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Correlation between skinfold thickness and bioelectrical impedance analysis for the evaluation of body composition in patients on dialysis

Correlación entre la plicometría y el análisis de bioimpedancia eléctrica para la evaluación de la composición corporal en pacientes en diálisis

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ABSTRACT

Introduction: Patients on dialysis have important changes in body composition.

Objectives: To determine the correlation between skinfold thickness (SKF) and bioimpedance analysis (BIA) for estimating fat mass (FM) and lean body mass (LBM) in patients undergoing hemodialysis (HD) and peritoneal dialysis (PD).

Methods: Cross-sectional study. We included 50 patients under dialysis treatment. To measure SKF, we used the Lange® skinfold caliper (Beta Technology, California, USA) and we carried out the impedance analysis with the Bodystat Quadscan 4000® (Quadscan, Isle of Man, UK). The measurements were performed post-hemodialysis. The PD patients were measured with and without peritoneal dialysate and body weight was corrected for peritoneal fluid. We determined the Pearson's correlation coefficient between SKF and BIA for estimating FM and LBM. We also evaluated the influence of age, sex, diuretic use, dialysis vintage, extracellular water (ECW), and intracellular water (ICW) through a multivariate regression analysis.

Results: Of the 50-patient total, 29 were men (58%) and patient mean age was 46.3 ± 16.5 years. The correlation between SKF and BIA was $r = 0.784$ ($p < 0.001$) for FM and $r = 0.925$ ($p < 0.001$) for LBM. Age and sex influenced the variability of FM, whereas sex, age, and ECW influenced the variability of LBM, both evaluated through the SKF and BIA methods.

Conclusion: SKF and BIA are useful methods in clinical practice. The strong and statistically significant correlations between the two methods show they are interchangeable. Age, sex, ECW, and ICW influence the variability of FM and LBM.

Key words: Fat mass. Lean body mass. Skinfold thickness. Bioelectrical impedance analysis. Dialysis.

RESUMEN

Introducción: los pacientes en tratamiento con diálisis presentan cambios importantes en la composición corporal.

Objetivos: determinar la correlación entre la plicometría y el análisis de bioimpedancia eléctrica (BIE) para la estimación de la masa grasa (MG) y la masa magra (MM) en pacientes sometidos a hemodiálisis (HD) y diálisis peritoneal (DP).

Métodos: diseño transversal-analítico. Se incluyeron 50 pacientes en tratamiento con diálisis. Se utilizó el plicómetro Lange® (Beta Technology, California, USA) para la medición de pliegues cutáneos y la BIE fue realizada con el Bodystat Quadscan 4000® (Quadscan, Isle of Man, UK). Las mediciones fueron realizadas poshemodiálisis. Los pacientes en DP fueron medidos con y sin líquido peritoneal y el peso corporal fue corregido. Determinamos el coeficiente de correlación de Pearson entre la plicometría y la BIE en la estimación de la MG y la MM. Se evaluaron otras variables como edad, sexo, uso de diuréticos, tiempo en tratamiento de diálisis, agua extracelular (AEC) e intracelular (AIC) a través de un análisis de regresión multivariada.

Resultados: veintinueve pacientes (58%) son del sexo masculino; la edad promedio de 46,3 ± 16,5 años. Se obtuvo una correlación significativa y positiva entre la plicometría y la BIE [r = 0,784 (p < 0,001) para MG y r = 0,925 (p < 0,001)] para MM. La edad y el sexo influyeron en la variabilidad de la MG, mientras que el sexo, la edad y el AEC influyeron en la variabilidad de la MM, evaluados con ambos métodos.

Conclusiones: la plicometría y la BIE son métodos útiles en la práctica clínica. La correlación que se obtuvo entre los dos métodos muestra que son intercambiables. Por otro lado, variables como la edad, el sexo, el agua AEC y AIC se identificó que influyen en la variabilidad de la MG y MM.

Palabras clave: Masa grasa. Masa magra. Pliegues cutaneous. Bioimpedancia eléctrica. Diálisis.

INTRODUCTION

Nutritional status is one of the most important factors influencing the quality life of patients on hemodialysis (HD) and peritoneal dialysis (PD). Poor nutritional status leads to a high risk of morbidities, hospitalization, catabolic stress, and mortality (1,2).

