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Evaluation of the Relationship between Adherence to the Mediterranean Diet and Healthy Eating Attitudes and Phase Angle in University Students A Cross-sectional Study

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Abstract

Objective: This study is an observational descriptive cross-sectional study and it was aimed to evaluate the relationship between healthy eating attitude and phase angle of adherence to the Mediterranean diet in university students.

Methods: The study was carried out with university students aged 18-33, between August and September 2022. Sociodemographic characteristics, nutritional habits and physical activity status of individuals, information on disease status and anthropometric measurements were recorded in the questionnaire. The adaptation of individuals to the Mediterranean diet was evaluated with the "Mediterranean Diet Adherence Scale" and their attitudes towards nutrition were evaluated with the "Attitude Scale Towards Healthy Eating (SBITO)".

Results: 8.3% of individuals are underweight, 66.7% are normal, 25% are slightly overweight and obese. The median phase angle of women was 6.07° and men 7.3°, and the median phase angle of all individuals was 6.26°. It was determined that 59% of the individuals had low adherence to the Mediterranean diet, 34.7% had acceptable compliance, and 6.3% had strict compliance ($p>0.05$). It was determined that 16.7% of the individuals exhibited low-medium, 61.8% high, 21.5% ideally high healthy eating attitudes according to the SBITO classification. The phase angle cut-off point was found to be ≥5.94 with the Mediterranean Diet Adherence Scale and the Attitude Scale Towards Healthy Eating. It was observed that the phase angle had a diagnostic value in predicting adherence to the Mediterranean diet, but this was not statistically significant ($p>0.05$). A significant positive relationship was determined between adherence to the Mediterranean diet and healthy eating attitude ($r=0.310$, $p=0.001$).

Conclusion: As a result, phase angle evaluated by bioelectrical impedance analysis in individuals can be used as an indicator in the evaluation of cell health and quality nutrition.

Keywords: Mediterranean Diet, Phase Angle, Healthy Eating Attitude, Bioelectrical Impedance Analysis

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Introduction

The Mediterranean diet is accepted as a healthy diet model that is sufficient in terms of nutrition and ease of follow (1). Many important intervention studies have been conducted to evaluate the health effects of the Mediterranean diet (2, 3, 4). Foods in the Mediterranean diet (for example, extra virgin olive oil and nuts) have positive effects on health. The relatively high consumption of nuts and olive oil and moderate consumption of wine with meals (especially red wine) differentiate the Mediterranean diet from other healthy diet models (5). The Mediterranean diet has also been found to actively modulate cell membrane properties (6, 7), with potential benefits for health outcomes including type 2 diabetes (T2DM) (8), glycemic control (9), metabolic syndrome (10), obesity (11), cancer (12), cognitive impairment (13), and cardiovascular disease (CVD) (14). Adherence to the Mediterranean diet has been observed to reduce mortality, thus increasing life expectancy (5, 15).

Besides the protective effects of the Mediterranean diet on health, its effects on weight control are known. In particular, it has been reported that anthropometric measurements such as body mass index (BMI) and waist circumference are lower in people with high adherence to the Mediterranean diet (16). Bioelectrical impedance analysis (BIA), which has an important place in the evaluation of body composition in clinical applications, also determines the phase angle (PhA) with a direct measurement (17). PhA is used as a marker of cell membrane integrity and body cell mass (18, 19) and as an indicator of morbidity and mortality in various diseases (20, 21).

PhA also represents cellular health (22, 23). Therefore, phase angle measurement with BIA can provide an easy approach to determine cellular damage and cell death in chronic inflammatory conditions (24). In addition, a relationship between PhA and nutritional status has been reported in individuals. Consumption of foods such as extra virgin olive oil, grains, legumes and meat showed a weak but significant positive correlation with PhA (25). A relationship between adherence to the Mediterranean diet and PhA values has been reported (26). High phase angle values are an indicator of cellular membrane integrity. It has been reported that oxidative stress and inflammatory biomarkers are lower in those with higher phase angle values. Therefore, it is predicted that cell membrane damage, oxidative stress and inflammation can be reduced by increasing diet quality (25). Since there are few studies explaining the relationship between the Mediterranean diet and PhA (26), this study was planned to evaluate the relationship between adherence of university students to the Mediterranean diet, their attitudes towards healthy eating, and PhA.

