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ORIGINAL ARTICLE

Association of anthropometric measures of obesity and chronic kidney disease in elderly women

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Abstract

Introduction and objective. Growing evidence suggests that obesity is an important contributor to the development of chronic kidney disease (CKD). The relationship between obesity and CKD is complex and not completely understood, and the best anthropometric index of obesity in predicting CKD is controversial. This study aimed to determine the best anthropometric index of obesity in predicting CKD in a population of elderly women.

Materials and methods. Anthropometric indexes of obesity including body mass index (BMI), waist circumference (WC), waist-to-height ratio (WheiR) and waist-to-hip-ratio (WHR), were obtained in 730 selected females. Biochemical measurements including blood glucose, lipid profile, and 2-h postprandial blood glucose were performed. GFR was estimated by using CKD-EPI equation.

Results. The prevalence of CKD stage ≥ 3 was 12.2%. Overweight and obesity was found in 50% and 36% of participants, respectively. Increased central fat distribution, as defined by WheiR, WC and WHR, was found in 89.6%, 91.7% and 89.4% individuals, respectively. Univariate linear regression analysis showed positive correlations between CKD and age ($p<0.001$), BMI ($p<0.001$), WC ($p<0.001$), WHR ($p=0.007$), WheiR ($p<0.001$), diabetes ($p=0.002$), as well as triglicerydes ($p=0.031$), and negative correlation between CKD and HDL level ($p=0.017$). Multivariable analysis demonstrated that hypertension, diabetes, WC and WheiR were independent predictors of CKD. The area under the receiver operating characteristics curve was best for WheiR (0.647), followed by WC (0.620), BMI (0.616), and WHR (0.532).

Conclusions. Abdominal obesity is an important predictor of CKD. Of commonly used anthropometric parameters of obesity WheiR ≥ 0.6 is particularly associated with CKD in elderly females.

Key words

obesity, chronic kidney disease, waist-to-height ratio, waist-to-hip ratio, body mass index, waist circumference

INTRODUCTION

Obesity is an escalating global health concern. In the last decade, the prevalence of obesity increased significantly at all ages in high-income countries [1, 2]. Growing evidence suggests that obesity is a potentially important contributor to the development of chronic kidney disease (CKD). The relationship between obesity and CKD is complex and not completely understood. Obesity can influence CKD indirectly; however, a direct causality link between obesity and CKD appears highly likely. Obesity is recognized as a major risk factor for diabetes and hypertension, as well as cardiovascular disease, all of which are risk factors for CKD. Given that diabetes and hypertension account together for ~70% of all cases of **End Stage Renal Disease (ESRD),** most of the increasing prevalence of CKD may be attributed to the sharp and parallel increase in obesity and diabetes during the same period [1, 3, 4, 5]. An increasing body of evidence suggests, however, that obesity *per se*, even in the absence of diabetes, may attribute to renal damage. Adipose tissue is hormonally active and releases a large number of bioactive adipokine proteins that target numerous tissues and organs. Adipose tissue may affect the incidence and progression of CKD by oxidative stress, inflammation, insulin resistance, plasma lipids and coagulation abnormalities, and endothelial dysfunction [4, 5].

Given the epidemic rates of both obesity and CKD, and that obesity in potentially reversible, the ability to identify risk factors for developing CKD is crucial. However, the best anthropometric index of obesity in predicting CKD is controversial [5], especially in elderly women [5, 6, 7]. Moreover, there are ethnic differences affecting relations between CKD and anthropometric parametres [4, 5], and the association between CKD and obesity indexes have not been evaluated in the Polish population.

This study was designed to determine the best anthropometric index of obesity in predicting CKD in a population of elderly women.

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MATERIALS AND METHOD

Study participants. The study included female subjects, aged 65 – 80, representing a population of women living in rural areas who reported for the screening for diabetes. The exclusion criteria were: neoplasma, NYHA class IV heart failure, severe liver damage, chronic inflammatory diseases, or other diseases affecting nutritional status. Excluded from the study were also subjects with altered TSH levels as well as those taking steroids. To verify chronicity, and thus to diagnose CKD, participants with eGFR < 60 ml/min were included to the study only if a second creatinine measurement, at least 3months before the first measurement, was available. All subjects gave written consent, and the studies were approved by the local Ethics Committee.

