

# Evaluation of phase angle measurements and nutrient consumption by bioelectrical impedance method of 20-65 years old women

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**Summary.** *Background/Objectives:* This study was carried out to determine the nutritional status of women between the ages of 20-65 and to evaluate the relationship between phase angles and nutrition by Bioelectric Impedance Analysis (BIA) method. 75 volunteer women between the ages of 20-65 who applied to a special clinic were included to survey. *Subjects (or Materials) and Methods:* The application of questionnaire form that is aimed at general features nutrition behaviours, nutrient frequency of individuals and anthropometric measurements and nutrient consumption of individuals were recorded. The mean age was  $39.4 \pm 9.6$  years and the mean body mass index was  $28.7 \pm 6.1$  kg/m<sup>2</sup>. *Results:* It was determined that 17.3% of the participants did not skip meals, 82.7% of them skipped meals and the most skipped main meal was lunch with 53.3%. The ratio of daily energy taken from carbohydrate was lower than recommended ( $47 \pm 8.7\%$ ), while the ratio of fat from fat was higher than recommended ( $37.8 \pm 6.4\%$ ). Phase angle averages are  $5.9 \pm 0.80$ . *Conclusions:* There was no relationship between the parameters such as age groups, BMI groups, physical activity status and disease status of participants and phase angle values. A weak positive correlation was found between the body mass index and phase angle values of the participants ( $p=0.040$ ,  $p<0.05$ ). There was a moderately positive correlation between body muscle and phase angle values ( $p=0.000$ ,  $p<0.05$ ). According to the results of the study, it was seen that body mass indexes and body muscle amounts increased and phase angle values increased

**Key words:** bioelectrical impedance analysis, body mass index, waist hip ratio, phase angle, food consumption

## 1. Introduction

The assessment of the nutritional status of the organism shows the balance between the intake, and consumption of nutrients. The balance between nutrient intake, and requirement is important for optimal health. Determining the nutritional status is an indication of the extent to which nutrient requirements are met (1). Methods used to determine nutritional status are biochemical tests, clinical indicators, health history, anthropometric measurements, and psychosocial data. Nutritional status detection methods can be used together with some or all of them (2). In recent years, Bioelectrical Impedance Analysis (BIA) frequency of

use in determining the nutritional status by anthropometric measurements began to increase because of easy to implement, non-invasive, repeatable, fast results can be obtained, and be portable (3). BIA measures the resistances, and reactance of the body component by recording the voltage drops in the current applied to the body. The phase shifts during this measurements are quantified ratio of reactance to resistance as phase angle. Phase angle is thought to be indicative of body cell mass, nutritional status, reflects relative contributions of fluid (resistance), and cell membranes (reactance) of the body (4). The impedance parameter, which has been recently popular and deteriorated, provides a high rate of mortality of various diseases, is the phase

angle (5). Phase Angle (PhA) clinically characterized by increased ECM (extra cell mass) and reduced BCM (body cell mass) is thought to be an indicator of malnutrition (6). Additionally, Digant et al. (7) reported that phase angle is an indicator of nutritional status in advanced colorectal cancer. Generally, phase angle values in healthy individuals are between  $5^{\circ}$ - $7^{\circ}$  (8). In our study, it is planned to evaluate the food consumption of women between the ages of 20-65 and the phase angle values by bioelectric impedance method and to obtain a data. The aim of study was to determine the nutritional status of women, as well as to determine the extent to which nutritional status reflects or contributes to phase angle values.

## 2. Material and Methods

This study was carried out with 75 volunteers randomly selected among women aged 20-65 who applied to a private clinic. Women under 20 years of age and over 65 years of age, pregnant women, breastfeeding mothers, and individuals having cardiac pacemaker are not included. The data were obtained by a face-to-face questionnaire. The questionnaire includes the data about demographic characteristics, health status, feeding habits, and nutrient consumption status of the participants. In addition, 3 consecutive days of food consumption was recorded, 2 days on weekdays, and 1 day at weekends. The anthropometric values of the participants (height, waist-hip circumference) were written down by measuring with the help of a non-stretched tape measure, and body weights were measured by electronic bascule. Body components such as phase angle, total body water, body fat amount, body muscle amount was analysed by lying position by BIA 500 bioelectrical impedance analyser, and by attaching two electrodes to special points of hands, and feet. The energy and nutrient intake of the participants were calculated on computer, by using food analysis program named BeBIS (9) which adapted to Turkey. The data was analysed statistically by using SPSS 20 program, and evaluated by chi-square, Kruskal Wallis, Mann Whitney U, and Nonparametric Correlate tests, and  $p < 0.05$  was accepted as significance limit.

