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Dietary total antioxidant capacity, cardiovascular risk, and anthropometric obesity indices in hemodialysis patients: A case-control study

Capacidade antioxidante total da dieta, risco cardiovascular e índices antropométricos de obesidade em pacientes em hemodiálise: um estudo de caso-controle

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ABSTRACT

Objective

Oxidative stress is triggered by malnutrition and antioxidant losses due to dialysis in hemodialysis patients and thus, oxidative stress increases the risk of mortality in patients with cardiovascular disease and obesity. The study aims to determine differences in cardiovascular risk scores and obesity indices between hemodialysis and control groups and to examine the relationship between the tertiles of dietary total antioxidant capacity with cardiovascular risk, and obesity in hemodialysis and control groups.

Methods

This is a cross-sectional case-control study involving hemodialysis patients (n=46) and healthy individuals (n=46). Participants' general characteristics were obtained via a questionnaire, and the Framingham Risk Score was calculated. The dietary total antioxidant capacity was calculated using two methods based on a seven-day food record. Obesity indices, such as Basal Metabolism Index and Body Shape Index, were calculated using anthropometric measurements.

Results

The mean age of the participants was 51.1±10.4 years. In the hemodialysis group, obesity indices including body weight, Basal Metabolism Index, waist circumference, fat mass index, and fat-free mass index were lower, while Framingham Risk Score values were higher than the control group (p<0.05). Energy-adjusted dietary total antioksidant capacity values were lower in hemodialysis group, and most patients were in the low tertiles of Trolox equivalent antioxidant capacity, total radical-trapping antioxidant parameter, ferric reducing-antioxidant power and vitamin C equivalent antioxidant capacity (p<0.05).

Conclusion

Providing hemodialysis patients with a healthy diet can increase the dietary total antioxidant capacity, and potentially reduce cardiovascular risk, and obesity indices.

Keywords: Anthropometry. Antioxidant. Cardiovascular risk. Hemodialysis. Patients.

RESUMO

Objetivo

O estresse oxidativo é desencadeado pela desnutrição e perdas de antioxidantes devido à diálise em pacientes em hemodiálise, portanto, o estresse oxidativo aumenta o risco de mortalidade em pacientes com doenças cardiovasculares e obesidade. O estudo visa determinar as diferenças nos escores de risco cardiovascular e índices de obesidade entre os grupos de hemodiálise e controle, bem como examinar a relação entre os tercis da capacidade antioxidante total da dieta e o risco cardiovascular e obesidade nos grupos de hemodiálise e controle.

Métodos

Este é um estudo transversal de caso-controle envolvendo pacientes em hemodiálise (n=46) e indivíduos saudáveis (n=46). As características gerais dos participantes foram obtidas por meio de um questionário, e o Escore de Risco de Framingham foi calculado. A capacidade antioxidante total da dieta foi calculada utilizando dois métodos baseados em um registro alimentar de sete dias. Índices de obesidade como o Índice de Metabolismo Basal e o Índice de Forma Corporal, foram calculados por meio de medidas antropométricas.

Resultados

A média de idade dos participantes foi de 51.1±10.4 anos. No grupo de hemodiálise, os índices de obesidade, incluindo peso corporal, Índice de Metabolismo Basal, circunferência da cintura, índice de massa gorda e índice de massa livre de gordura, foram menores, enquanto os valores do Escore de Risco de Framingham foram maiores do que no grupo controle (p<0.05). Os valores de dTAC ajustados pela energia foram menores no grupo de foram hemodiálise, e a maioria dos pacientes estava nos tercis mais baixos de Capacidade antioxidante equivalente ao Trolox, parâmetro antioxidante total de captura de radicais, poder antioxidante redutor férrico e capacidade antioxidante equivalente à vitamina C (p <0.05).

Conclusão

Fornecer aos pacientes em hemodiálise uma dieta saudável pode aumentar a capacidade antioxidante total da dieta, reduzindo potencialmente o risco cardiovascular e os índices de obesidade.

Palavras-chave**:** *Antropometria. Antioxidante. Risco cardiovascular. Hemodiálise. Pacientes.*

INTRODUCTION

Oxidative stress, characterized by an imbalance between antioxidants and oxidants, plays a crucial role in the pathogenesis of chronic renal failure, as well as other diseases like obesity, diabetes, and cardiovascular diseases [1]. Hemodialysis (HD) patients come upon with oxidative stress processes of renal failure and hemodialysis [2]. Factors such as antioxidant loss during renal replacement therapy, turnover of antioxidants, inadequate antioxidant intake with diet, and high toxin levels contribute to increased oxidative stress in these patients [3]. To maintain the oxidants-antioxidants balance, the endogenous antioxidant defense system must be supported with exogenous antioxidants such as vitamin C, vitamin E, carotenoids, and polyphenols, and the main way of exogenous antioxidant intake is through the diet. Increasing the antioxidant capacity of foods can prevent the overdose risk caused by antioxidant supplements [4].