Basic data and biochemical measurements. Biochemical measurements, including blood glucose, lipid profile, and 2-h postprandial blood glucose, were performed. Blood was obtained after at least 10 h fasting. The following lipid parameters were measured by automated analysers: total cholesterol, high-density lipoprotein (HDL cholesterol) and triglycerides (TG). Low-density lipoprotein (LDL cholesterol) cholesterol was calculated using the Friedewald equation: LDL (mg/dl) = total cholesterol– HDL–(triglycerides/5). Smoking was defined as a history of smoking longer than two pack-years. Diabetes was defined as a history of treatment for diabetes or fasting glucose concentration ≥ 140 mg/dl or non-fasting glucose level ≥ 200 mg/dl [8]. Hypertension was defined as a history of hypertension that required antihypertensive therapy.

Glomerular filtration rate (GFR) estimation. GFR was estimated using the CKD-EPI equation [9]:

$$eGFR = 144 \times (0.993)^{Age} \times (Scr/0.7)^{-0.329}$$
(if serum creatinine ≤ 0.7 mg/dl)

$$eGFR = 144 \times (0.993)^{Age} \times (Scr/0.7)^{-1.209}$$
(if serum creatinine > 0.7 mg/dl)

where: Scr is serum creatinine (mg/dl),

CKD was defined as an eGFR < 60 ml/min per 1.73 m^2 [9].

Anthropometric measurements. Standard demographic information as well as anthropometric indexes of obesity, including body mass index (BMI), waist circumference (WC), waist-to-height ratio (WheiR) and waist-to-hip-ratio (WHR), were obtained in all participants. Height and weight were measured by professional health staff with the participants standing without shoes and heavy outer garments. BMI was calculated as weight divided by height squared (kg/m^2). Waist circumference was measured at the level midway between the lower rib margin and the iliac crest with participants in a standing position without heavy outer garments and with emptied pockets, breathing out gently. Hip circumference was recorded as the maximum circumference over the buttocks. WHR and WheiR were consequently calculated by dividing the WC by the hip circumference and the height, respectively. Anthropometric measurements were categorized as follows: BMI was expressed as normal (<25 kg/m^2), overweight (25 < 30 kg/m^2) and obese (>30 kg/m^2); central fat distribution was defined as a WHR ≥ 0.85; a WC > 80 cm; a WheiR > 0.5 [10].

Statistical analysis. Statistical analysis was carried out on an IBM PC using Statistica Version 10. Results were tested for normality by using the Kolmogorv-Smirnov test. When normally distributed, continuous variables were expressed as mean ± SD, and as median and range when non-normally distributed. Continuous data were compared using the Student t-test when normally distributed, and using Mann-Whitney U-test when non-normally distributed. Categorical data were expressed as frequencies and percentages and were compared using the $\chi 2$ test. Linear regression analysis was assessed using the Pearson correlation coefficient or Spearmans' rank correlation coefficient when appropriate. The area under the receiver operating characteristics curves (AUC) was to determine optimal cutoff points in predicting CKD. Multiple logistic regression analysis, with adjustment for age, was performed in order to establish the independent determinants of CKD. For all tests, a p-value <0.05 was considered statistically significant.

RESULTS

Of the total of 887 female initially identified, 148 subjects were not qualified due to exclusion criteria, and 9 participants with eGFR < 60 ml/min were excluded due to missing second creatinine measurements. The remaining 730 female subjects, aged 65–80 years (mean 71.4±4.98), entered the study.

Based on the eGFR calculated by CKD-EPI formula, the prevalence of CKD was 12.2%. The distribution of eGFR is shown in Figure 1.

