Artículo Original / Original Article

Evaluation of adductor pollicis muscle thickness obtained by ultrasonography and adipometer in patients with chronic kidney disease under conservative treatment

Evaluación del políptico adductor espesor muscular obtenido por ultrasonografía y adipómetro en pacientes con enfermedad renal crónica bajo tratamiento conservador

ABSTRACT

The aim of this study was to evaluate the concordance between adductor pollicis muscle thickness (APMT) measured by ultrasonography and adipometer and the applicability of the measurement as an indicator of the nutritional status of patients with chronic kidney disease (CKD). Methods: Epidemiological study with a cross-sectional design (n= 137). The concordance between APMT assessed by both methods were evaluated by intraclass correlation coefficient. Bland-Altman graphics were produced. APMTs were correlated with body mass index (BMI); calf circumference (CC), brachial circumference (BC) and brachial muscle (BMC); lean tissue mass (LTM); LTM index and body cell mass (BCM) via Pearson correlation. The adipometer overestimated APMT by 7 mm when compared to ultrasonography. APMT measured by adipometer was moderately correlated with BMI, CC, BC, BMC, LTM and BCM. APMT by ultrasonography was weakly correlated with CC, BMC, LTM, and LTM index. Conclusion: APMT presented weak or moderate correlation between methods. The measurement was predictive of muscle mass. We suggest that APMT be used in a complementary way in the evaluation of body composition. Keywords: Anthropometry; Chronic kidney disease; Conservative treatment; Nutritional evaluation; Muscle.

RESUMEN

El objetivo de este estudio es evaluar la concordancia entre el espesor de músculo aductor pollicis (EMAP), medido por ecografía y adipómetro, con aplicabilidad de la medición como indicador del estado nutricional de los pacientes con enfermedad renal crónica (ERC). Métodos: Estudio epidemiológico con diseño transversal. La concordancia entre los APMT estimados por ambos métodos se evaluó mediante el coeficiente de correlación intraclase y se diseñaron gráficos de Bland-Altman. En 137 pacientes con ERC, el APMT se correlacionó con índice de masa corporal (IMC); circunferencias de la pantorrilla (CP), circunferencia braquial (CB) y circunferencia del músculo braquial (CMB); masa de tejido magro (MTM); índice de masa magra (IMM) y masa celular corporal (MCC) mediante correlación de Pearson. Se obtuvo que el adipómetro sobreestima EMAP en 7 mm en comparación con la ecografía. EMAP medido por adipómetro se

Priscila Pereira^{1*}, Iris Soares¹, Melina Monteiro¹,
Cássia Oliveira¹, Tatiana Thees¹,
Marcus Bastos², Ana Paula Cândido¹.

1. Universidade Federal de Juiz de Fora, Instituto de Ciências Biológicas, Departamento de Nutrição. Juiz de Fora-MG, Brasil.
2. Universidade Federal de Juiz de Fora, Faculdade de Medicina, Departamento de Clínica Médica. Juiz de Fora-MG, Brasil.

*Corresponding author: Priscila Moreira de Lima Pereira.
Universidade Federal de Juiz de Fora, Instituto de Ciências
Biológicas, Departamento de Nutrição. Rua José Lourenço
Kelmer, s/n, Campus Universitário, Bairro São Pedro.
CEP: 36036-900. Juiz de Fora-MG, Brasil.
Cell phone: + 55 (32) 99119-9940.
E-mail: priscilamlp_jf@hotmail.com

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correlacionó moderadamente con IMC, CP, CB, CMB, MTM e IMM. EMAP por ecografía se correlacionó débilmente con el CP, CMB, MTM y IMM. Conclusión: EMAP presentó una baja o moderada correlación con otras mediciones de estado nutricional. La EMAP predice la masa muscular, ya que presentó correlación con marcadores de este compartimento. Se sugiere que EMAP se utilice de manera complementaria en la evaluación de la composición corporal.

Palabras clave: Antropometría; Enfermedad renal crónica; Evaluación nutricional; Músculos; Tratamiento conservador.

INTRODUCTION

Chronic kidney disease (CKD) predisposes a person to changes in body composition and functional capacity, such

as decreased muscle mass and declining muscle function and strength^{1,2}, which are associated with a lower quality of life, depression, cardiometabolic complications, increased risk of hospitalization, worse prognosis and death³.