Material and Method

Research Location, Time and Sample Size

This study was conducted with a total of 144 university students, male and female, studying at the Faculty of Health Sciences of a foundation university to evaluate the relationship between adherence of university students to the Mediterranean diet, healthy eating attitude and phase angle between August and September 2022. The study is an observational descriptive cross-sectional study. The sample size was calculated with a margin of error of 0.05 and a power of 0.95, based on the results obtained from studies with phase angle (17, 27).

Inclusion and Exclusion Criteria for Research

University students who volunteered to participate in the study were included in the study. Permission for the study was obtained from the Human Research Ethics Committee of Istanbul Bilgi University on 20/07/2022 and with the project number 2022-20016-125. Individuals with lymphedema in their lower or upper extremities, individuals using drugs that may affect fluid balance, and pregnant women were not included in the study.

Data Collection Tools

In this study, data collection tools consist of 6 parts, including sociodemographic characteristics, nutritional habits, anthropometric measurements, phase angle measurement, compliance with the Mediterranean diet, and information on healthy nutrition.

Sociodemographic Characteristics

The participants were asked about age, gender, marital status, department they studied, current disease status, drug use, food supplement use by the researcher using face-to-face interview method.

Information on Nutrition and Physical Habits

Consumption of main and snack meals, reasons for skipping meals, physical activity status, frequency and type, smoking status were questioned regarding nutrition and physical activity habits.

Anthropometric Measurements

Body weight, height, waist and hip circumference of the participants were measured in accordance with the standards (28). Body weights were measured with a calibrated clinical scale (TANITA BC-601) device and height was measured with a stadiometer (29). Body mass index was calculated with the formula weight (kg)/height squared (m^2) (30). BMI is classified according to WHO criteria (31).

Measurement of Phase Angle

The phase angle of the individuals was measured using a single frequency 50 kHz current Premium BIA600, nutribox rev. 1.0 device. Before the measurement, attention was paid to the fact that the individuals did not have metal objects on them, did not consume alcohol in the last 24 hours, and did not engage in heavy physical activity. Shoes and socks were removed and contact areas were cleaned with alcohol just before electrode placement. After the skin was cleaned, the measurements were made as in the user manual of the device by placing a total of 4 electrodes on the dorsal side of the individual's right hand (proximal to the phalangeal-metacarpal joint) and the right wrist, the dorsal side of the right foot and the right ankle (midpoint between the medial and lateral malleoli). Individuals were placed in a supine position on a stretcher, palms facing in, arms at 30° and feet at 45° angles, and measurements were made. The parameters obtained according to the measurement result were classified as low, normal and high in each participant. All measurements were made by the principal investigator under standardized conditions using the same device to avoid variability (19).

Mediterranean Diet Adherence Scale (MEDAS)

Adherence to the Mediterranean diet was assessed by the Mediterranean Diet Adherence Scale (MEDAS) developed by Martinez González et al. (32). It is a survey consisting of 14 questions. In the questionnaire, the type of basic oil used by individuals in meals, the amount of olive oil consumed daily, the consumption and portions of fruit and vegetables, the consumption of margarine-butter and red meat, the amount of wine consumed weekly, pulses, fish-seafood, nuts, sweets/pastries, olive oil sauce consumption and whether white meat is preferred more than red meat were asked. 1 or 0 points are taken for each question asked according to the amount of consumption, and the total score is calculated. Total MEDAS score; a value below 7 indicates low adherence to the Mediterranean diet, a score of 7-8 indicates an acceptable degree of adherence to the Mediterranean diet, and a score of 9 or above indicates that the individual has a strict adherence to the Mediterranean diet (33).

Attitude Scale Towards Healthy Eating (SBITO)

Attitudes towards healthy eating were evaluated with the Attitudes towards Healthy Eating Scale (SBITO) (34). SBITO consists of 4 sub-dimensions, including 21 items. The scale is evaluated with 5-point Likert type options, “Strongly Disagree”, “Disagree”, “Undecided”, “Agree” and “Strongly Agree”. Positive attitude items are scored as 1, 2, 3, 4 and 5, and negative attitude items are scored as 5, 4, 3, 2 and 1, respectively. Positive items consist of 1., 2., 3., 4., 5., 12., 13., 14., 15., 16. items. Negative items consist of 6th, 7th, 8th, 9th, 10th, 11th, 17th, 18th, 19th, 20th and

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21st items. As a result of scoring, the total score that can be obtained from the scale is between 21 and 105. As the total score increases, the attitudes of the participants towards healthy eating increase. As a result of the scoring of the SBITO, the participants will have a very low 21 points, 23-42 points low, 43-63 points medium, 64-84 points high, 85-105 points ideally high attitude towards healthy eating.

