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The Effect of Meal Frequency on Body Composition, Biochemical Parameters and Diet Quality in Overweight/Obese Individuals

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ABSTRACT

Objectives: There is no consensus on the ideal frequency of meals for the prevention and treatment of obesity. While some studies have reported that increasing meal frequency might be beneficial in the treatment of obesity due to its positive effects on glycemic regulation, appetite and diet quality, other studies have reported negative effects. In this study, it was aimed to examine the effect of meal frequency on body composition, anthropometric measurements, some of the biochemical parameters and diet quality in overweight/obese adults.

Methods: A total of 91 individuals, all overweight/obese, between the ages of 18-64, including 46 consuming 2 main meals (2MMG) and 45 consuming 3 main meals (3MMG) participated in the study. General characteristics and dietary habits of the individuals were obtained with a questionnaire. A 3-day food consumption record was taken to determine their daily energy and nutrient intake and to evaluate their diet quality with the "Healthy Eating Index 2015". Anthropometric measurements of the individuals were performed, body compositions were analyzed and some blood parameters were evaluated.

Results: The median values of body weight, lean body mass (kg), total body water, basal metabolic rate and hip circumference of men in the 3MMG were found to be higher than men in the 2MMG ($p < 0.05$). The anthropometric measurements and body composition components of women were similar between the two groups ($p > 0.05$). The renal urea nitrogen and total cholesterol values of women in 2MMG were higher than those of women in the 3MMG. In the regression analysis, a 1-unit increase in the number of main meals was determined to lead to a 9.3 points increase in the total score of HEI 2015.

Conclusions: Regular consumption of main meals may have positive effects on diet quality, some of the biochemical parameters, basal metabolic rate and body composition in overweight/obese adults. In this group, which is known to have incorrect food preferences in general, it is important to plan the number of meals and the content of these meals correctly.

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Introduction

Obesity is a multifactorial disease affecting individuals from all parts of society with an increasing prevalence worldwide. It is an epidemic public health problem that increases the risk of many diseases, especially cardiovascular diseases (CVD) and diabetes mellitus (1).

Although there are different approaches in the fight against obesity, nutrition is the main element in weight management. However, there is no consensus on the ideal diet although many studies have been conducted to achieve weight loss (2). Meal frequency, one of the main elements of diet planning, is one of the disputed topics in the treatment and prevention of obesity. With the increase in studies on intermittent fasting and chrono-nutrition in recent years, recommendations regarding the frequency, number and timing of meals have become more complex.

For many years, small portions and frequent meals have been recommended for weight control and appetite suppression. However, the evidence from the existing studies is not sufficient to explain the effect of meal frequency on body weight and composition (3, 4). The lack of a common terminology (definition of main and intermediate meals/snacks), the definition of the same behavior (number of meals eaten) with different terms (frequency of eating, frequency of meals, frequency of nutrition, frequency of snacking, etc.), differences in research methods and different evaluations of food consumption prevent reaching definite and general conclusions on the subject (3).

Studies considering increased meal frequency as a risk for obesity, diabetes and CVD have reported that insulin release is stimulated after each meal and this leads to chronic hyperinsulinemia (5–7). An increased insulin level increases the amount of free fatty acids and inflammation markers. Accordingly, insulin resistance, obesity, abdominal adiposity,

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chronic inflammation and susceptibility to CVD increase (8). This process accelerates with a sedentary lifestyle and the prognosis worsens (9).

Studies expressing positive opinions have stated that an increase in the number of meals also leads to an increase in the basal metabolic rate (BMR) due to the thermic effect of foods, reduces the glycemic load by positively affecting appetite, and can reduce the risk of obesity with the correct food preferences (10–12).

A systematic review reported that changing meal frequency had no effect on obesity, especially when evaluated according to anthropometric data (13).

The number of meals has been reported to affect the daily intake of energy and the type and amount of nutrients and thus diet quality (14, 15). An increase in the number of meals has been noted to lead to an increase in total energy intake, especially in obese individuals, and diet quality deteriorates due to incorrect food choices (15). Improving diet quality is important because it might provide additional contribution to weight loss achieved with energy-restricted diets in obese individuals (16).

Most of the studies examining the relationship between meal frequency and obesity have limited data. Some studies focused only on anthropometric measurements or changes in body composition, while others only investigated the effect of dietary intake of daily energy and nutrients. In this study, it was aimed to examine the effect of meal frequency on body composition, anthropometric measurements, some of the biochemical parameters and diet quality in overweight/obese adults.

Materials and methods

This study was conducted in the diet outpatient clinic of Çankırı Private Karatekin Hospital between November 2019 and March 2021. The study was suspended in December 2019 during the COVID-19 pandemic. In order to minimize the effects of seasonal changes (food diversity, physical activity level, meal pattern, etc.) with the normalization of pandemic conditions, the data collection process was completed by accepting participants mainly in the autumn-winter period, similar to the beginning of the study.

A total of 91 individuals, all overweight/obese (BMI 25.00-39.99 kg/m^2), between the ages of 18-64, including 45 who regularly consumed main meals (3 main meal group, 3MMG) and 46 who skipped one main meal (2MMG) participated in the study. The main meal definition was categorized according to self-report. When determining the frequency of the main meals of the participants, their dietary patterns in most of their lives were taken into consideration. Individuals who reduced/increased the number of main meals due to the pandemic conditions were not included in the study. Being pregnant or breastfeeding, having a diagnosis of chronic disease, being on a special nutrition program for more than one week, taking medication that may affect the blood lipid profile, glycemic control and body composition, having allergy/intolerance to any food, long-term use of supplements, having a physical disability or mental illness, being on any alternative treatment for weight management, having a history of bariatric surgery, and consumption of alcohol were the exclusion criteria.

Participation in the study was voluntary. Informed Consent Form was obtained from all the participants in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Gazi University Ethics Commission for the study on 04/12/2018 (14574941-199- 159749).