Studies about the association between muscle mass and survival reinforce the importance of nutritional assessment of patients with CKD³. However, precise and simple methods for this evaluation are limited, since alterations in body water and bone mass contribute to errors in determining body composition⁴. Thus, new anthropometric measures have been introduced to complement existing gaps in practicality, cost, reliability and reproducibility, such as the adductor pollicis muscle thickness (APMT)⁵.

Evaluation of APMT is a simple, low-cost and non-invasive procedure. This muscle is the only muscle that can be measured directly, is influenced by nutritional status and physical inactivity, has minimal interference of fat and body water, and correlates with lean mass^{6,7}. Thus, measurement of APMT is useful for detecting early changes related to malnutrition and to monitor the nutritional status. The measurement is usually performed using the adipometer, but can also be measured by ultrasonography. Ultrasound measurement is a method that has high reproducibility and validity to verify thickness, area and size of various muscular structures, which minimizes inter and intra-rater variations^{5,8}. It also has a good correlation with methods of body composition evaluation considered to be the gold standard, such as dual-energy X-ray absorptiometry (DEXA)⁹.

The aim of this study was to compare APMT measured by ultrasonography and adipometer, determining the concordance between the methods, and to evaluate the applicability of the measurement as an indicator of the nutritional status of patients with CKD under conservative treatment.

MATERIALS AND METHODS

We conducted an epidemiological study with a cross-sectional design, in which the nutritional status of patients with CKD in stages 3 to 5 in conservative treatment, of both sexes and aged 60 years or older was evaluated. Participants were patients at the Centro Estadual de Atenção Especializada (CEAE) and Fundação Instituto Mineiro de Ensino e Pesquisa em Nefrologia (IMEPEN) in the city of Juiz de Fora in Minas Gerais, Brazil.

Sample design

The Epi Info program was used for sample size calculation. The population living in cities covered by the service was considered¹⁰ along with the prevalence of the disease in stages 3 to 5¹¹, a standard error of 2%, a confidence level of 99% and a 20% loss. Using these estimates a sample size of 120 individuals was estimated.

Participants who met the inclusion criteria were randomly selected from the appointment book. The inclusion criteria were: having CKD in stages 3, 4 or 5; in follow-up treatment at either of the two participating centers; age greater than or equal to 60 years; agree to participate in the study.

Exclusion criteria were: presence of hypermetabolic

diseases; hand fracture; amputation of any limb; wheelchair user, use pacemaker, patients with implantable defibrillator; having stents or metal-heart sutures.

The approval of the Ethics Committee (case number: 1.323.441) was obtained and participant signature were requested on informed consent forms before study initiation.

Variables of the study

Measures for each participant were performed individually, on the same day, by the responsible researcher with the assistance of a team, which was previously trained prior to data collection and supervised throughout the process.

Participants responded to a questionnaire containing demographic information, recent lesions and / or hand fractures and dominant side (left or right handed).

Weight was measured on a Tanita Ironman Scale (model BC 553®). For stature, a field stadiometer (Alturaexata®) was used. Both were measured according to the standardization protocol detailed by the Brazilian Ministry of Health¹². Body Mass Index (BMI) was calculated and classified according to Lipschitz¹³, as recommended by the Ministry of Health¹². Calf circumference (CC) was evaluated with the individual sitting and the knee flexed at a 90° angle. Tape was positioned horizontally, in the larger diameter area of the left calf¹⁴. Brachial circumference (BC) was measured in the left arm at the midpoint between the acromion and the olecranon. Triceps skinfold thickness (TST) was measured in the posterior midline of the left arm, between the acromion and the olecranon, in triplicate, using analog caliper (Lange®), considering the mean value among the closest values. Subsequently, brachial muscle circumference (BMC) was calculated using the equation detailed in Harrison et al.¹⁵.