Patients on dialysis have important changes in body composition because of decreased protein and/or energy intake, chronic inflammation, physical inactivity, concurrent acute or chronic conditions, illness, and catabolism induced by the dialysis process. Previous studies have shown that changes in body composition occur after dialysis treatment, with a significant decrease in lean body mass (LBM) and an increase in body weight and fat mass (FM), whereas other studies state that FM and body weight decrease over time (3-7).

Total body weight can be divided into the compartments of FM and LBM. The FM represents an essential energetic reserve and 50% is situated in the subcutaneous tissue.

The LBM includes minerals, proteins, glycogen, extracellular water (ECW) and intracellular water (ICW) (8).

Dual-energy X-ray absorptiometry (DXA) is considered the gold standard in the assessment of body composition in patients on dialysis. However, this method is not always available and is both expensive and impractical. There are various methods for estimating body composition in patients on dialysis, one of which is bioelectrical impedance analysis (BIA). BIA measures impedance and resistance with a small electrical current as it travels through the body's water pool. In addition, BIA divides total body water (TBW) into ECW and ICW. Another available and practical method for estimating FM is skinfold thickness (SKF). It measures specific skinfolds and uses the Durnin and Womersley formulas to estimate density and FM. Both BIA and SKF are methods that have shown significant correlations with the gold standard (1,9-14).

We consider the adequate assessment of body composition with practical and available methods and tools in patients on dialysis to be very important. Therefore the aims of this study were to determine the correlation between SKF and BIA for estimating FM and LBM in HD and PD patients, and to analyze the influence of the variables that can affect body composition.

METHODS

A cross-sectional study was performed in thirty-eight patients undergoing HD and 12 patients undergoing PD at two dialysis units in Colima, Mexico, were included.

The inclusion criteria were: age ≥ 18 years old, on HD or continuous ambulatory PD or automated PD treatment for at least 2 months. Exclusion criteria were patients with pacemakers, patients with metallic implants, amputees, and pregnant women.

The measurements were performed on the HD patients after dialysis, in accordance with previous methodologies. For the PD patients, the measurements were taken during a visit to the outpatient clinic. For practical reasons, measurements were performed with intraperitoneal fluid and body weight was corrected (body weight minus 2 kg corresponding to the peritoneal fluid). Body composition was not affected by intraperitoneal dialysate because the trunk contributes to less than 10% of total body impedance (9,15-20).

Anthropometric measurements

Height, body weight, and mid-upper arm circumference (MUAC) were measured in all patients. MUAC was assessed using Seca 201® (Hamburg, Deutschland) non-stretchable metric tape. The Seca 700® Mechanical Column Scale (Hamburg, Deutschland) was used to measure height and body weight, applying the previously described standard techniques (21).

Four SKF -biceps, triceps, subscapular, and suprailiac- were measured 3 times using a Lange® skinfold caliper (California, USA) and then averaged. The logarithm of the sum of the four SKF was calculated, as well as body density (D) according to age and sex. The Durnin and Womersley equations were used to calculate FM and LBM with the formulas (22): FM = body weight (kg) - [(4.95/D)-4.5)] and LBM = body weight (kg) - FM.

Body composition analysis

To determine ICW, ECW, FM, and LBM, we used a Bodystat Quadscan 4000® (Isle of Man, UK) multi-frequency body composition analyzer. The measurements were carried out with the patient in the supine position for 5 minutes, with the arms parallel to and separated from the trunk and the legs apart. Two electrodes were placed on the hand and wrist and another two on the foot and ankle. The electrodes were placed on the non-access site of the body of the HD patients and on the right side of the PD patients (19,20,23,24).

Statistical methods

The Kolmogorov-Smirnov test was used to test for the distribution normality of the variables. Descriptive analyses were presented as mean ± standard deviation (SD), frequencies, and percentages. We determined the Pearson’s correlation coefficient between SKF and BIA for estimating FM and LBM. We also evaluated the influence of age, sex, diuretic use, ECW, and HD and PD vintage on FM and LBM through a multivariate regression analysis. Stepwise regression and backward elimination (automatic procedure) were carried out.

Statistical significance was accepted as $p < 0.05$ and all statistical tests were two-tailed. The statistical analyses were performed using the IBM SPSS version 20 program (IBM, Chicago, IL).

Ethics statement

Written informed consent was obtained from each patient before participation. The present study was structured according to the ethical requirements of the Declaration of Helsinki and approved by the local Ethics and Health Research Committee (2014/SR/CLIN/PED/96).