The dietary total antioxidant capacity (dTAC) is an indicator of diet quality used to estimate the cumulative power of antioxidants in the whole diet [5]. Studies also show a significant relationship between dTAC and the plasma total antioxidant capacity [6,7]. In addition to the negative effect of oxidative stress in hemodialysis patients, inadequate intake of nutrients and antioxidants and antioxidant losses with the dialysis showed the importance of dTAC parameter in these patients. Since the leading cause of death of hemodialysis patients is cardiovascular diseases [8] and obesity is one of the factors that increase the mortality and morbidity of cardiovascular diseases [9], and also oxidative stress is involved in the pathogenesis of the two diseases, that is why cardiovascular risk score and some obesity indices of hemodialysis patients keep the interests. Studies regarding the total antioxidant capacity of the diet in hemodialysis patients are limited in number. Malnutrition due to loss of appetite caused by the disease and nutrient losses resulting from dialysis have underscored the significance of nutritional research for hemodialysis patients. Furthermore, the elevated mortality rate from cardiovascular diseases and the high prevalence of obesity in hemodialysis patients have highlighted the importance of investigating the potential relationship between diet's antioxidant capacity and these factors, prompting the design of such a study. The study aims to determine whether there is any difference in cardiovascular risk scores and obesity indices between hemodialysis and control groups and to examine the differences between the tertiles of dietary total antioxidant capacity with cardiovascular risk and obesity in hemodialysis and control groups.

METHODS

This cross-sectional study was conducted in 92 subjects, including 46 cases in each group (hemodialysis patients and healthy subjects). The data of the study were collected from two hemodialysis units in Bingöl province of Turkey, in 2016. The sample size for the study has been determined to require a minimum of 37 individuals in each group with an 80% power and a 5% margin of error. Considering the possibility of data loss due to reasons such as patients leaving the study, undergoing kidney transplantation, and mortality, a total of 46 patients were recruited. After forming the patient group, a control group comprised healthy individuals aged 19 to 64 who had visited the hospital for check-ups. The control group was matched with the patient group regarding age and gender.

The inclusion criteria for patients in the hemodialysis group include receiving hemodialysis for at least 6 months, having a stable clinical condition, undergoing dialysis at least 2 days a week, and not meeting the exclusion criteria outlined below. As for individuals in the control group, the inclusion criteria involve having no existing illnesses, not meeting the exclusion criteria, and being willing to participate in the study. Exclusion criteria for the hemodialysis group were medically diagnosed diabetes, cancer, stroke, liver disease, active hepatitis, HIV (+), cardiac disease, endocrine disease such as hypo- or hyperthyroidism, neurological or psychiatric disease, alcohol consumers, smokers, pregnant or lactated women, taking medications such as aspirin, beta-blockers, etc., those who are scheduled for transplantation and those who have recently been planted and re-dialysis, omega-3, and vitamins as supplement users. In addition to those criteria, a Glomerular filtration rate below 90 mL/min/1.73 m^2 for the control group is also an exclusion criterion. The Modification of Diet in Renal Disease equation was used to determine the glomerular filtration rate. Also, subjects in both groups, those who did not agree to participate in the study or accepted and then later gave up, were excluded from the study.

The study was conducted following the Declaration of Helsinki, and the study protocol was approved by the Hacettepe University Non-Interventional Clinical Research Ethics Board (Ref Code: GO 16/459). Informed consent was obtained from all subjects.

Dietary Intake Assessment

Participants were interviewed to take their 7-day food diary by using a photographic atlas of food portion size according to institutional standard recipes [10,11] and dietary intakes were converted to the gram, and then daily energy and nutrient intakes were determined by using BeBiS 7.2 software. Dietary intakes were used to calculate dTAC. Dietary total antioxidant capacity values were calculated according to the grams of the foods consumed by the individuals in proportion to the antioxidant compounds in 100 grams.

This study used two different methods of calculating dTAC. First, the formula created for the theoretical dTAC calculation using the values of the National Food Composition Databases [12] determined by the United States Department of Agriculture for each nutrient (Theoretical dTAC = ∑ (Antioxidant Content (mg / 100 g)) * Antioxidant Capacity (mg VCE / 100 g)) was used [13]. After determining the individual antioxidant content, each food's total amount of antioxidants taken in one day was calculated. The averages of the seven-day dTAC values were expressed in Vitamin C equivalent mg/day (VCE mg/day). Second, due to the lack of a national antioxidant database of foods consumed across our country, the dTAC database was derived from databases of international studies for 100 grams of foods. Oxygen Radical Absorbance Capacity (ORAC) [14-17], Trolox Equivalent Antioxidant Capacity (TEAC), Total Radical-trapping Antioxidant Parameters (TRAP) [18, 19], and the Ferric-reducing Ability of Plasma (FRAP) [20] methods were used to determine the total antioxidant capacity of foods. The antioxidant contents of similar foods were used for foods not included in any of the relevant databases.