Using the bio-impedance Body Composition Monitor (BCM; Fresenius Medical Care®) we obtained data on lean mass tissue (LTM), which represents the body mass without adipose tissue and excess extracellular water; lean tissue index (LMT index), calculated as the quotient between LTM / height² and body cell mass (BCM), which corresponds to the metabolically active BCM, excluding the extracellular fluid of this tissue. The BCM was designed specifically for patients with renal failure at different stages and is able to distinguish muscle mass from pathological fluid overload¹⁶. Volunteers were placed supine, relaxed, with legs separated and arms away from the trunk. Body surface was previously sanitized and electrodes placed on the hands and feet, according to the manufacturer's instructions, with a minimum distance between them of five centimeters. During the evaluation, participants did not touch metal surfaces or objects.

For the evaluation of APMT, we followed the recommendations of Lameu et al.⁶. Measurement was performed with the individual sitting, with hands relaxed and supported on the knee, and elbow flexed 90°. Participants were instructed to move their thumbs away at an angle of approximately 90° with the index finger. The analog adipometer (Lange®) was applied to the adductor muscle of the thumb situated at the apex of the imaginary triangle formed by the extension of the thumb and index finger. Measurements were performed in both hands, in

triplicate, and the mean of the nearest values was considered.

For APMT estimation by ultrasonography, portable equipment (SONOSITE M-TURBO®) was used with a high frequency linear probe (71-13 MHz). The individual remained in the same position recommended for evaluation of APMT by adipometer. Gel was used as the coupling agent and adjustments were made for image gain and depth, allowing adequate visualization of the muscles. The transducer was positioned with the minimum required pressure, perpendicular to the muscle and in the transverse section, in the same anatomical position in which the clamping was done. Once a clear image was obtained, it was frozen on the screen of the device. The thickness of the interosseous muscle, located above the adductor muscle of the thumb, was also measured. Thickness was measured by a straight line drawn on the image, between the inferior and upper muscular fascia (Figure 1). Measurements were performed on both hands in triplicate and mean values were considered.

From the most recent creatinine test, the glomerular filtration rate (GFR) was calculated using the CKD-EPI (Chronic Kidney Disease Epidemiology Collaboration) equation¹⁷ and later classified according to CKD stage¹⁸.

Statistical analysis

Initially, exploratory analyses were carried out to verify the integrity and consistency of data. Quantitative variables were evaluated for the presence of outliers and type of distribution using the Kolmogorov-Smirnov test. For the descriptive analysis of the sample, individuals were grouped according to sex and compared by Student t-test.

Concordance between the measurements by adipometer and ultrasonography were tested using the Intraclass Correlation Coefficient (ICC) and classified according to Fleiss & Cohen's proposal: weak (<0.4); regular (0.4-0.75); and excellent (> 0.75)¹⁹. For the visual inspection of the

Figure 1: Measurement of the adductor pollicis muscle thickness and the interosseous muscle by portable ultrasonography.

concordance, the graphical arrangement of Bland & Altman was used, which projects in the axis the absolute difference of the measurements and in the abscissa, the arithmetic mean between them²⁰.

APMT by both methods were correlated with other anthropometric measurements (BMI, CC, BC, BMC, LTM and BCM) using Pearson correlation. Correlations were considered weak if less than 0.3; as moderate between 0.3 and 0.7 and as strong when greater than 0.7.

The Statistical Package for Social Sciences (SPSS®) version 17.0 was used for the analyses, considering a significance level of 5%.

RESULTS

The sample consisted of 137 individuals, who were 60.6% male, with a mean age of 72.9 ± 7.7 . Regarding CKD stage, 14.7% were classified as stage 3A, the majority (52.2%) were in stage 3B, 27.2% in stage 4 and 5.9% in stage 5. According to BMI, 60.3% of the participants were overweight and 9.6% were malnourished. Females presented significantly higher values of BMI and lower muscle mass (obtained by CP, CMB, LTM, BCM and APMT) when compared to males. Table 1 presents the anthropometric characteristics of the sample by sex.

The intraclass correlation coefficients between APMT obtained by adipometer with APMT and APMT associated to the interosseous muscle, measured by ultrasonography, indicated weak concordance between methods. However, APMT was associated with interosseous muscle of the non-dominant hand; agreement was moderate (Table 2).

Figure 2 shows the graphical representation of the concordance pattern between the APMT measures measured by adipometer and ultrasound (A) and between APMT by adipometer and APMT associated to the interosseous measured by ultrasonography (B) of the dominant hands. The bias in (A) was 7.80 mm (95% CI 6.98 - 8.61) and the limits of agreement ranged from -1.69 to 17.29 mm. By associating the thickness of the interosseous muscle, the bias was reduced to 0.81 mm (95% CI 0.08 - 1.69 mm) and the agreement limits were -9.46 to 11.08 mm.