Statistical Evaluation of Data

The analysis of the data obtained in this study was carried out using the IBM Statistical Package for Social Science Statistics (SPSS) 25.0 statistical package program. As descriptive statistical data, the number of units (n) and percentage (%) in qualitative variables; arithmetic mean ($\bar{X}$) and standard deviation (SD) in quantitative parametric variables. For quantitative non-parametric variables, median (Xort), lower value (minimum) and upper value (maximum) expressions were used. Pearson Chi-squarre (Chi-square or x2) or Fisher's Exact tests were used in the comparison of categorical/qualitative variables, and Bonferroni correction was applied in post-hoc complementary analyzes to determine the differences. The suitability of quantitative variables to normal distribution was examined using visual (histogram and probability charts) and analytical methods (Kolmogorov-Smirnov/Shapiro-Wilk tests). "Independent Samples T-Test" and "ANOVA", which are parametric tests, were used for quantitative variables that were found to be normally distributed, and "Mann-Whitney U" and "Kruskal Wallis H" tests, which are non-parametric tests, were used for quantitative variables that were found to be not normally distributed. In the correlation analyzes carried out to examine the relationships between the variables, the "Pearson" correlation coefficient was used for the normally distributed variables, and the "Spearman's Rho" correlation coefficient for the non-normally distributed variables. “Receiver Operating Characteristic or ROC” curve analysis was performed for the phase angle variable. In the presence of significant breakpoints, the sensitivity (sensitivity) and specificity (specificity) values of these limits were calculated. In the evaluation of the Area Under Curve or AUC, the cases where the Type-1 error level was below 5% were interpreted as the diagnostic value of the relevant variable was statistically significant. All the statistical results obtained were evaluated at the 95% confidence interval and the significance level of $p<0.05$ (35).

Results

Of the individuals, 77.1% were female (n=111) and 22.9% were male (n=33). Sociodemographic characteristics and health information of individuals are given in Table 1. It was determined that 55.9% of women and 30.3% of men skipped at least one main meal, and 26.4% of all individuals did not consume snacks. 8.3% (n=12) of the individuals were underweight, 66.7% (n=96) were normal, and 25% (n=36) were overweight or obese. It was observed that 74.8% of the female individuals were normal weight, 54.6% of the males were overweight, and 49.3% of the individuals regularly engaged in physical activity (Table 2). Age, anthropometric measurement and BIA results of the individuals by gender are shown in Table 3. The median age of individuals

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was 22 (18-33) years, the median body mass index for women was 21.16 (15.77-36.95) kg/m^2, and for men 25.73 (17.53-34.08) kg/m^2. In addition, the median waist/hip ratio for women was 0.69 (0.51-0.85) cm, and 0.77 (0.70-0.94) cm for men.

The median MEDAS score of the individuals is 6, the mean of the SBITO score is 74.3, the median of the phase angle values is 6.07° for women and 7.3° for men, and the median of all individuals is 6.26°. When the MEDAS score, phase angle, body fat percentage, lean body mass, phase angle and fat free mass index (FFMI) parameters of the individuals were compared according to gender, it was determined that they were statistically significant (p<0.05) (Table 4).

Table 1. Sociodemographic Characteristics of Individuals

		Woman		Male		Total			
		n	%	n	%	n	%	x^2	P
Section	**Nutrition and Dietetics**	42	37.9	13	39.4	55	38.2	25.053	**<0.001**
	Child Development	32◆	28.8	1	3.0	33	22.9		
	Physical Therapy and Rehabilitation	12	10.8	15	45.5	27	18.8		
	Nursing	25	22.5	4	12.1	29	20.1		
Class	**1st Class**	9	8.2	6	18.2	15	10.5	9.245	**0.025**
	2nd Class	27	24.5	13	39.3	40	28.0		
	3rd Class	29	26.4	9	27.3	38	26.5		
	4th Class	45◆	40.9	5	15.2	50	35.0		
Marital status	**Single**	108	97.3	33	100.0	141	97.9	0.911	0.455*
	Married	3	2.7	-	-	3	2.1		
Working status	**Working**	19	17.1	9	27.3	28	19.4	1.675	0.215
	Not working	92	82.9	24	72.7	116	80.6		
Illness status	**Yes**	28	25.2	2◆	6.1	30	20.8	5.665	**0.026**
	No	83	74.8	31	93.9	114	79.2		
Smoking status	**Yes**	33	29.7	12	36.4	45	31.3	0.521	0.770
	No	67	60.4	18	54.5	85	59.0		
	Sometimes	11th	9.9	3	9.1	14	9.7		
	Total	**111**	**77.1**	**33**	**22.9**	**144**	**100.0**		

