sixth months: "0.262, p=0.005" for MetS z-score BMI. Baseline: "1.006, p=0.000" and sixth months "0.203,

Table 1: Characteristics of the patients pre-operative and 6 months after surgery for weight loss tertiles

Variables	Mild weight loss Group-1 (n=22)		Moderate weight loss Group-2 (n=22)		High weight loss Group-3 (n=22)		p values	
	Pre-op	Post-op 6th months	Pre-op	Post-op 6th months	Pre-op	Post-op 6th months	Pre-op	Post-op 6th months
Age, year	40.29±12.36		38.00±11.77		36.82±8.45		0.648	
Weight, kg	141.42±25.51	108.02±18.61*	133.02±22.42	95.54±15.85*	142.99±39.70	92.62±26.98	0.594	0.087
Weight loss, %	23.30±2.97		28.12±1.40		35.28±3.32		**0.000**	
Fat mass, %	49.47±7.24	39.80±7.43*	47.19±6.68	34.20±8.59	49.77±7.20	31.22±8.04*	0.512	**0.011**
BMI, kg/m²	51.08±7.49	38.97±5.64*	48.53±7.78	34.80±5.88*	49.75±8.66	32.32±7.43*	0.700	**0.013**
Waist, cm	136.88±19.71	115.73±15.31	134.52±13.95	107.00±10.61	135.58±23.41	108.46±19.15	0.256	0.309
MetS z-score BMI	2.06±1.10*	0.56±0.55	1.83±1.37	0.17±0.61	1.28±0.53*	-0.08±0.43	0.100	**0.004**
MetS z-score waist	1.80±1.05*	0.32±0.29	1.64±1.35	0.11±0.50	1.11±0.44*	-0.15±0.49	0.134	**0.034**
Fasting glucose, mg/dl	125.70±50.02	92.41±20.89	125.00±53.15*	80.92±11.64	93.72±11.08*	85.14±15.78	0.053	0.056
HbA1c, %	6.48±1.07*	5.45±0.74	6.36±1.58	5.10±0.43	5.73±0.74*	5.02±0.32	0.210	0.082
HOMA	8.60±5.97	2.25±1.10*	12.50±10.07*	1.92±1.18	5.97±2.94*	1.48±0.73*	0.060	0.104
Systolic blood pressure, mmHg	140.88±16.60*	126.91±24.14	130.00±12.99*	115.50±10.12	130.64±11.27*	124.00±8.43	0.398	0.273
Diastolic blood pressure, mmHg	84.70±13.04	78.00±13.71	81.76±11.71	73.50±4.11	80.88±12.77	74.50±5.98	0.880	0.499
MAP, mmHg	103.43±12.78	94.30±16.61	97.84±10.60	87.50±5.04	97.47±11.12	91.00±5.56	0.210	0.082
C-reactive protein, mg/L	9.19±6.51	4.66±3.18	11.95±8.22	1.92±1.18	8.79±5.88	1.48±0.73	0.590	0.479
HDL-C, mg/dl	45.70±9.98	47.43±8.67	43.58±10.77	45.96±7.45	43.76±8.67	46.00±7.42	0.611	0.834
LDL-C, mg/dl	125.58±20.28	102.43±27.55	122.52±32.25	107.87±36.79	125.17±24.84	103.87±29.72	0.934	0.881
Triglycerides, mg/dl	161.58±75.10	109.62±47.78	163.82±69.96	92.93±22.11	153.64±131.07	90.62±30.39	0.950	0.265

BMI: Body mass index, MetS: Metabolic syndrome, HbA1c: Glycated haemoglobin, HOMA: Homeostatic Model Assessment of Insulin Resistance, MAP: Mean Arterial Pressure, HDL-C: High-density lipoprotein-cholesterol, LDL-C: Low-density lipoprotein-cholesterol. "p" values that are significant by the ANOVA test are written in bold. *: p<0.050; t Test

Table 2: Changes in all cardiometabolic parameters of the patients 6 months after the bariatric surgery

