http://dx.doi.org/10.1590/1678-98652016000200005

ORIGINAL | *ORIGINAL*

Anthropometric measurements and markers of renal function in adults and older adults

Indicadores antropométricos e marcadores de função renal em adultos e idosos

Victoria Araujo Ganzaroli AMADOR[1]
Ana Tereza Vaz de Sousa FREITAS[1]
Alessandra Vitorino NAGHETTINI[2]
Edna Regina Silva PEREIRA[3]
Maria do Rosário Gondim PEIXOTO[1]

ABSTRACT

Objective

To determine whether anthropometric indicators are associated with markers of renal function in adults and older adults.

Methods

This cross-sectional study included 279 adults and older adults attending eight primary healthcare units in eastern *Goiânia*, *Góias*. Sociodemographic, lifestyle, and clinical data were collected using a standard questionnaire. Body mass index was categorized as overweight (≥25 kg/m²) or non-overweight. Waist circumference was classified as normal or high; chronic kidney disease was defined as a glomerular filtration rate below 60 mL/minutes/1.73 m²; micro/macroalbuminuria was defined as an albumin/creatinine *ratio* above 30 mg/g. The association between anthropometric indicators and renal function markers was assessed by multiple linear regression analysis.

Results

Chronic kidney disease was present in 8.9% and micro/macroalbuminuria in 34.8% of the sample. The prevalence of overweight was 57.0%. Waist circumference and body mass index were positively associated with glomerular

[1] Universidade Federal de Goiás, Faculdade de Nutrição, Programa de Pós-Graduação em Nutrição e Saúde. R. 227, Qd. 68, s/n., Setor Leste Universitário, 74605-080, Goiânia, GO, Brasil. *Correspondência para*/Correspondence to: MRG PEIXOTO. E-mail: <mrg.peixoto@uol.com.br>.
[2] Universidade Federal de Goiás, Faculdade de Medicina, Departamento de Pediatria. Goiânia, GO, Brasil.
[3] Universidade Federal de Goiás, Faculdade de Medicina, Departamento de Nefrologia. Goiânia, GO, Brasil.

filtration rate, characterized as glomerular hyperfiltration. Microalbuminuria was positively associated with body mass index in women.

Conclusion

The prevalences of chronic kidney disease and overweight were high in the study population. Overweight was positively associated with glomerular filtration rate.

Keywords: Albuminuria. Glomerular filtration rate. Nutritional status. Obesity. Renal insuffiemcy, chronic.

RESUMO

Objetivo

Avaliar a associação entre indicadores antropométricos do estado nutricional e marcadores da função renal em adultos e idosos.

Métodos

Estudo transversal realizado com 279 adultos e idosos atendidos por oito Unidades de Atenção Básica à Saúde da Família da região Leste de Goiânia por meio de visitas domiciliares. Foram coletados dados socioeconômicos, de estilo de vida e clínicos. Para avaliação do estado nutricional foi considerado o índice de massa corporal, com classificação para excesso de peso (≥25 kg/m²) e sem excesso de peso; também foi avaliada a circunferência da cintura, caracterizada como aumentada ou normal. Para o diagnóstico de doença renal crônica foi considerada uma taxa de filtração glomerular <60 mL/minutos/1,73m² e para detecção de presença de albuminúria moderadamente/acentuadamente aumentada foi considerada a relação albumina/creatinina urinária >30 mg/g. A associação entre os indicadores antropométricos e marcadores da função renal foi avaliada com regressão linear múltipla.

Resultados

A prevalência de doença renal crônica foi de 8,9% e de albuminúria foi de 34,8%. O excesso de peso foi detectado em 57,0% da amostra. Houve associação positiva do índice de massa corporal e da circunferência da cintura com a taxa de filtração glomerular em ambos os sexos (p<0,01), enquanto a albuminúria apresentou associação positiva somente com o índice de massa corporal e apenas em mulheres (p=0,016).

Conclusão

A amostra apresentou alta prevalência de doença renal crônica e excesso de peso, sendo que os indicadores antropométricos apresentaram associação positiva com a taxa de filtração glomerular.

Palavras-chave: *Albuminúria. Taxa de filtração glomerular. Estado nutricional. Obesidade. Insuficiência renal crônica.*

INTRODUCTION

Chronic Kidney Disease (CKD) consists of renal lesion and progressive and irreversible loss of the endocrine, glomerular, and tubular kidney functions present for three months or more with various health implications[1]. Important clinical implications appear[2] when the glomerular filtration rate is below 60 mL/minutes/1.73 m².

In Brazil chronic kidney disease has an incidence of approximately 115 cases for every one million inhabitants, while its prevalence is roughly 500 cases in every one million inhabitants[3]. The increasing incidence and prevalence of CKD is directly associated with an increase in the main risk factors associated with its development and progression, such as excess weight, high blood pressure, diabetes, personal and family history of CKD, smoking, age higher than 60 years, low socioeconomic class, alcoholism, and physical inactivity[4-6].