## 3. Results

The mean age of the women participants in the study was  $39.4 \pm 9.6$  years, 73% of those were married, 41.3% of those have two children and 22.7% of those did not have children. While 60% of the participants did not have a disease diagnosed by the doctor, 16% of those have some diseases which was not questioned in the questionnaire, and 37.3% of those use the medication prescribed by the doctor. The percentage of smokers was 47.2% and 92% of those did not consume alcohol. 41.3% of the participants did not make any physical activity. The percentage of those who make physical activity daily was 4%.

When the feeding habits were examined, 54.6% of those have less than three meals a day, 45.3% consume three main meals a day and 35.7% have more than one snack a day. The rate of them who fed variuously is 25.3%, and also the consumption rate of sugary products such as chocolate, wafers and starchy foods, pastry is 29.4%. It was found that 54.7% of the participants skipped meals, and it was lunch with a rate of 53.3%. While the reason for skipping the meal was insufficient time, 25.3%, the rate of those skipping meals to lose weight was 6.7%. Water consumption average was  $1453 \pm 677$  ml. The average daily energy intake of the participants was  $1125 \pm 311$  kcal and the percentage of daily energy from carbohydrate, protein and fat were  $47 \pm 8.7\%$ ,  $15 \pm 3\%$  and  $37.8 \pm 6.4\%$ , respectively. In terms of milk and milk products consumption, fat cheese was highly consumed (53.3%). The rate of those who did not consume any kefir was 74.7%. The consumption of red meat was 29.3% and the rate of those consuming eggs every day was 37.3%. The rate of those who did not consume any fish was 4.0%. The most commonly consumed nutrient was lentil in the legume group (45.6%). 52% of the participants did not consume cowpea. The rate of those who consume oilseed every day was 30.6%, and according to the 1-2 days per week frequency, the most consumed nutrition was nutmeat (28%). The rate of those who did not consume any pine nut was 40%. 64% of the participants consume bread every day, and 26.6% of the participants consume bread each meal, and the most commonly consumed kind of the bread was white bread with the rate of 49.3%. The rate of those who did not con-

sume any rye bread was 58.7%. Macaroni which was in grain group was the most consumed food according to once a week consumption frequency (38.7%). In the vegetable group, lycopene-rich tomatoes were the most consumed food every day (52%). In terms of the green leafy vegetables, according to 1-2 days per week consumption frequency, the spinach was the most consumed vegetable with 48% and 66.7% of the participants did not consume any artichoke. The most consumed fruit was watermelon with 52.2% and cherry with 41.4%, but 57.3% of participants did not consume any black mulberry. The rate of those consuming the lemon every day is 60%. According to 1-2 times a week consumption frequency, the most consumed fruit was banana (37%). When the fat consumption rate of participants was taken into consideration, olive oil was the most consumed with rate 72% every day. In terms of saturated fats, butter was the most consumed fat with 32%. The percentage of those who did not consume soya bean and corn oil was 98.7% and 85.3%, respectively. The percentage of those who did not consume any margarine from saturated fat was 60%. From the sugar group, the most commonly consumed foods were honey with 48% and refined sugar with 45.3%.

As seen from the Table 1, the average BMI of the participants in the evaluation of anthropometric measurement was  $28.7 \pm 6.1$  kg/m<sup>2</sup>. According to the BMI evaluations of the participants, 32% was in the normal class, 28% was in the mildly fat class, 25.3% was in the I. Degree obese class, 9.3% was in the II. Degree obese class, and 5.3% was in the morbid obesity class.