Variables	Difference values (n=66)	Max-Min	Mild weight loss Group-1 (n=22)	Moderate weight loss Group-2 (n=22)	High weight loss Group-3 (n=22)	p values (intergroup difference)	p value (intragroup difference)
ΔWeight, kg	40.41±12.43	-7.00-149.00	33.40±8.52	37.47±6.94	50.36±13.98	*0.000*	**0.000**
ΔWeight, %	28.90±5.63	-13.98-41.30	23.30±2.97	28.12±1.40	35.28±3.32	*0.000*	**0.000**
ΔFat mass (%)	13.73±6.69	-0.40-34.10	9.67±5.67	12.99±4.49	18.54±6.68	*0.000*	**0.000**
ΔBMI, kg/m²	14.42±3.58	7.00-23.60	12.11±2.24	13.73±2.20	17.42±3.79	*0.000*	**0.000**
ΔWaist, cm	30.41±9.11	8.00-50.00	26.35±7.20	30.41±10.06	34.47±8.44	*0.000*	**0.031**
ΔMetS z-score BMI	1.50±0.74	0.09-4.49	1.49±0.74	1.65±0.94	1.36±0.48	*0.000*	0.527
ΔMetS z-score waist	1.42±0.82	-0.44-4.78	1.47±0.75	1.53±1.12	1.27±0.49	*0.000*	0.638
ΔFasting glucose, mg/dl	28.82±33.89	-7.00-149.00	33.29±33.78	36.85±37.78	13.01±8.65	*0.000*	**0.038**
ΔHbA1c, %	1.08±1.09	-0.10-4.80	1.06±0.96	1.38±1.48	0.80±0.74	*0.000*	0.323
ΔHOMA	7.13±7.17	-1.54-39.82	6.34±5.76	10.53±9.99	4.51±2.70	*0.000*	**0.039**
ΔSBP, mmHg	10.74±13.61	-20.00-50.00	10.16±25.64	13.50±12.48	14.50±16.23	*0.000*	0.860
ΔDBP, mmHg	7.33±13.37	-30.00-50.00	5.75±20.25	6.50±10.01	9.50±16.90	*0.000*	0.861
ΔMAP, mmHg	8.47±11.40	-16.67-48.33	10.19±15.22	7.45±7.33	7.76±10.75	*0.000*	0.752
ΔC-reactive protein, mg/L	6.01±5.77	-4.55-21.46	5,17±6.16	7,20±5.99	5.66±5.27	*0.000*	0.572
ΔHDL-C, mg/dl	-1.58±7.96	-23.00-19.00	-1.47±8.33	-1.41±9.02	-1.88±6.85	0.160	0.983
ΔLDL-C, mg/dl	19.91±33.20	-97.00-81.00	22.75±34.45	14.68±40.19	22.31±24.67	*0.000*	0.750
ΔTriglycerides, mg/dl	60.54±85.16	-50.00-527.00	52.64±54.89	67.11±53.19	61.88±129.24	*0.000*	0.886

BMI: Body mass index, MetS: Metabolic syndrome, HbA1c: Glycated haemoglobin, HOMA: Homeostatic Model Assessment of Insulin Resistance, SBP: systolic blood pressure, DBP: Diastolic blood pressure, MAP: Mean Arterial Pressure, HDL: High-density lipoprotein-cholesterol, LDL: Low-density lipoprotein-cholesterol, *: p<0.050; t Test

p=0.003" for MetS z-score waist (Figure 2 and 3). Patients with higher scores than these cut-offs were considered to have higher CMRs. Accordingly, it was observed that the CMR of patients who lost less weight was higher than those who lost more (Table 3).

In the 6th month, the mean BMI of all patients in the groups was 35.36±6.83 kg/m², and the patients in all three groups were still in the "obese" class according to the BMI category (BMI values Group-1: 38.97±5.64 kg/m²; Group-2: 34.80±5.88 kg/m²; Group-3: 32.32±7.43 kg/m²).

The high cardiometabolic risk, determined by preoperative MetS prevalence, was promoted in the low cardiometabolic risk class in 8% of patients in Group-2 who lost moderate weight and 11% in Group-3 who lost high weight at sixth months postoperatively. However, it was observed that "mild weight loss, Group-1" had a high cardiometabolic risk ratio of 60%.

At sixth months postoperatively, % weight loss showed a significant negative correlation with both MetS z-score BMI and MetS z-score waist, as well as glycemic parameters (FBP, HbA1c, HOMA) (Table 4). There was no relationship between the amount of weight loss and waist circumference, TG, HDL-C, LDL-C, MAP, SBP, DBP, and CRP values, each of which is a MetS component (Table 4).