RESULTS

We evaluated fifty patients and their mean age was 46.3 ± 16.5 years. Demographic, clinical, and body composition characteristics of the patients undergoing dialysis treatment are shown in table I.

The patients with PD presented with greater body weight, FM, LBM, ECW, and ICW. FM measured by the two methods, ECW, and body weight showed statistically significant differences between the HD and DP patients ($p < 0.05$).

Pearson's correlation between SKF and BIA for estimating fat mass and lean body mass

Figure 1 show the correlation between SKF and BIA for estimating FM and LBM. They were positive and statistically significant and the SKF and BIA correlation was highest for evaluating LBM.

Multivariate regression analysis

We analyzed the degree of influence of the variables that can influence FM and LBM measured by both methods and the results are shown in table II.

Regarding table II, the variables of sex and age influenced the variability of FM and LBM to different degrees when evaluated by each of the two methods. Sex, age, and ECW influenced the variability of LBM, and the BIA estimate had the greatest influence on the variability of LBM.

DISCUSSION

The nutritional status of patients undergoing HD and PD is a survival indicator. Patients, whose FM is lower than the normal range, have been reported to have a higher risk of mortality due to catabolic stress. Patients on dialysis have changes in body composition, such as greater FM, lower LBM, and an altered hydration status. These changes can directly affect nutritional status, making body composition measurement an important issue. Through body composition evaluation, adequate nutritional status can be maintained, resulting in a better quality of life (25-27).

Many methods have been used for assessing body composition in patients undergoing dialysis, but the ideal method should be a noninvasive one with reproducible results, as well as being low cost and easily available. DXA is considered the gold standard, but in relation to clinical practice, it is not always available in dialysis care units or in primary care units, given that it requires a trained staff and a specific area for taking the measurements, in addition to its high cost. Therefore, alternative methods that meet the criteria of an ideal method, such as SKF or BIA, are being used. Both methods have shown a statistically significant correlation with the gold standard, which is why we decided on the two-compartment model and analyzed the correlation between SKF and BIA for estimating FM and LBM in dialysis patients (8,26,28,29).

Our results showed high and statistically significant correlations between SKF and BIA for estimating FM and LBM, with a stronger correlation for the LBM evaluation.

SKF and BIA are methods for estimating FM and LBM that can be available at all dialysis care units, nutrition departments, and primary care units. They are reproducible, low-cost, noninvasive, and can be used by health professionals with a minimum of training. Kamimura et al. analyzed FM in 30 Brazilian HD patients using DXA, BIA, and SKF. They reported excellent and statistically significant correlations with BIA and SKF. Lamarca et al. correlated DXA with BIA and SKF for estimating LBM in 102 Brazilian HD patients. Both correlations were statistically significant, and the correlation between DXA and BIA was superior. Unlike our study, Kamimura et al. and Lamarca et al. analyzed only one body composition compartment and correlated the measuring methods with the gold standard. They did not correlate BIA and SKF with two compartments, as we did. Bravo et al also correlated DXA with BIA and SKF for estimating FM and LBM in 20 Mexican HD patients. They found high and statistically significant correlations, but did not estimate body composition with those methods in PD patients. To the best of our knowledge, ours is the first study conducted on Mexican patients that correlates the two methods in the assessment of FM and LBM in HD and PD patients. In regard to previous studies on method correlations in DP patients, Dong et al reported a statistically significant correlation between SKF and DXA in the analysis of LBM in 60 Korean PD patients. Another relevant study by Chow et al found a statistically significant correlation between SKF and BIA for estimating FM in 60 Chinese PD patients (14,19,23,25,26,30-32).

In the multivariate regression analysis of our study, we showed the influence of the variables of age and sex on the variability of FM assessed through SKF. Only age influenced the variability of fat mass evaluated by BIA. LBM was influenced by sex, age, and ECW, when estimated using BIA and by sex and ECW, when using SKF. In general, age, sex, and ECW influenced different grades of body composition variability, regardless of the measuring method employed.

Similar to what occurs in the healthy population, body composition suffers changes with age. Once the individual reaches 30 years of age, LBM decreases from 1 to 1.5% per year, and there is a simultaneous increase in FM, mainly in the trunk area. There are also many differences in relation to sex, given that women have more FM and less LBM than men (10,29,33-36).