While the waist / hip rate of participants was evaluated, the mean waist / hip rate was  $0.80 \pm 0.07$  cm. It was seen that 57 participants (<0.85cm) were in the risk-free range and 18 participants (>0.85 cm) were in the risk-free range. Phase angle values were minimum 4.50, maximum 8.40 and average was  $5.90 \pm 0.81$ . The average values of body components were as in Table 1. Therefore; the average amount of muscle was  $23.8 \pm 3.5$  kg, the amount of fat was  $28.2 \pm 10.9$  kg and the total amount of body water was  $34.0 \pm 4.1$  kg.

The contribution rates of macro and micronutrients to daily energy taken by the individuals participating in the study was shown in Table 2. Therefore; the average of daily energy taken by participants was  $1125 \pm 311$  kcal. On average,  $47.05 \pm 8.7$  % of the amount of energy daily received was from carbohydrate,  $15.0 \pm 3.0$  % from protein and  $37.8 \pm 6.4$  % from fat.

When the relationship among age groups, BMI groups, physical activity status, disease status and phase angle values of the participants were examined, ac-

**Table 2.** The contribution rates of macro and micronutrients to daily energy taken by participants

	Minimum	Maximum	Mean, Standard Deviation
Energy(kcal)	667	2718	1125±311
Carbohydrate (%)	11.8	66.2	47.05±8.7
Protein (%)	5.8	26.2	15.0±3.0
Fat (%)	21.1	61.9	37.8±6.4

**Table 1.** Evaluation of participants' anthropometric measurements

Anthropometric Measurements	Minimum	Maximum	Mean	Standard Deviation
Height (cm)	144	180	161.1	6.8
Weight (kg)	45.6	116.4	74.8	15.7
BMI (kg/m <sup>2</sup> )	18.3	47.3	28.7	6.1
Waist/Hip (cm)	0.6	1.0	0.8	0.07
Phase angle (°)	4.5	8.4	5.9	0.8
Body Muscle Amount (kg)	16.9	36.3	23.8	3.5
Amount of body fat (kg)	6.0	60.1	28.2	1.,9
Total body water (kg)	25.8	49.7	34.0	4.1

**Table 3.** The relationship between age, anthropometric measurements, body components, taken nutritional ingredient percentages with phase angle of the participants

Variables	p
Age (year)	0.913
BMI (kg/ m <sup>2</sup> )	0.040
Waist/Hip Ratio (cm)	0.951
Body Muscle Amount (%)	0.000
Amount of body fat (kg)	0.29
Total body water (kg)	0.165
Carbohydrate Percentage (%)	0.248
Protein Percentage (%)	0,58
Fat Percentage (%)	0,413

*Nonparametric Correlate Test*

cording to the results of this evaluation; the difference between the age groups, BMI groups, physical activity status, disease status and phase angle values of the participants were not statistically significant ( $p=0.244$ ,  $p=0.117$ ,  $p=0.18$ ,  $p=0.842$ ), respectively ( $p>0.05$ ).

In the analysis of the relationship between drug, vitamin support, alcohol, smoking and phase angle of the participants, the difference between the drug, vitamin support, alcohol and smoking status and phase angle values of the participants, respectively, ( $p=0.759$ ,  $p=0.583$ ,  $p=0.358$ ,  $p=0.111$ ) are not statistically significant ( $p>0.05$ ).

The analysis results of the relationship between age, anthropometric measurements, body components, taken nutritional ingredient percentages and phase angle of the participants are in Table 3. It is seen (Table 3) that there is a statistically, weakly positive correlation between body mass index and phase angle values of the participants ( $p<0.05$ ). When the relationship between the body muscle amount and phase angle values of women is examined, it is seen a moderate positive correlation ( $p<0.05$ ). There isn't a correlation statistically between the participant's age, waist / hip rate, amount of body fat, amount of body water, taken energy's protein, fat, carbohydrate contribution rates and phase angle values ( $p>0.05$ ).