Nutritional status assessment is important for the identification of nutritional status-related problems and/or inadequacies in any life stage since it directly or indirectly influences one's health prognosis[7]. Many studies have found that excess weight and abdominal fat are risk factors for

CKD[8-11]. Abdominal obesity, one of the components of the metabolic syndrome, dramatically increases the rates of metabolic, cardiovascular, and renal diseases globally[12].

Excess weight, characterized by an increase in Body Mass Index (BMI) or waist circumference, increases the number of adipocytes in the body, which increase oxidative stress and inflammatory status, which in turn many result in renal failure associated with overweight and obesity[13,14].

In addition to assessing nutritional status, one should also assess the main biochemical markers used for screening kidney disease. These markers include albuminuria and serum creatinine, used for estimating the glomerular filtration rate[2,15].

Since the initial stages of CKD are asymptomatic and CKD development and progression have numerous risk factors, epidemiological, clinical, and nutritional surveillance should be conducted by primary healthcare, whose critical role is to try to contain its growing incidence and mortality[2,3]. National data on the association between anthropometric indicators and markers of renal function, and on the prevalence of CKD in the population covered by the Family Health Strategy are scarce. Thus, this study aimed to assess the association between anthropometric indicators of nutritional status and markers of renal function in adults and older adults.

METHODS

This is a cross-sectional study originating from a parent project called "Mapping of chronic kidney disease and its risk factors in families covered by the Family Health Strategy of eastern *Goiânia*". The study was approved by the Human and Animal Medical Research Ethics Committee of the Clinics Hospital of the *Universidade Federal de Goiás* under Protocol nº CEPMHA/HC/UFG nº 170/09. The sample of the parent study represented the users of eight Family Health Strategy units in eastern *Goiânia*, who were interviewed at home. The households were selected randomly in the catchment area of each unit. The study included males and females living in the selected households aged ≥6 years covered by the Family Health Strategy. Individuals who could not walk or were hospitalized at the time of data collection were excluded.

The study sample consisted of 279 adults and older adults submitted to biochemical tests and anthropometric assessment. A *posteriori* calculation showed that the sample size (n=279) allowed estimating the prevalence of CKD in the study population with an error margin of 3.5%, considering an expected prevalence of 9.6% and confidence level of 95.0%. For the measures of association, the study[16] had a power of 90.0% (β=10.0%) and a confidence level of 95.0% (α=5.0%) for detecting significant correlations between the anthropometric indicators and outcomes ≥2.0.

Data were collected from September 2011 to March 2013 after conducting a pilot study with 10 families. Trained interviewers accompanied by community health agents used a standardized questionnaire to collect socioeconomic, demographic, lifestyle, anthropometric, and laboratory data in home interviews.

Socioeconomic class was classified as recommended by the *Critério Padrão de Classificação Economica Brasil* - 2008[17]. The socioeconomic classes were grouped because of the small sample size as follows: class A/B, class C, and class D/E; class A/B consists of individuals with the highest income and class D/E, of individuals with the lowest income.

The study lifestyle variables were smoking status and regular physical activity. For the variable 'regular physical activity', individuals who practiced more than 30 minutes of leisure-time physical activity at least three times a week were classified as 'yes'; the others were classified as 'no'[18]. Smoking status was classified as follows: smoker (smokes or quit smoking less than six months ago);

 http://dx.doi.org/10.1590/1678-98652016000200005

ex-smoker (quit smoking six or more months ago); and nonsmoker (never smoked)[19].

Weight, height, and waist circumference were collected using the standard procedures[20]. The individuals were weighed and measured barefoot, wearing light clothing, by the electronic scale Plenna (*São Paulo*, Brazil - capacity of 150 kg and accuracy of 100 g) and portable stadiometer Seca (*Cotia*, *São Paulo*, Brazil - accuracy of 0.1 cm). Waist circumference was measured by an inelastic tape measure (accuracy of 0.1 cm) at the midpoint between the anterior superior iliac crest and the last rib. BMI was calculated by dividing body weight by the square of the height.

Body mass index was classified into two categories only, non-overweight and overweight. Adults with BMI <25 kg/m² and older adults with BMI ≤27 kg/m² were considered non-overweight. Adults with BMI ≥25 kg/m² and older adults with BMI >27 kg/m² were considered overweight[21,22]. Waist circumference was classified as recommended by the World Health Organization[22]: women with Waist circumference >80 cm and men with waist circumference >94 cm are considered at higher risk of obesity-related metabolic complications.

The percentage of Body Fat (%BF) was given by the formula proposed by Deurenberg *et al.*[23]: %BF= (1.2 x BMI) + (0.23 x age) - (10.8 x sex) - 5.4, where BMI is measured in kg/m², age in years; and female sex = 0 and male sex = 1. The cut-off point for high %BF was 32% for females and 25% for males[24].

Blood pressure was measured by the semi-automatic devices Omron - HEM 705 CP (Omoron Health Care, *São Paulo*, Brazil), using the technique standardized by the VI Brazilian Guideline for Hypertension. Blood pressure was measured in both arms at the beginning of the interview and again in the arm with the higher value at the end of the interview. Both measurements were made by the same interviewer. The analyses used the mean of the baseline and final Blood pressure measurements. Individuals with casual systolic blood pressure ≥140 mmHg and/or casual diastolic blood pressure ≥90 mmHg were considered hypertensive[25].