General characteristics (age, gender, marital status, education level, and meal pattern) of the participants were collected by face-to-face interview method with a questionnaire form. Three-day (one day on weekends + two days on weekdays) food consumption records were taken to determine the dietary habits and diet quality of the individuals. Daily energy, macro and micronutrient intake were calculated using the Nutrition Information System BeBiS 7.2 package program.

Diet quality was assessed using the Healthy Eating Index 2015 (HEI 2015). HEI 2015, which was created according to the American Dietary Guide 2015-2020, is assessed according to diet density. HEI 2015 includes adequacy ('total fruits', 'whole fruits', 'total vegetables', 'greens and beans', 'whole grains', 'dairy', 'total protein foods', 'seafood and plant proteins' and 'fatty acids') and moderation components ('refined grains', 'sodium', 'added sugar' and 'saturated fats') (17). A score of 50 points and below is defined as 'poor', 51-80 points as 'needs improvement' and 81-100 points as 'good' diet quality (18). HEI 2015 components, food groups, subgroups, and nutrients that contribute to the components of the HEI-2015, point values and standards for scoring are shown in Table 1 (19).

Anthropometric measurements were carried out according to standard methods. Waist-hip ratio, waist-height ratio and BMI values were calculated with this measurement data. Furthermore, the Lipid Accumulation Product (LAP) index was calculated using waist circumference length and triglyceride (TG) values. A high LAP index indicates an increased risk of metabolic syndrome (20).

Body composition (body weight (kg), body fat (percentage (%) and mass (kg)), lean body mass (kg), and total body water (%)) were analyzed with the bioelectrical impedance analysis and BMR was measured.

For biochemical parameters, the blood analysis values requested by the internal medicine specialist for referral to the dietary outpatient clinic were used. The results were evaluated according to the reference ranges of the hospital. Homeostatic model assessment (HOMA-IR) was calculated with the formula [(Fasting insulin (uU/Ml) X Fasting plasma glucose (mg/dL)/405] to investigate the presence of insulin resistance in individuals (21).

Statistical analyses were performed using the IBM SPSS Statistics 25.0 package program. In all analyses, the significance level was accepted as 0.05.

Results

The general characteristics of the participants are shown in Table 2. In the 2MMG, more than half of the women

Table 1. Healthy Eating Index-2015 components, food groups, subgroups, and nutrients that contribute to the components of the HEI-2015, point values and standards for scoring.

	Food groups, subgroups, and nutrients	Max. points	Standard for max.score	Standard for min. score of zero
Adequacy Components				
Total Fruits	Whole Fruit, Fruit Juice	5	≥0.8 c equivalents/1,000 kcal	No fruit
Whole fruits	Whole Fruit	5	≥0.4 c equivalents/1,000 kcal	No whole fruit
Total Vegetables	Legumes (Beans & Peas), Dark-Green Vegetables, All Other Vegetables	5	≥1.1 c equivalents/1,000 kcal	No vegetables
Greens and Beans	Legumes (Beans & Peas), Dark-Green Vegetables,	5	≥0.2 c equivalents/1,000 kcal	No dark green vegetables or beans and peas
Whole Grains	Whole Grains	10	≥1.5 oz equivalents/1,000 kcal	No whole grains
Dairy	All milk products (fluid milk, yogurt, and cheese, and fortified soy beverages)	10	≥1.3 c equivalents/1,000 kcal	No dairy
Total Protein Foods	Meat, Poultry, Eggs, Seafood, Nuts, Seeds, Soy Products, Legumes (Beans & Peas)	5	≥2.5 oz equivalents/1,000 kcal	No protein foods
Seafood and Plant Proteins	Seafood, Nuts, Seeds, Soy Products, Legumes (Beans & Peas)	5	≥0.8 c equivalents/1,000 kcal	No seafood or plant proteins
Fatty Acids	PUFA, MUFA, SFA	10	(PUFAs + MUFAs)/SFAs ≥2.5	(PUFAs + MUFAs)/SFAs ≤ 1.2
Moderation Components				
Refined Grains	Refined Grains	10	≤1.8 oz equivalents/1,000 kcal	≥4.3 oz equivalents/1,000 kcal
Sodium	Sodium	10	≤1.1 g/1,000 kcal	≥2.0 g/1,000 kcal
Added Sugars	Added sugars	10	≤6.5% of energy	≥26% of energy
Saturated Fats	Saturated Fats	10	≤8% of energy	≥16% of energy

PUFAs: polyunsaturated fatty acids, MUFAs:monounsaturated fatty acids, SFAs:saturated fatty acids.

Table 2. General characteristics of individuals.

	2 main meal group				3 main meal group					
	Women (n:35)		Men (n:11)		Women (n:34)		Men (n:11)			
Descriptive Characteristics	S	%	S	%	S	%	S	%	p/χ2	
Occupational status									p^3= 0.381	**p^4= 0.001**
Housewife	22	62.9	0	0.0	8	23.6	0	0.00	χ^2= 3.264	χ^2=14.507
Healthcare professional	3	8.6	1	9.1	13	38.2	2	18.2		
Retired	1	2.9	3	27.3	0	0.0	0	0.0		
Others	9	25.7	7	63.6	13	38.2	9	81.8		
	χ^2= 17.184 **p^1<0.001**				χ^2= 6.170 **p^2= 0.043**					
Number of snacks									p^3=0.369	p^4=0.621
1 Snack/day	5	14.3	2	18.2	4	11.8	1	9.10	χ2 = 4.484	χ2 = 2.948
2 Snacks/day	22	62.9	6	54.5	17	50.0	9	81.8		
3 Snacks/day	5	14.3	2	18.2	7	20.6	0	0.00		
4 Snacks/day	0	0.00	0	0.00	2	5.90	1	9.10		
None	3	8.60	1	9.10	4	11.8	0	0.00		
	χ2 = 0.816 p^1=0.894				χ^2=4.669 p^2=0.273					
Marital Status									p^3= 0.671	p^4= 0.796
Married	28	80.0	10	90.9	28	82.4	8	72.7	χ^2=1.72	χ^2= 0.453
Not married	7	20.0	1	9.1	6	17.6	3	27.3		
	χ^2= 3.062 p^1= 0.764				χ^2= 2.404 p^2= 0.943					
Age (years) x ± SD	44.36 ± 12.126		43.4 ± 12.436		36.27 ± 4.9414		39.47 ± 7.8169		p^3= 0.133	p^4= 0.227
	Z = 0.193 p^1= 0.823				*Z* = 1.179 p^2= 0.230				*Z* = 1.548	*Z* = 1.208

Fisher's exact test and Mann Whitney U test $p < 0.05$ if chi-square test $n < 5$.
p^1= Comparison of values between men and women consuming two main meals.
p^2= Comparison of values between men and women consuming three main meals.
p^3= Comparison of values between men consuming two main meals and men consuming three main meals.
p^4= Comparison of values between women consuming two main meals and women consuming three main meals.