Sociodemographic and Anthropometric Measurements

General characteristics, including age, educational level, marital and economic status were obtained via the questionnaire. Also, some anthropometric measurements and indices are used to assesses obesity for participants. The indices used in the study are given below.

Body Mass Index (BMI) – Height (Ht) was measured using a wall-mounted stadiometer with a precision of 0.5 cm and the measurement was made with the feet side by side and the head on the Frankfort plane (the eye triangle and the upper auricle are at the same level). Bodyweight, in the hemodialysis group dry weight after dialysis, was measured with a portable digital scale (F. Bosch FB-721) sensitive to 0.1 kg with light clothing and without shoes. BMI is the weight to the square of height ratio in the unit of kg/m^2.

A Body Shape Index (ABSI) – While BMI shows general adiposity, ABSI shows abdominal adiposity as in waist circumference and waist-to-hip ratio [21]. The formula (WC*BMI−2/3*Ht1/2) was used to calculate ABSI in a unit of $m^{11/6}$ $kg^{-2/3}$ [22].

Waist and Hip Circumference (WC) – Waist circumference (WC) was assessed with a 0.5 cm precision-flexible tape at the midpoint between the lowest rib and the iliac crest. Hip circumference was measured at the level of the greatest protrusion of the buttocks when the subject was standing upright with the feet together.

Waist-to-Hip Ratio (WHR) – The waist-hip ratio of the individuals was calculated by proportioning circumferences of the waist to the hip.

Waist-to-Height Ratio (WHtR) – It was developed by Ashwell and Hsieh [23] and it can be used for all age groups. The waist-to-height ratio was calculated by proportioning the waist circumference (cm) to the height (cm).

Fat Mass Index (FMI) – The measurements of the patients were made by the Bioelectrical Impedance Analysis device (Omron BF 306 Body Fat Monitor) after dialysis, under the measurement criteria [24]. After determining the body fat percentage (%), body fat weight (kg), and lean tissue weight (kg) over body weight were determined. Fat Mass Index (FMI) was used in to evaluate body fat ratio, and it was calculated by the ratio of fat tissue mass to the square of the neck in the unit of kg/m^2 [25].

Fat-Free Mass Index (FFMI) – There are differences in body composition among individuals. Therefore, a FFMI was used to examine lean tissue mass. The FFMI was calculated similarly to BMI, but by the ratio of body lean tissue mass (kg) to the square of the height (m^2) [25].

Mean arterial pressure (MAP) – Individuals' blood pressure was measured with an oscillometric method. Participants were seated and allowed to rest in a sitting position for at least 5 minutes at the hospital. Subsequently, their arm was positioned for blood pressure measurement, and an oscillometric method was employed using a blood pressure monitor (Omron M6 Comfort BP Monitor). At least two measurements were taken with a one-minute interval between them. For diastolic blood pressure (DBP) and systolic blood pressure (SBP), <130 and <85 mmHg; 130-139 and 85-89 mmHg; and >140 and >90 mmHg were considered as normal, high-normal, and high, respectively. Mean arterial pressure (MAP) was calculated by the formula (MAP = [(1/3 * SBP) + (2/3 * DBP)]) over systolic and diastolic blood pressure [26,27].

Cardiovascular Risk Determination- Framingham Risk Score – The "Framingham Coronary Heart Disease Risk Calculation System", that is the "Framingham Risk Score (FRS)" [28] was used to determine the cardiovascular risk of the participants. From the obtained data, the risk of death of individuals due to myocardial infarction or coronary artery disease within 10 years is calculated [29]. In this study, BMI and serum lipid levels were used in the calculation of FRS. The necessary information for the calculation of FRS was obtained from the participants during the interview, and after all the findings were collected, they were analyzed.

The IBM®SPSS® software version 22 (Inc, Chicago, IL) was applied to carry out all analyses [30]. Parameters were checked for normality by the Kolmogorov-Smirnov test, and data were reported as mean± standard deviation and median (interquartile range) for normal and non-normal distribution, respectively. Dietary TAC was adjusted for energy intake through the nutrient density method [31] and separated tertiles. Categorical and continuous variables were summarized with n (%) and mean (standard deviation), respectively. The Chi-square test was used to compare categorical variables such as marital, economic status, and dTAC tertiles. Determining the difference between hemodialysis and control groups was made by the Mann-Whitney U test for continuous variables such as energy and nutrient intakes, energy-adjusted dTAC values, FRS, and obesity indices [32,33]. A significance level of 5% was adopted for all tests.

