Nutrición Hospitalaria

Trabajo Original

Valoración nutricional

The feasibility of anthropometric measurements for evaluation of abdominal obesity in patients with autosomal dominant polycystic kidney disease: a cross-sectional study

La viabilidad de las mediciones antropométricas para la evaluación de la obesidad abdominal en pacientes con enfermedad renal poliquística autosómica dominante: un estudio transversal

Ozlem Persil-Ozkan[1], Egemen Cebeci[2], Yonca Sevim[3], Yildiray Savas[4], Savas Ozturk[5], Muhittin Tayfur[6]

[1]Department of Nutrition and Dietetics. School of Health Sciences. Istanbul Arel University. Istanbul, Turkey. [2]Department of Nephrology. Haseki Training and Research Hospital. Istanbul, Turkey. [3]Department of Nutrition and Dietetics. Faculty of Health Sciences. Bahcesehir University. Istanbul, Turkey. [4]Department of Radiology. Haseki Training and Research Hospital. Istanbul, Turkey. [5]Department of Nephrology. School of Medicine. Istanbul University. Istanbul, Turkey. [6]Department of Nutrition and Dietetics. Faculty of Health Sciences. Bolu Abant Izzet Baysal University. Bolu, Turkey

Abstract

Introduction: total kidney volume (TKV) increases in patients with autosomal dominant polycystic kidney disease (ADPKD), which perturbs anthropometric measurements.

Objectives: the primary objectives were to investigate the accuracy of waist circumference (WC) and waist-to-hip ratio (WHR) for determining abdominal obesity in patients with ADPKD by comparison with magnetic resonance images. The secondary objectives were to investigate the associations of energy/macronutrient intake with WC and WHR.

Methods: sixty patients with ADPKD were recruited from a nephrology outpatient clinic in this cross-sectional study. Main outcome measures were: TKV, total subcutaneous fat (TSF), total intraperitoneal fat (TIF), WC, WHR, body mass index (BMI), skinfold thickness (SFT), and energy/macronutrient intake.

Results: mean age was 48.6 ± 11.3 years, 38 of 60 were women, median TKV was 1486 (IQR, 981-2847) mL. The patients classed as obese by the BMI had higher WC, TSF, TIF, and SFT than did non-obese; however, WHR was similar in obese and non-obese men. In the all-patients group, the WHR of obese and non-obese patients were also similar. TKV was positively correlated with WC and WHR in women, but not in men. In the multivariate analysis, TKV was an independent factor affecting WC and WHR in women. Dietary fat intake was similar in groups with and without abdominal obesity according to WC and WHR.

Conclusions: in women with ADPKD, WC and WHR may not be accurate anthropometric measurements for evaluation of abdominal obesity; however, they may be associated with TKV.

Correspondence:

Ozlem Persil-Ozkan. Department of Nutrition and Dietetics. Istanbul Arel University Faculty of Health Sciences. Merkez Efendi Mahallesi. Eski Londra Asfaltı Cd. No 1/3. 34010 Cevizlibağ – Zeytinburnu, Istanbul, Turkey
e-mail: ozlempersil@yahoo.com

THE FEASIBILITY OF ANTHROPOMETRIC MEASUREMENTS FOR EVALUATION OF ABDOMINAL OBESITY IN PATIENTS
WITH AUTOSOMAL DOMINANT POLYCYSTIC KIDNEY DISEASE: A CROSS-SECTIONAL STUDY

825

Resumen

Introducción: el volumen total del riñón (TKV) crece en los pacientes con enfermedad poliquística autosómica dominante del riñón (ADPKD), la cual perturba las mediciones antropométricas.

Objetivos: los principales objetivos eran investigar la precisión de la circunferencia de la cintura (WC) y del cociente cintura-cadera (WHR) para determinar la obesidad abdominal en pacientes con ADPKD en comparación con imágenes de resonancia magnética. Los objetivos secundarios eran investigar las asociaciones entre consumo de energía/macronutrientes y WC y WHR.

Métodos: sesenta pacientes con ADPKD fueron reclutados por una clínica ambulatoria de nefrología en este estudio transversal. Las medidas resultantes principales fueron: TKV, grasa subcutánea total (TSF), grasa intraperitoneal total (TIF), WC, WHR, índice de masa corporal (BMI), espesor del pliegue cutáneo (SFT) y consumo de energía/macronutrientes.

Resultados: la edad media era de 48,6 ± 11,3 años, 38 de 60 eran mujeres, la media de TKV era 1486 (IQR: 981-2847) mL. Los pacientes clasificados como obesos por el BMI tenían niveles más altos de WC, TSF, TIF y SFT que los no obesos; sin embargo, el WHR era similar en los hombres obesos y no obesos. En el grupo de todos los pacientes, el WHR de obesos y no obesos era también similar. El TKV se correlacionó positivamente con la WC y el WHR en las mujeres pero no en los hombres. En el análisis multivariado, el TKV era un factor independiente que afectaba a la WC y el WHR en las mujeres. La ingesta de grasas en la dieta era similar en los grupos con y sin obesidad abdominal de acuerdo con la WC y el WHR.

Conclusiones: en las mujeres con ADPKD, la WC y el WHR quizá no son las medidas antropométricas más apropiadas para evaluar la obesidad abdominal; sin embargo, quizá esté relacionada con el TKV.

INTRODUCTION

Autosomal dominant polycystic kidney disease (ADPKD) is an inherited and systemic disease characterized by bilateral kidney cysts which progressively cause nephron loss and end-stage renal disease (1). The normal parenchyma is replaced by numerous fluid-filled cysts (2), and the total kidney volume (TKV) becomes enlarged bilaterally (3). The enlarged kidneys take up more space in the abdomen and cause abdominal distension. An increased prevalence of obesity in patients with ADPKD has been shown in some studies (4-8). A recent study of kidney transplant patients with ADPKD found overweight and obesity ratios of 31.4 % and 24.3 %, respectively (9). In addition, the rate of kidney transplantation in patients with ADPKD is high, and body mass index (BMI) is an important factor for the exclusion or inclusion criteria of transplantation (10). Obesity increases the risk of kidney disease in the general population and negatively affects the progression of kidney disease in patients with kidney-related diseases (11). It is also an independent risk factor for the development and progression of chronic kidney disease (CKD) (12) and end-stage renal disease (13,14). Obesity is one of the risk factors for rapid ADPKD progression (15-17) and has been associated with an increase in TKV and a decline in glomerular filtration rate (8).