(62.9%) were housewives and 63.6% of the men were in other occupational groups. While 38.2% of women in the 3MMG were healthcare professionals, 81.8% of men were in the other occupational groups. About one-fifth of the women in the 2MMG (20%) and 3MMG (17.6%) groups were not married. Among men, 9.1% in 3MMG and 27.3% in 2MMG were single. According to the number of main meals, the number of snacks and mean age were similar between the groups for men and women ($p > 0.05$).

There was no statistically significant difference between men and women for the most skipped main meal and the reason for skipping meals ($p > 0.05$). Participants stated that they skipped lunch the most (women: 80.0%, men: 72.7%) and that they skipped meals "because they had a late

breakfast" (women: 65.7%, men: 54.5%) (data not shown in the table).

BMI classification of men and women participants was similar between the groups ($p > 0.05$). While 37.1% of women and 72.7% of men were overweight in 2MMG, 50.0% of women and 54.5% of men in 3MMG (Figure 1).

Some of the anthropometric measurements of the participants according to main meal frequency are shown in Table 3. The median values of body weight, lean body mass, total body water and hip circumference of men in 2MMG were lower than those in 3MMG ($p < 0.05$). BMR median value was higher in men in the 3MMG.

Some biochemical parameters of participants according to meal frequency are shown in Table 4. The median values of fasting blood glucose (FBG), fasting insulin, and HOMA-IR of men in 3MMG were lower than the median values of men in 2MMG, but the difference was not statistically significant ($p > 0.05$). While the median total cholesterol value of women in 2MMG was 199,9 ± 59.1 (144-274) mg/dL, it was 184,4 ± 37.72 (130-265.2) mg/dL in women in 3MMG and the difference was significant ($p < 0.05$).

The classification of participants according to diet quality is shown in Figure 2. While 63.6% of men in 2MMG had poor diet quality, all the men (100.0%) in 3MMG had diet quality which needs improvement ($p < 0.05$). Among women, 57.1% of those at 2MMG and 94.1% of those at 3MMG had diet quality that needs improvement ($p < 0.05$). None of the participants had a good diet quality.

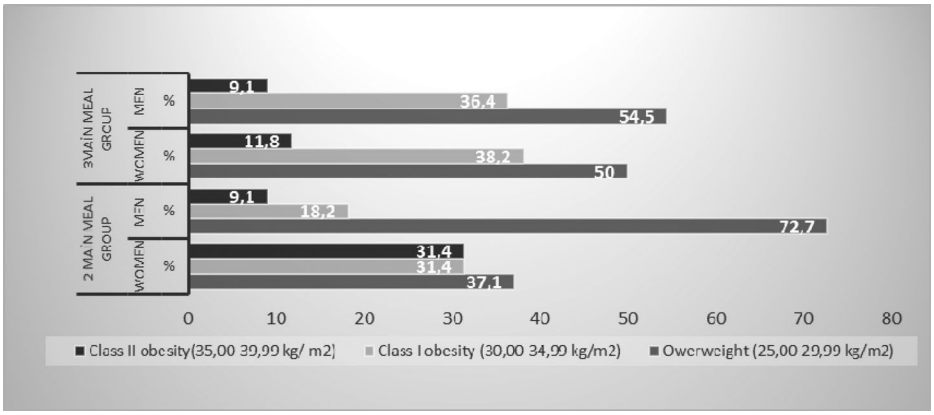


Figure 1. Body Mass Index value distributions of participants according to meal frequency.

Table 3. Some of the anthropometric measurements of participants according to main meal frequency.