RESULTS

The mean age of the participants and the rate of women in the groups are 51.1±10.4 years and 58.7%, respectively. As can be seen from the anthropometric measurements in Table 1, significant differences were found for WC and FFMI in men and for ABSI and WHR in women ($p<0.05$). Bodyweight, BMI, WC, FMI, and FFMI values of the hemodialysis group were lower than those of the control group ($p<0.05$). FRS-lipid and FRS-BMI values, which are cardiovascular risk scores, were found to be higher in the hemodialysis group ($p<0.05$).

Table 1 – Sociodemographic profiles, some anthropometric obesity indices and cardiovascular risk scores of subjects.

Characteristics	Hemodialysis (n=46)	Control (n=46)	*p*-value
Sociodemographic factors			
Age (years)	51.1±11.9	51.0±8.8	1.000
Women, n (%)	27 (58.7)	27 (58.7)	1.000
Education, (years)	4.5±4.9	10.5±5.5	**0.001**
Age range of men (n (%))			
19-30	2 (10.6)	1 (5.3)	0.827
31-50	7 (36.8)	7 (36.8)	
51-64	10 (52.6)	11 (57.9)	
Marital status (n (%))			
Married	32 (69.6)	40 (87.0)	0.076
Single/ divorced	14 (30.4)	6 (13.0)	
Economic status (n (%))			
High	9 (19.6)	36 (78.3)	**0.001**
Average/ Low	37 (80.4)	10 (21.7)	
Anthropometric obesity indices (M±SD)			
Weight (kg)	66.6±11.8	81.5±9.9	**0.001**
Male	66.9±11.4	84.7±9.7	**0.001**
Female	66.3±12.3	79.2±9.5	0.550
Height (cm)	161.0±10.5	164.5±10.0	0.063
Male	170.4±9.2	174.5±5.6	0.191
Female	154.4±4.6	157.6±5.4	**0.033**
Body Mass Index (kg/m^2)	25.9±5.2	30.2±4.5	**0.001**
Male	23.1±4.0	27.7±3.3	**0.001**
Female	27.8±5.1	32.0±4.44	**0.001**
Waist Circumference (cm)	93.8±14.2	96.7±13.4	0.453
Male	89.0±13.1	97.1±7.9	**0.040**
Female	97.2±14.1	96.5±16.4	0.550
A Body Shape Index	0.085±0.01	0.078±0.01	**0.001**
Male	0.084±0.01	0.080±0.003	0.070
Female	0.085±0.01	0.076±0.01	**0.001**
Waist-to-Hip Ratio	0.94±0.09	0.89±0.12	**0.003**
Male	0.91±0.1	0.93±0.1	0.840
Female	0.95±0.1	0.86±1.1	**0.001**
Waist-to-Height Ratio	0.59±.010	0.59±0.09	0.861
Male	0.52±0.1	0.56±0.1	0.212
Female	0.63±0.1	0.61±0.1	0.330
FMI (kg/m^2)	7.88±4.11	11.34±3.85	**0.001**
Male	4.8±2.5	8.1±2.2	**0.001**
Female	10.0±3.6	13.6±3.0	**0.001**
Fat Mass Index (kg/m^2)	17.99±2.88	18.95±1.82	**0.008**
Male	18.3±3.0	19.8±1.8	**0.032**
Female	17.8±2.9	18.4±1.6	0.060
Systolic Blood Pressure (mmHg)	125.8±12.9	128.4±15.3	0.559
Pre-dialysis SBP	130.2±16.1	–	–
Post- dialysis SBP	121.3±14.2	–	–
Diastolic Blood Pressure (mmHg)	77.6±8.5	76.5±11.4	0.242
Pre-dialysis DBP	80.7±9.8	–	–
Post- dialysis DBP	74.6±9.6	–	–
Mean Arterial Pressure (mmHg)	109.7±11.0	111.1±13.0	0.809
Pre-dialysis MAP	113.7±13.4	–	–
Post- dialysis MAP	105.7±12.1	–	–
Cardiovascular Risk Scores (M±SD)			
Framingham Risk Score - Lipid	9.4±6.4	6.4±4.1	**0.020**
Male	12.2±8.0	7.4±4.3	0.065
Female	7.5±4.3	5.6±4.0	0.100
Framingham Risk Score- Body Mass Index	11.6±7.6	6.6±4.6	**0.001**
Male	15.2±8.8	7.9±4.9	**0.010**
Female	9.1±5.5	5.7±4.3	**0.040**

Note: Calculated using Mann Whitney U test for non-parametric distribution. Significance (p<0.05) is given in bold.

