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Evaluation of body composition and biochemistry of patients with chronic kidney disease undergoing non-dialysis treatment

Avaliação da composição corporal e bioquímica de pacientes com doença renal crônica em tratamento não dialítico

Resumo

Introduction. The study evaluated the body composition and biochemical tests of patients with chronic kidney disease (CKD) undergoing non-dialysis treatment. ***Method***. Cross-sectional study including patients with CKD stages 3 to 5, older than 60 years (n=138). Body Mass Index (BMI), calf (CC), brachial (BC), brachial muscle (BMC), and waist circumferences (WC) and triceps skinfold thickness (TST) were evaluated. Through bioimpedance, it was obtained: lean tissue mass (LTM), LTM index, body cell mass (BCM), adipose tissue mass (ATM), ATM index, fat percentage, total body water (TBW), extracellular water (ECW) and intracellular water (ICW). Biochemical tests, such as blood glucose, lipid profile, uric acid, urea, creatinine, vitamin D, and minerals were evaluated. Descriptive analysis was performed according to sex and compared using Student's t, Mann-Whitney, and chi-square tests. Simple linear regression was performed to predict body composition and biochemical tests, according to glomerular filtration rate (GFR), adjusted for sex and age. ***Results***. The prevalence of overweight was 70.4% in females and 53.7% in males. The percentage of fat was high in 90.7% of women and 91.7% of men. On the other hand, muscle mass depletion had a prevalence of 35.2% and 30.0%, respectively. Men presented higher values of BMC, BCM, LTM, LTM index, TBW, ECW and ICW. Women, presented higher values of BMI, PCT, body fat, ATM and ATM index. GFR correlated with serum urea (^{r2} = 0.279), potassium (r^2 = 0.018) and HDL (r^2 = 0.202). ***Conclusion***. High prevalence of changes in body composition and biochemical tests were identified in patients with CKD undergoing non-dialysis treatment.

Keywords: Renal Insufficiency Chronic. Body Composition. Nutritional Status. Anthropometry.

Resumo

Introdução. O estudo avaliou a composição corporal e exames bioquímicos de pacientes com doença renal crônica (DRC) em tratamento não dialítico. ***Método***. Estudo transversal incluindo pacientes com DRC nos estágios 3 a 5, maiores de 60 anos (n=138). Avaliaram-se índice de massa corporal (IMC), circunferências da panturrilha (CP), braquial (CB), muscular braquial (CMB), cintura (CC) e prega cutânea tricipital (PCT). Por meio de bioimpedância, foram obtidos: tecido de massa magra (LTM), índice de LTM, massa celular corporal (BCM), massa de tecido adiposo (ATM), índice de ATM, percentual de gordura, água corporal total (TBW), extracelular (ECW) e intracelular (ICW). Exames bioquímicos, como glicemia, lipidograma, ácido úrico, ureia, creatinina, vitamina D e minerais foram avaliados. A análise descritiva foi realizada de acordo com o sexo e comparadas pelos testes *t* de Student, Mann-Whitney e qui-quadrado. Realizaram-se regressão linear simples para previsão da composição corporal e exames bioquímicos de acordo com a taxa de filtração glomerular (TFG), ajustada por sexo e idade. ***Resultados***: A prevalência de sobrepeso foi de 70,4% no sexo feminino e de 53,7% no sexo masculino. O percentual de gordura foi elevado em 90,7% das mulheres e 91,7% dos homens. Já a depleção de massa muscular teve prevalência de 35,2% e 30,0%, respectivamente. Os homens apresentaram maiores valores de CMB, BCM, LTM, índice de LTM, TBW, ECW e ICW. Já as mulheres, de IMC, PCT, gordura corporal, ATM e índice de ATM. A TFG apresentou correlação com ureia sérica (r2 = 0,279), potássio (r2 = 0,018) e HDL (r2 = 0,202). ***Conclusão***: Foram identificadas elevadas prevalências de alterações na composição corporal e exames bioquímicos em portadores de DRC em tratamento não dialítico.

Palavras-chave: Doença Renal Crônica. Composição Corporal. Estado Nutricional. Antropometria.

INTRODUÇÃO

The prevalence of chronic kidney disease (CKD) has been increasing in many countries, becoming an important public health challenge. An overall prevalence of 11% to 13% is estimated considering all stages.[1]

Chronic Kidney Disease is defined as progressive and irreversible abnormalities in the structure or function of the kidneys, present for more than three months,[2] which affect multiple metabolic pathways, causing alterations in protein and energy homeostasis, abnormal protein catabolism, acid-based disturbances, and hormonal dysfunctions.