	2 main meal group		3 main meal group			
Anthropometric Parameters	Women (n:35) Median (IQR) [min-max]	Men (n:11) Median (IQR) [min-max]	Women (n:34) Median (IQR) [min-max]	Men (n:11) Median (IQR) [min-max]	p[1]	p[2]
Body weight (kg)	78.9 (17.80) (62.5-112.4)	81.2 (5.80) (65.5-105.3)	76.3 (12.28) (62.4-116.6)	91.0 (6.10) (79.5-127.3)	**0.019** $Z = 2.232$	0.728 Z=-0.348
Height (cm)	158.0 (9.00) (146-176)	171.0 (13.00) (154-180)	161.0 (12.25) (16-176)	177.0 (7.00) (170-185)	0.065 $Z = 1.877$	0.174 $Z = 1.358$
BMI (kg/m^2)	30.4 (9.70) (25-39.87)	27.6 (4.90) (25.3-35.4)	29.6 (4.57) (25.3-39.4)	29.7 (2.80) (26.5-37.2)	0.151 $Z = 1.446$	0.141 Z=-1.471
Body fat (%)	38.4 (10.10) (26.7-46.9)	25.8 (7.90) (17.2-40.1)	35.8 (3.40) (31.3-44.6)	25.2 (3.60) (19.7-27.3)	0.401 Z=-0.887	0.056 Z=-1.915
Body fat (kg)	29.6 (14.20) (19.1-52.1)	20.1 (8.10) (13.9-38.3)	27.9 (7.72) (21.6-52)	22.6 (4.90) (17.9-34.4)	0.478 $Z = 0.755$	0.319 Z=-0.996
Lean body mass (kg)	48.4 (8.00) (40.6-60.9)	60.5 (8.09) (46.3-69.6)	49.1 (7.45) (40.1-64.6)	69.4 (6.20) (58.1-92.9)	**0.004** $Z = 2.792$	0.900 $Z = 0.126$
Total Body Water (%)	34.8 (10.10) (29.2-52.6)	45.0 (7.70) (33.3-56.2)	35.9 (7.45) (28.9-48.0)	51.3 (4.00) (41.8-66.9)	**0.028** $Z = 2.200$	0.692 $Z = 0.396$
Basal metabolic rate (kcal)	1243.0 (342.00) (11.64-1921)	1574.0 (194.00) (1084-1739)	1250.5 (133.00) (1066-1993)	1719.0 (122.00) (1465-2065)	**0.008** $Z = 2.595$	0.627 $Z = 0.486$
Waist circumference (cm)	97.0 (15.00) (80-131)	98.0 (17.00) (91-113)	91.5 (9.25) (76.0-124.0)	101.0 (1.22) (96-120)	0.438 $Z = 0.791$	0.058 Z=-1.898
Hip circumference (cm)	115.0 (17.00) (99-140)	105.0 (5.00) (100-118)	109.5 (11.25) (100-163)	111.0 (112.00) (105-125)	**0.010** $Z = 2.540$	0.135 Z=-1.497
Waist-hip ratio	0.84 (0.07) (0.75-0.99)	0.9 (0.10) (0-1.02)	0.9 (0.06) (0.48-0.97)	0.9 (0.07) (0.86-1.05)	0.438 Z=-0.825	0.947 $Z = 0.066$
LAP Index	50.4 (45.82) (9.9-175.6)	88.8 (39.52) (23.5-171.6)	43.5 (25.90) (17.7-142,9)	100.6 (67.89) (27.1-191.2)	0.519 $Z = 0.689$	0.313 Z=-1.008

Mann Whitney U test, $p < 0.05$.
BMI: Body Mass Index, LAP: Lipid Accumulation Product.
p[1]= Comparison of values between men consuming two main meals and men consuming three main meals.
p[2]= Comparison of values between women consuming two main meals and women consuming three main meals.

Table 4. Biochemical parameters of participants according to main meal frequency.

	2 main meal group		3 main meal group			
Biochemical Findings	Women (n:35) Median (IQR) [min-max]	Men (n:11) Median (IQR) [min-max]	Women (n:34) Median (IQR) [min-max]	Men (n:11) Median (IQR) [min-max]	p[1*]	p[2*]
Fasting blood glucose (mg/dL)	99.0 (20.65) (79.01-208.3)	98.0 (16.70) (79.98-115.6)	98.3 (11.68) (80.93-216.03)	80.9 (10.05) (216.03-93.4)	0.088 Z=-1.741	0.319 Z=-0.996
Fasting Insulin (uIU/mL)	12.2 (7.38) (5.1-70.46)	9.5 (7.06) (3.7-75.9)	11.2 (8.08) (4.57-34.1)	4.5 (8.39) (34.1-9.51)	0.652 Z=0.492	0.606 Z=-0.516
HOMA- IR	3.1 (2.41) (1.17-36.23)	2.3 (1.67) (0.85-14.99)	2.8 (2.17) (0.93-7.32)	0.9 (1.97) (7.32-2.08)	0.606 Z=-0.558	0.471 Z=-0.720
Renal Urea Nitrogen (mg/dL)	15.0 (8.43) (7.7-32)	16.4 (12.74) (6.97-26)	10.9 (4.63) (5.76-21)	5.8 (5.65) (21-15.4)	0.949 Z=-0.066	**<0.001** Z=-4.051
Creatinine (mg/dL)	0.8 (0.24) (0.35-1.03)	1.0 (0.31) (0.78-1.25)	0.8 (0.15) (0.51-1.12)	0.5 (0.29) (1.12-1)	0.652 Z=2.803	0.093 Z=1.681
Triglycerides (mg/dL)	144.4 (79.8) (55-370)	169.8 (38.7) (63-337.53)	142.2 (56.03) (70.02-269.1)	70.0 (80.5) (269.1-185)	0.652 Z=0.460	0.848 Z=0.192
Total Cholesterol (mg/dL)	199.9 (59.1) (144-274)	192.5 (51.6) (149-272)	184.4 (37.72) (130-265.2)	130.0 (44.00) (265.2-212)	0.999 Z=0.492	**0.022** Z=-2.286
ALT (U/L)	17.7 (75.39) (10.81-75.39)	29.4 (18.63) (9-70.56)	18.1 (6.65) (5.99-39.27)	5.9 (20.38) (39.27-29.28)	0.478 Z=-0.033	0.914 Z=0.108
AST (U/L)	21.0 (7.65) (13.8-85.68)	25.0 (14.82) (11.25-33)	22.3 (8.89) (12.53-53)	12.5 (9.75) (53-25.2)	0.519 Z=0.755	0.355 Z=0.924
TSH (mIU/L)	2.6 (2.03) (1.1-8.47)	2.1 (1.26) (1.12-6.17)	2.5 (1.50) (0.6-6.26)	0.6 (1.27) (6.26-1.95)	0.949 Z=0.689	0.581 Z=-0.552
Hemoglobin (g/dL)	13.1 (1.30) (10.9-15.5)	15.2 (1.50) (13.7-16.8)	12.8 (1.72) (9.7-15.2)	9.7 (1.10) (15.2-15.2)	0.949 Z=-0.066	0.205 Z=-1.267
Hematocrit (%)	39.9 (4.30) (30.7-47.9)	45.1 (5.70) (40.6-50.2)	38.6 (4.97) (30.5-45.5)	30.5 (4.00) (45.5-45.4)	0.699 Z=0.427	0.475 Z=-0.714

Mann Whitney U test, $p<0.05$.
HOMA-IR: Insulin resistance test, AST: Aspartate Aminotransferase, ALT: Alanine Aminotransferase TSH: Thyroid stimulating hormone.
p[1]= Comparison of values between men consuming two main meals and men consuming three main meals.
p[2]= Comparison of values between women consuming two main meals and women consuming three main meals.