Individuals with a diagnosis of diabetes, using antidiabetic drugs, or whose fasting blood glucose ≥126 were considered diabetic[26].

The markers of renal function were: serum creatinine (for calculating the Glomerular Filtration Rate [GFR] and determining hypercreatininemia), urinary creatinine, and urinary albumin (for calculating the albumin/creatinine *ratio*). Albumin and creatinine were quantified by the biochemical analyzer Konelab 30 (Thermo Fisher Scientific Inc., Wattham, Massachusetts, United States), albumin by the colorimetric method (bromocresol green) and creatinine by the kinetic method.

Glomerular filtration rate was calculated by the method proposed by Cockcroft & Gault[15], which includes the variables serum creatinine, weight, age, and sex. Any individual with a GFR <60 mL/minutes/1.73m² regardless of cause was considered CKD positive[1].

Microalbuminuria was defined as urinary albumin/creatinine *ratio* between 30 and 299 mg; macroalbuminuria was defined as urinary albumin/creatinine *ratio* ≥300 mg[1]. Individuals with micro- and macroalbuminuria were grouped together for data analysis because the number of individuals with macroalbuminuria was low (n=2). Hypercreatininemia was defined as serum creatinine >1.3 mg/dL[27].

The database was constructed in the software Microsoft Office Excel (Microsoft Corporation, Redmond, Washington, United States) version 2013, and the analyses were performed by the software Stata (Stata Corporation, College Station, Texas, United States) version 12.0. The Shapiro Wilk test determined whether the continuous variables had normal distribution, given by $p>0.05$. The continuous variables with normal distribution were expressed as mean ± standard deviation, and the other variables, as median and interquartile range (25th and 75th percentiles). The categorical variables were expressed as absolute and relative frequencies. The associations between the categorical variables were measured by the Chi-square test. The differences between the continuous variables were measured by the Student's *t* test or the Mann-Whitney test. Spearman's correlation coefficient determined whether BMI and waist circumference were correlated.

Multiple linear regressions assessed the independent effect of anthropometric indicators (BMI and waist circumference) on GFR and albuminuria (dependent variables) adjusted for age, mean diastolic and systolic blood pressure, and diabetes *Mellitus* status. The significance level was set at 5% ($p<0.05$). The dependent variables were transformed to a logarithmic scale to achieve normal distribution.

RESULTS

A total of 279 individuals were assessed, 70.9% females and 22.6% older adults. The prevalence of CKD, defined as a GFR ≤60 mL/minutes, was 8.9% in the population covered by the Family Health Strategy in east *Goiânia*. Micro- and macroalbuminuria were present in 34.8% of the sample.

Table 1 shows the general characteristics of the participants. The median age was 45 years and did not differ between the genders. The frequency of BMI-based overweight was 57%, which also did not differ between the genders. High waist circumference was more common in

Table 1. Sociodemographic and health characteristics of users of the Family Health Strategy in Eastern *Goiânia* (GO), Brazil, 2013.

Variable	Total n=279		Male n=81		Female n=198		p^*
	n	%	n	%	n	%	
Age (years)	45	33.0-59.0	47	35.0-61.0	44	32.0-57.0	0.176
Socioeconomic class							
A/B	89	32.9	28	35.4	61	31.9	0.855
C	145	53.7	41	51.9	104	54.5	
D/E	36	13.4	10	12.7	26	15.6	
Regular physical activity							
Yes	93	33.4	34	41.9	59	29.9	0.053
No	185	66.6	47	58.1	138	70.1	
Body mass index							
Non-overweight	120	43.0	38	46.9	82	41.4	0.400
Overweight	159	57.0	43	53.1	116	58.6	
Percentage of body fat							
Normal	87	31.2	30	37	57	28.8	0.177
High	192	68.8	51	63	141	71.2	
Waist circumference							
Normal	83.0	29.7	39.0	48.1	44.0	22.2	<0.001
High	196.0	70.3	42.0	51.9	154.0	77.8	
Systolic blood pressure (mmHg)	127.0	116.0-140.0	130.0	119.0-141.0	125.5	115.8-138.8	0.067
Diastolic blood pressure (mmHg)	78.0	72.0-86.0	77.0	72.5-86.0	78.0	72.0-86.0	0.554
High blood pressure	85.0	30.4	26.0	32.1	59.0	29.8	0.705
Smokers	44.0	15.8	16.0	19.7	28.0	14.1	0.243
Casual glycemia (mg/dL)	92.0	80.0-107.0	91.0	78.0-106.5	92.0	81.0-108.5	0.363
Diabetes	32.0	11.6	11.0	13.9	21.0	10.7	0.453
Serum creatinine (mg/dL)	0.7	0.6-0.8	0.9	0.7-1.1	0.7	0.6-0.8	<0.001
Hypercreatininemia	60.0	21.5	25.0	30.8	35.0	17.6	0.015
Urinary albumin (mg/dL)	13.0	8.0-22.1	13.9	7.0-23.3	13.0	8.1-21.8	0.710
Micro/macroalbuminuria	97.0	34.7	36.0	44.4	61.0	30.8	0.030
Glomerular filtration rate (mL/minutes)	99.2	79.0-122.0	102.5	74.5-124.0	98.7	81.0-121.0	0.772
Chronic kidney disease	25.0	8.9	15.0	7.5	10.0	12.3	0.205

Note: **p*-value of the Chi-square test (categorical variables) or Mann-Whitney test (continuous variables).
The continuous variables are presented as median and interquartile range (P_{25}-P_{75}); and the categorical variables as number (percentage). Chronic kidney disease defined as glomerular filtration rate <60 mL/minutes. The differences in absolute frequencies correspond to the missing values.

females ($p<0.001$). Waist circumference was highly correlated with BMI ($r=0.80$) in both genders.