The energy, nutrient intake, and energy-adjusted dTAC values of subjects in the HD group were examined in Table 2. As can be seen from Table 2, it was found that the energy intake, and the percentages of energy from fat, potassium, magnesium, and zinc intake levels were low ($p<0.05$), and the ratio of energy from protein was high ($p<0.05$). Energy-adjusted TEAC, TRAP, and VCEAC values were found to be lower in the hemodialysis group ($p<0.05$).

The distribution of dTAC tertiles was examined in Table 3. It was observed that HD patients were mostly in lower tertiles of TEAC, TRAP, FRAP, and VCEAC compared to the control group ($p<0.05$).

In Table 4, cardiovascular risk scores and standard deviation values of some anthropometric obesity indices in terms of energy-adjusted dTAC tertiles of the participants were given. Hence, FRS values in high tertiles of ORAC, TRAP, FRAP, and VCEAC were higher in the HD group, BMI, FMI, and FFMI values were lower and ABSI values were higher in all tertiles in the HD group ($p<0.05$). While there was no significant difference in WC and WHtR values, WHR values in ORAC, TRAP, FRAP, and VCEAC high tertiles were higher ($p<0.05$).

DISCUSSION

It has been shown that the prevalence of patients with end-stage renal disease who received renal replacement therapy has been in a steady increasing trend over the years and the increase continues despite the decrease in the rate in recent years. Hemodialysis treatment is the most preferred method in Turkey, and the prevalence of patients receiving hemodialysis as renal replacement therapy was 73.2% [34]. Cardiovascular diseases are the main cause of death for hemodialysis patients [35-37]. Besides, obesity and oxidative stress increase the mortality and morbidity of these cardiovascular diseases, and that is why nutrition is a crucial factor for hemodialysis patients. The patients need to ensure a diet with adequate-balanced nutrients and sufficient antioxidants.

Table 2 – Dietary intakes and dietary total antioxidant capacity values of subjects.

Characteristics	Hemodialysis (n=46) M±SD	Control (n=46) M±SD	*p*-value
Dietary Intakes			
Total energy (kcal)	1489.5±416.4	2013.2±515.1	**0.001**
Protein (g/kg)	0.83±0.24	0.83±0.22	0.988
Protein (% energy)	15.1±1.9	13.6±1.3	**0.001**
Carbohydrate (% energy)	42.8±6.3	41.0±4.3	0.231
Total fat (% energy)	42.2±5.8	45.4±4.4	**0.008**
Dietary fiber (g/1000 kcal)	10.5±2.6	9.8±1.7	0.321
Vitamin C (mg/1000 kcal)	80.8±2.6	70.6±28.7	0.217
Vitamin E (mg/1000 kcal)	14.5±4.6	13.1±2.7	0.065
β-Carotene (μg/1000 kcal)	1.7±1.1	1.9±1.4	0.773
Potassium (mg/1000 kcal)	1153.9±232.9	1454.1±340.7	**0.001**
Magnesium (mg/1000 kcal)	119.4±22.1	145.4±34.1	**0.001**
Zinc (mg/1000 kcal)	4.8±0.7	5.7±4.9	**0.004**
Energy-adjusted dietary total antioxidant capacity			
Total Oxygen Radical Absorbans Capacity (μmol TE/1000 kcal)	8468.3±1955.6	9051.8±2059.8	0.078
Trolox Equivalent Antioxidant Capacity (mmol TE/1000 kcal)	2.18±1.7	3.12±1.3	**0.001**
Total Radical-trapping Antioxidant Parameters (mmol TE/1000 kcal)	2.18±0.8	3.65±1.9	**0.001**
Ferric Reducing Antioxidant Potential (mmol/1000 kcal)	1.49±1.6	1.64±0.7	0.561
Vitamin C Equivalent Antioxidant Capacity-Total (mg VCE/1000 kcal)	588.8±221.4	792.8±401.8	**0.004**
Carotenoids (mg VCE/1000 kcal)	1.9±0.95	2.16±1.1	0.453
Retinol (mg VCE/1000 kcal)	0.13±0.2	0.08±0.1	0.128
Ascorbic Acid (mg VCE/1000 kcal)	47.2±27.2	71.3±72.4	**0.011**
Tocopherols (mg VCE/1000 kcal)	13.9±10.6	22.1±16.6	**0.020**
Flavonoids (mg VCE/1000 kcal)	254.9±109.1	336.5±180.5	**0.014**

Note: Calculated using Mann Whitney U for non-parametric distribution. Significance ($p<0.05$) is given in bold. TE: Trolox Equivalent; VCE: Vitamin C Equivalent.

