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*Original Article*

# Parameters to Assess Nutritional Status in a Moroccan Hemodialysis Cohort

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## Abstract

**Introduction**: Malnutrition is common in maintenance hemodialysis (HD) and is associated with increased mortality and morbidity in affected patients. The aim of this study was to determine the prevalence of malnutrition and correlate the methods of nutritional assessment.

**Methods**: We evaluated the nutritional status of 40 prevalent HD patients by subjective global assessment (SGA) score, anthropometrics [body mass index (BMI), arm circumference (AC), triceps skin-fold thicknesses (TSF), arm muscle circumference (AMC)], biochemical tests [normalized protein equivalent to total nitrogen appearance (nPNA), and pre-dialysis serum albumin and serum prealbumin levels] and bio-electrical impedance (BEI) analysis to estimate body composition [lean tissue index (LTI) and fat tissue index (FTI)].

**Results**: The study assessed 40 patients (20 males and 20 females) with a mean age of 50.7±16.5 years. The prevalence of malnutrition according to the different methods ranged from 5 % to 65%. There were highly significant gender-specific differences in AMC ($p < 0.001$) and TSF ($p < 0.001$). The BEI revealed a highly significant difference in LTI ($p < 0.001$) but no difference in FTI ($p = 0.14$) according to gender. There was a positive correlation between LTI and both serum albumin ($r = 0.37$; $p = 0.018$) and serum prealbumin ($r = 0.53$; $p < 0.001$). Also, there was a significant positive correlation between FTI and BMI ($r = 0.59$; $p < 0.001$), AC ($r = 0.44$; $p = 0.004$) and TSF ($r = 0.61$; $p < 0.001$).

**Conclusion:** Our data suggest that BEI analysis provides a useful means of assessing nutritional status and was correlated with anthropometrics and biochemical findings.

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## Introduction

Malnutrition (MN) is associated with increased morbidity and mortality in dialysis patients. The physiopathology of MN in hemodialysis (HD) is complex and involves a great number of factors that contribute to anorexia and catabolism. It may be secondary to deficient nutritional ingestion, severe dietary restrictions, hormonal and gastrointestinal disorders, metabolic acidosis, interference of medications with food absorption, intercurrent diseases, nutrient losses during dialysis and inadequate dialysis [1, 2]. Several studies have documented malnutrition in 23%-76% of patients on HD and in 18%-50% of patients on peritoneal dialysis [3-5].

Nutrient loss during the HD procedure may be an important factor for malnutrition in those patients. Amino acids, peptides, and water soluble vitamins are primarily lost. The mean amino acid loss in the dialysate is 4-8 g/day [6]. A low chronic inflammatory state (the microinflammatory state of uremia) with elevated circulating levels of C reactive protein and pro-inflammatory cytokines, such as tumor necrosis factor-alpha (TNF-alpha) and interleukin 6 (IL-6), has been increasingly recognized as an important factor for protein-energy MN in patients with chronic kidney disease (CKD) [4]. The proinflammatory cytokines can increase protein catabolism and baseline energy expenditure, in addition to interfering with appetite. Assessment of inflammatory markers is useful for distinguishing between both types of MN in CKD: type 1 or pure MN and type 2 or inflammatory MN [8]. The prognosis of patients with type 1 MN and no inflammation is usually more favorable.

Periodical monitoring of the nutritional status should be part of the follow-up of dialysis patients, and is fundamental for preventing, diagnosing, and treating protein-energy MN. Early identification and treatment of nutritional deficit can reduce the risk of infections, other complications and mortality for those patients. An ideal nutritional marker should correlate with morbidity and mortality, such as hospitalization and death, and should identify patients who need nutritional intervention [9].