Regarding the study chronic non-communicable diseases, 32 (11.6%) individuals were diabetic and 85 (30.4%) were hypertensive, with no differences between the genders. Males had higher median serum creatinine (0.93 mg/dL). The median urinary albumin was 13 mg/dL, with no differences between the genders. Hypercreatininemia was found in 60 (21.5%) individuals, mostly males ($p=0.015$).

Table 2 shows the clinical and lifestyle characteristics, and markers of renal function according to BMI. High waist circumference and

Table 2. Clinical and lifestyle characteristics, and markers of renal function according to the body mass index of users of the Family Health Strategy, eastern *Goiânia* (GO), Brazil, 2013.

Variable	Male					Female				
	Not overweight		Overweight		p^*	Not overweight		Overweight		p^*
	n	%	n	%		n	%	n	%	
Age (years)	57	30.0-64.0	45	38.0-55.0	0.252	41	26.0-56.0	46	36.0-57.0	0.054
Smoker	11	28.9	5	11.6	0.051	13	15.8	15	12.9	0.561
Regular physical activity	16	42.1	18	41.8	0.982	27	33.3	32	27.5	0.386
High WC	7	18.4	35	81.4	<0.001	42	51.2	112	96.5	<0.001
Median SBP (mmHg)	127	113.0-134.0	133	125.0-147.0	0.010	120	110.0-134.0	128	119.0-140.0	0.003
Median DBP (mmHg)	74	65.0-82.0	81	74.0-88.0	<0.001	77	68.0-82.0	82	74.0-88.0	<0.001
High blood pressure	8	21.1	18	41.8	0.045	18	21.9	41	35.3	0.042
Diabetes *Mellitus*	4	10.8	7	16.6	0.453	5	6.1	16	13.9	0.084
Serum creat. (mg/dL)	0.9	0.7-1.3	0.9	0.8-1.1	0.617	0.6	0.6-0.8	0.7	0.6-0.8	0.102
GFR (mL/min)	92	63.0-106.0	116	89.0-141.0	0.009	91	73.0-110.0	106	90.0-129.0	<0.001
Chronic kidney disease	7	18.4	3	6.9	0.118	9	10.9	6	5.17	0.128
ACR (mg/g)	22	14.0-52.5	18.5	10.5-35.5	0.009	15	10.0-25.7	20.5	13.0-33.5	<0.001
Micro/macroalbuminuria	17	44.7	19	44.1	0.960	20	24.3	41	35.3	0.105

Note: **p*-value in the Chi-square test (categorical variables) or Mann-Whitney test (continuous variables).
WC: Waist Circumference; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; Serum creat.: Serum Creatinine; GFR: Glomerular Filtration Rate; ACR: Urinary Albumin/Creatinine *Ratio*.

Table 3. Clinical and lifestyle characteristics, and markers of renal function according to the waist circumference of users of the Family Health Strategy, eastern *Goiânia* (GO), Brazil, 2013

Variable	Male (n=81)					Female (n=198)				
	Normal WC		High WC		p^*	Normal WC		High WC		p^*
	n	%	n	%		n	%	n	%	
Age (years)	47	30.0-63.0	47	38.0-57.0	0.830	32	22.0-44.0	47	36.0-61.0	<0.001
Smoker	8	20.5	8	19.1	0.869	7	16.0	21	13.6	0.703
Regular physical activity	13	33.3	21	50.0	0.129	13	30.2	46	29.8	0.963
Median SBP (mmHg)	127	114.0-134.0	133	122.0-145.0	0.030	118	111.0-129.0	127	118.0-140.0	0.004
Median DBP (mmHg)	75	70.0-82.0	81	74.0-88.0	0.016	75	68.0-81.0	80	73.0-87.0	0.007
High blood pressure	8	20.5	18	42.8	0.031	8	18.2	51	33.1	0.056
Diabetes *Mellitus*	3	7.8	8	19.5	0.136	2	4.5	19	12.5	0.133
Serum creatinine (mg/dL)	0.8	0.7-1.1	0.9	0.8-1.3	0.061	0.7	0.6-0.7	0.7	0.6-0.8	0.424
GFR (mL/min)	100	71.0-118.0	102	74.0-141.0	0.060	95	80.0-116.0	99	80.0-122.0	0.420
Chronic kidney disease	4	10.2	6	14.2	0.582	4	9.1	11	7.1	0.667
ACR (mg/g)	20	11.0-40.0	23	12.0-42.0	0.771	15	11.0-22.0	19	11.0-33.0	0.139
Micro/macroalbuminuria	15	38.4	21	50.0	0.296	8	18.2	53	34.4	0.040

Note: **p*-value in the Chi-square test (categorical variables) or Mann-Whitney test (continuous variables).
WC: Waist Circumference; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; DM: Diabetes *Mellitus*; GFR: Glomerular Filtration Rate; ACR: Urinary Albumin/Creatinine *Ratio*.