Patients were classified as having high or low cardiometabolic risks according to the MetS z-score cut-offs values calculated six months after surgery, and Binary logistic regression was performed. It was determined that the probability of entering the low-risk group from the high-risk group in the cardiometabolic risk classification increased 0.57 times for each 1% weight loss of the patients (p=0.002). On the other hand, it was observed that the probability of remaining in the high cardiometabolic risk category of patients despite having undergone bariatric

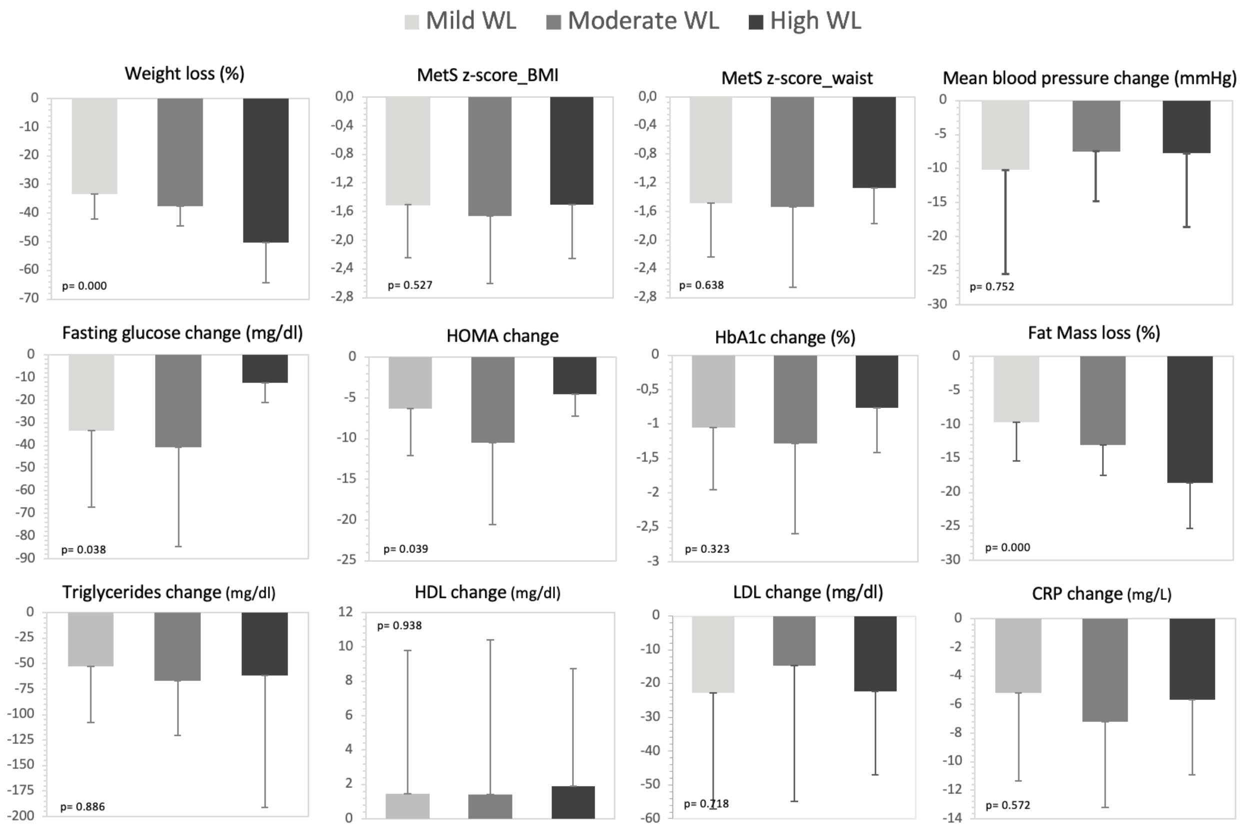

Figure 1: Comparison of changes in cardiometabolic risk parameters six months after surgery in high, moderate, and mild weight loss groups