In figure 3, the non-dominant hand data for APMT measured by adipometer and ultrasound (A) and APMT measured by adipometer and APMT associated with the interosseous by ultrasonography (B) are presented. The bias in (A) was 7.28 mm (95% CI of 6.51 - 8.06), with concordance limits of -1.71 to 16.28mm. When the interosseous muscle thickness was also considered, the bias decreased to 0.66 mm (95% CI 0.16 - 1.48) with concordance limits of -8.61 to 10.15 mm.

APMT measured by the adipometer in both hands were moderately correlated to all measures tested (BMI, CC, BC, BMC, LTM, BCM) except the dominant hand APMT with BMC. However, APMTs assessed by ultrasonography of both hands were poorly correlated with CC, BMC, LTM, LTM index and BCM. When the thickness of the interosseus was also considered, the values of the dominant hand were weakly correlated with CC, BC and BMC. Non-dominant hand measurements were also correlated with LTM and BCM index (Table 3).

Table 1. Anthropometric characteristics of patients with chronic renal disease undergoing conservative treatment in Juiz de Fora, Brazil, according to sex.

Variable	Female	Male	p [§]
BMI (kg/m ²)	29.8 ± 5.2	27.8 ± 4.9	0.019
CC (cm)	35.2 ± 3.4	36.8 ± 3.8	0.011
BC (cm)	31.3 ± 3.7	29.9 ± 3.8	0.056
BMC (cm)	23.3 ± 2.4	24.8 ± 3.2	0.004
LTM (kg)	29.9 ± 8.4	42.6 ± 9.0	<0.001
LTM Index (kg/m ²)	13.1 ± 3.7	15.6 ± 3.1	<0.001
BCM (kg)	16.6 ± 5.9	24.6 ± 6.3	<0.001
APMT dominant (mm) -Adipometer	17.2 ± 3.6	20.4 ± 5.1	<0.001
APMT dominant (mm) - Ultrasonography	10.7 ± 1.7	11.8 ± 2.4	0.001
APMT + Interosseous dominant (mm) - Ultrasonography	17.5 ± 2.6	18.9 ± 3.6	0.010
APMT non-dominant			
Adipometer (mm)	16.4 ± 3.9	19.7 ± 4.9	<0.001
APMT non-dominant (mm) - Ultrasonography	10.4 ± 2.1	11.6 ± 2.3	0.003
APMT + Interosseous non-dominant (mm) - Ultrasonography	16.5 ± 2.9	18.6 ± 3.5	<0.001

§ Student T Test

GFR: Glomerular filtration rate, BMI: body mass index, CC: calf circumference, BC: brachial circumference, BMC: brachial muscle circumference, LTM: lean tissue mass, BCM: body cell mass, APMT: adductor pollicis muscle thickness.

Table 2. Intraclass correlation coefficient between APMT obtained by adipometer with APMT and APMT associated with the interosseous muscle, obtained by ultrasonography.

	APMT Dominant (mm) - Adipometer <i>r</i> (95% CI)	<i>p</i>
APMT Dominant (mm) - Ultrasonography	0.11 (-0.11 – 0.32)	0.02
APMT + Interosseous Dominant (mm) - Ultrasonography	0.33 (0.07 – 0.52)	0.01
	APMT Non Dominant (mm) - Adipometer <i>r</i> (95% CI)	<i>p</i>
APMT Non-dominant (mm) - Ultrasonography	0.17 (-0.14 – 0.42)	0.001
APMT + Interosseous Non-dominant (mm) - Ultrasonography	0.50 (0.30 – 0.64)	<0.001

APMT: adductor pollicis muscle thickness.

Figure 2: Bland & Altman graphics for the evaluation of the concordance between APMT measurement by adipometer and ultrasonography (A) and between the APMT measured by adipometer and APMT associated to the interosseous by ultrasonography (B) of the dominant hands. APMT: adductor pollicis muscle thickness; UCL: upper confidence limit; LCL: lower confidence limit. Dashed line: mean of differences in measurements. Dotted lines: 95% range of distributions of measurement differences (mean $\pm$ 1.96 x standard deviation).