Table 4. Results of the multiple linear regression models that assess whether body mass index and waist circumference are associated with the markers of renal function. *Goiânia* (GO), Brazil, 2013.

Outcome	Male				
	β adjusted	SE	Adjusted R² (%)	β std.	*p*
Glomerular filtration rate					
Body mass index (kg/m²)	0.037	0.010	45	0.39	<0.001
Waist circumference (cm)	0.011	0.004	44	0.29	0.007
Mi/MaA					
Body mass index (kg/m²)	-0.004	0.02	7	-0.02	0.853
Waist circumference (cm)	-0.004	0.01	7	-0.05	0.642
	Female				
	β adjusted	SE	Adjusted R² (%)	β std.	*p*
Glomerular filtration rate					
Body mass index (kg/m²)	0.023	0.004	28	0.35	0.001
Waist circumference (cm)	0.009	0.002	26	0.35	<0.001
Mi/MaA					
Body mass index (kg/m²)	0.028	0.010	22	0.16	0.016
Waist circumference (cm)	0.008	0.005	21	0.13	0.070

Note: Linear regression results are expressed as β coefficient ± standard error and standardized β coefficient (standardized measure that verifies the effects of anthropometric parameters on glomerular filtration rate). Models adjusted for age, diabetes *Mellitus*, and systolic and diastolic blood pressure.
GFR: Glomerular Filtration Rate <60 mL/minutes; SE: Standard Error; Mi/MaA: Microalbuminuria or Macroalbuminuria.

GFR were more common in overweight than in non-overweight males ($p<0.05$). Similar results were found in females.

Table 3 shows the clinical and lifestyles characteristics, and markers of renal function according to waist circumference. The markers of renal function did not differ significantly in males. However, in females the frequency of micro- and macroalbuminuria was higher in those with high waist circumference ($p=0.04$).

The multiple linear regression model (Table 4) showed that for each 1 kg/m^2 increase in BMI, log GFR increased 0.037±0.01 mL/minutes in males ($p<0.001$) and 0.023±0.004 mL/minutes in females ($p=0.001$). For each 1 cm increase in waist circumference, log GFR increased 0.0011±0.37 mL/minutes in males ($p=0.007$) and 0.009±0.002 mL/minutes ($p<0.001$) in females.

Only body mass index was associated with albuminuria. For each 1 kg/m^2 increase in BMI, log albuminuria increased 0.028±0.01 mL/minutes in females ($p=0.016$).

DISCUSSION

Overweight based on BMI and abdominal obesity based on waist circumference were positively associated with GFR. Albuminuria was associated with high waist circumference only in females. Moreover, the study sample had a high prevalence of CKD (8.9%).

This prevalence is similar to those found in other Brazilian cities. In *Juiz de Fora* (MG) the prevalence of CKD in individuals aged more than 18 years was 9.6%[9], and in *São Paulo* (SP) the prevalence in adults was 8.4%[28].

The prevalence of CKD in the study sample was similar to the prevalences reported by foreign studies, such as two studies from Peking (China), which found prevalences of 9.4% in 2006[29] and 10.8% in 2012[30]. In Liege (Belgium) the prevalence of CKD was 9.8%[31]. However, some studies find higher prevalences of CKD, ranging from 15.3% in a community of ethnic minorities in China[32] to 21.8% in Iran[33]. Hence, the prevalence of CKD in the global population, especially in developing

http://dx.doi.org/10.1590/1678-98652016000200005

countries, is already a serious public health problem[12,28,33].

The 34.7% prevalence of micro- and macroalbuminuria in the study sample is similar to the 38.8% found in Tibet[34]. Smaller prevalences have been found in other locations, varying from 4.51 to 12.5%[28,30,33,35]. This difference between the prevalences can be explained by the fact that albuminuria increases gradually according to age and many studies did not include older adults. Król *et al.*[36] found that the prevalence of albuminuria increased from 8.8% in younger individuals to 32.0% in older adults, pointing out the influence of age. Brown *et al.*[37] reported that the prevalences of albuminuria increase when family members of CKD patients are included in a study since family history has a direct influence on kidney disease.

The present study collected data from individuals belonging to the same family and many already had CKD (8.9% of the sample), justifying the high prevalence of albuminuria. Boer *et al.*[38] believe that the prevalence of microalbuminuria can vary greatly if two consecutive albuminuria tests are not performed.

The present study found a frequency of hypercreatininemia of 21.5%. On the other hand, two other studies conducted in Brazil, one in *Salvado*r (BA)[27] and another in *Bambuí* (MG)[39] reported hypercreatininemia prevalences of 3.1 and 5.1%, respectively. These differences may be explained by the different serum creatinine cut-off points used by the three studies - the present study used a cut-off point of 1.3 mg/dL. Additionally, antihypertensive drugs and higher age increase creatinine levels in males[27,40,41].