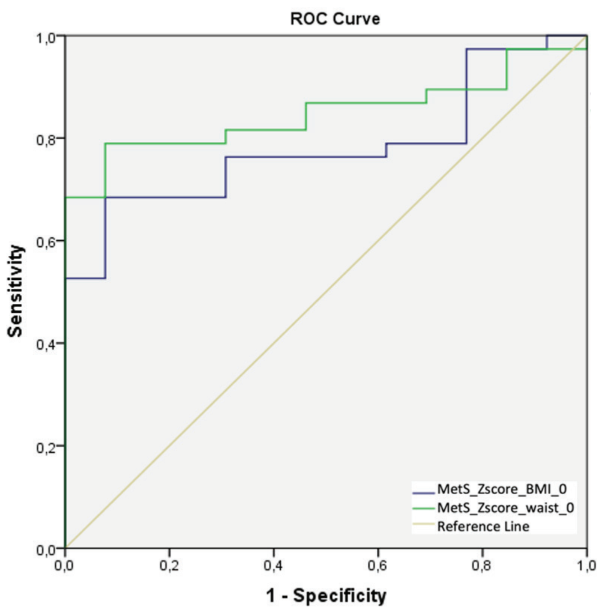

Figure 2: cMetS z-score ROC curve at pre-op for BMI and waist circumference

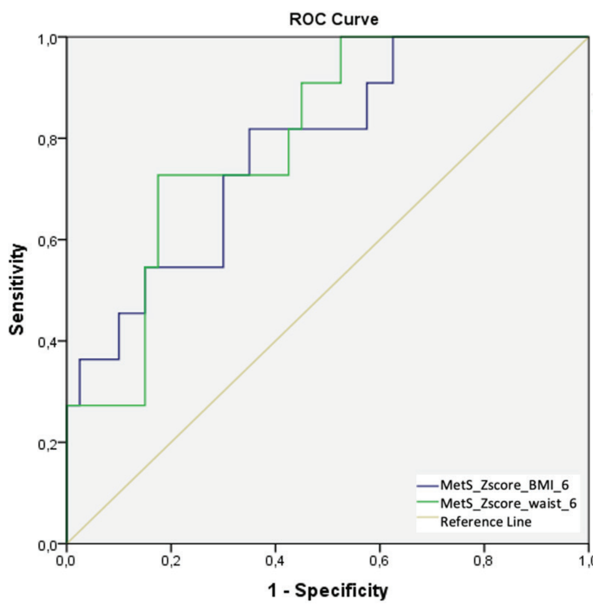

Figure 3: cMetS z-score ROC curve at 6 months for BMI and waist circumference

Table 3: Distribution of patients with high CMR in groups formed according to weight loss percentages

Variables	Mild weight loss (n%)	Moderate weight loss (n%)	High weight loss (n%)	p value
MetS z-scores BMI				
Baseline	40.0	33.3	26.7	>0.050
6th month	60.0	25.0	15.0	*0.004*
MetS z-scores waist				
Baseline	36.4	30.3	33.3	>0.050
6th month	47.4	31.6	21.1	>0.050

CMR: Cardiometabolic risk, MetS: Metabolic syndrome, BMI: Body mass index

Table 4: The relationship between weight loss (%) after bariatric surgery and values of cardiometabolic parameters at sixth months and changes at 0-6 months

Values	Weight loss, %			
	The values at 6th months		Change values between 0-6 months	
	p	r	p	r
MetS z-scores BMI	*0.000*	-0.566	0.569	-0.082
MetS z-scores waist	*0.001*	-0.470	0.272	-0.157
Waist, cm	0.119	-0.221	0.053	0.409
SBP, mmHg	0.986	-0.002	0.763	-0.043
Fasting blood glucose, mg/dl	*0.050*	-0.276	*0.042*	-0.285
HOMA	*0.016*	-0.337	0.624	-0.070
HbA1c, %	*0.010*	-0.357	0.426	-0.131
Triglyceride, mg/dl	0.061	-0.264	0.342	-0.136
HDL-C, mg/dl	0.643	-0.066	0.568	-0.082
C-reactive protein, mg/L	0.581	-0.079	0.365	0.130

MetS: Metabolic syndrome, BMI: Body mass index, SBP: systolic blood pressure, HOMA: Homeostatic Model Assessment of Insulin Resistance, HbA1c: Glycated haemoglobin, HDL-C: High-density lipoprotein-cholesterol

surgery increased 25.8 times (p=0.005) in the presence of TD2 and increased 0.20 times (p=0.013) if they were still in the obese class.

DISCUSSION

The main finding of our study is that although there was a significant decrease in all cardiometabolic risk parameters of the patients six months after bariatric surgery, no correlation was found between the amount of weight loss and any parameter except fasting blood glucose and HOMA. However, the statistically significant negative correlation between the change in the calculated MetS z-scores compared to the preoperative period, and the amount of weight loss suggested that the use of risk scores would be a more objective approach to evaluate the reduction in cardiometabolic risks of patients after bariatric surgery.

In the literature, the prevalence of MetS in morbidly obese patients before surgery varies (52% to 87%) (17, 18). In our study, the prevalence of MetS in the preoperative period was found to be approximately 74%, which is consistent with the rates reported in the literature. This rate, which decreased to 26% in the postoperative sixth months, is similar to the decrease rates in the literature (17-20).