Figure 2. Diet quality characteristics of the participants according to main meal frequency.

The total score and components scores of participants obtained from HEI 2015 according to main meal frequency are shown in Table 5. The median value of the HEI 2015 total score of women and men in 3MMG was higher than that of women and men in 2MMG ($p<0.05$). The median value of the 'total protein foods' component score of women in the 2MMG (5.0 ± 0.30 [2.45-5.0]) was higher than the median value of men in the same group (4.1 ± 2.51 [1.68-5]) ($p<0.05$). The median value of the 'refined grains' component score of the women in this group (6.1 ± 3.62 [0.0-10]) was also higher than the median value of the men in the same group (1.7 ± 3.95 [0.0-6.44]) ($p<0.05$). The total fruits, whole fruits, total protein foods and refined grains component scores of men showed differences between the groups ($p<0.05$).

The model established with the dependent variable HEI 2015 and the number of snacks, number of main meals, BMI, LAP index, and HOMA-IR was found to be statistically significant in the regression analysis ($p<0.05$). The effect of the number of main meals on the HEI 2015 total score was positive. A 1-unit change in the number of main meals increases the total score of HEI 2015 by 9.3 points (data not shown in the table).

The relationship between meal frequency and anthropometric measurements and some biochemical parameters of the participants is shown in Table 6. There was a significant weak negative correlation between the total number of meals and total cholesterol (mg/dL) level (r=-0.232, $p<0.05$).

Table 5. Participants' total score and components scores of HEI 2015 according to main meal frequency.

	2 main meal group			3 main meal group				
HEI 2015 Components	Women (n:35) Median (IQR) [min-max]	Men (n:11) Median (IQR) [min-max]	p[1]	Women (n:34) Median (IQR) [min-max]	Men (n:11) Median (IQR) [min-max]	p[2]	p[3]	p[4]
HEI score	52.9 (16.06) (31.96-70.31)	47.1 (10.75) (37.7-60.56)	0.105 Z=-1.635	56.9 (11.10) (48.1-79.1)	56.4 (14.48) (53.78-75.79)	0.649 $Z=0.475$	**<0.001** $Z=3.513$	**0.003** $Z=2.965$
Total Fruits	1.0 (1.25) (0-2.80)	0.7 (1.29) (0-2.07)	0,629 Z=-0,503	3,9 (1,81) (2,11-5,00)	4,2 (1,60) (2,47-5,00)	0,70 Z=-0,385	**<0.001** $Z=3,974$	**<0.001** $Z=7,055$
Whole Fruits	2,0 (2,51) (0,00-5,00)	1,4 (0,39) (0,00-4,14)	0,629 Z=-0,503	5,0 (0,00) (4,22-5,00)	5,0 (0,00) (4,95-5,00)	0,785 Z=-0,813	**<0.001** $Z=4,173$	**<0.001** $Z=7,339$
Total Vegetables	2,4 (1,14) (0,54-4,86)	1,8 (1,53) (0,88-4,62)	0,192 Z=-1,326	2,8 (1,99) (0,61-5,00)	1,9 (1,39) (0,84-4,24)	0,160 Z=-1,426	0.652 $Z=0.492$	0,160 $Z=1,404$
Greens and beans	3,7 (4,13) (0,00-5,00)	1,4 (3,39) (0,00-5,00)	0,629 Z=-0,504	3,1 (4,06) (0,00-5,00)	2,7 (4,85) (0,00-5,00)	0,523 Z=-0,674	0,847 $Z=0.198$	0,706 $Z=0.377$
Whole Grains	0,0 (6,87) (0,00-10,00)	0,0 (0,00) (0,00-1,99)	0,167 Z=-1,767	0,0 (6,78) (0,00-10,00)	0,0 (0,00) (0,00-10,00)	0,277 Z=-1,283	0.699 $Z=0.715$	0,634 $Z=0.476$
Dairy	2,9 (2,75) (0,36-9,18)	2,5 (2,66) (1, 82)	0,780 Z=-0,296	3,2 (2,60) (0,94-8,59)	3,9 (2,27) (0,98-6,04)	0,825 $Z=0.238$	0,562 $Z=0.624$	0,565 $Z=576$
Total Protein Foods	5,0 (0,30) (2,45-5,00)	4,1 (2,51) (1,68-5,00)	**0,036** Z=-2,469	5,0 (0,38) (0,53-5,00)	5,0 (0,00) (4,31-5,00)	0,490 $Z=0.916$	**0,034** $Z=2,394$	0,760 Z=-0,305
Seafood and Plant Proteins	5,0 (0,00) (0,96-5,00)	5,0 (1,99) (0,97-5,00)	0,415 Z=-1,119	5,0 (0,00) (3,58-5,00)	5,0 (0,00) (4,07-5,00)	0,886 Z=-0,366	0,243 $Z=1,654$	0,074 $Z=1,784$
Fatty Acids	7,4 (3,74) (0,22-10,00)	8,7 (3,28) (3,19-10,00)	0,201 $Z=1,312$	6,4 (3,77) (2,34-10,00)	7,8 (2,23) (4,27-10,00)	0,176 $Z=1,374$	0.478 Z=-0,759	0,312 Z=-1,011
Refined Grains	6,1 (3,62) (0,00-10,00)	1,7 (3,95) (0,00-6,44)	**0,002** Z=-2,937	7,4 (6,06) (0-10,00)	7,3 (5,91) (1,88-10,00)	0,825 $Z=0.241$	**0.003** $Z=2,865$	0,116 $Z=1,572$
Sodium	0,9 (3,35) (0,00-10,00)	1,6 (3,77) (0,00-9,57)	0,576 $Z=0.598$	0,3 (2,92) (0,00-8,38)	3,6 (5,84) (0,00-10,00)	0,255 $Z=1,217$	0.606 $Z=0.572$	0.581 Z=-0,551
Added Sugar	10,0 (0,33) (5,34-10,00)	10,0 (1,43) (7,12-10,00)	0,819 Z=-0,273	10,0 (0,00) (5,97-10,0)	10,0 (0,08) (7,24-10,00)	0,667 Z=-0,595	0.652 $Z=0.596$	0,146 $Z=1,453$
Saturated Fats	4,0 (4,99) (0,00-10,00)	5,5 (4,96) (0,86-9,83)	0,175 $Z=1,378$	4,4 (4,98) (0,00-10,00)	4,9 (4,25) (2,09-8,56)	0,540 $Z=0.634$	0.438 Z=-0,821	0,810 $Z=0.240$