ECW influenced the variability of LBM, which can be explained by the fact that LBM contains protein mass and minerals and ECW and ICW depend on hydration status, thus affecting LBM by underestimating or overestimating it. It is important to keep in mind that over-hydration can increase SKF, resulting in an overestimation of FM and % of fat. In addition, catabolic stress can increase oncotic pressure and permeability and produce an increase in capillary filtration and interstitial volume, resulting in tissular edema (37,38).

Dialysis vintage was also analyzed in the multivariate regression analysis and did not present statistical significance. However, reports in the literature state that patients have important changes in body composition associated with dialysis vintage and the most significant changes present in the first year of treatment, mainly as increased FM and decreased LBM (1,3,4).

Diuretic use was another variable analyzed in the multivariate regression, but it did not correlate with the body composition compartments.

SKF and BIA are useful methods in clinical practice for estimating FM and LBM in dialysis patients. Our results showed high and statistically significant correlations, signifying that the methods are interchangeable and offer an alternative in the evaluation of dialysis patients when DXA is not available. SKF and BIA can be used in dialysis care units and/or primary and secondary care units to identify early changes in body composition that affect the nutritional status of these patients. Sex and age influenced the variability of FM, whereas age, sex, and ECW influenced the variability of LBM.

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Table I. Demographic, clinical, and body composition characteristics in patients undergoing dialysis treatment (n = 50)

	HD (n = 38)	*PD (n = 12)*	*p value*
Age (y)	42.1 ± 15.6	59.6 ± 11.9	< 0.001[3]
Sex (male), n (%)	21 (55.3%)	8 (66.7%)	-
HD or PD vintage (months)	22.2 ± 20.69	15.7 ± 12.7	0.202
Access (Fistula/catheter),	27/11	-	-
PD modality (CAPD/APD)	-	4/8	-
Diuretic use n (%)	11 (28.9%)	5 (41.7%)	-
Comorbidities			
Hypertension n (%)	34 (89.5%)	12 (100%)	-
Diabetes n (%)	13 (34.2%)	11 (91.7%)	-
Body composition			
Body weight (kg)	58.2 ± 10.3[1]	68.9 ± 11.3[2]	0.01[3]
FM (kg)	11.65 ± 4.68*	17.1 ± 4.9*	0.001[3]
	13.9 ± 5.59**	19.6 ± 5.7**	0.003[3]
LBM (kg)	46.55 ± 9.69*	51.8 ± 10.8*	0.116
	44.56 ± 10.11**	49.2 ± 11.7**	0.186
ECW (l)	15.4 ± 2.55**	17.8 ± 3.35**	0.014[3]

HD: hemodialysis; PD: peritoneal dialysis; CAPD: continuous ambulatory PD; APC: automated PD; FM: fat mass; LBM: lean body mass; ECW: extracellular water. [1]Body weight post-dialysis; [2]Body weight corrected in patients with peritoneal fluid; [3]Statistically significant. *Measured with SKF; **Measured with BIA.

Data are presented as mean ± standard deviation. p < 0.05 statistical significance.

Table II. Predictors of FM and LBM according to SKF and BIA (multivariable regression)

Variable	B- Coefficient (95% CI)	*p*	B Coefficient (95% CI)	*p*
FM by SKF R^2 *= 57.7%*			*FM by BIA* R^2 *= 47.6%*	
Sex	*-5.46 (-4.2 to -6.6)*	*< 0.001*	-1.37 (0.2 to -2.9)	0.38
Age	*0.17 (0.2 to 0.13)*	*< 0.001*	*0.27 (0.31 to 0.22)*	*< 0.001*
Dialysis vintage (months)	-0.02 (0.002 to -0.05)	0.35	0.029 (0.06 to -0.009)	0.44
Diuretic use	-0.44 (0.6 to -1.5)	0.69	1.25 (2.7 to -0.22)	0.39
ECW	0.41 (0.6 to 0.2)	0.07	-0.52 (-0.23 to -0.81)	0.08
LBM by SKF R^2 *= 84.5%*			*LBM by BIA* R^2 *= 90.4%*	
Sex	*10.4 (11.8 to 8.9)*	*< 0.001*	*7.18 (8.3 to 6)*	*< 0.001*
Age	-0.12 (0.02 to -0.05)	0.76	*-0.1 (-0.07 to -0.13)*	*0.002*
Dialysis vintage (months)	0.06 (0.09 to 0.02)	0.06	0.01(0.03 to -0.01)	0.71
Diuretic use	2.03 (3.3 to 0.7)	0.13	-0.35 (0.74 to -1.4)	0.74
ECW	*2.07 (2.3 to 1.8)*	*< 0.001*	*2.83 (3.05 to 2.61)*	*< 0.001*