Table 3 – Distribution of participants by dietary total antioxidant capacity tertiles, n (%).

Tertiles of energy-adjusted dietary total antioxidant capacity	Hemodialysis (n=46)		Control (n=46)		*p*-value
	n	%	n	%	
Total Oxygen Radical Absorbans Capacity					
Tertile-1	19	41.3	11	23.9	
Tertile-2	15	32.6	17	37.0	0.177
Tertile-3	12	26.1	18	39.1	
Trolox Equivalent Antioxidant Capacity					
Tertile-1	22	47.8	7	15.2	
Tertile-2	21	45.7	12	26.1	**0.001**
Tertile-3	3	6.5	27	58.7	
Total Radical-trapping Antioxidant Parameters					
Tertile-1	21	45.7	9	19.6	
Tertile-2	21	45.7	10	21.7	**0.001**
Tertile-3	4	8.7	27	58.7	
Ferric Reducing Antioxidant Potential					
Tertile-1	21	45.7	9	19.6	
Tertile-2	16	34.8	16	34.8	**0.008**
Tertile-3	9	19.6	21	45.7	
Vitamin C Equivalent Antioxidant Capacity -Total					
Tertile-1	21	45.7	9	19.6	
Tertile-2	15	32.6	17	37.0	**0.016**
Tertile-3	10	21.7	20	43.5	

Note: Calculated using Chi-square test. Significance ($p<0.05$) is given in bold.

Moreover, in this study, it was found that the cardiovascular risk scores were higher, and the majority of obesity indices were lower in the HD group than in the control, but ABSI and WHR were higher in women of the HD group. It has been shown in previous studies that the risk of cardiovascular disease is high in hemodialysis patients [35-37]. Risk factors such as renal dysfunction, duration of dialysis, uremic cardiomyopathy, oxidative stress, anemia, inflammation, and malnutrition may have resulted in a high risk of cardiovascular disease in the patients [36,38]. Although most of the obesity indices were found to be low due to inadequate energy and nutrient intake in the patients, ABSI and WHR values were high in the HD group of women in this study. The reason why the values were higher might be conditions such as higher waist circumference measurements, irregular menstruation, and edema.

It has been reported that malnutrition is high in hemodialysis patients, and malnutrition accompany by oxidative stress and inflammation is associated with high mortality [39]. Also, the progression of chronic kidney disease is closely associated with systemic inflammation and oxidative stress, which are responsible for the manifestation of numerous complications such as malnutrition, atherosclerosis, coronary artery calcification, heart failure, anemia, and mineral and bone disorders, as well as enhanced cardiovascular mortality [40]. Like studies showing inadequate energy and nutrient intake and high malnutrition prevalence in hemodialysis patients [36,41], it was found that energy and some nutrient intakes were lower in the HD patients than in the control in this study. Furthermore, energy-adjusted dTAC values were observed to be low, and it was noticed that the majority of subjects in the HD group were found in lower tertiles of dTAC than healthy controls.

Table 4 – Comparison of cardiovascular risk scores and some anthropometric obesity indices in hemodialysis and healthy control group among different tertiles of dietary total antioxidant capacity (presented as mean and standard deviation).