The methods for nutritional status assessment can be subjective (clinical history and physical examination) or objective (anthropometry, biochemical exams, and bioelectrical impedance (BEI)). Subjective global assessment (SGA) [10] is a useful and reproducible instrument for assessing the nutritional status of dialysis patients. The NKF K/DOQI 2000 guidelines have recommended that SGA be performed every six months in the dialysis population with that purpose in mind [11]. BEI is a quick, relatively inexpensive and noninvasive method for assessing body compartments. To apply this technique, an electric current is introduced through the injector electrodes and captured by the detector electrodes, generating vectors of resistance and reactance. Resistance is the measure of opposition to the flow of electric current through the body and reactance is opposition to the flow of electric current caused by the capacitance produced by cell membranes. From the identification of resistance and reactance levels, total body water, lean mass, fat mass and extracellular water can be obtained [12-14].

This report aimed to assess the prevalence of MN in a cohort of Moroccan HD patients and correlate different techniques of nutritional assessment.

## Methods

This cross-sectional study was conducted in 2011 in a single hemodialysis center in the Military Hospital of Rabat in Morocco. The study protocol was approved by the Committee on Ethics and Research of the institution. The study population included 40 HD patients aged over 18 years who had been on maintenance HD for at least three months. We excluded patients who had lower limb amputation or paraplegia, pregnant women, patients with active underlying disease or infection and patients who were hospitalized during the month preceding the study. We also excluded patients if they had advanced senility or dementia interfering with application of the nutritional questionnaire or refused to cooperate with the study.

All Patients were dialyzed with volumetric dialyzer machines, three times per week, with arterio-venous (AV) fistulas, using a bicarbonate buffer-based dialysate and hollow fiber membrane dialyzers with low-permeability (polyamide). The anticoagulation used was low-molecular-weight heparin. The study population underwent nutritional assessment by use of clinical, anthropometric, biochemical indicators, and BEI.

The clinical evaluation of nutritional status was performed by two trained physicians using Subjective Global Assessment (SGA). SGA comprised five clinical history criteria and two items of physical examination. Clinical history criteria included weight loss in the last six months, gastrointestinal symptoms (anorexia, nauseas, vomiting, diarrhea), dietary intake, functional capacity and comorbidities. The physical examination items were subcutaneous fat and muscle mass losses. Patients were categorized as SGA-A (adequately nourished), SGA-B (suspected or moderately malnourished) or SGA-C (severely malnourished).

Anthropometric indices assessed were: post-dialysis weight (kg); height (cm); body mass index (BMI) (kg/$m^2$); measurement of arm circumference (AC) using tape measure; and measurement of the triceps skin-fold thicknesses (TSF) by adipometer skin-fold caliper. Arm muscle circumference (AMC) was calculated as follows: AMC = AC - (3.14 x TSF). Skin fold thicknesses and circumferences were measured before HD on the limb without the vascular access.

Blood samples were taken just before the beginning of a dialysis session. The biochemical indices assessed were serum albumin measured by use of bromcresol green (BCG), serum prealbumin measured by immunonephelemetry, serum creatinine, blood urea nitrogen (BUN), serum cholesterol and lymphocytic count. Also, a post dialysis blood sample was taken for measuring the BUN [15]. The urea reduction ratio (URR) as an indicator of dialysis adequacy was calculated by the formula: URR = 100 (1 – post-BUN/pre-BUN) [15]. We also calculated the Kt/V (double pool) and normalized protein equivalent of total nitrogen appearance (nPNA) by Garred's method [16, 17].

BEI analysis was done with a Body Composition Monitor (BCM) (Fresenius Medical Care) 30 minutes before the beginning of dialysis. While the patient lay comfortably without their limbs touching their bodies, current-injector electrodes were placed just below the metacarpo-phalangeal joint in the middle of the dorsal side of the right hand and just below the transverse (metatarsal) arch on the superior side of the right foot for each subject. Detector electrodes were placed on the posterior side of the right wrist and across the medial ankle bone of the right ankle. Five resistance and reactance readings were averaged for each subject. Body composition values calculated by the instrument included total water, intracellular and extracellular water, lean tissue index (LTI) and fat tissue index (FTI).