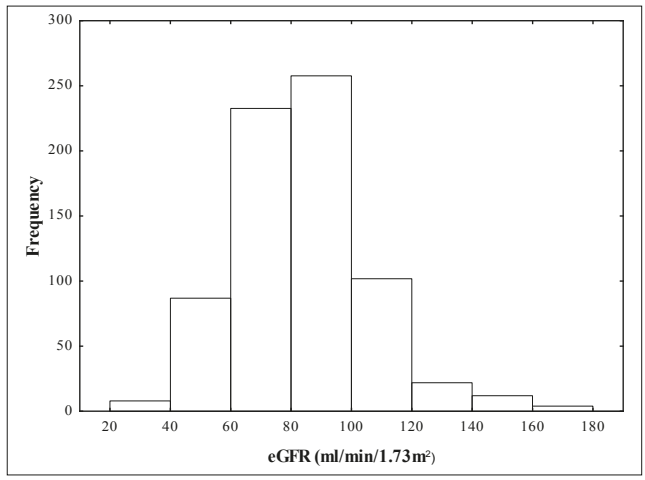


Figure 1. Distribution of eGFR

Baseline characteristics of all participants as well as split into two groups according to eGFR are shown in Table 1. Nearly 50% of the cohort were classified overweighr, and 36% were classified obese, whereas BMI was normal in 14.5% participants. Increased central fat distribution as defined by WheiR, WC and WHR was found in 89.6%, 91.7% and 89.4% individuals, respectively.

Participants with CKD were older (p<0.001), had higher prevalence of either diabetes or hypertension (p<0.001 in both cases), as well as smoking (p=0.011), lower HDL concentration (p<0.001), and higher TG level (p<0.001). The serum creatinine, part of CKD-EPI formula, was also higher in subjects with CKD (p<0.001). Participants with CKD also

Table 1. Baseline characteristics of all participants split into two groups according to eGFR

	All (n=730)	eGFR ≥ 60 (n=641)	eGFR < 60 (n=89)	p
Age (y)	71.4±4.98	70.5±4.72	74.84±5.00	<0.001
Diabetes (%)	20.1	18.8	30.30	<0.001
Hypertension (%)	39.6	36.8	59.6	<0.001
Smoking (%)	18.2	17.6	22.5	0.011
Systolic blood pressure (mmHg)	150.3±22.05	150.3±21.921	150.1±22.28	0.925
Diastolic blood pressure (mmHg)	83.67±10.47	83.91±10.57	81.92±9.37	0.124
Body mass index (kg/m^2)	30.64±5.26	30.42±5.28	32.43±4.80	0.001
Waist circumference (cm)	98.02±12.50	97.28±12.79	103.2±8.95	<0.001
Waist-to-hip ratio	0.870±0.085	0.869±0.088	0.878±0.055	0.009
Waist-to-height ratio	0.623±0.082	0.619±0.084	0.649±0.058	<0.001
Creatinine (mg/dl)	0.735±0.190	0.691±0.130	1.15±0.52	<0.001
eGFR (ml/min)	83.59±23.43	87.57±21.51	52.44±11.48	<0.001
Cholesterol (mg/dl)	214.9±49.21	215.1±48.76	211.6±49.62	0.536
LDL (mg/dl)	124.4±45.05	123.5±46.21	127.7±44.87	0.108
HDL (mg/d)	65.88±17.48	66.58±17.03	60.14±15.01	<0.001
Triglycerides (mg/dl)	127.7±65.11	125.9±63.89	141.3±67.03	<0.001

Table 2. Associations between risk factors and chronic kidney disese

	parameter	r	p
Chronic kidney disease	age	0.263	<0.001
	BMI	0.127	<0.001
	WC	0.175	<0.001
	WHR	0.102	0.009
	WheiR	0.182	<0.001
	HDL	– 0.086	0.021
	TG	0.079	0.034
	smoking	0.068	0.081
	diabetes	0.114	0.003
	hypertension	0.241	<0.001

BMI – body mass index; WC – waist circumference; WHR – waist-to-hip ratio; WheiR – Waist-to-height ratio; HDL – high-density lipoprotein cholesterol; TG – triglicerydes.

had higher values for BMI (p=0.001), WC (p<0.001), WHR (p=0.008), and WheiR (p<0.001).

Univariate linear regression analysis showed positive correlations between CKD and age (p<0.001), BMI (p<0.001), WC (p<0.001), WHR (p=0.007), WheiR (p<0.001), diabetes (p=0.002), as well as TG (p=0.031), and negative correlation between CKD and HDL concentration (p=0.017).