Energy-adjusted dTAC Tertiles	Cardiovascular Risk Scores and Anthropometric Obesity İndices (x±SD)																	
	FRS-Lipid (score)		FRS-BMI (score)		BMI (kg/m2)		FMI (kg/m2)		FFMI (kg/m2)		ABSI		WC (cm)		WHR		WHtR	
ORAC	HD	Control	HD	Control	HD	Control	HD	Control	HD	Control	HD	Control	HD	Control	HD	Control	HD	Control
Tertile-1	8.2±6.4	6.7±4.7	9.9±8.0	6.4±4.7	**26.5±5.7**	**32.6±5.7**	**8.9±4.2**	**13.2±4.7**	**17.6±3.0**	**19.3±1.8**	**0.084±0.0**	**0.080±0.0**	94.2±15.3	103.5±19.7	0.93±0.1	0.93±0.2	0.59±0.1	0.65±0.1
Tertile-2	8.3±5.7	6.7±4.0	11.0±6.9	7.1±4.8	**25.5±4.5**	**28.6±4.1**	**7.3±3.7**	**10.3±3.4**	18.1±2.8	18.5±2.1	**0.084±0.0**	**0.077±0.0**	92.1±14.2	92.4±9.7	0.92±0.1	0.86±0.1	0.58±0.1	0.56±0.1
Tertile-3	**12.8±6.6**	**5.8±4.2**	**15.1±7.2**	**6.2±4.6**	**25.2±5.4**	**30.2±3.6**	**7.0±4.4**	**11.2±3.5**	18.4±3.0	19.1±1.6	**0.088±0.0**	**0.078±0.0**	95.4±13.3	96.8±10.6	**0.96±0.1**	**0.89±0.1**	0.59±0.1	0.59±0.1
TEAC																		
Tertile-1	8.4±6.2	8.5±5.7	11.1±8.3	8.2±4.8	**25.9±4.7**	**31.1±5.9**	7.7±4.2	11.7±5.0	18.3±2.9	19.5±1.6	0.084±0.0	0.084±0.0	93.9±14.5	105.8±23.5	0.94±0.1	0.96±0.2	0.58±0.1.1	0.65±0.2
Tertile-2	**10.1±5.6**	**6.7±4.3**	12.1±7.1	7.4±5.7	25.9±6.0	29.5±5.3	**8.4±4.2**	**9.7±3.9**	17.5±3.0	19.6±2.0	**0.085±0.0**	**0.079±0.0**	93.8±15.2	96.8±9.9	0.93±0.1	0.91±0.1	0.59±0.1	0.58±0.1
Tertile-3	12.2±13.5	5.7±3.5	11.3±8.3	5.8±4.1	**25.0±1.5**	**30.3±3.8**	**5.9±3.1**	**12.0±3.4**	20.0±1.8	18.5±1.7	**0.086±0.0**	**0.076±0.0**	93.8±3.3	94.3±10.7	0.96±0.1	0.86±0.1	0.58±0.1	0.58±0.1
TRAP																		
Tertile-1	8.7±6.4	8.1±5.1	11.5±8.6	8.5±4.6	**26.1±5.2**	**31.2±4.5**	**7.5±4.2**	**11.5±4.2**	18.6±3.1	19.8±1.4	0.084±0.0	0.082±0.0	94.8±14.9	105.1±20.8	0.94±0.1	0.96±0.2	0.58±0.1	0.64±0.1
Tertile-2	**9.7±5.7**	**5.8±3.5**	**11.6±7.0**	**5.5±3.9**	25.8±5.7	29.7±6.2	**8.5±4.2**	**10.7±4.5**	17.3±2.8	18.8±1.8	**0.085±0.0**	**0.079±0.0**	92.5±15.0	95.8±9.3	0.92±0.1	0.90±0.1	0.59±0.1	0.58±0.1
Tertile-3	11.9±11.0	6.0±4.0	11.7±6.8	6.3±4.8	**25.2±1.3**	**30.1±3.9**	**6.9±3.2**	**11.5±3.6**	18.2±2.1	18.7±1.9	**0.088±0.0**	**0.076±0.0**	95.6±4.5	94.3±10.9	**0.98±0.1**	**0.86±0.1**	0.59±0.1	0.58±0.1
FRAP																		
Tertile-1	8.5±6.7	6.0±3.2	11.4±8.6	4.9±2.6	**25.4±5.8**	**32.3±6.1**	**7.9±4.6**	**12.5±5.5**	**17.4±2.3**	**20.3±1.7**	**0.084±0.0**	**0.075±0.0**	92.0±14.0	97.0±13.6	0.92±0.1	0.87±0.1	0.57±0.1	0.60±0.1
Tertile-2	8.6±4.1	7.4±5.2	11.1±6.5	8.2±6.0	**25.7±4.4**	**29.5±4.7**	**7.4±3.3**	**11.0±3.8**	18.3±3.3	18.5±1.7	0.084±0.0	0.081±0.0	92.3±13.4	98.7±16.5	0.93±0.1	0.92±0.2	0.58±0.1	0.61±0.1
Tertile-3	**13.1±8.3**	**5.7±3.6**	**12.9±7.5**	**6.1±3.9**	27.3±5.3	29.8±3.4	8.5±4.5	11.1±3.2	18.8±3.3	18.7±1.7	**0.088±0.0**	**0.077±0.0**	100.8±15.4	95.1±11.0	**0.98±0.1**	**0.87±0.1**	0.63±0.1	0.57±0.1
VCEAC																		
Tertile-1	9.6±7.6	8.2±5.1	12.0±8.8	9.2±5.6	25.8±5.4	28.5±4.5	7.2±4.2	8.4±2.2	18.6±3.0	19.6±2.0	0.084±0.0	0.081±0.0	93.8±14.0	97.7±4.8	0.94±0.1	0.94±0.1	0.57±0.1	0.57±0.0
Tertile-2	**9.1±5.9**	**6.0±4.3**	10.8±7.1	6.0±4.4	26.4±5.4	30.2±4.9	**8.6±4.0**	**12.0±3.8**	17.9±3.2	18.2±1.6	**0.086±0.0**	**0.078±0.0**	94.4±15.5	96.6±18.8	**0.94±0.1**	**0.88±0.2**	0.61±0.1	0.60±0.1
Tertile-3	**9.6±5.0**	**5.8±3.4**	**12.0±6.3**	**5.8±4.1**	**25.1±4.7**	**31.0±4.1**	**8.2±4.3**	**12.1±4.0**	**16.9±1.8**	**19.3±1.8**	**0.085±0.0**	**0.077±0.0**	92.9±13.9	96.4±10.4	0.92±0.1	0.88±0.1	0.58±0.1	0.59±0.1