**Table 1: Demographic, anthropometric, laboratory and dialysis characteristics of the population study , according to the patients' gender**

| Variables | Mean (n=40) | Gender difference | | |
|---|---|---|---|---|
| | | Male (n=20) | Female (n=20) | p |
| Age (years) | 50.7±16.5 | 47.7±16.4 | 53.6±16.5 | 0.26 |
| Duration of HD (months) | 36 [16.5-106]* | 28 [16.5-95.5]* | 66.5 [14.25-109]* | 0.49 |
| Week duration of HD (hours) | 12.29±0.92 | 12.39±0.97 | 12.2±0.89 | 0.51 |
| Weight (kg) | 63.8±12 | 66.4±10.8 | 61.2±12.8 | 0.17 |
| Height (cm) | 165±7 | 170±6 | 160±5 | <0.001 |
| BMI (kg/m$^2$) | 23.2±3.4 | 22.9±2.9 | 23.6±4 | 0.48 |
| AC (cm) | 25.4±2.4 | 25.8±2.4 | 25.1±2.5 | 0.43 |
| AMC (cm) | 21.1±2.5 | 22.5±2.2 | 17.4±4.2 | <0.001 |
| TSF (mm) | 14.1±5.7 | 10.8±5.1 | 17.4±4.2 | <0.001 |
| LTI (kg/m$^2$) | 10.8±2.8 | 12.6±2.6 | 9.1±2 | <0.001 |
| FTI (kg/m$^2$) | 12.4±3.7 | 11±4.3 | 13.8±2.2 | 0.14 |
| Albumin (g/L) | 34.1±3.3 | 34.2±3.7 | 34±3 | 0.81 |
| Prealbumin (mg/L) | 290±80 | 319±77 | 262±73 | 0.021 |
| Creatinine (mg/L) | 92.7±25.1 | 105.9±26.4 | 79.5±15.4 | <0.001 |
| Cholesterol (g/L) | 1.8±0.33 | 1.8±0.3 | 1.7±0.2 | 0.43 |
| Lymphocytic count | 1505±677 | 1442±454 | 1568±853 | 0.56 |
| Urea reduction ratio (%) | 79±5.5 | 77.9±4.6 | 80±6.1 | 0.26 |
| Kt/V | 1.5±0.19 | 1.43±0.18 | 1.58±0.18 | 0.019 |
| nPNA (g/kg/day) | 1.06±0.15 | 1.05±0.18 | 1.07±0.12 | 0.71 |

* results are shown as median and quartiles.

HD: hemodialysis; BMI: body mass index; AC: arm circumference; AMC: arm muscle circumference; TSF: triceps skin-fold thickness; LTI: lean tissue index; FTI: fat tissue index; Kt/Vdp: Kt/V; nPNA: normalized protein equivalent of total nitrogen appearance.

The results were expressed as mean ± standard deviation. Variables with normal distribution were compared by use of the Student t test. For variables with non normal distribution Mann-Whitney test was used. Pearson's test was used to assess the linear correlation between the variables studied. Statistical analysis was performed with the SPSS software, version 10.0. p value < 5% was considered statistically significant.

## Results

A total of 40 patients including 20 males and 20 females were investigated. The etiology of CKD was undetermined in 32.5% of the patients. Other causes included glomerulonephritis (20%), chronic tubulointerstitial nephritis (17.5%), diabetes (15%), polycystic kidney disease (5%) and miscellaneous causes (10%).The main comorbidities encountered were arterial hypertension in 30%, diabetes in 15%, and heart failure in 2.5% of cases. Erythropoietin stimulating agent (ESA) was administered to 90% of patients.