It is accepted that the most important indicator of the success of treatment and superiority of bariatric surgery over other obesity treatments is the amount of weight lost after surgery (7). It is known that only a six-month period after bariatric surgery is sufficient for body weight to decrease in a way that positively affects primary cardiometabolic risk factors such as DM, hypertension, and dyslipidemia (21). In studies evaluating the change in cardiometabolic risk during this period, there is a significant improvement after surgery in each risk parameter; however, no relationship has been shown between this improvement and the amount of weight loss (19,20). In their study, Gil S. et al. investigated the effects of the amount of fat mass lost instead of the total amount of weight loss. They showed that even if obesity remission is achieved after surgery, patients with higher fat mass loss have less insulin sensitivity and higher triglyceride levels and that, contrary to their previous findings, there is a significant relationship between the amount of fat mass loss and continued cardiometabolic risk score (16).

After RYGB, weight loss is very rapid because both food intake is reduced and malabsorption occurs, and it is essential to ensure the loss of fat mass by preserving lean body mass. For this reason, patients should be closely followed up on nutrition, and adequate protein intake should be ensured. In our study, when we made a separate evaluation of patients with a fat mass loss instead of weight loss, we did not obtain a different result from the previous one. We think this is because the total weight loss of the patients and the loss of fat mass are parallel to each other, and the lean body mass of the patients is preserved. In Goday A et al.'s study evaluating the factors affecting the decrease in cardiometabolic risk parameters, healthy obese patients with normal cardiometabolic risk parameters were compared to pathological ones in the pre-op period. Although the patients lost a similar amount of weight in the post-op period, it was observed that the values decreased more in the healthy obese group and reached healthier values than in the pathological group. In other words, in this study, it was emphasized that cardiometabolic risk reduction was associated with the pre-op health status of the patients, independent of weight loss (22). When we evaluated our study from this perspective, we also observed no significant difference between the weight and fat mass losses of those with pre-op MetS parameters within healthy limits and those with pathological parameters.

In the study by Honk YR et al. using the National Health and Nutrition Examination Survey (NHANES) 2015-2018, 6274 patients were divided into three groups: those who have undergone bariatric surgery but are still obese, obese patients who are candidates for surgery, and adults with normal weight (23). In this study, the selection bias of bariatric surgery was minimized using the propensity score weighting technique. Thus, only the effect of patients' current weight on cardiometabolic risk factors was evaluated. Although there was no significant difference between the parameters of patients who are still obese despite bariatric surgery and adults with normal weight, the cardiometabolic risk parameters of the obese who are surgical candidates were found to be different from the other two groups (23). This picture indicates that cardiometabolic risks are normalized mainly, even if a BMI within the normal range cannot be achieved after bariatric surgery, as we have seen in our study.

Studies show that insulin sensitivity in patients improves by 25% at one week after RYGB, without weight loss yet, and this is attributed to the post-op low-calorie diet. As a matter of fact, similar improvements in insulin sensitivity were observed in obese patients who followed the liquid diet prescribed after bariatric surgery for only four days without surgery. In the longer term, the effect on diabetes remission cannot, of course, be attributed to calorie restriction alone because the increase in GLP-1 secretion due to the mechanism of the operation was not observed in nonsurgical and hypocalorically fed obese subjects (24). On the other hand, in another study, three different weight maintenance diets with low, medium, and high carbohydrate contents were given to patients diagnosed with MetS for four weeks. At the end of the study, when patients were fed with low carbohydrates, it was observed that there was a significant improvement in TG and LDL-C levels without weight loss (25). In other words, lipid control as well, like glycemic control, can be modified by dietary content without weight loss. When we evaluate all these studies, it is not surprising that a low-calorie and low-carbohydrate nutrition program after surgery improves both glycemic and lipid parameters, independently of weight loss in the short term and with the effect of weight loss in the long term. The degree of improvement in the long term is closely related to the amount of weight lost by the patients. The frequency of care and follow-up visits of patients after the operation contributes to the success of the surgery. Studies show that 60% of patients who do not reach their target weight after surgery have no nutritional follow-up (26). For this reason, the importance of close follow-up of patients and nutritional guidance to get the most efficient results from surgery is indisputable.

The strongest aspect of this study is that although there are many studies evaluating the effect of bariatric surgery on metabolic syndrome parameters, it is one of the few studies evaluating its effect on cumulative cardiovascular risk using the MetS score. The weaknesses of the study are the small number of patients and the short follow-up period. Therefore, there is a need for studies in which more patients who were operated on with different types of bariatric operations (malabsorptive and restrictive) were followed for a more extended period.

In conclusion, although there is a significant decrease in cardiometabolic risk parameters after bariatric surgery, the amount of weight loss of the patients does not affect this. However, using a scoring system to evaluate and monitor the cardiometabolic cluster risks of patients will make it possible to follow the gradual changes in patients after surgery, making the interventions of physicians and nutritionists more targeted and efficient.

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