Kidney patients should be routinely evaluated with anthropometric measurements to determine the degree of obesity (18). Examples of such measurements are BMI and the triceps, biceps, subscapular, and suprailiac skinfold thicknesses (SFT). Waist circumference (WC) and waist to hip ratio (WHR) are used to determine abdominal obesity (i.e., visceral fat) (19). Skinfold thickness evaluates subcutaneous fat and is not sensitive to changes in visceral fat (20). BMI is affected by variable factors such as muscle mass, sex, ethnicity, age, and health status. It has been reported that SFT, WHR, and multifrequency bioelectrical impedance analysis are superior to BMI in measuring body fat in patients with CKD (21). However, previous studies on patients with ADPKD reported that WHR and WC may be affected by the presence of enlarged kidneys and unfortunately, ADPKD is associated with abdominal obesity (22,23). The study hypothesis was that WC and WHR, which are used in the evaluation of obesity in the general population, are not correct evaluation methods in patients with ADPKD due to the presence of bilaterally enlarged kidneys.

The primary objectives of this study were to investigate the accuracy of WC and WHR in the evaluation of abdominal obesity in patients with ADPKD by comparisons with MRI data, and the secondary objectives were to investigate the associations of energy and macronutrient intake with WC and WHR.

METHODS

STUDY DESIGN AND PARTICIPANTS

This was a cross-sectional cohort study conducted at a nephrology outpatient clinic from April to July 2014. An offer to participate was extended to a total of 312 patients consecutively diagnosed with ADPKD at the clinic between April and July of 2014. Sixty adult patients accepted to participate in the study and were included. ADPKD was diagnosed from family history and imaging methods according to Ravine criteria. Patients were followed up at the same center. The cohort was used for the doctoral thesis entitled "The relationship between anthropometric measurements and diet & renal functions on patients with autosomal dominant polycystic kidney disease" (24).

Patients who were pregnant, had chronic liver or lung disease, hyperthyroidism, active infection, malignancy, malnutrition, or used drugs that could affect cyst volume (tolvaptan, rapamycin, lithium, etc.), or were receiving renal replacement therapy were excluded.

ETHICAL APPROVAL

The study was approved by the ethics committee of the hospital (research registration: 112), and conducted according to the Declaration of Helsinki guidelines. After being fully informed

about the study, participants voluntarily signed a consent form prior to study start.

DATA COLLECTION AND PROCEDURES

Patient age, sex, duration of qualifying ADPKD diagnosis, presence of comorbidities (diabetes *mellitus*, hypertension, ischemic heart disease) were collected through face-to-face interviews.

ANTHROPOMETRIC MEASUREMENTS

All measurements were performed by the same trained researcher. Measurements were made three times and the mean value was calculated. Height was measured to the nearest 0.5 cm using a stadiometer. Body weight was measured to the nearest 0.1 kg using an electronic scale. This measurement was repeated twice, and the mean value was calculated. BMI (kg/m^2) was calculated as weight (kg) divided by the squared height (m^2). The participants were divided into two groups, non-obese (BMI < 30 kg/m^2) and obese (BMI ≥ 30.0 kg/m^2) according to the World Health Organization (WHO) BMI-based classification (25).

To measure the hip circumference, the researcher stood beside the patient, and the measurement was made with a non-elastic measure under the crista iliaca and at the widest portion of the hip. To measure the waist circumference, the midpoint between the lowest rib and the *crista iliaca* was marked and the circumference was measured at this height with a non-elastic measuring tape. The patients were divided into two groups with WC < 88 cm versus ≥ 88 cm for women, and WC < 102 cm versus ≥ 102 cm for men, according to the WHO WC-based classification method. WHR was calculated by the formula, WHR = (waist circumference, cm)/(hip circumference, cm). The patients were divided in two groups with WHR < 0.85 versus ≥ 0.85 for women and WHR < 0.90 versus ≥ 0.90 for men according to the WHO WHR-based classification method (26).

When measuring the upper middle arm circumference (UMAC), the arm was bent 90° at the elbow, the midpoint between the acromial protrusion on the shoulder and the olecranon protrusion on the elbow was marked, and the circumference was measured with a measuring tape. Triceps, biceps, subscapular, and suprailiac SFT were measured with a Holtain skinfold caliper. When measuring the triceps SFT, the patients stood upright, the left arm was bent 90° at the elbow, the midpoint between the acromion and olecranon protrusions was marked, the arm was released, the layer was held with the left index finger and thumb, and the measurement was made at the marked place with a caliper. Biceps and triceps SFT were measured by placing a mark on the cubital fossa in the anterior part of the middle arm. To measure the subscapular SFT, the inferior corner of the left scapula bone was marked and the layer was held at an angle of 45° to the spinal cord. Suprailiac SFT was measured by placing a marker on the midaxillary line 2 cm above the iliac bone (27).

BIOCHEMICAL PARAMETERS

Complete blood count was analyzed by a Sysmex XT 1800i device (ROCHE-2011, Kobe, Japan) and biochemical parameters (glucose, urea, uric acid, creatinine, C-reactive protein, prealbumin, albumin, total protein, aspartate aminotransferase, alanine aminotransferase, total cholesterol, low density lipoprotein cholesterol, high density cholesterol, triglycerides, sodium, potassium, calcium, phosphorus, and ferritin) were analyzed by a COBAS 8000 device (ROCHE-2007, Tokyo, Japan) the morning after an overnight fast.

Urine protein and creatinine levels were analyzed in fresh midstream urine collected in the morning on the first outpatient visit. The protein to creatinine ratio in urine specimens was measured by dividing urine protein by urine creatinine, both measured in the same concentration units.

The estimated glomerular filtration rate (eGFR) was calculated using the Creatinine Equation published by The Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) (28).

The equation is:

$$eGFR = 141 \times min\ (Scr/\kappa, 1)^\alpha \times max\ (Scr/\kappa, 1)^{1.209}$$
$$\times\ 0.993^{Age} \times 1.018\ [if\ female]\ \_\ 1.159\ [if\ black]$$

SCr (standardized serum creatinine) = mg/dL (to convert to mmol/L, multiply by 0.0884).

eGFR (estimated glomerular filtration rate) = mL/min/1.73 m^2; Scr = standardized serum creatinine (mg/dL); κ = 0.7 if female or 0.9 if male, α = -0.329 if female or -0.411 if male, min = the minimum of Scr/κ or 1; max = the maximum of Scr/κ or 1; age = years.