Mann Whitney U test, $p<0.05$.
HEI: Healthy Eating Index.
p[1]= Comparison of values between men and women consuming two main meals.
p[2]= Comparison of values between men and women consuming three main meals.
p[3]= Comparison of values between men consuming two main meals and men consuming three main meals.
p[4]= Comparison of values between women consuming two main meals and women consuming three main meals.

Discussion

The number of meals individuals consume is influenced by their sociodemographic characteristics and living conditions. Lack of time, cost, weight management, education level, smoking and gender were reported to be the main reasons for skipping meals in a systematic review. In the same study, breakfast was noted as the most skipped main meal by the participants, while women mostly skipped lunch or dinner and men skipped breakfast (22). In our study, the main meal that both men and women skipped the most was lunch. The most frequently cited reason for skipping meals was having a late breakfast. The determining factor for the most skipped main meal is believed to be the employment status of the individuals. Since the majority of individuals in 2MMG were housewives and retired men, they get up late in the morning and have long breakfasts.

The majority of participants in this study were found to have two snacks per day. The mean frequency of snacks was reported to be 1.74 times/day in a study conducted in Japan (23), and it was 2-3 times/day in a study conducted in Canada (24). The frequency of main and snack meals was reported to be higher in women than in men in other studies (25, 26). There was no statistically significant difference between men and women in terms of the number of snacks in this study ($p>0.05$). The fact that all of the participants were overweight/obese, they had similar socio-cultural characteristics, and there were no significant differences between them in terms of some factors (age, screen use time, BMI,

Table 6. The relationship between meal frequency and anthropometric measurements and some biochemical parameters of participants.

	Total Number Snacks		Total Number Meals	
	r	p	r	p
Fasting blood glucose (mg/dL)	−0,067	0,530	−0,119	0,261
Fasting insulin (uIU/mL)	0,031	0,768	−0,010	0,926
HOMA-IR	0,057	0,593	−0,016	0,883
Total cholesterol	−0,160	0,129	−0,232	**0,027**
Triglycerides (mg/dL)	0,102	0,334	0,081	0,446
ALT(U/L)	−0,100	0,348	−0,033	0,754
AST(U/L)	0.065	0,540	0.135	0,200
Hemoglobin(g/dL)	0,062	0,557	0,015	0,887
Hematocrit (%)	0,016	0,883	−0,002	0,987
Body Weight(kg)	−0,018	0,862	0,020	0.848
Body fat (%)	0,082	0,440	0,026	0,807
Body fat (%)	0,075	0.478	−0,044	0,679
Lean body mass (kg)	−0,009	0,930	0.056	0,597
Waist circumference(cm)	−0,034	0,751	−0,096	0,364
HEI score	−0,046	0,664	0,182	0,085
BMI (kg/m^2)	0,104	0,327	0,045	0,672

*The total number of meals is the sum of the snacks and main meals consumed in a day.
Spearman Correlation Analysis, $p<0.05$.
HOMA-IR: Homeostatic Model Assessment for Insulin Resistance, ALT: Alanine Aminotransferase, AST: Aspartate Aminotransferase, BMI: Body mass index, SYI: Healthy eating index.

etc.) affecting snack consumption suggests that they might have similar eating habits (consumption of foods with similar energy and nutrient content and in approximately the same amounts).

Snacks generally consist of energy-dense foods with high sugar and saturated fat content and low nutritional quality (27, 28). When the food consumption records were examined, it was seen that the participants in this study generally preferred pastries, fruits, nuts, biscuits, chocolate and beverages (sugar-sweetened drinks, tea, coffee) in their snacks. In studies conducted in different countries, it has been reported that the most preferred snacks are chips, sweets and sugar-sweetened drinks (29, 30). Similarly, in a study conducted in the USA, it was reported that less healthy snacks (chocolates, regular cookies, cakes, snack cakes, donuts, regular potato chips, salted nuts, regular ice cream, etc.) were generally more common in homes than healthy snack alternatives (granola or granola bars, whole grain snack crackers unsalted nuts, sherbet, sorbet, or frozen fruit juice bars, reduced fat ice cream, etc.) (31).

In relevant studies, it has been reported that approximately one quarter of the daily dietary energy intake is provided from snacks (28, 32) In this study, it was determined that 23.21 ± 10.39% of the daily energy in 2MMG and 17.11 ± 10.82% in 3MMG was provided from snacks. In addition, the amounts of energy and macronutrients obtained from snacks were similar between the main meal groups ($p < 0.05$) (data not shown in the table). Considering that snacks constitute an important part of daily energy intake, the importance of planning their composition and amounts correctly emerges. Snacks with inadequate nutritional value and high energy may cause many health problems, especially obesity, diabetes and cardiovascular diseases. In relevant studies, fresh fruits, vegetables, dairy products, nuts, oilseeds and products derived from them are recommended as healthy snacks (32, 33).

One of the important factors for the risk of chronic diseases and obesity has been reported to be snacking at late hours (27, 34). In this study, the afternoon snack was the most energy-intensive snack for individuals in 2MMG, while the night snack was the most energy-intensive snack for those in the 3MMG (data not shown in the table). The most significant factor in this difference is the employment status of the individuals. Individuals in the two-meal group are mostly housewives and generally consume pastry products as they make home visits in the afternoon. The 3MMG on contrary, generally consists of working people and their accessibility to food increases in the evening hours. Due to the mentioned risks, healthy snack alternatives should be offered to individuals, especially for the night snack, and suitable recommendations should be developed for the amounts and frequencies of foods that can be consumed.