The disease is classified into stages, based on glomerular filtration rate (GFR) and albuminuria, namely: Stage1: normal or high (GFR 90 mL/min/1.73 m^2); Stage 2: slightly decreased (GFR between 60 to 89 mL/min/1.73 m^2); Stage 3A: slightly to moderately decreased (GFR between 45 to 59 mL/min/1.73 m^2); Stage 3B: moderately to severely decreased (GFR between 30 to 44 mL/min/1.73 m^2); Stage 4: severely decreased (GFR between 15 to 29 mL/min/1.73 m^2); Stage 5: renal failure: (GFR < 15 mL/min/1.73 m^2).[2]

As the disease progresses, the accumulation of nitrogen-containing products from dietary and intrinsic protein catabolism can alter taste, smell, and appetite. Furthermore, loss of fat and muscle mass may develop as renal failure progresses and may be exacerbated by coexisting clinical conditions, particularly in the elderly, who are most affected.[3]

Thus, the disease predisposes to changes in body composition and functional capacity.[4] Excess body fat, as well as muscle mass depletion, has been consistently associated with a worse prognosis, lower quality of life, higher risk of hospitalization, and mortality in patients with CKD.[5] Moreover, there is evidence that a worse nutritional condition at the beginning of dialysis treatment contributes to a lower survival rate and greater complications.[6]

Therefore, the assessment of body composition and biochemical tests are essential in the follow-up of patients with CKD[5] and contributes to the adequacy of nutritional status, as well as to the control of other complications, such as electrolyte and acid-base imbalances, uremia, retention of water and sodium, mineral and bone disorders, helping to slow the progression of the disease and delay the start of replacement therapy.[3]

The main of this study was to evaluate body composition and biochemical tests of patients with CKD undergoing non-dialysis treatment and to identify the influence of GFR on these parameters.

METHODS

Epidemiological study, with a cross-sectional design, whose sample consisted of elderly patients with CKD undergoing conservative treatment, of both sexes, monitored at the State Center of Specialized Care (SCSC) of the Minas Gerais Institute of Education and Research in Nephrology Foundation (IMEPEN Foundation). The institute is a referral center and covers the population residing in 37 municipalities that are part of the Zona da Mata region of Minas Gerais.

To calculate the sample, the population residing in the cities covered by the service,[7] the prevalence of the disease in stages 3 to 5 (10.6%),[1] 2% of standard error, 99% of confidence level, and 20% of losses were considered, totaling a minimum sample of 120 individuals. The sample size was calculated using the Epi Info™ software.

The inclusion criteria were patients with CKD in stages 3 to 5, monitored at the SCSC, age greater than or equal to 60 years, and not being the first appointment at the service. The exclusion criteria were presence of hypermetabolic diseases, amputation of a limb, being in a wheelchair, and/or using a pacemaker. Participants who met the inclusion criteria were randomly selected from the appointment schedule. Subsequently, through telephone contact, an active search, awareness, and explanation of the project, and evaluation schedules were carried out.

In accordance with ethical issues, the study was approved by the Research Ethics Committee on Human Beings of Federal University of Juiz de Fora (n 1.323.441 - CAAE: 48067815.2.0000.5260). Participants were asked to sign a Free and Informed Consent Form.

Initially, the participants answered a questionnaire containing information about the presence of illness and practice of physical activity, considering as physically active those who reported at least 150 minutes of weekly practice.[8]

The weight was measured using the Tanita Ironman™ scale (model BC-553; Tanita Corporation, Japan). For height, an Alturexata® stadiometer (Alturexata, Brazil) was used. The body mass index (BMI) was calculated and classified according to Lipschitz,[9] as recommended by the Brazilian Ministry of Health.[10]

Calf circumference (CC) was measured with the participant seated, flexed knee at a 90º angle, in the area of greatest diameter of the left calf. Values lower than 31 cm were classified as muscle mass depletion.[11] Brachial circumference (BC) was measured on the left arm, at the midpoint between acromion and olecranon. To assess suitability, Frisancho's recommendations were considered.[12] The triceps skinfold thickness (TST), was measured on the posterior midline on the left arm, between the acromion and the olecranon, in triplicate, and the simple arithmetic mean between the two closest values were considered. Subsequently, the brachial muscle circumference (BMC) was calculated using the equation of Harrison et al.[13] The adequacy of BC, TST, and BCM were determined according to Frisancho.[12]

Waist circumference (WC) was measured around the lesser curvature and the values found were classified according to the World Health Organization (OMS)[14].