CALCULATION OF KIDNEY VOLUME AND TOTAL SUBCUTANEOUS AND INTRAPERITONEAL ADIPOSE TISSUE FROM MRI DATA

MRI scans were acquired with a gradient strength of 48 mT on a 1.5-T ACHIEVA NOVA MRI system (Philips, The Netherlands). The imaging protocols were: 16-channel XL-TORSO body coil, 4-mm slice thickness, T2, T1, and fat-suppressed T2, and continuous sections in the transverse and frontal planes over the entire abdominal region. Images were processed with an Extended MR Workstation (4.2.3.2) and an Extended Brilliance Workspace workstation (3,2,1,2; Philips) running on CT viewer workstations. Post-processing was performed with Hounsfield-intensity tissue separation and the manual staining method. The volumes of bilateral polycystic kidneys were calculated in cm^3 (mL). Total subcutaneous and intraperitoneal adipose tissue volumes were calculated from fat areas in slices between the xiphoid process and pubis, passing through the L2-3 and L4-5 intervertebral discs, respectively. Abdominal slices from the xiphoid process to the pubis were included in the calculation of total subcutaneous fat tissue. The workstation software separated the adipose tissue from other tissues by making use of the Hounsfield difference of the adipose tissue, whose boundaries were determined by the auto-

THE FEASIBILITY OF ANTHROPOMETRIC MEASUREMENTS FOR EVALUATION OF ABDOMINAL OBESITY IN PATIENTS
WITH AUTOSOMAL DOMINANT POLYCYSTIC KIDNEY DISEASE: A CROSS-SECTIONAL STUDY

827

matic painting program. The measured tissue amount is given in cm³. Since the density of fat and water are very similar, they were directly converted to liters (L). For the determination of intra-peritoneal adipose tissue, solid organs and intestinal structures were manually traced and removed, to ensure that only fat remained.

EVALUATION OF DIETARY INTAKE

Food consumption records for three days (two weekdays and one weekend day) were collected to determine the dietary intakes of the patients. Initially, patients trained with a dietitian on how to self-record food consumption using supporting materials such as photographs and replicas of various foods. After training, dietary intakes were recorded by the participants for 3 days, and the records were collected by a dietitian.

All dietary analyses were performed by a dietitian. Daily intakes of energy and macronutrients were calculated from the diet record data using the nutrition information system Ebispro for Windows, Turkish Version 2010 (BeBiS 7.2), which contains composition data on food and drink from the U.S. Department of Agriculture, the Diyetturk Nutrient Database, and the German Food Code and Nutrient Database (29). Standardized recipes and values were used when the dietary records were ambiguous (30). When a food was unavailable from a dietary database, a new food was added to the software based on the composition data on the food package.

STATISTICAL ANALYSIS

Statistical analysis was performed with the IBM SPSS Statistics for Windows, version 20.0 package (31). Categorical variables were given in numbers and percentages, and numerical variables were given as mean ± standard deviation if homogeneous and as median (interquartile range: 25 %-75 %) if nonhomogeneous. The Kruskal-Wallis test was used to evaluate the distributions. When the participants were grouped according to the BMI-based WHO classification, a Mann-Whitney U-test was used for parametric data and a chi-square test was used for non-parametric data. The relationships between the variables were investigated using Pearson's correlation test. Linear regression analysis was used for multivariate analysis of data related to the WC and WHC measures in women and men. A p-value < 0.05 was considered statistically significant.

RESULTS

This study was performed on 60 adult patients with ADPKD; 38 (63.3 %) were women and 25 (41.6 %) were obese. The numbers of patients in CKD stages 1, 2, 3, 4, and 5 were: 14 (23.3 %), 13 (21.7 %), 16 (26.7 %), 12 (20 %), and 5 (8.3 %), respectively.

Table I shows the general characteristics of the patients, broken down by the BMI-based classification of obese versus non-obese. The diabetes *mellitus* ratio was higher in the obese group than in the non-obese group. Age, sex, duration of qualifying ADPKD diagnosis, hypertension ratio, and ischemic heart disease ratio were similar in the two groups.

Clinical characteristics such as laboratory findings, kidney function, and TKV are shown in table II. C-reactive protein was higher in the obese group (p = 0.001). Kidney functions, TKV, and laboratory findings were similar in the two groups. Table III shows anthropometric measurements of patients according to BMI.

Table I. General characteristics of the patients according to their body mass index

Characteristics (Mean ± SD)/(Median [Q1-Q3])	All patients (n = 60)	BMI < 30 kg/m² (n = 35)	BMI ≥ 30 kg/m² (n = 25)	p-value
Age (years)	48.6 ± 11.3	46.8 ± 12.7	51.2 ± 8.4	0.06
Female sex, n/N (%)	38/60 (63.3)	19/35 (54.2)	19/25 (76)	0.08
Duration of ADPKD (months)	101 (46-180)	96 (17-132)	120 (67-180)	0.116
Height (cm)	76.5 ± 15.5	67.4 ± 12.2	89.2 ± 9.5	< 0.001
Weight (kg)	164 ± 9	164 ± 9	163 ± 8	0.658
BMI (kg/m²)	28.4 ± 5.6	24.8 ± 3.6	33.5 ± 3.6	< 0.001
Coexisting disorders, n/N (%) Diabetes *mellitus* Hypertension Ischemic heart disease	4/60 (6.7) 43/60 (71.7) 6/60 (10)	0/35 (0) 22/35 (62.8) 2/35 (5.7)	4/25 (16) 21/25 (84) 4/25 (16)	0.026 0.089 0.223

BMI: body mass index; ADPKD: autosomal dominant polycystic kidney disease. p-value was obtained from the Mann-Whitney U-test for parametric data, and the Chi-square test for non-parametric data.

Table II. Clinical characteristics of the patients according to their body mass index