Chi-square test; *: Fisher's Exact test; ◆: It was determined that there was a significant difference with the Post-Hoc analysis. ◆: The number of n exceeds the sample size because multiple responses can be given; The % parameter is given over the total number.

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Table 2. Nutritional Habits, Physical Activity Status and BMI Classification of Individuals

		Woman		Male		Total			
		n	**%**	**n**	**%**	**n**	**%**	x^2	**P**
Number of main meals (days)	**1 meal**	3	2.7	1	3.0	4	2.8	7.194	**0.019***
	2 meals	59•	53.2	9	27.3	68	47.2		
	≥3 meals	49	44.1	23	69.7	72	50.0		
Skipped main meal (women: 62; men: 10)◆	**Breakfast**	21	34.4	2	16.7	23	31.5	7.263	0.064*
	Noon	37	60.7	7	58.3	44	60.3		
	Evening	3	4.9	3	25.0	6	8.2		
Snack consumption	**Yes**	83	74.8	23	69.7	106	73.6	0.338	0.653
	No	28	25.2	10	30.3	38	26.4		
Number of snacks (days)	**1 meal**	30	36.6	6	26.1	36	34.3	1.120	0.616
	2 meals	40	48.8	14	60.9	54	51.4		
	≥3 meals	12	14.6	3	13.0	15	14.3		
Activity Status	**Yes**	44	39.6	27•	81.8	71	49.3	18.105	**<0.001**
	No	67	60.4	6	18.2	73	50.7		
Body Mass Index Classification	**Weak**	11th•	9.9	1	3.0	12	8.3	28.361	**<0.001***
	Normal	83	74.8	13	39.4	96	66.7		
	Overweight	10	9.0	18	54.6	28	19.4		
	Obese	7	6.3	1	3.0	8	5.6		
	Total	**111**	**77.1**	**33**	**22.9**	**144**	**100.0**		

Chi-square test; *: Fisher's Exact test; •: It was determined that there was a significant difference with the Post-Hoc analysis. ◆: The number of n exceeds the sample size because multiple responses can be given; The % parameter is given over the total number.

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Table 3. Anthropometric Measurements

	Female (n=111)	Male (n=33)	Total (n=144)
	x̄ ± SD / Xort (Lower Value - Upper Value)	x̄ ± SD / Xort (Lower Value - Upper Value)	x̄ ± SD / Xort (Lower Value - Upper Value)
Age (years)	22 (18-33)	21 (20-26)	22 (18-33)
Height (cm)	163 (144-178)	180 (163-188)	165 (144-188)
Body weight (kg)	55.6 (40.6-100.6)	82.9 (60-109.2)	60.1 (40.6-109.2)
BMI (kg/m^2)	21.16 (15.77-36.95)	25.73 (17.53-34.08)	21.79 (15.77-36.95)
Waist circumference (cm)	68 (54-107)	81 (66-102)	70 (54-107)
Hip circumference (cm)	96 (78-134)	104 (88-125)	98 (78-134)
Waist/hip	0.69 (0.51-0.85)	0.77 (0.70-0.94)	0.71 (0.51-0.94)
Bellhop	0.41 (0.33-0.65)	0.45 (0.36-0.57)	0.42 (0.33-0.65)

*: Normal distribution. Normally distributed x̄ ± SD; those not normally distributed are shown as Xort (Lower Value-Upper Value). x̄: Arithmetic mean; SD: Standard deviation; Xort: Median, [a] : Independent Samples T-Test; [b] : Mann-Whitney U Test, FFMI: Lean Body Mass Index, BMI: Body Mass Index