## 4. Discussion

In this study, it was determined that 54.6% of women had fewer main meals than three meals, 45% of those had three main meals, and 35.7% of those had more than one meal. It was determined that 54.7% of the participants skip meals, 28% of those skip meals sometimes and the most skipped meal was lunch (53.3%). When the food consumed by the participants in snacks was questioned, it was seen that the most consumed nutrition was the fresh fruit (18.7%). The rate of participants fed complexly in snacks was 25.3% and the consumption rate of pastry with high carbohydrate content and sweets such as chocolate, wafer was 29.4%. For adequate and balanced nutrition, to maintain meal order was the most important point (10). In the study conducted on women living in Ankara, by Yardimci and Özçelik (11), 63.4% of women generally had three main meals, 35.5% of those had two main meals and, 1.1% of those eat a main meal. When skipping meal statue was examined, it was seen that 36.8% of those skip the meal, 34.2% of those sometimes skip the meal and 29% of those did not skip any meal. It was determined that 71% of the women who skipped the meal sometimes and always skip breakfast, 28.4% of those skip lunch and 4.9% of those skip the evening meal. In the study conducted by Koruk and ahin (12), obesity prevalence and risk factors of housewives who were 15-49 years of age had been examined and individual's the average number of meals had been determined as  $2.7\pm 0.6$ . While women who had 4 and over meal were 3.5% women who skip meal was 49%, and women who had snack were 67.6%. According to Turkey Dietary Guidelines published on 2015 (13) recommendations, at least three meals should be fed daily by providing food diversity. For healthy nutrition, the choice of foods to be consumed at the meal should be taken into consideration as well as not to skip the main meals.

Fluid consumption and balance are crucial for a healthy life. When it is taken in consideration that water is crucial for the body and the amount of fluid being discharged from the body should be approximately 2.5 L. It was seen that the water consumption of the women participating in our research was insufficient. In the study conducted by Ercim et al. (14), status of

fluid intake of adults had been examined, and it was determined that individuals consume an average of 1980 ml. water.

When the consumption of milk products which is the main source of calcium which is an important source of bone health for women, was examined, the frequency of daily consuming is 53.3% and fat cheese (including 45% fat) was consumed. It is suggested that the widespread production of fat cheese in the region may had been influence on having a general consumption habit. In parallel with this study, according to the report of the study conducted in order to determine the consumption of milk and milk products and having breakfast habits of the participants in Turkey; participants' cheese consumption was more than milk and yoghurt consumption, and this rate was 89.9% at women 88.1% at men and totally 89.3% in Turkey Dietary Guidelines published on 2015 (13).

Meat consumption was 29.3% and rate of individuals consuming egg every day was 37.3%. The rate of those who do not consume any fish was 4%. The egg consumption which was described as "sample quality protein" was not very lower than the expected level. In our study, it had been found that daily consumption of red meat was very low (1.3%). The rate of those who did not consume any red meat was 17.3%. Chicken was mostly preferred to beef. The reason was that may be due to low income levels. In another study conducted by Yurtseven et al. (15), in order to determine the dietary habits of the working individuals, according to the frequency of consumption once or twice a week; it was pointed out that chicken/turkey with rate 45.4%, red meat with rate 43.1% and fish with rate 27.7% have been preferred.

When frequency of legume consumption was examined, it was seen that although lentil was consumed frequently, consumption of pea was low. The reason for this may be a general habit. According to the results of Turkey Nutrition and Health Survey (TNHS) conducted on 2010 (16), it was determined that 42.9% women consume legume once or twice in a week. In our study, it was detected that 30.6% of participants consume oilseed every day and by depending upon the frequency of consumption once or twice a week, individuals consume walnuts at most (28%), 40% of individuals did not consume any pine nut. In this study, the

percentage of those who consumed oil seed daily was found to be higher (30.6%). According to the results of TNHS (16) when participants frequency of oilseeds consumption (such as; nut, walnut) was examined, it was seen that 24.4% of those consumed once or twice a week, and 23.4% of those did not consume at all. In a study carried out by Onay Derin et al. (17), examined the nutritional status of similar public employees in Konya, the rate of those consuming oil seeds (such as; hazelnuts, almonds) every day was determined 18%. The rate of those who did not consume oilseeds was stated as 3.4%.

According to our study, the daily bread consumption rate was 64% and most commonly consumed bread was white bread. The rate of those who did not consume any rye bread was 58.7%. Macaroni which is grain group is the most consumed food with 38.7% rate, on condition of consuming frequency once or twice a week. With respect to these results, we can say that individuals prefer the bread from the daily grain group more than the other grain products.