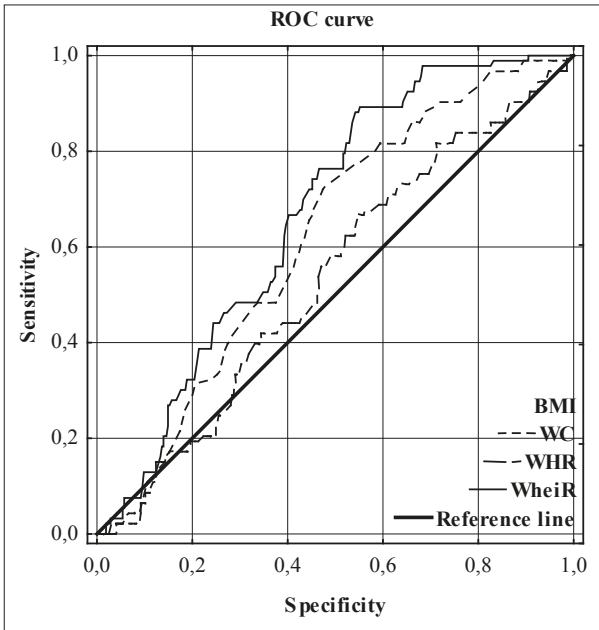
In order to indentify potential predictors of CKD, logistic regression analysis with adjustment for age was performed. Multivariable analysis demonstrated that hypertension, diabetes, WC and WheiR were were independent predictors of CKD (Table 3).

The AUC was best for WheiR (0.647), followed by WC (0.620), BMI (0.616), and WHR (0.532) (Fig. 2). The optimal cut-off values were 0.60 for WheiR, 34 for BMI,104 for WC, and 0.87 for WHR. At these cut-off points, the sensitivity and specificity were 68% and 60% for WheiR, 56% and 64% for WC, 51% and 61% for BMI, and 62% and 50% for WHR.

Table 3. Multivariable logistic regression analysis of association between chronic kidney disease and obesity indexes, as well as traditional risk factors with adjustment for age

	OR	95% CI	p
diabetes	2.1	1.64–2.82	<0.001
hypertension	2.3	1.70–3.04	<0.001
smoking	1.11	0.59–3.08	0.393
HDL	0.92	0.49–2.32	0.632
TG	1.07	0.74–2.03	0.173
BMI	1.19	0.61–2.97	0.103
WC	1.52	0.77–2.73	0.096
WHR	1.25	0.78–4.94	0.515
WheiR	1.38	0.89–1.74	0.003

Only baseline parameters with a p value <0.10 at the univariate analysis are shown.
OR – odds ratio; CI – confidence interval; BMI – body mass index; WC – waist circumference; WHR – waist-to-hip ratio, WheiR – Waist-to-height r atio; HDL – high-density lipoprotein cholesterol; TG – triglicerydes.



	area	95% CI	sens/spec (%)	cut-off
WheiR	0.647	0.598–0.690	0.6787/0.600	0.60
WC	0.620	0.581–0.676	0.558/0.642	104
BMI	0.616	0.535–0.692	0.514/0.607	34
WHR	0.532	0.475–0.623	0.622/0.498	0.87

ROC – receiver operating characteristic; WC – waist circumference; BMI – body mass index; WHR – waist-to-hip ratio; WheiR – waist-to-height ratio; CI – confidence interval; sens/spec – sensitivity/specificity.

Figure 2. ROC curve of anthropometric indexes in predicting chronic kidney disease

DISCUSSION

The presented study provides evidence that abdominal obesity is an important predictor of CKD. Of the commonly used anthropometric parameters of obesity, WheiR ≥ 0.6 is particularly associated with CKD in elderly females.