Clinical findings (Mean ± SD)/(Median [Q1-Q3])	All patients (n = 60)	BMI < 30 kg/m² (n = 35)	BMI ≥ 30 kg/m² (n = 25)	p-value
Glucose (mg/dL)	95.2 ± 11.7	93.7 ± 10.4	97.2 ± 13.3	0.217
Urea (mg/dL)	46 (34-76)	48 (38-78)	46 (32-74)	0.626
Uric asit (mg/dL)	6.1 ± 1.6	6.0 ± 1.7	6.3 ± 1.6	0.341
Creatinine (mg/dL)	1.35 (0.86-2.35)	1.43 (0.86-2.63)	1.13 (0.95-2.49)	0.922
Hemoglobin (g/dL)	12.8 ± 1.7	13.1 ± 1.6	12.5 ± 1.7	0.170
CRP (mg/dL)	2.5 (1.0-7.8)	2.0 (0.7-5.3)	6.2 (2.5-12.7)	0.001
Prealbumin (mg/dL)	25.0 ± 4.7	24.9 ± 3.7	25.4 ± 6.0	0.975
Albumin (g/dL)	4.2 ± 0.2	4.3 ± 0.2	4.2 ± 0.3	0.394
Total protein (g/dL)	7.3 ± 0.5	7.3 ± 0.6	7.5 ± 0.4	0.179
AST (U/L)	19.9 ± 5.6	20.1 ± 4.6	19.7 ± 6.9	0.222
ALT (U/L)	14.1 ± 4.4	14.4 ± 4.2	13.7 ± 4.8	0.264
Total cholesterol (mg/dL)	201 ± 45	198 ± 39	204 ± 52	0.500
LDL-C (mg/dL)	126 ± 36	124 ± 32	128 ± 42	0.534
HDL-C (mg/dL)	46 ± 10	48 ± 10	45 ± 11	0.495
Triglycerides (mg/dL)	140 ± 67	129 ± 65	157 ± 68	0.08
Sodium (mEq/L)	140 ± 2	140 ± 2	140 ± 3	0.618
Potassium (mmol/L)	4.6 ± 0.5	4.6 ± 0.5	4.6 ± 0.4	0.916
Calcium (mg/dL)	9.4 ± 0.5	9.4 ± 0.5	9.5 ± 0.5	0.684
Phosphorus (mg/dL)	3.5 (3.1-3.9)	3.5 (3.1-3.9)	3.6 (3.0-3.9)	0.970
Ferritin (ng/mL)	37 (18-70)	50 (21-79)	32 (15-50)	0.092
eGFR (mL/dk/1.73 m²)	53 (22-88)	49 (24-112)	57 (20-82)	0.642
Proteinuria (mg/g)	0.22 (0.13-0.51)	0.25 (0.13-0.59)	0.20 (0.15-0.32)	0.397
Total kidney volume (mL)	1486 (981-2847)	1345 (829-2986)	1824 (1029-2540)	0.637

BMI: body mass index; CRP: C-reactive protein; AST: aspartate aminotransferase; ALT: alanine aminotransferase; eGFR; estimated glomerular filtration rate; HDL-C: high density lipoprotein cholesterol; LDL-C: low density lipoprotein cholesterol. p-value was obtained from the Mann-Whitney U-test for parametric data, and the Chi-square test for non-parametric data.

Table III. Anthropometric characteristic of the patients according to their body mass index

Anthropometric measurements (Mean ± SD)/(Median [Q1-Q3])	All patients (n = 60)	BMI < 30 kg/m² (n = 35)	BMI ≥ 30 kg/m² (n = 25)	p-value
Waist circumference (cm)				
All	97 ± 13	90 ± 11	107 ± 10	< 0.001[‡]
Female	96 ± 14	86 ± 10	106 ± 11	< 0.001[‡]
Male	98 ± 12	94 ± 11	109 ± 4	0.002[†]

THE FEASIBILITY OF ANTHROPOMETRIC MEASUREMENTS FOR EVALUATION OF ABDOMINAL OBESITY IN PATIENTS
WITH AUTOSOMAL DOMINANT POLYCYSTIC KIDNEY DISEASE: A CROSS-SECTIONAL STUDY

829

Table III (Cont.). Anthropometric characteristic of the patients according to their body mass index

Anthropometric measurements (Mean ± SD)/(Median [Q1-Q3])	All patients (n = 60)	BMI < 30 kg/m² (n = 35)	BMI ≥ 30 kg/m² (n = 25)	p-value
Waist to hip ratio				
All	0.92 ± 0.09	0.90 ± 0.09	0.95 ± 0.11	0.113
Female	0.88 ± 0.08	0.85 ± 00.7	0.91 ± 0.08	0.034*
Male	0.98 ± 0.09	0.95 ± 0.07	1.05 ± 0.11	0.055
Total subcutenous fat (L)				
All	8.2 (4.8-13.1)	5.4 (3.5-8.8)	12.9 (10.2-18.0)	< 0.001‡
Female	11.3 (7.1-16.0)	7.7 (5.1-12.4)	14.1 (11.0-18.7)	0.001†
Male	5.0 (3.2-8.8)	4.1 (2.5-6.2)	10.4 (7.5-11.6)	0.006†
Total intraperitoneal fat (L)				
All	3.0 (1.8-4.7)	1.9 (1.3-3.0)	4.3 (3.5-5.5)	< 0.001‡
Female	3.0 (1.8-4.1)	1.9 (1.1-2.4)	4.0 (3.2-5.0)	< 0.001‡
Male	3.4 (1.6-5.9)	1.9 (1.4-4.7)	5.9 (4.4-6.1)	0.021*
UMAC (cm)	31.9 ± 4.5	29.1 ± 3.4	35.9 ± 2.6	< 0.001‡
Triceps SFT (mm)	20.5 ± 8.5	16.6 ± 7.3	25.9 ± 7.2	< 0.001‡
Biceps SFT (mm)	10.6 ± 5.5	8.2 ± 4.4	14.0 ± 5.1	< 0.001‡
Subscapular SFT (mm)	21.5 ± 8.8	17.0 ± 7.5	27.9 ± 6.3	< 0.001‡
Suprailiac SFT (mm)	16.7 ± 8.6	13.0 ± 7.1	22.1 ± 7.7	< 0.001‡

*BMI: body mass index; UMAC: upper middle arm circumference; SFT: skinfold thickness. *p-value < 0.05; †p-value < 0.01, ‡p-value < 0.001, obtained from the Mann-Whitney U-test for parametric data, and the Chi-square test for non-parametric data.*

Women and men in the obese group had higher WC, TSF, TIF, UMAC, and triceps, biceps, subscapular, and suprailiac SFT values when compared with the non-obese group. However, WHR in obese versus non-obese men was similar. Women in the obese group had higher WHRs than those in the non-obese group (p = 0.034). In the all-patients group, the WHRs of obese and non-obese patients were similar.