Note: Calculated using Mann Whitney U for non-parametric distribution. Significance (p<0.05) is given in bold. ABSI: A Body Shape Index; BMI: Body Mass Index; FFMI: Fat Free Mass Index; FMI: Fat Mass Inde; FRAP: Ferric Reducing Antioxidant Potential; FRS: Framingham Risk Score; ORAC: Total Oxygen Radical Absorbans Capacity; TEAC: Trolox Equivalent Antioxidant Capacity; TRAP: Total Radical-trapping Antioxidant Parameters; VCEAC: Vitamin C Equivalent Antioxidant Capacity; WC: Waist Circumference; WHR: Waist-to-Hip Ratio; WHtR: Waist-to-Height Ratio.

In this paper, although energy and protein intake amounts were not adequate in HD patients, the energy percentage coming from protein was found to be high. Protein-energy deficiency has been associated with low quality of life, complications, and increased mortality in hemodialysis patients [42]. It has also been shown that moderate and severe cardiovascular risk is 4 times higher in chronic renal failure patients with malnutrition [36]. Therefore, it is important to ensure adequate nutritional intake for the patients to reduce complications and increase life quality. Furthermore, the deficiency of nutrients and antioxidant dietary components lost during dialysis can be prevented with adequate and balanced nutrition. Thus, the intake of dietary antioxidants can prevent complications caused by oxidative damage.

In the literature, it was stated that the dTAC value is inversely correlated with ischemic stroke and hemorrhagic stroke and that the risk of myocardial infarction was 20% lower with high dTAC intakes [43]. This study found that FRS values were higher in high dTAC tertiles in HD patients, BMI, FMI, and FFMI values were lower, and ABSI and WHR were higher in all tertiles in hemodialysis patients than the control. Here, higher FRS, BMI, FMI, and FFMI values in high dTAC tertiles depended on the increase of food consumption as the patients an increase in body weight and vice versa. The increased food consumption provided an increase in energy and nutrient values as well as the number of antioxidant compounds. Depending on energy and nutrient intake, an increase in body weight and blood lipid levels of subjects was observed resulting in high cardiovascular risk. Hence, it has been found that food diversity and diet quality should also be considered while increasing the food consumption of the patients. In this way, by providing adequate levels of energy and nutrients, obesity and cardiovascular risk can be reduced.

In addition to the limitations commonly encountered in human studies, such as participant attrition, potential disparities in factors other than age and gender between the control and patient groups, and similar issues, there are specific constraints inherent to this study. The most significant among these limitations is our regions absence of a country-specific antioxidant database. Creating national databases using different methods and conducting multi-center studies would be beneficial in this regard. Another limitation is that, despite the practicality, non-invasiveness, painlessness, and good validity of Bioelectrical Impedance Analysis in hemodialysis patients, the formulas used for calculations are derived from healthy individuals, and the results are subject to hydration status. To ensure that the study results remained unaffected, strict adherence to the Bioelectrical Impedance Analysis measurement procedures was observed, and measurements were conducted post-dialysis to minimize the potential impact of overhydration on the measurement outcomes.

CONCLUSION

It has been observed that energy-adjusted nutrient intake is lower in hemodialysis patients compared to healthy individuals, and hemodialysis patients exhibit an elevated cardiovascular risk. Regarding dTAC tertiles, the distribution of cardiovascular risk and anthropometric obesity indices differs. Among healthy individuals, cardiovascular risk is lower in the higher dTAC tertiles, whereas in the patient group, it is higher. Obesity and cardiovascular diseases risk, and the antioxidant content of the diet shown in the general population could not be demonstrated in hemodialysis patients. The primary reasons for this might be the low antioxidant intake due to the disease, dialysis, and high plasm antioxidant losses. Adequate antioxidant intake should be ensured to prevent or improve existing oxidative damage with an adequate and balanced diet including high antioxidant contents of food. The effect of antioxidant losses caused by the disease can be reduced in that way. To sum up, even though there is no significant relationship between dTAC and obesity in this study, dTAC is an important factor in obesity since dietary antioxidants can effectively prevent chronic diseases accompanying obesity after occurring.

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