The evidence levels of studies examining the relationship between meal frequency and body weight and body composition are low and the results are inconsistent (4). Two separate studies conducted in Spain and Japan reported that skipping dinner was associated with obesity (34, 35). Another study conducted in Japan found an increase in BMI, body weight and incidence of obesity in men who consumed three main meals irregularly at the end of a two-year follow-up period, whereas a decrease in BMI and body weight was observed in women (36). In this study, almost half of the participants ($n = 44$) were classified as overweight. No statistically significant difference was found between genders in both groups according to the median values of BMI, waist circumference, waist-hip ratio and LAP index, which are parameters related to overweight/obesity ($p > 0.05$). Only the hip circumference median value of the men in the 3MMG was higher than the men in the 2MMG ($p < 0.05$).

When the literature is reviewed, studies conducted with the participation of healthy, normal body weight individuals reported that snacking small portions of healthy foods between main meals helps weight control and improves diet quality by increasing food diversity and suppressing appetite (12, 37). Studies conducted with overweight/obese individuals or individuals with any disease found that this group consumes unhealthy, high-energy foods predominantly at snacks, generally snacks without feeling hungry, and overeats without realizing it due to the influence of external stimuli (TV, computer, etc.). It has been reported that increasing the frequency of snacks as a result of these behaviors may decrease diet quality by increasing daily energy intake (38, 39). However, in the correlation and regression analyses carried out in this study, no statistically significant relationship was found between the total number of meals, the number of snacks and main meals and anthropometric measurements related to obesity. The fact that a significant proportion of the participants were pre-obese might have prevented optimal evaluation of obesity-related parameters.

When the body composition of the participants was compared, the median values of body fat (% and kg), lean body mass (kg), total body water (%) and BMR were similar in both groups ($p > 0.05$). In the experimental study conducted by Alencar et al. (40), 11 obese women had a low-energy portion-controlled diet in the form of 2 meals/day and 6 meals/day for 2-week periods. At the end of the study, weight loss was observed in both groups, but lean body mass (kg) value decreased in the 2-meal/day period and increased in the 6-meal/day period. The median values of lean body mass, total body water and BMI of men in 3MMG were determined to be higher than those in 2MMG in this study ($p < 0.05$). Similarly, some studies noting that increasing meal frequency may be beneficial in the treatment of obesity reported that frequent food consumption helps body weight control by increasing BMR value (6, 10). Another study reported that those with more meals had lower body fat (%) (41), however, our study results showed that the amount of body fat (%) was similar in both groups ($p > 0.05$). In this study, organizing the groups according to the number of main meals is believed to have caused this difference because similar studies have reported that the main determinant of central obesity risk may be the frequency of snacks (42, 43).

Studies examining the relationship between meal frequency and diseases have mostly focused on cardiometabolic risk factors (44, 45). Some studies have argued that increased meal frequency leads to chronic hyperinsulinemia and that increased insulin levels might also increase free fatty acids

and inflammation markers, which increases the risk of cardiometabolic diseases (5, 7, 8). Opposing studies have reported that when the number of meals increases, post-prandial insulin levels become lower due to a decrease in the glycemic load and the amount of food intake in the meal, which improves glycemic regulation (11, 46).

An experimental study in which the effects of having 3 meals/day and 1 meal/day on glycemic control and appetite were investigated stated that the positive effects of decreasing meal frequency on blood glucose regulation and hormones that provide appetite control could only be possible in cases of energy restriction (47). In the present study, the median values of FBG, fasting insulin and HOMA-IR in women were similar between the groups ($p > 0.05$). The median values of FBG, fasting insulin and HOMA-IR of men in 2MMG were higher than those in 3MMG, but this difference was not statistically significant ($p > 0.05$). The fact that the basic factors affecting the parameters related to glycemic regulation (BMI, food consumption, physical activity, presence of chronic diseases, etc.) were similar might have led to similar blood analyses. Furthermore, studies evaluating the effect of changes in meal frequency on glycemic regulation are experimental or epidemiologic studies in general. Since the current study was conducted with fewer participants compared to epidemiologic studies and there was no intervention on the number of meals of individuals, different results may have been obtained compared to other studies. In interventional studies, inferences are made based on short-term changes in blood glucose levels by changing meal frequencies. However, in this study, the evaluation was carried out according to the frequency of meals that participants generally have. Experimental interventions may not always be adapted to the routine diet of individuals. Therefore, the recommendations to be developed in line with the evaluations carried out according to the current habits of individuals are thought to be more efficient in terms of sustainability.

When participants' other biochemical parameters were evaluated, the median values of BUN, creatinine, TG, total cholesterol, ALT, AST, TSH, hemoglobin, and hematocrit were found to be similar in the groups for men ($p > 0.05$). Total cholesterol and BUN median values were found to be higher in women in 2MMG than those in 3MMG ($p < 0.05$). There are studies indicating that skipping main meals may increase the risk of chronic kidney disease (48, 49). Therefore, high BUN levels in women in the 2MMG are a significant finding. It is thought that individuals in this group should be made aware of healthy nutrition, especially sodium, protein and fluid intake, which are known to affect kidney function. Furthermore, providing information about the negative effects of obesity on kidney functions might encourage body weight loss in this group of individuals known to be overweight/obese.