To assess body composition, the tetrapolar bioimpedance Body Composition Monitor™ (model BCM; Fresenius Medical Care) was used. The following data were obtained: lean tissue mass (LTM), which consists of body mass without adipose tissue and excess extracellular water; LTM Index, which is calculated by quotient between LTM/height^2; body cell mass (BCM), which represents the metabolically active cell mass, excluding the extracellular fluid of that tissue; adipose tissue mass (ATM), which is the mass of body lipids including the water content of the adipose tissue; ATM Index, calculated by quotient between ATM/height^2; body fat percentage; total body water (TBW); extracellular water (ECW), which includes interstitial water, plasma water, and extracellular water; intracellular water (ICW), and the ratio between extracellular and intracellular water (E/I). Hypervolemia is defined as the excess of liquid stored, almost exclusively, in the extracellular volume, and for its classification, values above the 90th percentile are considered, that is, values greater than 1 liter for men and women.[15] The results obtained were classified according to the manufacture's recommendations.[15] The percentage of body fat (% BF) was classified according to Lohman.[16]

Prior to the bioimpedance test, the participants were instructed to fast for eight hours, do not practice physical activities, do not consume alcohol and food containing caffeine in the 12 hours before the test, wear light clothing, and remove metal objects at the time of the assessment.

To obtain the biochemical data, the medical records of the participants were consulted, in order to obtain the results of tests previously requested by the responsible physicians. Tests that do not exceed 60 days were selected. Fasting glucose, glycated hemoglobin (HbA1C), total cholesterol (TC), high-density lipoprotein cholesterol (HDL-c), low-density lipoprotein cholesterol (LDL-c), triglycerides, uric acid, urea, creatinine, vitamin D, and the minerals calcium, phosphorus, sodium and potassium were evaluated. The tests were classified according to the reference values.[17] For the classification of blood glucose, the specific reference values for diabetics and non-diabetics were considered. As there is no consensus on the lipid profile target values to be achieved in patients with CKD, the lipid profile values of this study were evaluated based on the update made in 2017, of the Brazilian Dyslipidemia and Atherosclerosis Prevention Guideline.[18]

From the creatinine test, the GFR was calculated using the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI)[19] equation and classified into stages according to KDIGO (2017).[20]

A team duly trained by a senior researcher collected all data in a single assessment and individually.

For the statistical evaluation, exploratory analyzes were carried out first, in order to verify the integrity and coherence of the data. Quantitative variables were evaluated for the presence of outliers and the type of distribution using the Kolmogorov-Smirnov test. Descriptive analysis of the sample was perfomed according to sex. Continuous variables with normal distribution were represented by mean ±, standard deviation, and compared using t Student's test; nonparametric variables were described with median values and interquartile ranges, and the Mann-Whitney test was performed; categorical variables were presented with absolute and relative frequencies, and compared using Pearson's qui-square test. Simple linear regression analysis was performed to predict body composition and biochemical tests, according to GFR, adjusted for sex and age. For these analyses, nonparametric variables were logarithmically transformed.

The SPSS version 20 software was used. The significance level adopted was 5%.

RESULTS

The sample consisted of 138 individuals, of whom 60.87% were male, median age of 73.03 ± 7.81 years. Regarding CKD staging, 15.3% were classified as stage 3, the majority (51.8%) was in stage 3B, 27.0% in stage 4, and only 5.8% in stage 5. Furthermore, 87.0% presented high blood pressure, and 50.7% presented diabetes.

According to BMI, there was a high percentage of individuals overweight (60.3%); whom 70.4% were female and 53.7% male. The prevalence of underweight was 9.5% (5.6% of women and 12.0% of men). It is noteworthy that 87% of women and 60.7% of men presented high WC, and that 90.7% of women and 91.7% of men presented fat percentage higher than the recommendations. Despite the prevalence of overweight and excess body fat, the percentage of women and men with muscle mass depletion, according to the LTM Index was 35.2% and 30.0%, respectively. Moreover, 36.2% of women were hypo hydrated and 39.3% of the men were considered to be hyper hydrated ($p = 0.003$).

Regarding the biochemical tests, it is noteworthy that 40.7% and 58.3% of females and males, respectively, presented low HDL-c. Glycated hemoglobin was elevated in 75.9% of women and 69.0% of men. Uric acid, on the other hand, presented values higher than the recommendations in 79.6% of women and 69.0% of men. Among minerals, 31.5% of women and 44.0% of men presented high values (Table 1).

Table 1. Anthropometric assessment, body composition, and biochemical tests of patients with chronic kidney disease undergoing conservative treatment according to sex, Juiz de Fora, Minas Gerais, 2020.