Excess weight is considered a risk factor for the onset of CKD, and its prevalence has increased significantly in all continents[3]. The frequency found by this study was similar to those reported by other studies[41-43].

In this study excess weight based on BMI and central obesity based on waist circumference were positively associated with high GFR. Other studies found similar results[41,43-45].

Excess weight increases sodium retention in renal tubules, reducing sodium excretion in the urine. To reduce the effects of retention in the short run, the body expands the intravascular volume, increases blood pressure and plasma flow in the kidneys, and increases the GFR, resulting in glomerular hyperfiltration, which reinforces the positive association between anthropometric indicators and GFR. However, as this scenario persists in the long run, microalbuminuria would develop followed by a decrease in GFR[46].

Higher body weight may increase angiotensinogen expression in adipocytes, with greater formation of circulating angiotensin II and consequently, more lipogenesis. This mechanism changes blood pressure homeostasis, which may also change glomerular homeostasis[47].

Obesity also affects the structure of the renal medulla because adipose tissue on the renal capsule, which is more developed in overweight individuals, may penetrate the renal medulla and compress the glomerular and tubular filtration systems, leading to higher blood pressure to compensate nephron compression, which in turn increases GFR and consequently, causes hyperfiltration and higher tubular reabsorption of sodium[48].

The current study used the formula for estimating the glomerular filtration rate proposed by Cockcroft & Gault[15], but this formula is known for not taking into account the low excretion of creatinine in obese individuals, resulting in an overestimation of the GFR of individuals with BMI >25 kg/m² [49]. In Brazil Napoli-Filho *et al*.[41] found that renal function estimated by the formula of Cockcroft-Gault was overestimated by 8.0% in individuals with BMI between 25 and 30 kg/m² and by as much as 29.6% in individuals with grade III obesity.

Regarding the association between anthropometric indicators and albuminuria, only BMI was associated with albuminuria, and this association occurred only in females, a finding also reported by Thoenes *et al.*[50].

Boer *et al.*[38] found that BMI and waist circumference were associated with a greater likelihood of albuminuria. Clinical studies suggest that adiponectin can have a key role in the development of obesity-related albuminuria[51]. Moreover, high leptin secretion in individuals with abdominal obesity is one of the mechanisms associated with the development of albuminuria. The development of CKD varies between males and females, and Franceschini *et al*.[14] found that central obesity in menopausal women is associated with the risk of CKD development and progression, even in women with normal BMI. This study did not investigate albuminuria.

The cross-sectional design of the present study does not allow identifying what occurs between exposure and outcome. Other limitations include the small number of older adults in the sample and the instrument used for assessing the level of physical activity: although widely used, it is limited because of its lack of quantitative accuracy.

The high prevalence of CKD found by this population-based study reinforces the need of primary healthcare to identify and control early on the risk factors for CKD. The anthropometric indicators emphasize the importance of intensifying the strategies that prevent increases in BMI and waist circumference in adults and older adults.

CONCLUSION

The study sample had a high prevalence of chronic kidney disease and excess weight. The anthropometric indicators body mass index and waist circumference were positively associated with glomerular filtration rate in both genders.

CONTRIBUTORS

VAG AMADOR, AV NAGHETTINI, and ERS PEREIRA participated in data collection and analysis, literature search, and article writing. ATVS FREITAS participated in literature search and article writing. MRG PEIXOTO participated in data analysis, literature search, and article writing.

REFERENCES

1. Kidney Disease Improving Global Outcomes CKD Work Group. KDIGO 2012 clinical practice guideline for the evaluation and management of chronic kidney disease. Kidney Int Suppl. 2013; 3(1):1-150.
2. Kwon KS, Bang H, Bomback AS, Koh DH, Yum JH, Lee JH, *et al*. A simple prediction score for kidney disease in the Korean population. Nephrology. 2012; 17(3):278-84. https://dx.doi.org/10.1111/j.1440-1797.2011.01552.x
3. Jha V, Garcia-Garcia G, Iseki K, Li Z, Naicker S, Plattner B, *et al*. Chronic kidney disease: Global dimension and perspectives. Lancet. 2013; 382(9888):260-72. https://dx.doi.org/10.1016/S0140-6736(13)60687.x
4. Cabrera SS. Definición y classificación de lós estádios de La enfermedad renal crónica: prevalência, claves para el diagnóstico precoz, factores de riesgo de enfermedad renal crónica. Nefrologia. 2004; 24(6):27-34.
5. Dummer CD, Thomé FS, Veronese FV. Doença renal crônica, inflamação e aterosclerose: novos conceitos de um velho problema. Rev Assoc Med Bras. 2007; 53(5):446-50.
6. Levey AS, Coresh J. Chronic kidney disease. Lancet. 2012; 379(1):165-80. https://dx.doi.org/10.1016/S0140-6736(11)60178-5
7. Martins KA, Monego ET, Paulinelli RR, Freitas-Junior R. Comparação de métodos de avaliação da gordura corporal total e sua distribuição. Rev Bras Epidemiol. 2011; 14(4):677-87.
8. França AKT, Santos AM, Calado IL, Santos EM, Cabral PC, Salgado JVL, *et al*. Filtração glomerular e fatores associados em hipertensos atendidos na atenção básica. Arq Bras Cardiol. 2009; 94(6):779-87.
9. Bastos RMR, Bastos MG, Ribeiro LC, Bastos RV, Teixeira MTB. Prevalência da doença renal crônica nos estágios 3, 4 e 5 em adultos. Rev Assoc Med Bras. 2009; 55(1):40-4.
10. Ejerblad E, Fored M, Lindblad P, Fryzek J, McLaughlin JK, Nyre O. Obesity and risk for chronic renal failure. J Am Soc Nephrol. 2006; 17(6):1695-702. https://dx.doi.org/10.1681/ASN.2005060638
11. Ferraz FHRP, Martins CGB, Cavalcanti JC, Oliveira FL, Quirino RM, Chicon R, *et al*. Perfil das doenças glomerulares em um hospital público do Distrito Federal. J Bras Nefrol. 2010; 32(3):249-56.