Table 4. MEDAS and SBITO Total Score and BIA Results of Individuals by Gender

	Female (n=111)	Male (n=33)	Total (n=144)		
	x̄ ± SD / Xort (Lower Value - Upper Value)	x̄ ± SD / Xort (Lower Value - Upper Value)	x̄ ± SD / Xort (Lower Value - Upper Value)	t [a] /z [b]	p
MEDAS	6 (3-10)	5 (3-9)	6 (3-10)	-2.114	**0.034**
SBITO*	73.7±11.78	76.4±11.32	74.3±11.69	-1,180	0.243
Phase angle (°)	6.07 (4.62-9.58)	7.3 (5.47-9.12)	6.26 (4.62-9.58)	-6,964	**<0.001**
Body fat (kg)	16.23 (7.68-44.68)	17.13 (8.33-34.32)	16.69 (7.68-44.68)	-1,146	0.252
Body fat (%)*	30.0±6.10	22.7±5.64	28.3±6.72	6.405	**<0.001**
Lean body mass (kg)	39.48 (31.31-55.92)	62.36 (40.04-74.88)	41.98 (31.31-74.88)	-8.425	**<0.001**
ECM/BCM index*	0.9±0.10	0.7±0.10	0.9±0.12	8,886	**<0.001**
FFMI	15.15 (12.70-20.54)	19.69 (15.07-23.37)	15.44 (12.70-23.37)	-7.696	**<0.001**

*: Normal distribution. Normally distributed x̄ ± SD; those not normally distributed are shown as Xort (Lower Value-Upper Value). x̄: Arithmetic mean; SD: Standard deviation; Xort: Hydrangea. [a] : Independent Samples T-Test; [b] : Mann-Whitney U Test. ECM/BCM: Extracellular Mass/Muscle and Organ Mass , FFMI: Lean Body Mass Index

It was determined that 59% of the individuals had low adherence to the Mediterranean diet, 34.7% had acceptable compliance and 6.3% had strict adherence, and the difference according to gender

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was not significant (p>0.05). It was determined that 16.7% of the individuals exhibited low-medium, 61.8% high, 21.5% ideally high healthy eating attitudes according to the SBITO classification (Table 5).

Table 5. Classification of Individuals by Gender and MEDAS and SBITO Scores

		Woman		Male		Total			
		n	**%**	**n**	**%**	**n**	**%**	**x^2**	**p**
MEDAS	**Low fit**	61	55.0	24	72.7	85	59.0	3.614	0.164
	Acceptable fit	43	38.7	7	21.2	50	34.7		
	Tight fit	7	6.3	2	6.1	9	6.3		
SBITO	**Low**	2	1.8	-	-	2	1.4	1.852	0.604*
	Middle	16	14.4	6	18.2	22	15.3		
	High	71	64.0	18	54.5	89	61.8		
	Ideally high	22	19.8	9	27.3	31	21.5		
Total		**111**	**77.1**	**33**	**22.9**	**144**	**100.0**		

Chi-square test; *: Fisher's Exact test.

ROC curve analysis was performed for the phase angle cut-off point with the MEDAS and SBITO classifications (Figure 1).

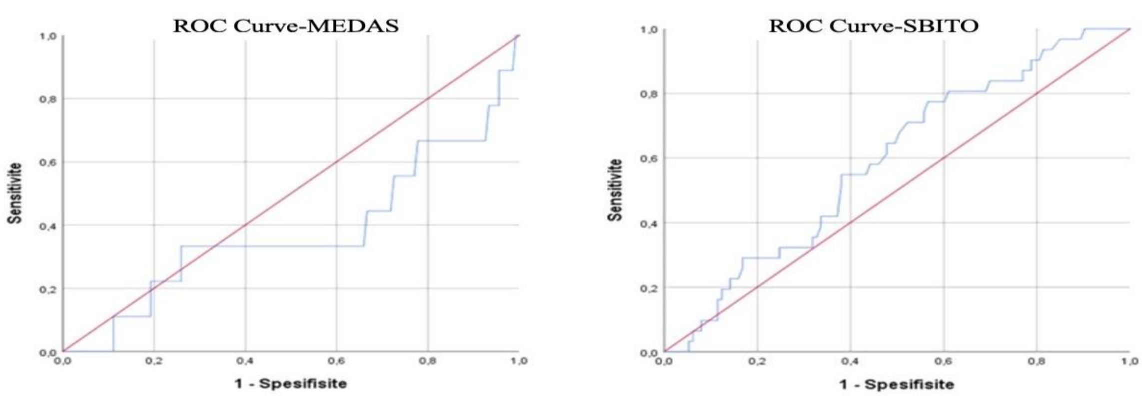

Figure 1. Diagnostic Value of Phase Angle in Predicting MEDAS and SBITO Outcomes: ROC Curve with MEDAS and SBITO Classification