Variable		Sex Female	SexMale	Total	p
BMI	Underweight	3 (5.6)	10 (12.0)	13 (9.5)	0.128
	Eutrophic	13 (24.1)	28 (34.1)	41 (30.1)	
	Overweight	38 (70.4)	44 (53.7)	82 (60.3)	
WC	Appropriated	7 (13.0)	33 (39.3)	40 (29.0)	0.001
	High	47 (87.0)	51 (60.7)	98 (71.0)	
CC	Appropriated	49 (90.7)	78 (94)	127 (92.7)	0.515
	Malnutrition	5 (9.3)	5 (6.0)	10 (7.3)	
BC	Severe malnutrition	0 (0.0)	1 (1.2)	1 (0.7)	0.006*
	Moderate malnutrition	2 (3.7)	1 (1.2)	3 (2.2)	
	Mild malnutrition	1 (1.9)	12 (14.5)	13 (9.5)	
	Eutrophic	22 (40.7)	48 (57.8)	70 (51.1)	
	Overweight	18 (33.3)	12 (14.5)	30 (21.9)	
	Obesity	11 (20.4)	9 (10.8)	20 (14.6)	
TST	Severe malnutrition	2 (3.7)	19 (22.9)	21 (15.3)	0.065
	Moderate malnutrition	1(1.9)	3 (3.6)	4 (2.9)	
	Mild nutrition	3 (5.6)	3 (3.6)	6 (4.4)	
	Eutrophic	9 (16.7)	9 (10.8)	18 (13.1)	
	Overweight	3 (5.6)	5 (6.0)	8 (5.8)	
	Obesity	36 (66.7)	44 (53.0)	80 (58.4)	
BMC	Severe malnutrition	0 (0.0)	2 (2.4)	2 (1.5)	0.697
	Moderate malnutrition	1 (1.9)	8 (9.6)	9 (6.6)	
	Mild malnutrition	5 (9.3)	28 (33.7)	33 (24.1)	
	Eutrophic	33 (61.1)	39 (47.0)	72 (52.6)	
LTM Index	Appropriated	35 (64.8)	56 (70.0)	91 (67.9)	0.574
	Depletion	19 (35.2)	24 (30.0)	43 (32.1)	
ATM Index	Appropriated	51 (94.4)	74 (90.2)	125 (91.9)	0.526
	Malnutrition	3 (5.6)	8 (9.8)	11 (8.1)	
Fat percentage	Appropriated	5 (9.3)	7 (8.3)	12 (8.7)	1.00
	High	49 (90.7)	77 (91.7)	126 (91.3)	
Blood volume	Hypo hydrated	19 (35.2)	16 (19.0)	35 (25.4)	0.003
	Normal hydrated	28 (51.9)	35 (41.7)	63 (45.7)	
	Hyper hydrated	7 (13.0)	33 (39.3)	40 (29.0)	
HDL-c	Appropriated	32 (59.3)	35 (41.7)	67 (48.6)	0.055
	Low	22 (40.7)	49 (58.3)	71 (51.4)	
TC	Desirable	42 (77.8)	70 (83.3)	112 (81.2)	0.001
	Altered	12 (22.2)	14(16.7)	26 (18.8)	
TG	Desirable	31 (57.4)	52 (61.9)	83 (60.1)	0.608
	Altered	33 (42.6)	32 (38.0)	65 (39.8)	
Blood glucose	Appropriated	36 (66.7)	51 (60.7)	87 (63.0)	0.588
	High	18 (33.3)	33 (39.3)	51 (37.0)	
Hb1Ac	Appropriated	13 (24.1)	26 (31.0)	39 (28.3)	0.441
	High	41 (75.9)	58 (69.0)	99 (71.7)	

Table 1. Anthropometric assessment, body composition, and biochemical tests of patients with chronic kidney disease undergoing conservative treatment according to sex, Juiz de Fora, Minas Gerais, 2020 (Continues).

Variable		Sex Female	SexMale	Total	p
Uric Acid	Appropriated	11 (20.4)	26 (31.0)	37 (26.8)	0.237
	High	43 (79.6)	58 (69.0)	101 (73.2)	
Urea	Appropriated	17 (31.5)	39 (46.4)	56 (40.6)	0.110
	High	37 (68.5)	45 (53.6)	82 (59.4)	
Vitamin D	Appropriated	36 (66.7)	53 (63.1)	89 (64.5)	0.718
	Low	18 (33.3)	31 (36.9)	49 (35.5)	
Calcium	Appropriated	41 (75.9)	59 (70.2)	100 (72.5)	0.559
	High	13 (24.1)	25 (29.8)	38 (27.5)	
Phosphorus	Appropriated	37 (68.5)	47 (56.0)	84 (60.9)	0.156
	High	17 (31.5)	37 (44.0)	54 (39.1)	
Potassium	Appropriated	16 (29.6)	21 (25.0)	37 (26.8)	0.561
	High	38 (70.4)	63 (75.0)	101 (73.2)	
Sodium	Appropriated	53 (98.1)	75 (89.3)	128 (92.8)	0.088
	High	1 (1.9)	9 (10.7)	10 (7.2)	

BMI: body mass index, WC: waist circumference, CC: calf circumference, BC: brachial circumference, TST: triceps skinfold thickness, BMC: brachial muscle circumference, LTM Index: lean tissue mass, ATM Index: adipose tissue mass, HDL-c: high-density lipoprotein cholesterol, LDL-c: low-density lipoprotein cholesterol, TC: total cholesterol, TG: triglyceride, HbA1c: glycated hemoglobin.