Table IV shows daily energy and macronutrient intakes stratified by the BMI, WC, and WHR classifications. Although the percentage of dietary fat in obese patients was higher than non-

Table IV. Daily energy and macronutrient intakes calculated through the 3-day food records according to body mass index, waist circumference, and waist-to-hip ratio classifications in patients

Characteristic (Mean ± SD)	Energy (kcal/kg)	Protein (g/kg)	Protein (%)	Carbohydrates (%)	Fat (%)
Body mass index (kg/m²)					
< 30 (n = 35)	29.3 ± 9.0	0.9 ± 0.3	14 ± 2	51 ± 7	34 ± 7
≥ 30 (n = 25)	20.3 ± 6.8	0.7 ± 0.2	15 ± 3	46 ± 6	39 ± 5
p-value	< 0.001‡	< 0.001‡	0.450	0.008†	0.017*
Waist circumference (cm)					
Normal (n = 22)	31.6 ± 9.3	1.0 ± 0.3	14 ± 2	51 ± 7	35 ± 7
High (n = 38)	22.0 ± 7.4	0.7 ± 0.23	14 ± 3	48 ± 7	37 ± 6
p-value	< 0.001‡	< 0.001‡	0.871	0.208	0.285
Waist to hip ratio					
Normal (n = 17)	29.8 ± 9.5	1.0 ± 0.3	15 ± 2	49 ± 7	36 ± 6
High (n = 43)	23.8 ± 8.7	0.8 ± 0.3	14 ± 3	49 ± 7	36 ± 6
p-value	0.022*	0.003†	0.452	0.915	0.837

*p-value < 0.05, †p-value < 0.01, ‡p-value < 0.001, obtained from the Mann-Whitney U-test for parametric data, and the Chi-square test for non-parametric data.

obese patients, the dietary fat percentages of groups with and without abdominal obesity according to WC and WHR were similar (p = 0.017, 0.285, and 0.837, respectively). The percentage of dietary fat was positively correlated with TSF and BMI, and there was no correlation between dietary fat and either WHR or WC. Pearson's correlation analysis of the anthropometric measurements, kidney function, total kidney volume, and daily intakes of energy and macronutrients are given in table V. WHR was negatively correlated with eGFR and positively correlated with age, TKV, UMAC, biceps, triceps, subscapular, and suprailiac SFT in all patient groups. WC was negatively correlated with eGFR and positively correlated with TIF, TSF, and BMI in all patient groups. TKV was positively correlated in all patients only with WHR. There was no correlation between TKV and other anthropometric measurements such as BMI, TIF, or TSF. While TKV was positively correlated with WC and WHR in women, no such correlation was observed in men (Fig. 1).

Table VI shows the results of the multivariate analysis of the independent parameters affecting WC and WHR stratified by sex. In the linear regression analysis, BMI, TKV, and UMAC were factors affecting WC in women; BMI, TKV, biceps and UMAC were factors affecting WHR in women. Age was the only factor affecting WHR in men. Age and UMAC were factors affecting WC in men.

DISCUSSION

In this single-center, cross-sectional study the accuracy of WC and WHR for the evaluation of obesity in adult patients with ADPKD was investigated. The WHR values of obese versus non-obese men were found to be similar. Total kidney volume was positively correlated with WC and WHR in women. In the multivariate analysis, TKV was an independent factor affecting WC and WHR in women. With age, the number of cysts in patients with ADPKD increases and TKV becomes enlarged bilaterally (3). Enlarged kidneys take up more space in the abdomen and cause abdominal distension. Therefore, while WC and WHR can be used to determine abdominal obesity in the general population, they may not be the accurate for evaluation of obesity in patients with ADPKD. It has been reported that SFT, WHR, and multifrequency bioelectrical impedance analysis are superior to BMI for measuring body fat in patients with CKD (21). The Reasons for Geographic and Racial Differences in Stroke Study (REGARDS; 2011) reported that WC alone reflects abdominal obesity, especially when applied with BMI in adults with CKD (32). Previous studies on patients with ADPKD reported that WHR and WC may be affected by the presence of enlarged kidneys, and that ADPKD is associated with abdominal obesity (22,23). In a study comparing ADPKD patients with control groups, WHR was found to be significantly higher, and WC was almost 3 cm greater in the ADPKD group (22). A six-year follow-up of that study found a significant increase in weight, BMI, and WC, and a significant decrease in eGFR in the ADPKD group. In addition, the follow-up study showed that the ADPKD group had higher rates of obesity when compared to the control group (23). Another previous study

suggested that overweight and obesity may have a significant impact on the progression of ADPKD. Obesity was associated with an increase in TKV and a decline in eGFR. The percentage increase in TKV was associated with increases in BMI (8). In the current study, 25 of 60 patients (41.6 %) were obese. Moreover, WHR was negatively correlated with eGFR and positively correlated with TKV in patients with ADPKD.

The acceptable macronutrient distribution ranges (AMDRs) were determined by the Institute of Medicine, which has developed AMDRs for macronutrients, carbohydrates, fat, and protein intake. Excessive consumption of macronutrients above the AMDR limit has the potential to increase the risk of chronic disease or cause inadequate intake of essential nutrients (33). In Turkey, the AMDRs were determined by the Ministry of Health. The AMDR for carbohydrates is 45-60 %, for fat is 20-35 %, and for protein is 10-20 % of energy intake for Turkish adults (34). In this study, when daily energy intake (kcal/day) was examined, neither the obese nor the non-obese group showed excessive values. The percentage of dietary energy from fat exceeded the AMDR in the all-patients group, but the carbohydrate and protein ratios were within the AMDR limits.

In the present study, obese patients had a significantly higher percentage of dietary energy from fat than did non-obese patients. The percentages of dietary energy from fat in the high-WC group and in the high-WHR group were similar to those in the normal-WC and normal-WHR groups. These results suggest that the percentage of dietary energy from fat may not be associated with high WC or high WHR. Similarly, in a previous study in which body fat and lean mass were measured with dual-energy X-ray absorptiometry and abdominal and hepatic fat were measured by computed tomography, the macronutrient content of the diet was not found to cause any changes in abdominal fat or hepatic fat (35).

The results of this study raise the question of which anthropometric measurements should be used to determine abdominal obesity in women with ADPKD. The results suggested that WC and WHR may not be an accurate anthropometric measurement for evaluating abdominal obesity in women with ADPKD, and that the percentage of dietary energy obtained from fat may be unrelated to either WHR or WC.

This study has several limitations. Our data are limited to a single center, and therefore may not be generalizable to other centers. Since this study is designed cross-sectionally, causal inferences cannot be made. Sample size was small, participants were Caucasian only, and there was no control group. Moreover, a three-day food consumption record may not be reflective of the usual intake. The strengths of our study include investigating the accuracy of WC and WHR measurements for the evaluation of obesity in ADPKD by comparisons with MRI data, SFT, and UMAC.

More research is needed to investigate optimal methods for evaluating obesity in patients with ADPKD. Future research should evaluate the accuracy of the anthropometric measurements used to determine obesity in patients with ADPKD in other cohorts, including cohorts representative of other races and geographical regions.