12. Huda MN, Alam KS, Rashid HU. Prevalence of chronic kidney disease and its association with risk factors in disavantageous population. Int J Nephrol. 2012; 12(1):1-7. https://dx.doi.org/10.1155/2012/267329

13. Ruster C, Wolf G. Adipokines promote chronic kidney disease. Nephrol Dial Transplant. 2013; 28(Suppl. 4):iv8-14. https://dx.doi.org/10.1093/ndt/gft191

14. Franceschini N, Gouskova NA, Reiner AP, Bostom A, Howard BV, Pettinger M, *et al*. Adiposity patterns and the risk for ESRD in postmenopausal women. Clin J Am Soc Nephrol. 2014; 10(2):1-10. https://dx.doi.org/10.2215/CJN.02860314

15. Cockcroft DW, Gault MH. Prediction of creatinine clearance from serum creatinine. Nephron. 1976; 16(1):31-41.

16. Hulley SP, Cummings SR. Designing Clinical research an epidemiologic approach. Baltimore: Williams & Wilkin; 1988.

17. Associação Brasileira dos Institutos de Pesquisa de Mercado. Critério padrão de classificação econômica Brasil-2008. Rio de Janeiro: Abep; 2007.

18. Organização Mundial de Saúde. Estratégia global em alimentação saudável, atividade física e saúde. Brasília: OMS; 2004.

19. Organización Panamericana de la Salud. Protocolo y directrices: conjunto de ações para la reducción multifactorial de enfermedades no transmisibles (CARMEN/CINDI). Washington (DC): OPAS; 1997.

20. Lohman TG, Roche AF, Martorell R. Antropometric standardization reference manual. Champaign (IL): Human Kinetics; 1988.

21. Lipschitz DA. Screening for nutritional status in elderly. Prim Care. 1994; 21(1):55-67.

22. World Health Organization. Obesity: Preventing and managing the global epidemic. Technical Report Series, nº 894. Geneva: WHO; 2000.

23. Deurenberg P, Weststrate JA, Seidell JC. Body mass index as a measure of body fatness: Age- and sex-specific prediction formulas. Br J Nutr. 1991; 65(2):105-14.

24. Lohman TG. Advances in body composition assessment. Champaign (IL): Human Kinectis Publishers; 1992.

25. Sociedade Brasileira de Cardiologia, Sociedade Brasileira de Hipertensão, Sociedade Brasileira de Nefrologia. VI Diretrizes Brasileiras de Hipertensão. Arq Bras Cardiol. 2010; 95(1):1-51.

26. Sociedade Brasileira de Diabetes. Diretrizes da Sociedade Brasileira de Diabetes 2013/2014. São Paulo: AC Farmacêutica; 2014.

27. Lessa I. Níveis séricos de creatinine: hipercreatininemia em segmento da população adulta de Salvador. Rev Bras Epidem. 2004; 7(2):176-86.

28. Lima AO, Kesrouani S, Gomes A, Cruz J, Mastroianni-Kirstajn G. Population screening for chronic kidney disease: A survey involving. Nephrol Dial Transplant. 2012; 27(Suppl. 3):35-8. https://dx.doi.org/10.1093/ndt/gfs063

29. Zhang LX, Topley N, Ito T. Interleukin-6 regulation of transforming grown factor (TGF)-beta receptor compartmentalization and turnover enhances TGF-beta 1 signaling. J Biol Chem. 2005; 280(13): 12239-45.

30. Zhang LX, Wang F, Wang L, Wang W, Liu J, Chen M, *et al*. Prevalence of chronic kidney disease in China: A cross-sectional survey. Lancet. 2012; 379(9818):815-22.

31. Delanaye P, Cavalier E, Moranne O, Lutteri L, Krzesinski JM, Bruyere O. Creatinine-or cystatin C-based equations to estimate glomerular filtration in the general population: Impact on the epidemiology of chronic kidney disease. BMC Nephrol. 2013; 14(57):2-10.