In general, men presented significantly higher values of BCM, BMC, LTM, LTM Index, TBW, ECW, ICW, and hypervolemia. Women, on the other hand, presented higher values of BMI, TST, body fat percentage, ATM, ATM Index with statistical significance (Table 2). Regarding the biochemical tests, HDL-c and cholesterol total values were significantly higher in females (Table 2).

Table 2. Anthropometric data, body composition, and biochemical tests of patients with chronic kidney disease undergoing conservative treatment, according to sex, Juiz de Fora, Minas Gerais, 2020.

Variable	Female	Male	Total	*p*
BMI (kg/m^2)	30.38 ± 5.85	28.59 ± 5.02	29.34 ± 5.44	0.015
WC (cm)	96.00 ± 12.79	99.90 ± 12.63	98.27 ± 12.80	0.113
CC	36.19 ± 3.66	37.55 ± 3.41	36.98 ± 3.57	0.059
BC (cm)	32.00 (29.00 – 34.50)	30.00 (28.25 – 33.75)	30.50 (29.00 – 34.00)	0.056
TST (mm)	25.85 (17.00 – 31.00)	15.85 (9.50 – 20.70)	20.00 (14.00 – 28.70)	<0.001
BMC (cm)	23.20 ± 2.67	24.85 ± 3.14	24.09 ± 3.08	<0.001
BCM (kg)	16.58 ± 5.95	24.58 ± 6.27	21.72 ± 7.36	<0.001
LTM (kg)	29.86 ± 8.37	42.65 ±9.03	38.18 ± 10.93	<0.001
LTM Index (kg/m^2)	13.09 ± 3.72	15.62 ± 3.06	14.70 ± 3.51	<0.001
Body fat (%)	40.98 ± 10.06	30.82 ± 9.28	35.29 ± 10.51	<0.001
ATM (kg)	38.79 ± 13.67	33.13 ± 13.60	36.89 ± 14.79	0.004
ATM Index (kg/m^2)	17.12 ± 5.53	12.14 ± 4.88	14.53 ± 6.16	<0.001
TBW (L)	30.08 ± 4.90	38.70 ± 6.19	35.10 ± 7.10	<0.001
ECW (L)	13.77 ± 2.33	17.53 ± 2.66	15.96 ± 3.14	<0.001
ICW (L)	16.32 ± 3.01	21.17 ± 4.03	19.15 ± 4.35	<0.001
E/I	0.87 ± 0.13	0.84 ± 0.11	0.85 ± 0.12	0.066

Table 2. Anthropometric data, body composition, and biochemical tests of patients with chronic kidney disease undergoing conservative treatment, according to sex, Juiz de Fora, Minas Gerais, 2020. (Continues).

Variable	Female	Male	Total	*p*
Blood volume (L)	-0.60 (-1.40 – 0.50)	0.20 (-0.70 – 1.30)	-0.15 (-1.10 – 1.10)	0.003
Uric acid (mg/dL)	7.8 ±5.3	7.2±1.5	7.15 ± 1.66	0.363
Urea	64.00 (40.00 – 79.00)	54.50 (45.00 – 105.00)	58.00 (42.50 – 93.00)	0.717
Calcium (mg/dL)	9.62 ± 0.57	9.77 ± 0.52	9.71 ± 0.54	0.578
Phosphorus (mg/dL)	4.20 ± 0.40	4.04 ± 0.79	4.11 ± 0.65	0.471
Potassium (mEq/L)	4.69 ± 0.65	5.05 ± 0.64	4.90 ± 0.66	0.051
Sodium (mEq/L)	140.00 (139.00– 144.00)	139.50 (138.0 – 142.0)	140.00 (138.00 – 143.00)	0.646
Vitamin D (pg/ml)	31.59 ± 10.15	37.40 ± 13.37	34.96 ±12.29	0.143
HDL-c (mg/dL)	48.00 (41.00 – 57.00)	38.00 (35.00 – 43.00)	41.00 (35.00 – 48.50)	0.003
LDL-c (mg/dL)	109.6 ± 45.8	91.1 ± 31.5	87.42 ± 30.22	0.008
Total cholesterol (mg/dL)	174.00 (160.00 – 179.00)	159.00 (133.00 – 181.00)	170.00 (143.50 – 180.00)	0.003
Triglycerides (mg/dL)	179.63±104.11	176.4±98.32	151.00 (108.50 – 214.50)	0.867
Diabetic blood glucose (mg/dL)	138.63 ± 43.56	138.58 ± 54.38	138.60 ± 50.08	0.592
Non-diabetic blood glucose (mg/dL)	112.64 ±38.95	97.08 ± 15.89	91.70 ± 29.65	0.527
HbA1c Diabetics (%)	7.70 ± 1.87	7.60 ± 1.73	7.64 ± 1,76	0.753
HbA1c Non-diabetics (%)	5.63 ± 1.25	5.27 ± 1.01	5.44 ±1,12	0.894