THE FEASIBILITY OF ANTHROPOMETRIC MEASUREMENTS FOR EVALUATION OF ABDOMINAL OBESITY IN PATIENTS WITH AUTOSOMAL DOMINANT POLYCYSTIC KIDNEY DISEASE: A CROSS-SECTIONAL STUDY

831

Table V. Correlation matrix between anthropometric measurements, kidney function, total kidney volume, daily intakes of energy, and macronutrients in the patients

Variable	eGFR	TKV	TSF	TIF	BMI	Energy	Protein	CHO	Fat	WC	WHR	UMAC	Skinfold Thickness				Age
													Biceps	Triceps	Subscapular	Suprailiac	
eGFR	1																
TKV	-0.519†	1															
TSF	-0.034	0.024	1														
TIF	-0.295*	-0.097	0.348†	1													
BMI	-0.249	0.132	0.721†	0.607†	1												
Energy	0.241	-0.046	-0.458†	-0.513†	-0.586†	1											
Protein	-0.169	-0.076	-0.494†	-0.460†	-0.560†	0.881†	1										
CHO	0.003	0.032	-0.297*	-0.211	-0.306*	0.281*	0.099	1									
Fat	0.071	-0.031	0.347†	0.166	0.297*	-0.230	-0.222	-0.925†	1								
WC	-0.382†	0.209	0.536†	0.657†	0.865†	-0.581†	-0.569†	-0.101	0.096	1							
WHR	-0.450†	0.275*	0.115	0.483†	0.386*	-0.333*	-0.309*	0.121	-0.152	0.759†	1						
UMAC	0.051	-0.024	0.648†	0.339†	0.651†	-0.329†	-0.376†	-0.330*	0.371†	0.371†	-0.077*	1					
Biceps SFT	-0.021	-0.039	0.655†	0.417†	0.660†	-0.421†	-0.378†	-0.374†	0.344†	0.438†	0.032	0.878†	1				
Triceps SFT	0.051	-0.024	0.648†	0.339†	0.651†	-0.329†	-0.376†	-0.330†	0.371†	0.371*	-0.077	0.725†	0.878†	1			
Subscapular SFT	-0.039	0.105	0.686†	0.473†	0.751†	-0.479†	0.499†	-0.259*	0.282*	0.554†	0.120	0.822†	0.840†	0.822†	1		
Suprailiac SFT	-0.004	0.051	0.653†	0.421†	0.693†	-0.443†	0.488†	-0.145	0.184	0.505†	0.065	0.763†	0.732†	0.763†	0.785†	1	
Age	-0.685†	0.190	-0.039	0.452†	0.233	-0.308†	0.204	0.055	-0.14	0.433†	0.566†	-0.029	-0.011	-0.029	0.038	-0.013	1

*eGFR: estimated glomerular filtration rate; TKV: total kidney volume (mL) from magnetic resonance images; TSF: total subcutenous fat (L); TIF: total intraperitoneal fat (L); BMI: body mass index; CHO: carbohydrate; WC: waist circumference (cm); WHR: waist-to-hip ratio; UMAC: upper middle arm circumference (cm); SFT: skinfold thickness. p-values obtained from Pearson's test. *Correlation is significant at the 0.05 level; †Correlation is significant at the 0.01 level.*
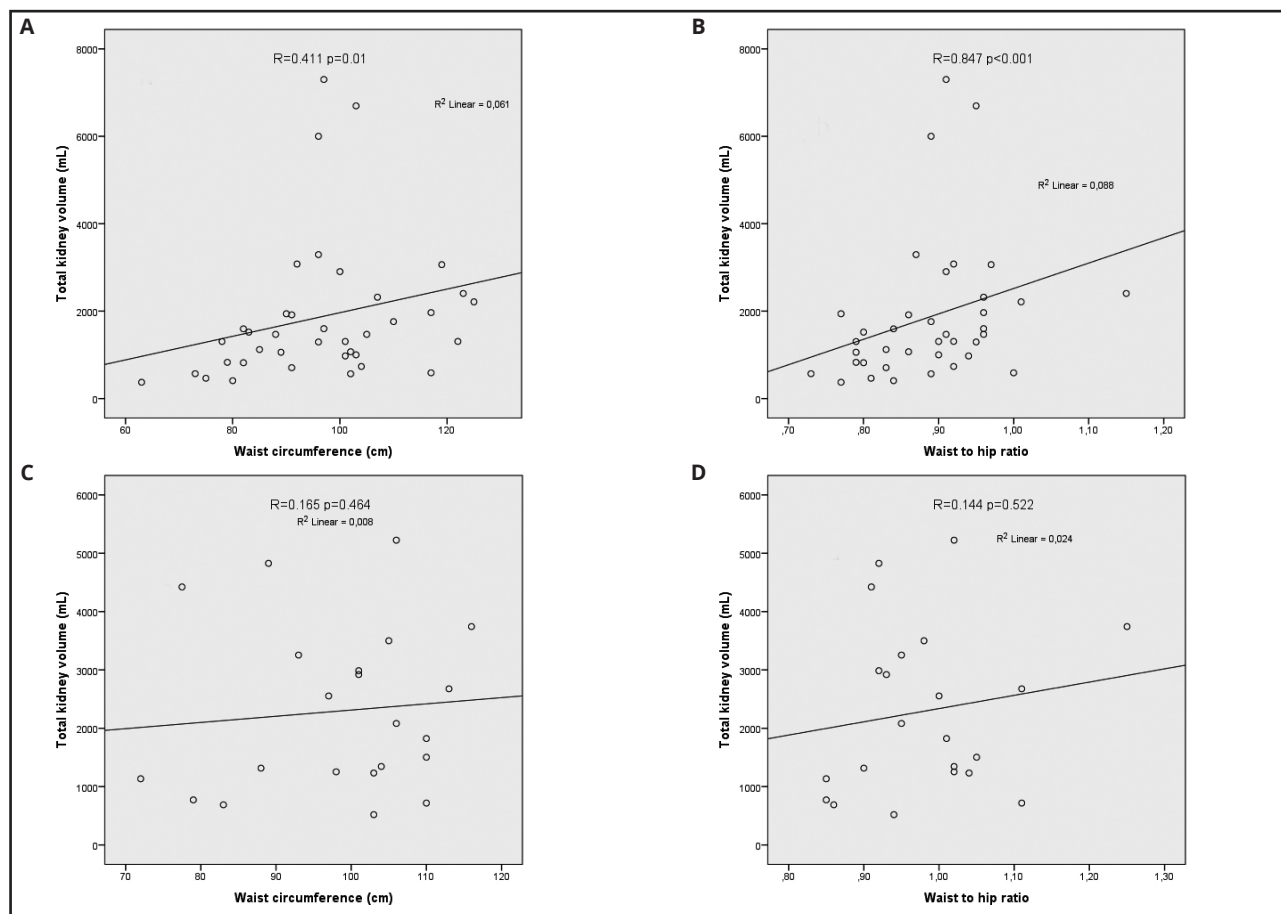
Figure 1.