Increasing meal frequency leads to less fluctuations in blood glucose and insulin levels. This which is important for glycemic regulation also helps to prevent cholesterol levels from rising. Insulin stimulates HmG-CoA reductase (the enzyme that regulates the rate of hepatic cholesterol synthesis). When plasma insulin levels are low, release slows down, thus reducing blood cholesterol levels. A decrease in cholesterol synthesis leads to an increase in LDL-C receptors. Increases in total and LDL-C levels are also prevented by this mechanism (50). In this study, total cholesterol levels were found to be high in women with a low number of main meals. Moreover, the TG median value of men in 2MMG was higher than that of men in 3MMG, but the difference was not statistically significant ($p > 0.05$). Similar to this study, there are studies reporting that total cholesterol, HDL-C and TG levels were higher in individuals who skipped breakfast (45, 51). The mechanism described for the insulin-cholesterol relationship is thought to be especially important for individuals who skip one of the main meals and consume more food at the following meal. The amount of insulin and blood cholesterol might increase in these people due to increased food consumption. Furthermore, given that obesity is one of the important risk factors for CVD, the importance of determining the appropriate number and content of meals should be emphasized once again.

In a study conducted with healthy individuals, meal frequency was determined to have a negative correlation with insulin level, HOMA-IR, postprandial blood glucose and heart rate (52). Among the biochemical parameters in this study, a weak negative statistically significant relationship was found only between total cholesterol and total number of meals (r=-232, $p < 0.05$). In contrast to this finding, Kulovitz et al.(3), reported in their review that there is no consensus in the literature on the ideal meal frequency for obesity treatment, however decreasing meal frequency may improve blood lipid profile in obese individuals. The fact that the participants in our study were metabolically healthy obese individuals might have been the reason for not having a significant relationship between blood parameters and meal frequency.

It is important to follow the nutritional recommendations set out in country-specific food-based dietary guidelines to prevent chronic non-communicable diseases and maintain health (53, 54). Various indexes have been developed to determine diet quality by measuring the level of compliance with these recommendations (54, 55). In this study, the diet quality of individuals was assessed with the HEI 2015. All of the men in 3MMG had diet quality that needs improvement and 63.6% of the men in 2MMG had poor diet quality ($p < 0.05$). Among the women, 94.1% of them in 3MMG and 57.1% of them in 2MMG had diet quality that needs improvement ($p < 0.05$). The fact that there was a higher number of individuals with diet quality in needs improvement in the 3MMG suggests that regular consumption of main meals might be beneficial in terms of food diversity, energy and nutrient intake balance.

A study conducted in Australia reported that the food diversity score, consumption of vegetables, fruits, milk and dairy products, grains and lean meats were better in individuals who consumed ≥3 meals (main + snacks)/day than those who consumed <3 meals (main + snacks)/day. However, with the increase in the frequency of snacks, the consumption of items that should be consumed in moderation (such as sugar, salt, and alcohol) has been noted to probably increase along with beneficial nutrients, and this situation is more

pronounced in men especially (14). Similarly, this study showed that men in 3MMG had higher scores on total fruits, whole fruits, total protein foods and refined grains components than men in 2MMG ($p<0.05$). In women, whole fruits and total fruits component scores were found to be higher in participants of 3MMG ($p<0.05$). Increasing the amounts of food consumed by individuals in 2MMG at main meals to meet their needs and providing menu examples in line with the healthy plate model may improve the diet quality of individuals in this group. In cases where the need cannot be fully met by consuming two main meals, adding an appropriate number of snacks to the diet might be more efficient in terms of meeting daily energy and nutrient needs, and prevention and treatment of obesity in individuals with irregular blood glucose regulation or difficulty in appetite control.

A study conducted with American adults reported that increasing meal frequency decreased the energy density of the diet in both genders while increasing the diet quality measured by the HEI 2010. The study results suggested that increased meal frequency is associated with a healthier diet with lower energy density and higher diet quality in American adults (56). The results of this and similar studies suggest that increasing meal frequency could improve diet quality. Supporting this suggestion, although the total score of the HEI 2015 was higher in individuals in 3MMG, there was no statistically significant relationship between the number of snacks (r=-0.04; $p=0.664$) and total meals ($r=0.182$; $p=0.085$) and diet quality in this study. The fact that all the individuals in the study were overweight/obese suggests that they might have similar eating habits and food preferences. Therefore, the possibility that the effect of changes in the number of meals on diet quality could not be clearly determined should be taken into consideration.

In a study conducted with American adults ($n=19,427$), increasing the number of main meals by one was reported to increase the HEI 2010 score by 2.14-5.35 points according to different meal definitions, and increasing the number of snacks by one increased the HEI 2010 score by 1.25-1.97 points (42). The same researchers reported in their study conducted with Japanese adults using a similar method that consuming an extra main meal increased the HEI 2015 score by 1.3-3.6 points (57). Similarly, in the regression analysis of the present study, a 1-unit increase in the number of main meals was determined to increase the HEI 2015 score by 9.3 points. An increase in the number of meals was generally associated with statistically significant increases in the HEI 2015 score in our study and similar studies. In order to achieve this improvement, meal contents should be planned correctly. Given that unhealthy and excessive food consumption is common, especially in obese individuals, meal planning (regulation of the number and content of meals according to the individual) becomes more important.

The most important limitation of the study is the small number of participants (especially men). The fact that the appetite levels, hormones affecting appetite, mood and income level of the individuals were not questioned is the other important limitations.

In conclusion, changing the number of main meals in overweight/obese individuals may affect the amount and type of energy and nutrients taken daily with the diet. Regular consumption of main meals may have positive effects on diet quality, some biochemical parameters, basal metabolic rate and body composition in individuals. However, individualized recommendations should be developed for snacks. Appropriately frequent snacks consisting of energy-controlled and healthy foods contribute to appetite control, glycemic regulation and optimization of dietary daily energy intake in overweight/obese individuals. It is important to plan the number of meals and the content of meals correctly, especially in overweight/obese individuals, since they have the wrong food preferences in general. A common terminology (especially for the definition of meals) should be developed and long-term, high-participant studies should be conducted with different groups to clarify the relationship between obesity and meal frequency.

Author contributions

The design of the study and the determination of the materials and methods were made jointly by the authors. SB, was responsible for literature review, data collection and analysis, and writing the manuscript. MGK, contributed to the technical review and interpretation parts of the study.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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