BMI: body mass index, WC: waist circumference, CC: calf circumference, BC: brachial circumference, TST: triceps skinfold thickness, BMC: brachial muscle circumference, BCM: body cell mass, LTM: lean tissue mass, ATM: adipose tissue mass, TBW: total body water, ECW: extracellular water, ICW: intracellular water, E/I: extracellular and intracellular water ratio, HDL-c: high-density lipoprotein cholesterol, LDL-c: low-density lipoprotein cholesterol, HbA1c: glycated hemoglobin.

When analyzing the influence of GFR on body composition and biochemical tests, adjusting for sex and age, a correlation was identified only with serum urea p<0.001), potassium (p = 0.049) and HDL-c (p = 0.025). For each 1ml/ increase at GFR, it was estimated that urea decrease by 1.561mg/dl (95%CI: -2.046 to -1.077), potassium by 0.002 mEq/L (95%CI -0.004 to 0.000) and HDL-c at 0.005 mg/dl (95%CI: -0.010 to 0.001) (Table 3).

Table 3. Simple linear regression to predict body composition and biochemical tests, according to glomerular filtration rate, adjusted to sex and age, Juiz de Fora, Minas Gerais, 2020.

Variable	B (95% CI)	β	*p*	R^2 adjusted
BMI (kg/m^2)	-0.008 (-0.082 – 0.065)	-0.019	0.820	0.068
WC (cm)	-0.040 (-0.217 – 0.137)	-0.038	0.655	0.040
CC (cm)	-0.001 (-0.055 – 0.053)	-0.003	0.975	0.079
BC (cm)	-0.014 (-0.069 -0.040)	-0.042	0.609	0.088
TST (mm)	0.003 (-0.005 – 0.011)	0.052	0.501	0.187
BMC (cm)	-0.030 (-0.073 – 0.013)	-0.114	0.171	0.067
BCM (kg)	-0.077 (-0.167 – 0.012)	-0.123	0.090	0.316
LTM (kg)	-0.112 (-0.240 – 0.016)	-0.120	0.085	0.370
LTM Index (kg/m^2)	-0.043 (-0.092 – 0.007)	-0.139	0.089	0.134

Table 3. Simple linear regression to predict body composition and biochemical tests, according to glomerular filtration rate, adjusted to sex and age, Juiz de Fora, Minas Gerais, 2020. (Continues).

Variable	B (95% CI)	β	*p*	R^2 adjusted
Body fat (%)	0.082 (-0.060 – 0.225)	0.088	0.256	0.218
ATM (kg)	0.081 (-0.119 – 0.280)	0.067	0.426	0.072
ATM Index (kg/m^2)	0.028 (-0.049 – 0.105)	0.057	0.470	0.188
TBW (L)	-0.051 (-0.163 – 0.062)	-0.065	0.375	0.295
ECW (L)	-0.002 (-0.040 – 0.036)	-0.007	0.919	0.389
ICW (L)	-0.42 (-0.099 – 0.0150	-0.102	0.151	0.328
Blood volume (L)	0.007 (-0.019 – 0.034)	0.047	0.582	0.049
Uric acid (mg/dL)	-0.001 (-0.034 – 0.032)	-0.004	0.967	-0.020
Urea (mg/dL)	-1.561 (-2.046 - -1.077)	-0.549	<0.001	0.279
Vitamin D (pg/dl)	0.002 (-0.004 – 0.007)	0.064	0.529	-0.012
Calcium (mg/dL)	0.001 (-0.001 – 0.004)	0.097	0.319	-0.012
Phosphorus (mg/dL)	-0.007 (-0.019 – 0.005)	-0.115	0.232	0.057
Potassium (mEq/L)	-0.002 (-0.004 – 0.001)	-0.176	0.049	0.018
Sodium (mEq/L)	0.001 (-0.001 – 0.001)	0.021	0.836	-0.018
HDL-c(mg/dL) *	-0.005 (-0.010 – 0.001)	-0.193	0.025	0.202
LDL-c(mg/dL) *	-0.001 (-0.007 – 0.005)	-0.040	0.668	0.071
Total cholesterol (mg/dL)*	-0.002 (-0.006 – 0.002)	-0.094	0.292	0.109
Triglycerides (mg/dL)*	-0.001 (-0.009 – 0.006)	-0.035	0.691	0.127
Blood glucose (mg/dl) £	-0.002 (-0.006 – 0.003)	-0.061	0.481	0.112
HbA1c (%) £	-0.003 (-0.004 – 0.004)	-0.002	0.985	0.218