Correlation analysis between waist circumference, waist-to-hip ratio and total kidney volume of the patients with autosomal dominant polycystic disease recruited to a cross-sectional study investigating the feasibility of anthropometric measurements for evaluation of abdominal obesity. A. Correlation analysis between waist circumference and total kidney volume of women. B. Correlation analysis between waist-to-hip ratio and total kidney volume of women. C. Correlation analysis between waist circumference and total kidney volume of men. D. Correlation analysis between waist-to-hip ratio and total kidney volume of men.

Table VI. The independent parameters related to waist circumference and waist-to-hip ratio in the patients

Parameters	Male			Female		
	p-value	OR	95 % CI	p-value	OR	95 % CI
Linear regression analysis for waist circumference						
Age (years)	< 0.001†	0.341	0.218-0.464	0.627	0.049	-0.157-0.256
Total kidney volume [Log (mL)]	0.256	2.645	-2.184-7.474	0.032*	7.234	0.670-13.799
Total subcutaneous fat (L)	0.895	0.040	-0.603-0.682	0.954	-0.013	-0.483-0.457
Body mass index (kg/m^2)	0.159	0.774	-0.349-1.897	< 0.001†	3.666	2.544-4.787
UMAC (cm)	0.017*	1.996	0.419-3.572	0.003*	-2.515	-4.111-0.920
Skinfold thickness Biceps (mm) Subscapular (mm) Suprailiak (mm) Triceps (mm)	0.549 0.588 0.340 0.998	-0.218 0.131 -0.180 -0.001	-0.989-0.552 -0.382-0.644 -0.576-0.215 -0.584-0.582	0.067 0.246 0.565 0.558	0.696 -0.238 0.096 0.172	-0.053-1.445 -0.650-0.173 -0.242-0.435 -0.421-0.765

(Continues on next page)

Table VI (Cont.). The independent parameters related to waist circumference and waist-to-hip ratio in the patients

Parameters	Male			Female		
	p-value	OR	95 % CI	p-value	OR	95 % CI
Linear regression analysis for waist to hip ratio						
Age (years)	0.011*	0.004	0.001-0.007	0.373	0.001	-0.001-0.003
Total kidney volume [Log (mL)]	0.636	0.026	-0.091-0.142	0.013*	0.093	0.021-0.164
Total subcutaneous fat (L)	0.577	0.004	-0.011-0.020	0.983	-0.005	-0.005-0.005
Body mass index (kg/m²)	0.731	0.004	-0.023-0.031	0.001*	0.022	0.010-0.034
UMAC (cm)	0.985	0.001	-0.038-0.038	0.003*	-0.028	-0.045-0.010
Skinfold thickness Biceps (mm) Subscapular (mm) Suprailiak (mm) Triceps (mm)	0.794 0.429 0.141 0.489	-0.002 0.005 -0.007 0.005	-0.021-0.016 -0.008-0.017 -0.016-0.003 -0.009-0.019	0.018* 0.116 0.457 0.537	0.010 -0.004 0.001 0.002	0.002-0.018 -0.008-0.001 -0.002-0.005 -0.004-0.008

*UMAC: upper middle arm circumference. *p-value < 0.05, †p-value < 0.001, obtained from the linear regression analysis for multivariate analysis.*

CONCLUSIONS

In women with ADPKD, total kidney volume was positively correlated with waist circumference and waist-hip ratio, and an independent factor affecting waist circumference and waist-hip ratio. Therefore, WC and WHR may not be accurate anthropometric measurements for the evaluation of abdominal obesity in women with ADPKD.