Figure 3: Bland & Altman graphics for the evaluation of concordance between the measurement of TATM by adipometer and ultrasonography (A) and between adipometer-TATM and TATM associated to interosseous by ultrasonography (B) of the non-dominant hands. APMT: adductor pollicis muscle thickness; UCL: upper confidence limit; LCL: lower confidence limit. Dashed line: mean of differences in measurements. Dotted lines: 95% range of distributions of measurement differences (mean $\pm$ 1.96 x standard deviation).

Table 3. Correlations between APMT obtained by adipometer, APMT and APMT associated with the interosseous muscle, obtained by ultrasonography, with anthropometric measurements.

<u>Dominant hand</u>	APMT (mm) Adipometer		APMT (mm) Ultrasonography		APMT + Interosseous (mm) Ultrasonography	
	r	p	r	p	r	p
BMI (kg/m ²)	0.40	<0.001	0.06	0.47	0.10	0.26
CC (cm)	0.54	<0.001	0.16	0.07	0.18	0.04
BC (cm)	0.38	<0.001	0.09	0.28	0.17	0.04
BMC (cm)	0.12	0.17	0.20	0.02	0.26	0.01
LTM (kg)	0.49	<0.001	0.21	0.02	0.11	0.20
LTM Index (kg/m ²)	0.34	<0.001	0.17	0.04	0.09	0.30
BCM (kg)	0.44	<0.001	0.23	0.01	0.14	0.12
<u>Non-dominant hand</u>	APMT (mm) Adipometer		APMT (mm) Ultrasonography		APMT + Interosseous (mm) Ultrasonography	
	r	p	r	p	r	p
BMI (kg/m ²)	0.39	<0.001	0.09	0.29	0.08	0.36
CC (cm)	0.54	<0.001	0.20	0.02	0.19	0.03
BC (cm)	0.44	<0.001	0.11	0.19	0.15	0.09
BMC (cm)	0.30	0.001	0.22	0.01	0.27	0.001
LTM (kg)	0.31	<0.001	0.20	0.02	0.12	0.16
LTM Index (kg/m ²)	0.50	<0.001	0.14	0.05	0.21	0.02
BCM (kg)	0.43	<0.001	0.21	0.01	0.21	0.02

APMT: adductor pollicis muscle thickness, BMI: body mass index, CC: calf circumference, BC: brachial circumference, BMC: brachial muscle circumference, LTM: lean tissue mass, BCM: body cell mass.

DISCUSSION

The evaluation of body composition is fundamental for the provision of nutritional care to patients with CKD³. Thus, assessment of muscle mass, using simple, low-cost and reliable techniques is important.

In the literature, there are no studies that have analyzed the APMT of patients with CKD in conservative treatment. The use of ultrasonography for the evaluation of this muscle is not described, limiting the comparison of the results. Thieme²¹ evaluated APMT, using adipometry and ultrasonography in patients candidates for elective medium and large surgery of the digestive system and found values lower than those of the present study for APMT of the dominant hand (11.30 mm) and non-dominant hand (10.33 mm) measured with adipometer. The results obtained by ultrasonography were similar to our findings (11.10 mm and 11.30 mm for the dominant and non-dominant hands, respectively). Mean values of APMT measured by the adipometer in this study were lower than those found in healthy and younger individuals^{7,22} and higher than other

studies with sick individuals, such as HIV^{23,24} patients and those in hospital intensive care units²⁵. Oliveira et al.²⁶ and Pereira et al.²⁷ evaluated patients with CKD in dialysis treatment, obtaining mean values lower than ours: 10.0 ± 4.5 mm and 11.9 ± 1.6 mm for both sexes, respectively. This finding may be justified by the fact that in the non-dialytic phase, the prevalence of muscle mass depletion is lower than in the dialysis phase²⁸.