Phase angle results were found to have diagnostic value in predicting the MEDAS outcome (specificity 72.6%), but not statistically significant (p=0.222) (Table 6). According to this result, in cases where the MEDAS scale is not performed, it can be considered that ≥5.94 value can be

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taken as the cut-off point for the phase angle in predicting strict adherence to the Mediterranean diet (p>0.05). According to the BMI classification, the phase angle of individuals with normal weight was found to be above the phase angle cut-off point (≥5.94) (p=0.006). It was observed that women whose phase angle was above the cut-off point were more in the normal class according to BMI when compared to men (p=0.001). It was determined that there was no statistically significant difference in the comparison of the MEDAS and SBITO classifications of the individuals according to the phase angle cutoff point (p>0.05) (Table 7).

According to the correlation results of the phase angle and the scales, it was determined that there was no statistically significant relationship between the phase angle and SBITO and MEDAS (p>0.05), the phase angle increased as the number of main meals increased and there was a statistically significant relationship (p<0.05). A weak and positive, statistically significant relationship was determined between SBITO and MEDAS (r=0.310 and p=0.001) (Table 8).

Table 6. Diagnostic Value of Phase Angle in Predicting MEDAS Outcomes: ROC Curve Analysis Results with MEDAS and SBITO Classification

Factor	Area Under the Curve (95%)	FA Cut Point	p	Sensitivity (%) [a]	Specificity (%) [b]
MEDAS	0.378 (0.161-0.595) [c]	5.94	0.222	55.6	72.6
SBITO	0.591 (0.485-0.696) [d]	6.31	0.123	58.1	55.8

[a] : Sensitivity; [b] : Specificity; [cd] : Figure 1

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Table 7. Comparison of Phase Angle Cutoff Point with MEDAS and SBITO and BMI Classifications

		Phase Angle																Total			
		<5.94								≥5.94											
		Woman		Male		Total				Woman		Male		Total							
		n	%	n	%	n	%	x^2	p	n	%	n	%	n	%	x^2	p	n	%	x^2	p
Body Mass Index	**Weak**	6	15.0	-	-	6	14.6			5	7.0	1	3.1	6	5.8			12	8.3		
	Normal	31	77.5	1	100.0	32	78.0	0.288	1.000	52•	73.2	12	37.5	64•	62.1	23,656	**<0.001**	96	66.7	11.435	**0.006**
	Overweight	3	7.5	-	-	3	7.3			7	9.9	18	56.3	25	24.3			28	19.4		
	Obese	-	-	-	-	-	-			7	9.9	1	3.1	8	7.8			8	5.6		
MEDAS	**Low adherence**	21	52.5	-	-	21	51.2			40	56.3	24	75.0	64	62.1			85	59.0		
	Acceptable adherence	16	40.0	-	-	16	39.0	4.965	0.098*	27	38.0	7	21.9	34	33.0	3.115	0.165*	50	34.7	2.025	0.372
	High adherence	3	7.5	1	100.0	4	9.8			4	5.6	1	3.1	5	4.9			9	6.3		
SBITO	**Low-Medium**	7	17.5	-	-	7	17.1			11	15.5	6	18.8	17	16.5			24	16.7		
	High	28	70.0	-	-	28	68.3	4.288	0.146*	43	60.6	18	56.3	61	59.2	0.221	0.873	89	61.8	1.661	0.455
	Ideally high	5	12.5	1	100.0	6	14.6			17	23.9	8	25.0	25	24.3			31	21.5		
	Total	**40**	**97.6**	**1**	**2.4**	***41***	***28.5***			**71**	**68.9**	**32**	**31.1**	***103***	***71.5***			***144***	***100.0***		

Chi-square test; *: Fisher's Exact test.