Growing evidence suggests that abdominal obesity is more strongly related to the presence and incidence of hypertension, diabetes, metabolic syndrome and cardiovascular disease mortality then peripheral fat [11, 12]. Although WC, WHR, WheiR and BMI are often highly correlated, BMI provide

data about entire body volume and mass, whereas WC and WHR, as well as WheiR, provide information about shape and fat distribution and are considered surrogate markers of central fat [5, 13, 14, 15, 16]. In the current study, WC and WheiR were independent predictors of CKD. This result is consistent with previous studies indicating that central fat is important risk factor for CKD [11, 15, 17, 18, 19]. Abdominal obesity may play a causal role in these associations by acting as an active endocrine organ. Central fat is associated with increased secretion of fatty acids, adipocytokines, hyperinsulinaemia, insulin resistance, hypertension, and atherogenic dyslipidemia [14, 20]. In CKD patients, abdominal fat has been associated with inflammation, insulin resistance, dyslipidemia, oxidative stress, coronary artery calcification, cardiovascular events, and moratlity [15, 18, 20].

A variety of methods can be used to assess abdominal obesity, including computed tomography, dual-energy X-ray absorptiometry, and magnetic resonance imaging. However, clinically, these techniques are not practical. Given the clinical importance of the relationship between obesity and CKD, identification of simple anthropometric surrogate measures of obesity that could be used as screening tools to identify individuals at risk for CKD development is crucial. Although WheiR, WC as well as WHR correlate well with computed tomography assessment of intraabdominal fat [16], the best anthropometric index of obesity in predicting CKD is still controversial. It should be emphasized, however, that anthropometric parameters do not accurately reflect body fat and these parameters must be considered only as a screening tool [18].

In the presented study, the ROC analysis proved that measurements of central obesity, especially WheiR, showed higher discriminative ability for CKD then BMI. The 'rank' order for AUC was WheiR > WC > WHR > BMI. Recently published papers showed that WheiR was a superior tool for discriminating obesity-related cardiometabolic risk, as well as cardiovascular disease, compared with WC, WHR and BMI [12, 16]; however, no data related to CKD. The current results are consistent with the results of Lin et al. [8] who showed that WheiR is particularly associated with CKD. Similarly, Tseng [21] found that WheiR was better associated with urinary albumin excretion than other anthropometric measures. However, both studie related to a Chineese population and it is well known that ethnic differences affect relations between CKD and anthropometric parametres [4, 5].

In this study, WheiR overperformed WC, WHR, as well as BMI in the detection of CKD. According to the authors' knowledge, the superiority of WheiR over other anthropometric measures in discriminating CKD risk have not been reported previously in a European population. The higher discriminative ability of WheiR at predicting CKD may probably result from the fact that WheiR has the advantage of better measurement of fat distribution in different ages and statures [22]. WC may over- or under-evaluate risk for tall or short individuals with similar WC [23]. The main limitation of the WHR is that both waist and hip can decrease with weight reduction and, as a consequence, changes in the ratio can frequently be small. Moreover, WHR increases in women with age which mostly reflects a reduction in fat deposits in the hips making this variable more difficult to interpret [7, 23]. Results of the presented study failed to find that BMI is an idependent factor predisposing to CKD. Studies using BMI to evaluate the risk of CKD development have conflicting results. Some studies found that BMI is a strong risk factor for CKD [5]. Others, however, have not revealed a relationship between BMI and CKD [18, 24], or the relationship was found in males but not in females [6]. The disagreement between these results may be due to the differences in race, age, gender, or study design. Moreover, BMI has well known limitations: it assesses entire body mass and does not distinguish between central and peripheral fat, between subcutaneous and visceral fat, nor between weight from muscle, bone, fat or oedema [5, 18].

According to the WHO guidelines [10], WheiR > 0.5 is the cut-off value characteristic for central fat distribution. In the current study it was found that WheiR value > 0.6 is associated with CKD. This is in agreement with the results of previous studies which also suggested that a value above 0.6 indicates a substantially increased risk for cardiovascular disease [25].

In conclusion, this study has demonstrated that central obesity is an important, independent, and potentially preventable predictor of CKD. WheiR ≥ 0.60 seems to be a simple and reliable anthropometric predictor of CKD in elderly femles.

Limitations of the study. The main limitations of the present study is that relations between anthropometric parameters and changes in renal function were not estimated in time. Further long-term studies are needed to demonstrate the relationship between anthropometric parameters and renal function decline. The second limitation was relatively low number of patients. It would be also of interest to evaluate if the reduction in WheiR will reduce the risk of the development of CKD.

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