Participants consuming tomato with 52% rate, consume the most spinach among green leafy vegetables with 48% rate. In the study, the rate of those who do not consume any artichoke is 66.7%. İnce (18), in a similar study, determined that 76.9% of women consumed fresh vegetables every day. In a study conducted by Nazif (19), on adult fat women, participants reported that their daily vegetable consumption was 70.3% and daily fruit consumption was 89.2%. Similarly, in our study, 49.5% red fruit and 44% citrus fruit are consumed, and in total, fruit is consumed, with at least 89.5% rate every day.

According to adequate and balanced nutrition rules, it is important that the participants firstly choice olive oil at oil consumption. 60% of participants do not consume margarine. This result can be interpreted as the initiation of awareness for healthy nutrition in the society. According to the Turkey Dietary Guidelines published on 2015 (13) report consumption frequency was stated that the rate of those consuming sunflower oil was 67.4% daily, the rate of those consuming olive oil was 35.3% and the rate of those consuming corn oil is 11.7%. In our study, participants consume olive oil and butter in higher rate compared to overall Turkey. In a study conducted by Onay Derin et al. (17),

the daily butter consumption rate of individuals was reported as 22%.

When the consumption of sugar group was examined, it is determined that 48% of the participants consumed honey and 45.3% of the participants often consumed basic carbohydrates such as; refined sugar. The rate of those who did not consume any sugar was determined as 24%. In a similar study, it was reported that sugar rate consumed by women every day is 53% (18). In the study examining feeding habits of white-collar workers, Yurtseven et al. (15), showed that the rate of individuals consuming honey and molasses every day is 23.8% and the rate of individuals consuming sugars is 35.4% and the rate of individuals who did not consume any sugar is 18.5%.

When the energy intake and macro nutrient consumption's contribution rate to energy, reported by the participants were analysed in Table 2, it was seen that the average energy intake was low for these age groups ( $1125 \pm 311$  kcal) however, it was seen that the rate from fat was high ( $37,8 \pm 6.4\%$ ). Likewise, the contribution of protein was at the upper limit ( $15 \pm 3\%$ ). In parallel with these findings, in the study examining the nutritional habits and nutritional patterns of participants of the Turkish Adult Risk Factor Survey in 2003-2004 (20), it was said that the results changed, compared to the previous years. While 53.3% of the daily energy was obtained from carbohydrates, 13.7% from protein and 33% from fat, it was referred that by decreasing the carbohydrate share of the energy 9%, and protein, total fat, nonvisible fat percentages increased 2%, 8%, and 14% respectively. The carbohydrate share of the energy taken in this study was found to be below the recommended value as  $47 \pm 8.7\%$ .

Regular physical activity reduces the risk of diseases such as; high blood pressure, diabetes, breast and colon cancer and depression (21). In our study, the rate's highness of the participants who did not have physical activity may be related to the lack of physical activity in the cultural habits of the study area. In the study conducted by Koruk and ahin (12), it was found that 66.4% of women did not do exercise or sport at all. According to the reports of Turkey Nutrition Health Survey (16), it was determined that 45.3% of individuals living in urban areas, 41.2% of individuals living in rural areas maintain sedentary life (low activity).

According to the anthropometric values, 68% of the individuals who participated in the study were above the normal BMI (Body Mass Index) and 39.9% of those were obese. One of the underlying reasons for the high rate of obesity is the wrong feeding habits and the other may be sedentary lifestyle. It is known that the prevalence of overweight and obesity is increasing all over the world. According to World Health Organization (WHO) data, there are over 400 million obese and 1.6 billion overweight individuals in the world. It is believed that this ratio will reach 700 million and 2.3 billion in 2015 (22). In the obesity prevalence study conducted by Zileli (23), in Bilecik City with 79 volunteer female participants between the ages of 18-54, the mean BMI of the participants was  $31,6 \pm 6,1$  kg/m<sup>2</sup> and in 62% of the women according to BMI, obesity was found in the same study. The ratio was found to be  $0.86 \pm 0.04$  cm.