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Table 8. Correlations with Phase Angle and Scale Results

			Phase Angle [a]	SBITO [b]	MEDAS [a]
SBITO	**Scoring**	**r**	0.104	-	0.310 **
		p	0.217	-	**<0.001**
MEDAS	**Scoring**	**r**	-0.143	0.310 **	-
		p	0.088	**<0.001**	-
Gender	**Woman**	**r**	0.582 **	0.096	-0.177 *
	Male	**p**	**<0.001**	0.250	**0.034**
Illness status	**Yes**	**r**	0.196 *	-0.054	-0.058
	No	**p**	**0.019**	0.518	0.492
Number of main meals (days)	**1 meal** **2 meals**	**r**	0.169 *	0.003	-0.094
	≥3 meals	**p**	**0.043**	0.976	0.262
Snack consumption	**Yes**	**r**	0.025	-0.265 **	-0.190 *
	No	**p**	0.764	**0.001**	**0.022**
Regular physical activity	**Yes**	**r**	-0.359 **	-0.188 *	-0.141
	No	**p**	**<0.001**	**0.024**	0.092
Body weight (kg)		**r**	0.511 **	0.144	-0.126
		p	**<0.001**	0.085	0.132
Waist Circumference (cm)		**r**	0.424 **	0.091	-0.105
		p	**<0.001**	0.277	0.209
Body mass index (kg/m^{2})		**r**	0.332 **	0.135	-0.035
		p	**<0.001**	0.108	0.681
Hip circumference (cm)		**r**	0.252 **	0.089	-0.073
		p	**0.002**	0.288	0.385
Waist/hip		**r**	0.443 **	0.102	-0.089
		p	**<0.001**	0.224	0.288
Bellhop		**r**	0.263 **	0.067	-0.035
		p	**0.001**	0.425	0.681
ECM/BCM index		**r**	-0.981 **	-0.111	0.156
		p	**<0.001**	0.186	0.061
FFMI		**r**	0.709 **	0.160	-0.117
		p	**<0.001**	0.055	0.162
Body fat percentage		**r**	-0.378 **	0.035	0.079
		p	**<0.001**	0.673	0.345
Lean body mass		**r**	0.700 **	0.140	-0.170 *
		p	**<0.001**	0.093	**0.041**

*: Correlation significance level 0.05; **: Correlation significance level 0.01. [a] : Spearman's Rho correlation coefficient; [b] : Pearson correlation coefficient.

Discussion

The Mediterranean diet is accepted as a health-promoting diet model due to its unique features such as unsaturated fat content, fiber, vitamin and antioxidant content, low glycemic index carbohydrates and consuming moderate amounts of animal protein (36). It has been proven by many studies that adherence to the Mediterranean diet has a significant impact on the prevention of chronic diseases, neurodegenerative diseases and improving the quality of life (5, 8-15). A positive relationship has been determined between individuals with high adherence to the Mediterranean diet and their body composition (16). PhA, which is a marker of cell membrane integrity and body cell mass, can also be measured with BIA, which is used in the evaluation of body composition (17-19). It has been reported that the Mediterranean diet actively modulates cell membrane properties (6, 7). In this study, it was aimed to evaluate the relationship between phase angle and adherence to the Mediterranean diet.

Food intakes of women are characterized by a higher intake of carbohydrates, including fruits and vegetables, while men have been observed to have a low adherence to the Mediterranean diet (37). Adherence to the Mediterranean diet was found to be lower in men than in women (27). In the study, which was classified according to BMI categories, it was determined that there was a higher adherence to the Mediterranean diet in women compared to men (26). In this study, it was determined that adherence to the Mediterranean diet was lower in men than in women, and adherence to the Mediterranean diet decreased ($p<0.05$).

Since men have higher body muscle mass than women, they have a higher phase angle value (19). In studies, PhA values were found to be significantly lower in women than in men (27, 38-40). In our study, the mean phase angle value was determined as 6.07° in women and 7.3° in men, and positive and statistically significant relationships were determined with phase angle in men compared to women ($p<0.05$) (Table 4).

There are studies evaluating PhA according to BMI classification (26, 40-42). In studies examining whether PhA differs between obese individuals and control groups, while some studies found no difference (38, 42), in a few studies PhA was found to be in Class II. and III. It was observed that it decreased in individuals with grade I obese and did not decrease in individuals with grade I (41, 43). Findings supporting this result were also obtained in different studies (26, 43). In a study conducted with a total of 15605 and 214732 adults consisting of children and adolescents, it was determined that when the BMI value increases, the phase angle also increases, and when the BMI value rises to 40 kg/m2, there is a negative correlation with the phase angle in normal and overweight adults (38). In other studies, it has been observed that the prevalence of obesity varies depending on PhA (20, 44-47). In this study, statistically significant relationships were determined between the phase angle results of individuals and BMI, waist circumference, hip circumference, waist/hip ratio, waist/height ratio (Table 8).