BMI: body mass index, CC: calf circumference, BC: brachial circumference, BMC: brachial muscle circumference, BCM: body mass cell, LTM: lean tissue mass, ATM: adipose tissue mass, TBW: total body water, ECW: extracellular water, ICW: intracellular water, HDL-c: high-density lipoprotein cholesterol, LDL-c: low-density lipoprotein cholesterol, HbA1c: glycated hemoglobin.

* Adjusted for sex, age, physical activity, and BMI (kg/m^2).

£ Adjusted for sex, age, physical activity, BMI (kg/m^2), and the presence of diabetes.

DISCUSSION

In the present study, high prevalence of alterations in nutritional status were observed, such as overweight and increased fat percentage, concurrently with lean mass depletion, and changes in body water volume. High prevalences of biochemical alterations were also identified, such as low HDL-c, poor glycemic control, in addition to increased serum levels of uric acid, potassium, and phosphorus. Moreover, it was identified that GFR influenced the values of serum urea, potassium, and HDL-c.

The sample was consisted of elderly people with a mean age of 73.03 ± 7.81 years, and with associated comorbidities, such as SAH (87.0%) and DM (50.7%). Such characteristics are expected, since they are risk factors for CKD,[20] thus corroborating with other studies.[21-23]

The mean values of BMI (29.34 ± 5.44 kg/m^2) and body fat percentage (35.29 ± 10.51%) were similar to those found on Fontes et al.,[23] whose values were 28.1 ± 5.6 kg and 33.7 ± 8.2%, respectively.

Analyzing the results related to the BMI of the sample, there was a high number of individuals overweight (60.3%) and the prevalence of underweight was 9.5%. Low BMI values represent the risk of malnutrition, low energy reserves, and infection;[24] on the other hand, high values indicate risk of DM, SAH, and cardiovascular disease, among others.[25] It is important to emphasize, however, that there is still no consensus on ideal BMI ranges for CKD patients and although, the index is widely used in epidemiological studies, its accuracy in the assessment of nutritional status, clinical monitoring of fat, and risk of malnutrition in diseases such as CKD is debatable.[26]

The fact that 91.3% of the sample presented a high percentage of fat draws attention, since excess body fat is an independent predictor for the progression of CKD.[27] It also contributes to the two main causes of kidney involvement: type 2 diabetes nephropathy and hypertensive glomerulosclerosis, which together represent almost 75% of the cause of end-stage of CKD.[28] Furthermore, the high prevalence of individuals with high WC is worrying, since excess abdominal fat has been considered as an important risk factor for cardiovascular disease and mortality.[29]

The prevalence of individuals with muscle mass depletion was 32.1%, according to the LTM Index and 47.5% presented some degree of malnutrition, according to BMC. It is known that increased protein catabolism in the disease leads to reduce muscle mass and function, and the more severe the loss of renal function, the greater is the risk of developing sarcopenia.[4] The etiology of muscle loss in renal patients is multifactorial and involves hormone causes, immunological, and myocellular changes, inflammation, metabolic acidosis reduced protein intake, physical inactivity, excess angiotensin II, abnormalities in insulin/IGF-1 signaling, in myostatin expression, and reduction in satellite cell function.[30] Therefore, CKD carries are predisposed to a series of risk factors for changes in body composition and functional capacity that lead to a decrease in muscle mass and a decline in muscle strength.[4]

Thus, early detection of muscle mass depletion is important, in order to promote well-being, prevent frailty syndrome, and reduce the risks inherent to the presence of sarcopenia in these individuals[4]. Sarcopenia is the loss of skeletal muscle mass, strength and/or physical function. The consequences range from decreased physical activity to reduced mobility, disability, falls, repeated hospitalizations and mortality.[31] Some studies with chronic kidney patients found associations between sarcopenia, progression to end-stage renal disease,[32] and increased risk of mortality.[32-34]