32. Tohidi M, Hasheminia M, Mohebi R, Khalili D, Hosseinpanah F, Yazdani B, *et al*. Incidence of chronic kidney disease and its risk factors, results of over 10 year follow up in an Iranian cohort. PLoS One. 2012; 7(9):e45304. https://dx.doi.org/10.1371/journal.pone.0045304

33. Xue C, Ye XD, Li W, Peng Q, Ding HY, Zhang YH, *et al*. Prevalence of chronic kidney disease in Jing adults in China: A village-based study. Clin Nephrol. 2013; 79(1):50-6. https://dx.doi.org/10.5414/CN107511

34. Chen W, Liu Q, Wang H, Chen W, Johnson RJ, Dong X, *et al*. Prevalence and risk factors of chronic kidney disease: A population study in the Tibetan population. Nephrol Dial Transplant. 2011; 26(5):1592-99. https://dx.doi.org/10.1093/ndt/gfq608

35. Shan Y, Zhang Q, Liu Z, Hu X, Liu D. Prevalence and risk factors associated with chronic kidney disease in adults over 40 years: A population study from Central China. Nephrology. 2010; 15(1):354-61.

36. Król E, Rutkowski B, Czarniak P. Early detection of chronic kidney disease: Results of the PolNef study. Am J Nephrol. 2009; 29(3):264-73.

37. Brown WW, Peters RM, Ohmit SE. Early detection of kidney disease in community settings: The Kidney Early Evaluation Program (KEEP). Am J Kidney Dis. 2003; 42(1):22-35.

38. Boer IH, Katz R, Fried LF, Luchsinger J, Sarnak M, Shlipak MG, *et al*. Obesity and change in estimated GFR among older adults. Am J Kidney Dis. 2009; 54(6):1043-51. https://dx.doi.org/10.1053/j.ajkd.2009.07.018

39. Passos VMA, Barreto SM, Lima-Costa MFF. Detection of renal disfunction based on sérum creatinine levels in a Brazilian community: The Bambui Health and Ageing Study. Bras J Med Biol Res. 2003; 17(11):3135-44.

40. Culleton BF, Larson MG, Evans JC, Wilson PW, Barret BJ, Parfrey PS, *et al*. Prevalence and correlates of elevated serum creatinine levels: The Framinghan Heart Study. Arch Int Med. 1999; 159(5):1785-90.

41. Napoli-Filho M, Burnmeister JE, Miltersteiner DR, Campos BM, Costa MG. Estimativa da função renal pela fórmula de Cockcroft e Gault em pacientes com sobrepeso ou com obesidade. J Bras Nefrol. 2008; 30(3):185-91.

42. Ramkumar N, Cheung AK, Pappas LM, Roberts WL, Beddhu S. Association of Obesity with Inflammation in Chronic Kidney Disease: A cross-sectional study. J Ren Nutr. 2004; 14(4):201-7.

43. Kao YM, Chen JD. Inverse association between body mass index and chronic kidney disease in older diabetic adults. Ann Epidemiol. 2013; 23:255-9. https://dx.doi.org/10.1016/j.annepidem.2013.03.005

44. Gerchman F, Tong J, Utzschneider K, Zraika S, Udayasankar J, McNeely MJ. BMI is associated with increased creatinine clearance by a mechanism independent of body fat distribution. J Clin Endocrinol Metab. 2009; 94(10):3781-88.

45. Kalantar-Zadeh K, Abbott KC, Salahudeen AK, Kilpatrick RD, Horwich TB. Survival advantages of obesity in dyalisis patients. Am J Clin Nutr. 2005; 81:543-54.

46. Gross JL, Azevedo MJ, Silverio SP, Canani LH, Caramori ML, Zelmanovitz T. Diabetic nephropathy: Diagnosis, prevention and treatment. Diabetes Care. 2005; 28(1):164-76.

47. Kim S, Soltani-Bejnood M, Quignard-Boulange A, Massiera F, Teboul M, Ailhaud G, *et al*. The adipose renin-angiotensin modulates systemic markers of insulin sensitivity and activates the intrarenal renin-angiotensin system. J Biomed Biotechnol. 2006; 20(5):212-17.

48. Chagnac A, Weinstein T, Herman M, Hirsh J, Gafter U, Ori Y. The effects of weight loss on renal function in patients with severe obesity. J Am Soc Nephrol. 2003; 14:1480-86. https://dx.doi.org/10.1097/01.ASN.0000068462.38661.89

49. Gabriel IC, Nishida SK, Mastroianni-Kirsztajn G. Cistatina C sérica: uma alternativa prática para avaliação de função renal? J Bras Nefrol. 2011; 33(2):261-7.

50. Thoenes M, Reil JC, Khan BV, Bramlage P, Volpe M, Kirch W, *et al*. Abdominal obesity is associated with microalbuminuria and an elevated cardiovascular risk profile in patients with hypertension. Vasc Health Risk Manag. 2009; 5(4):577-85.

51. Sharma K. The linkbetween obesity and albuminuria: Adiponectin and podocyte dysfunction. Kidney Int Suppl. 2009; 76(2):145-8. https://dx.doi.org/10.1038/ki.2009.137

Received: January 10, 2015
Final version: September 14, 2015
Approved: October 7, 2015