The mean phase angle values of the participants were  $5.9 \pm 0,8^\circ$ , the minimum value is  $4,5^\circ$  and the maximum value was found to be  $8,4^\circ$  (Table 1). The high values of the phase angle are considered as better cellular membrane integrity and an indicator of better cell function. Generally, for healthy individuals, this range is between  $5^\circ$  and  $7^\circ$ , but it is stated that it may be  $9.5^\circ$  for athletic individuals (8). In our study, the results were parallel and suitable for standards too. However; phase angle values of merely 4 participants were found to be below  $5^\circ$ . When the findings of individuals were examined, it was seen that there was no disease diagnose, but it was seen that the body muscle masses were in lower limits. In another study, carried out by De Luis et al. (24), it was stated that low phase angle may be a new way of categorizing the cardiovascular risk factor.

There was no statistically significant relationship between age groups, BMI groups, physical activity status and disease status of the participants, and phase angles ( $p > 0.05$ ). In research of Bosy-Westphal et al. (5), with 15.605 children, adolescents and 214.732 adults, according to age, gender and body mass index, in the population reference values study, it was reported that gender and age would be the main determinants of the phase angle in adults. In another study carried out by Kumar et al. (25), in India between the ages of 18-50, the women's phase angle values are determined as  $7.05 \pm 1.1^\circ$ .

According to our study, there was no statistically significant difference between the phase angle values of the participants and drug, vitamin support, use of alcohol ( $p>0.05$ ).

As shown in Table 3 when the relationship were analysed between participants' age, anthropometric values, body components and the phase angle values of the macro nutrients contributing to the energy they received, a weak correlation is found between the BMI values and the phase angle ( $p<0.05$ ). In the study by Barbosa- Silva et al. (26), it was determined that there was a positive correlation between BMI values and phase angle, and there was a negative correlation between BMI values and body fat index. In a similar study, by Bosity-Westphal et al. (5), it was found that in normal weight and overweight adults, the phase angle increased as BMI increased, but when there is BMI $>40$  kg/m<sup>2</sup>, there was an inverse relationship between BMI and phase angle. In parallel with these results, Kumar et al. (25) showed a statistically significant positive correlation between BMI values and phase angles of individuals.

The percentage of lean cell mass is an important indicator of the anabolic or catabolic process. The high values of the phase angle are a very useful parameter showing high values of the BCM and good nutritional status (27). In the study, by De França et al. (28), conducted with 493 people who were over 18 years of age in Brazil (97 males and 396 females), it showed that the participants with phase angle of 6.3° or less were older, lower body mass index, waist circumference, muscle mass index, energy intake and lower HEI (Healthy Eating Index) score. As a result, it was found that patients with high muscle mass index and higher HEI scores had lower phase angle ratios.

Moreover; it is reported that the phase angle is a superior prognostic indicator and may be a screening for the identification of patients with impaired nutritional functional status (8). Similarly, in a study of people with cirrhosis, Fernandes et al. (29), reported that it can be considered as a superior nutritional indicator than its tools and anthropometric methods in assessing any used nutritional status of Phase Angle (PhA). There are significant differences between phase angle reference values from different populations. These differences cannot be explained by age or BMI, and may

depend on differences between impedance analysers. The prognostic value of the phase angle may differ in different clinical situations. It is recommended that the reference values common to the public and possibly the impedance analyser are used for the phase angle (5).

## 5. Conclusions

In this study, phase angle measurements and nutrient consumption of women between the ages of 20 and 65 were evaluated by bioelectrical impedance method. No statistically significant difference was found between age groups, BMI groups, physical activity status, disease status and phase angle values ( $p>0.05$ ). Statistically weakly positive correlation was found between body mass index and phase angle values ( $p<0.05$ ). Statistically moderate positive correlation was found between body muscle and phase angle values ( $p<0.05$ ). In addition, as mentioned in many sources, the phase angle can be an indicator of the integrity and functional adequacy of the cells, especially in diseases with catabolism effect. At the same time, it is recommended to emphasize the phase angle parameter, which can be a good indicator of nutritional status, in applications. For this purpose, it is necessary to determine the phase angle reference intervals in healthy and sick individuals belonging to the Turkish population, which is performed with a large number of participants. For this, standard model BIA devices require adequate measurements by personnel with adequate equipment. It is recommended to evaluate the prognostic status and nutritional status of the population with specific reference-specific and analytical reference ranges.

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