Patients with CKD often develop body fluid retention. Expansion of extracellular water and total water are related to edema.[35] A systematic review and meta-analysis identified that hyper hydration is a predictor of mortality in renal patients.[36] Moreover, these fluid changes contribute to errors in body composition assessment methods. Therefore, specific measures to assess the body composition of these patients should be developed. The bioimpedance used in this study distinguishes muscle mass from pathological fluid overload,[37] and it is specific for patients with renal failure, being applicable in all stages of the disease.[38] Its accuracy for assessing body composition was validated with methods considered gold standard, such as double emission X-ray densitometry (DEXA).[39,40]

Several studies have evaluated body composition using this instrument in patients with CKD on dialysis,[41,42] but studies with patients undergoing non-dialysis treatment are still limited. Zhou et al.,[42] when evaluating 120 patients with CKD undergoing non-dialysis treatment, with a mean age of 65 ± 14 years, found a LTM index (14.4 ± 3.3 kg/m^2) similar to this study (14.70 ± 3.51kg/m^2). The ATM index was lower (12.5 ± 6 kg/m^2) than on this study (14.53 ± 6.16 kg/m^2). When comparing body fluids, it was found that ECW (18.9 ± 4.0 L), ICW (21.1 ± 4.7 L), E/I (0.9 ± 0.1), TBW (39 .9 ± 8.2), and hypervolemia (1.2 ± 1.0) were higher than the findings of this study. Lin et al.,[43] evaluated 326 patients, with a mean age of 65.8 ± 13.3 years, for approximately 4.6 years, and identified an inverse relationship between the high rate of LTM and mortality. It was observed that a LTM value lower than 9 kg/m^2 represents greater risk and values higher than 15 kg/m^2 have a protective effect. This suggests that LTM index assessment may provide better risk prediction than BMI in non-dialysis CKD patients.

In CKD, some characteristic complications, such as changes in phosphorus mineral metabolism, are more frequently observed from stage 3B onwards.[44] With the progressive decline in GFR, there is a parallel decrease in other renal functions. Therefore, with the progression of CKD, the development of anemia, metabolic acidosis, and changes in mineral and bone metabolism is expected. Thus, substances such as potassium, phosphorus, urea and sodium can accumulate in the blood, resulting in symptoms such as muscle weakness, fatigue, pallor, itching, decreased growth, bone pain, bone fragility, edema, oliguria, and even poor circulation, atherosclerosis, cardiovascular disease, and stroke.[20]

In the study of Filho & Rodrigues,[22] a high prevalence of alterations in the lipid profile of the participants was also found – 75.4% presented high LDL-c, 67.7% presented reduced HDL-c, and 67.7% presented hypertriglyceridemia, in addition, to a low rate of glycemic control (38.7%). It is noteworthy that these findings deserve attention, since the combination of these results in patients with CKD increases the risk of cardiovascular disease.[45,46] To assess cardiovascular risk (CVR), it is recommended to evaluate anthropometric and biochemical indices, measured alone or in conjunction with other variables, such as blood concentrations of triglycerides (TG), high-density lipoprotein cholesterol (HDL-c), and anthropometric measurements as waist circumference (WC). Such strategies are highly relevant, as they can help prevent certain cardiovascular complications, which represent the main cause of mortality in this population.[45,47]

Lastly, it is noteworthy that changes in body composition and biochemical tests are prevalent in patients with CKD undergoing dialysis treatment. However, studies with this population are still scarce. It is important to mention that the nutritional assessment of these patients, presents challenges, as there is no ideal protocol, and therefore, possible errors should not be ignored, as these may have clinical relevance. Thus, to improve the accuracy and precision of nutritional diagnosis, it is necessary to apply a combination of indicators, such as anthropometric, food consumption, biochemical, and clinical indicators and compare them, whenever possible using reference values appropriated to age, race, sex, and disease.[5,48]

Therefore, anthropometric and biochemical assessments make it possible to identify the risks or nutritional imbalances already installed, guiding the professional’s conduct, in order to promote de adequacy of nutritional status, biochemical changes control, and help to delay the need for renal replacement therapy. Hence, it contributes to reducing negative outcomes and treatment costs, in addition to providing a better quality of life for patients.[49]

CONCLUSION

In this study, high prevalence of changes in nutritional status, such as overweight and increased fat percentage, concurrently with lean mass depletion, changes in body water volume and changes in lipid profile, glycemic control, and minerals, such as potassium and increased phosphorus. Additionally, it was identified that GFR influenced serum urea, potassium, and HDL-c values.

Thus, it is concluded that the nutritional monitoring of CKD patients undergoing non-dialysis treatment is essential, in order to adjust the nutritional status, control biochemical changes, help delay the need for renal replacement, and provide a better quality of life for patients..

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Contributors

Pereira PML and Cândido APC in all stages, from the study design to review of the final version of the manuscript.

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