FM: fat mass; LBM: lean body mass; SKF: skinfold thickness; BIA: bioimpedance analysis; ECW: extracellular water; ICW: intracellular water. CI: confidence interval. $p < 0.05$ statistical significance.

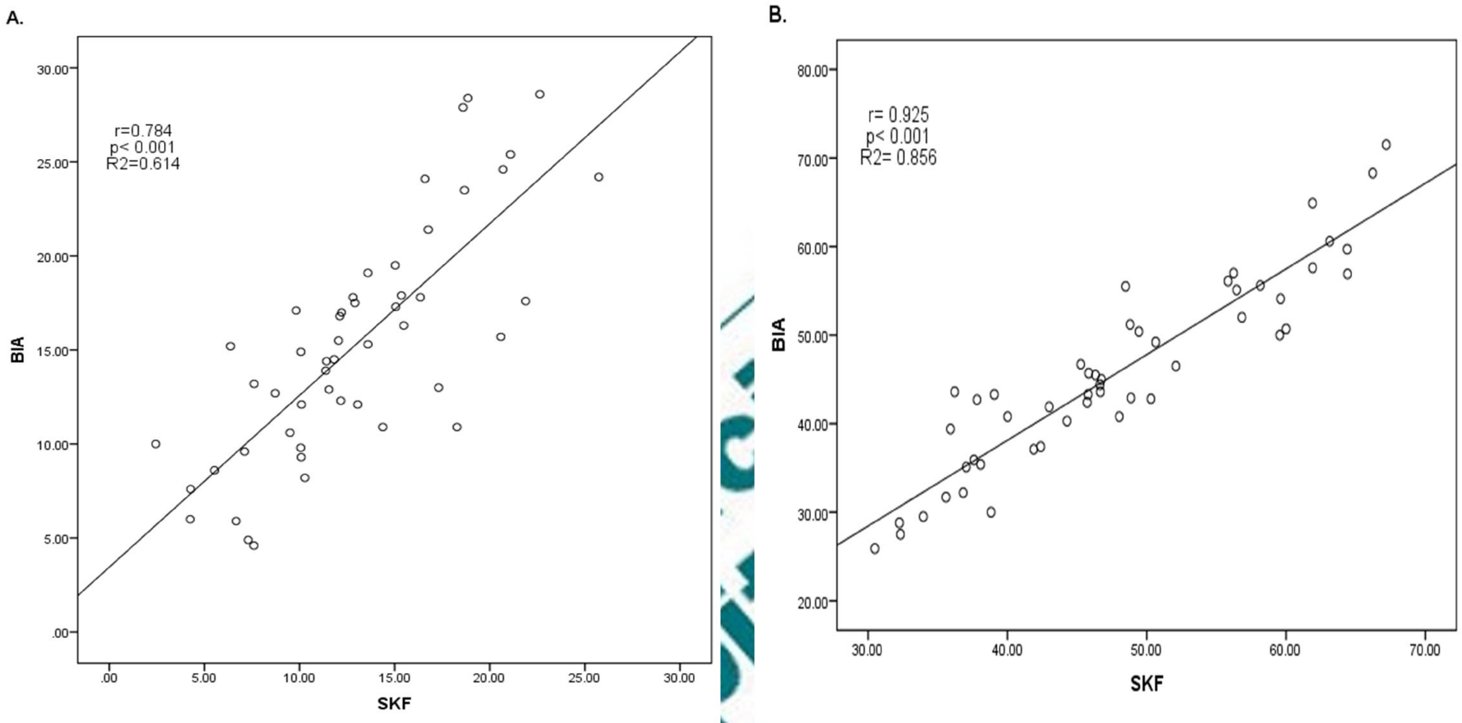

Figure 1. A. Correlation between SKF and BIA for estimating FM. B. Correlation between SKF and BIA for estimating LBM (SKF: skinfold thickness; BIA: bioelectrical impedance analysis).