To reduce the inaccuracy of the results, it is recommended that muscle mass be measured by methods with high accuracy, such as previously validated magnetic resonance imaging or equivalent, such as ultrasonography²⁹. Ultrasonography allows the visualization and quantification of the size, thickness and volume of the muscles with great accuracy and a strong correlation with magnetic resonance³⁰. In addition, computed tomography dual-energy X-ray absorptiometry (DEXA)⁹ is considered a reference for evaluation of muscle compartments. The technique has been used to evaluate healthy, institutionalized and chronic or acute patients^{8,31,32}. However, it should be emphasized that aging, sarcopenia

and some diseases can affect the quality of the image obtained, since the muscles become more echogenic, that is, with greater brightness or opacity, which makes it difficult to identify the muscular fascia and, therefore, the delimitation between their structures during the verification of the ultrasonographic image³³. Its reproducibility may also vary according to the muscular structure evaluated, the positioning of the individual³⁴ and the compression of the muscle caused by excessive pressure by the transducer³⁵.

Since ultrasound is an expensive and limited technology in health services, its agreement with a cheaper and accessible method is important for clinical practice. Thus, the use of this imaging test to verify APMT measurement can increase and confirm the accuracy of its measurement by adipometer. In this study, there was a weak concordance between the measures compared, except between APMT and the interosseous muscle of the non-dominant hand, which presented moderate agreement ($r = 0.50$). The adipometer tends to overestimate APMT measurement in 7.80 mm in the dominant hand and 7.28 mm in the non-dominant hand when compared to the ultrasound measurement. One possible justification is that the measurement using the adipometer includes the adductor pollicis muscle thickness and the interosseous muscle, skin and minimal amounts of fat. By adding the thickness of the interosseous muscle, biases were reduced to 0.81 mm and 0.66 mm, respectively, and the concordance increased from 0.11 to 0.33 in the dominant hand and from 0.17 to 0.50 in the non-dominant hand. No other studies were found that evaluated the concordance between these methods to determine APMT, however Thieme²¹ identified a moderate correlation between them.

Correlations between APMT measured with adipometry of both hands and other anthropometric measures were higher than those obtained by ultrasonography. APMT measured by adipometer was moderately correlated to anthropometric measures such as BMI and muscle mass indicators such as CC, BC, BMC, LTM, LTM index and BCM, similar to that found by other authors^{6, 23,24,25,26,27}. On the other hand the APMT measured by ultrasonography was poorly correlated with CC, BC, LTM, LTM index and BMC. When the thickness of the interosseus was also considered, measurements were poorly correlated with the CC, BC, BMC, LTM and BMC. In another study²¹, APMT measured by ultrasonography correlated moderately with corrected brachial muscle area, manual grip strength, and BMC.

These findings suggest that APMT measurement is indicative of muscle mass, however, caution should be exercised in interpreting the results, since the correlations were weak or moderate. Furthermore, when evaluating the correlation of APMT with other anthropometric measures, some considerations should be made, given possible inaccuracies. According to Al-Gindan et al.³⁶, anthropometric measures tend to overestimate muscle mass when compared to a reference standard. In addition, authors emphasize that there is insufficient evidence that locally assessed muscle mass - through circumferences and

thickness of skin folds - can be used to accurately estimate muscle mass throughout the body. Nevertheless, these measures have several advantages, such as simplicity and ease of measurement, time spent, low cost, non-invasive and provided immediate results, characteristics that make them applicable and widely used in clinical practice³⁷. Ultimately, some restrictions on the use of APMT should be specified. There are no studies evaluating intra and inter-rater reproducibility²⁷. Factors, such as the position of the individual during the measurement, dominant hand and the instrument used can influence³⁸ APMT. In addition, if the adipometer or ultrasound transducer is not applied at the correct anatomical point, the measure will not correspond to the real value of APMT²².

Among the limitations of this study are the cross-sectional study design and the absence of a gold standard for muscle mass evaluation, limiting the validity of the findings. In addition, because we studied a sample of elderly patients, who present a greater risk of sarcopenia, APMT values may be underestimated. However, although it presents limitations, the study is relevant due to the importance of the theme and the originality.

CONCLUSION

APMT, measured by adipometry and ultrasonography, showed poor concordance among the methods, except between APMT associated with the interosseous muscle of the non-dominant hand, which presented moderate agreement.

The APMT measure, measured by both methods, is predictive of muscle mass in patients with chronic renal disease on conservative treatment, since it was correlated with other markers of this compartment. However, such correlations were weak or moderate, suggesting that interpretation should be performed with caution and in a complementary way in the assessment of body composition.

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