REFERENCES

1. Campbell KL, Rangan GK, Lopez-Vargas P, Tong A. KHA-CARI Autosomal Dominant Polycystic Kidney Disease Guideline: Diet and Lifestyle Management. Semin Nephrol 2015;35(6):572-81.e17. DOI: 10.1016/j.semnephrol.2015.10.008
2. Müller R-U, Benzing T. Management of autosomal-dominant polycystic kidney disease—state-of-the-art. Clin Kidney J 2018;11(suppl 1):i2-13. DOI: 10.1093/ckj/sfy103
3. Chapman AB, Guay-Woodford LM, Grantham JJ, Torres VE, Bae KT, Baumgarten DA, et al. Renal structure in early autosomal-dominant polycystic kidney disease (ADPKD): The Consortium for Radiologic Imaging Studies of Polycystic Kidney Disease (CRISP) cohort. Kidney Int 2003;64(3):1035-45. DOI: 10.1046/j.1523-1755.2003.00185.x
4. Schrier RW, McFann KK, Johnson AM. Epidemiological study of kidney survival in autosomal dominant polycystic kidney disease. Kidney Int 2003;63(2):678-85. DOI: 10.1046/j.1523-1755.2003.00776.x
5. Helal I, McFann K, Reed B, Yan X-D, Schrier RW. Changing Referral Characteristics of Patients with Autosomal Dominant Polycystic Kidney Disease. Am J Med 2013;126(9):832.e7-e11. DOI: 10.1016/j.amjmed.2012.12.018
6. Fox CS. Predictors of New-Onset Kidney Disease in a Community-Based Population. JAMA 2004;291(7):844. DOI: 10.1001/jama.291.7.844
7. Freise J, Tavakol M, Gao Y, Klein O, Lee BK, Freise C, et al. The Effect of Enlarged Kidneys on Calculated Body Mass Index Categorization in Transplant Recipients With ADPKD. Kidney Int Reports 2019;4(4):606-9. DOI: 10.1016/j.ekir.2019.01.003
8. Nowak KL, You Z, Gitomer B, Brosnahan G, Torres VE, Chapman AB, et al. Overweight and Obesity Are Predictors of Progression in Early Autosomal Dominant Polycystic Kidney Disease. J Am Soc Nephrol 2018;29(2):571-8. DOI: 10.1681/ASN.2017070819
9. Akoh JA. Current management of autosomal dominant polycystic kidney disease. World J Nephrol 2015;4(4):468. DOI: 10.5527/wjn.v.4.i4.468
10. Pondrom S. The AJT Report: News and issues that affect organ and tissue transplantation. Am J Transplant 2012;12(7):1663-4. DOI: 10.1111/j.1600-6143.2012.04186.x
11. Wang Y, Chen X, Song Y, Caballero B, Cheskin LJ. Association between obesity and kidney disease: A systematic review and meta-analysis. Kidney Int 2008;73(1):19-33. DOI: 10.1038/sj.ki.5002586
12. Rüster C, Wolf G. The Role of the Renin-Angiotensin-Aldosterone System in Obesity-Related Renal Diseases. Semin Nephrol 2013;33(1):44-53. DOI: 10.1016/j.semnephrol.2012.12.002
13. Hsu CY, McCulloch CE, Iribarren C, Darbinian J, Go AS. Body mass index and risk for end-stage renal disease. Ann Intern Med 2006;144(1):21-8. DOI: 10.7326/0003-4819-144-1-200601030-00006
14. de Boer IH, Katz R, Fried LF, Ix JH, Luchsinger J, Sarnak MJ, et al. Obesity and Change in Estimated GFR Among Older Adults. Am J Kidney Dis 2009;54(6):1043-51. DOI: 10.1053/j.ajkd.2009.07.018
15. Nobakht N, Hanna RM, Al-Baghdadi M, Ameen KM, Arman F, Nobahkt E, et al. Advances in Autosomal Dominant Polycystic Kidney Disease: A Clinical Review. Kidney Med 2020;2(2):196-208. DOI: 10.1016/j.xkme.2019.11.009
16. Chebib FT, Perrone RD, Chapman AB, Dahl NK, Harris PC, Mrug M, et al. A practical guide for treatment of rapidly progressive ADPKD with tolvaptan. J Am Soc Nephrol 2018;29(10):2458-70. DOI: 10.1681/ASN.2018060590
17. Rastogi A, Ameen KM, Al-Baghdadi M, Shaffer K, Nobakht N, Kamgar M, et al. Autosomal dominant polycystic kidney disease: updated perspectives. Ther Clin Risk Manag 2019;15:1041-52. DOI: 10.2147/TCRM.S196244
18. Said S, Hernandez GT. The link between chronic kidney disease and cardiovascular disease. J Nephropathol 2014;3(3):99-104. DOI: 10.12860/jnp.2014.19
19. Sanches FMR, Avesani CM, Kamimura MA, Lemos MM, Axelsson J, Vasselai P, et al. Waist Circumference and Visceral Fat in CKD: A Cross-sectional Study. Am J Kidney Dis 2008;52(1):66-73. DOI: 10.1053/j.ajkd.2008.02.004
20. Woodrow G. Body composition analysis techniques in the aged adult: indications and limitations. Curr Opin Clin Nutr Metab Care 2009;12(1):8-14. DOI: 10.1097/MCO.0b013e32831b9c5b
21. Zoccali C, Torino C, Tripepiand G, Mallamaci F. Assessment of obesity in chronic kidney disease: What is the best measure? Curr Opin Nephrol Hypertens 2012;21(6):641-6. DOI: 10.1097/MNH.0b013e328358a02b
22. Pietrzak-Nowacka M, Safranow K, Byra E, Bińczak-Kuleta A, Ciechanowicz A, Ciechanowski K. Metabolic syndrome components in patients with autosomal-dominant polycystic kidney disease. Kidney Blood Press Res 2010;32(6):405-10. DOI: 10.1159/000260042
23. Pietrzak-Nowacka M, Safranow K, Marchelek-Myśliwiec M, Bodnar M, Przysiecka S, Nowosiad-Magda M, et al. Evolution of metabolic syndrome

components in patients with autosomal-dominant polycystic kidney disease: a six-year follow-up study. Postepy Hig Med Dosw 2019;73:598-607. DOI: 10.5604/01.3001.0013.5605

24. Persil Ozkan O. The relationship between anthropometric measurements and diet & renal functions on patients with autosomal dominant polycystic kidney disease. [doctoral thesis]. Ankara, Turkey: Başkent University Instute of Health Science, Nutrition and Dietetics; 2015.

25. World Health Organisation Europe. Body mass index - BMI. [Accessed 22 July 2021]. Available from: http://www.euro.who.int/en/health-topics/disease-prevention/nutrition/a-healthy-lifestyle/body-mass-index-bmi.

26. World Health Organization. Waist Circumference and Waist-Hip Ratio: Report of a WHO Expert Consultation. Geneva; 2008 [accessed 22 July 2021]. Available from: https://www.who.int/publications/i/item/9789241501491.

27. Reilly JJ, Wilson J, Durnin JVGA. Determination of body composition from skinfold thickness: A validation study. Arch Dis Child 1995;73(4):305-10. DOI: 10.1136/adc.73.4.305

28. Levey AS, Stevens LA, Schmid CH, Zhang Y (Lucy), Castro AF, Feldman HI, et al. A New Equation to Estimate Glomerular Filtration Rate. Ann Intern Med 2009;150(9):604. DOI: 10.7326/0003-4819-150-9-200905050-00006

29. Ebispro for Windows [computer program]. Stuttgart, Germany; Turkish Version (BeBiS 7.2). Istanbul, Turkey: Pasifik Elektirik Elektronik Ltd. Şti; 2010.

30. Kutluay Merdol T. Standart Yemek Tarifeleri. 4th ed. Ankara: Hatiboğlu; 2011.

31. IBM SPSS Statistics for Windows [computer program]. Version 20.0. Armonk, NY: IBM Corp; 2011.

32. Kramer H, Shoham D, McClure LA, Durazo-Arvizu R, Howard G, Judd S, et al. Association of waist circumference and body mass index with all-cause mortality in CKD: The REGARDS (Reasons for Geographic and Racial Differences in Stroke) study. Am J Kidney Dis 2011;58(2):177-85. DOI: 10.1053/j.ajkd.2011.02.390

33. Institute of Medicine. Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids. Washington, DC: The National Academies Press; 2005. DOI: 10.17226/10490

34. T.R. Public Health Agency of Turkey Ministry of Health, Obesity, Diabetes and Metabolic Diseases Department. Turkey Nutrition Guide; 2015 [accessed 22 July 2021]. Available from: https://dosyasb.saglik.gov.tr/Eklenti/10915,tuber-turkiye-beslenme-rehberipdf.pdf.

35. De Souza RJ, Bray GA, Carey VJ, et al. Effects of 4 weight-loss diets differing in fat, protein, and carbohydrate on fat mass, lean mass, visceral adipose tissue, and hepatic fat: Results from the POUNDS LOST trial. Am J Clin Nutr 2012;95(3):614-25. DOI: 10.3945/ajcn.111.026328