In studies investigating the relationship between PhA and body composition, it has been found that PhA is negatively associated with fat mass (FM) (41, 44, 48) and directly related to FFM (44). No firm conclusions can be drawn about the effect of high body fat on PhA (49). It has been observed that the phase angle is also related to muscle integrity. In a study by Norman et al., a strong correlation was observed between phase angle and hand grip strength, and phase angle was defined as an independent predictor for impaired muscle function (20). It has also been reported that increased waist circumference is associated with lower PhA values (50). In this study, a positive and significant relationship was observed between phase angle and body weight, BMI, waist circumference, hip circumference, waist/hip, waist/height, lean body mass, and FFMI. It was determined that there was a significant negative relationship (Table 8).

It has been reported that the PhA value may be affected in the presence of disease and the PhA value is lower than normal (21). In this study, a significant negative correlation was found between the presence of disease and the phase angle of the individuals ($p<0.05$) (Table 8).

Phase angle has also been found to be associated with the inflammatory state in various diseases (51). Its use as a prognostic marker of morbidity and mortality in a variety of chronic inflammatory conditions, including obesity (20), has been recommended (44). Many studies have reported that phase angle is a predictor of impaired prognosis (mortality, disease progression, incidence of postoperative complications, length of hospital stay) (52-63). A positive correlation was observed between PhA and Mediterranean diet adherence (39, 64). In another study, it was reported that participants with the highest PhA value showed high adherence to the Mediterranean diet (26). In this study, phase angle values were compared with MEDAS, which measures adherence to the Mediterranean diet, and it was seen that the phase angle results had a diagnostic value in predicting the MEDAS result (specificity 72.6%), but this was not statistically significant (Table 6). When the MEDAS and SBITO classifications of the individuals were compared both between genders and according to the phase angle cutoff point, it was determined that there was no statistically significant difference ($p>0.05$) (Table 7). However, according to our results, we can think that in cases where the MEDAS scale was not performed, ≥5.94 value could be used as the cut-off point for the phase angle in predicting strict adherence to the Mediterranean diet ($p>0.05$).

PhA values are also affected by physical activity (65). PhA value is directly associated with muscle strength (66). Studies have reported that PhA values are higher in athletes (67) and decrease due to physiological changes in BCM and ECW/ICW ratio with aging (68). In a study, an increase in the mean PhA value was observed in adult obese women after exercise training programs, and it was reported that this may be related to the improvement in muscle mass (69, 70). It has been observed that the PhA value improves with exercise training in different populations (71, 72). In our study, it was determined that 49.3% (n=71) of the individuals did regular physical activity, while 50.7% (n=73) did not (Table 2). In our study, it was determined that the phase angle value decreased with the decrease in the frequency of physical activity and the difference was statistically significant ($p<0.05$). It was determined that the phase angle decreased in the absence of regular physical activity ($p<0.05$) (Table 8). Those with high diet quality and muscle mass have higher phase angle values (25). Considering that the phase angle is an indicator of cell death, membrane integrity (73) and nutritional status (74), it is thought that diet quality may have a direct effect on these parameters (25). The use of scales based on food diversity to evaluate diet quality allows better evaluation of diet (73). In a study, it was determined that individuals with a phase angle of 6.35 or less have a lower Healthy Eating Index (HEI) score (25). In this study, no statistically significant difference was found between the attitude towards healthy eating and the Mediterranean diet compliance scores and the phase angle ($p>0.05$).

It has been determined that a high attitude towards healthy eating has a positive and statistically significant relationship with adherence to the Mediterranean diet. A significant negative correlation was found with the BMI values of individuals with a high SBITO score. Similar results were reported in the study of El Hajj and Julien (75).

Conclusion

Practical and easy determination of the phase angle with BIA can be an important evaluation method in predicting cell health and quality nutrition in individuals. Studies to be conducted in a larger population may yield more valuable results in terms of the importance of using the phase angle.

Disclosure Statement

The authors declare that they have no conflict of interest.

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