The demographic, anthropometric and laboratory characteristics according to gender are shown in Table-1. Women had significantly lower height and AMC but higher TSF in comparison to men. The BIA revealed a highly significant difference in LTI but no difference in FTI according to gender. Men had significantly higher LTI in comparison to women. The levels of serum albumin, serum cholesterol, and lymphocytic counts were

**Table 2: Prevalence of malnourished patients according to the nutritional markers used in the population studied**

| Nutritional Parameter | N (%) |
|---|---|
| BMI < 18.5 kg/m$^2$ | 5 (12.5) |
| Albumin < 35 g/L | 26 (65) |
| Prealbumin < 300 mg/L | 22 (55) |
| n PNA < 1 g/kg/day | 12 (30) |
| SGA B/C | 8 (20) |

BMI: Body mass index; nPNA normalized protein equivalent of total nitrogen appearance; SGA: Subjective Global Assessment

similar in men and women. Serum prealbumin and serum creatinine concentrations were significantly reduced in women as compared to men.

According to conventional SGA, 20% of the patients were moderately/severely malnourished (SGA - B/C), and 80% were well nourished (SGA - A). The prevalence of malnourished patients, according to some anthropometric and biochemical markers in the population studied is shown in Table-2.

LTI was positively correlated with serum albumin ($r = 0.37$; $p = 0.018$), serum prealbumin ($r = 0.53$; $p < 0.001$) and AMC ($r = 0.39$; $p = 0.012$) and negatively correlated with TSF ($r = -0.47$; $p = 0.002$). FTI was negatively correlated with prealbumin ($r = -0.35$; $p = 0.026$) and positively correlated with BMI ($r = 0.59$; $p < 0.001$) and AC ($r = 0.44$; $p = 0.004$) (Tables 3 and 4, Figures 1 and 2).

## Discussion

MN is a common problem in dialysis patients that increases patients' mortality and morbidity. Despite this, the nutritional status of HD patients is frequently ignored [15, 18]. Assessment of MN of dialysis patients has been suggested to be based on multiple indicators of the nutritional status, comprising the assessment of visceral protein deposits by use of biochemical parameters, and somatic deposits by use of the analysis of body composition (weight, anthropometry, BEI, total body nitrogen and DEXA) [4, 5]. The present study assesses the prevalence of MN in HD patients and correlates the methods used for monitoring nutritional status.

The prevalence of MN in the population studied varied a lot (from 5 to 65%), depending on the method used for diagnosis. In the literature, this prevalence is 25%-80% in different studies [4, 5, 9] and that variability is due to the different criteria for diagnosing the nutritional status. The NKF K/DOQI 2000 guidelines have recommended that SGA be performed every six months in HD patients, as a screening test, for early detection of patients at nutritional risk. However, it is not clear whether SGA is a nutritional marker. According to Cooper *et al* [19], SGA was not good for detecting the degree of MN, when compared to total body nitrogen content. It is worth emphasizing that total body nitrogen is the gold standard to assess protein MN, but it does not consider calorie MN, which is an important component of nutritional assessment [5]. SGA was a predictor of mortality in different studies [20, 21]. An ideal nutritional marker should be associated with morbidity and mortality, and identify patients who need nutritional intervention. Although SGA has several advantages such as low cost, easy performance, and predictive value for mortality, it is worth noting that visceral proteins are not assessed by use of that method, and its sensitivity, accuracy, and reproducibility over time has not been studied [5].

Anthropometry is a common method of nutritional assessment, but assessment errors in HD population may occur, due to the alteration in the hydration status of tissues. In addition, anthropometry is relatively inefficient for identifying MN in HD, especially in an early phase, due to lack of reliable patterns for comparison [22]. Another disadvantage in that method is its dependence on the examiner. Some authors have suggested that anthropometry markedly underestimates the degree of protein loss in CKD [23]. However, Nelson *et al* [22] have shown that anthropometry may be reproducible and its sensitivity is 90%.

According to the results of our study, mean anthropometric parameters in HD patients differed between men and women. Men had higher AMC while women had higher TSF and BMI values. In a study by Ahamadi *et al* [24], BMI, AC, AMC and TSF in women were more than in men but the difference was not significant. Oliveira *et al* [5] showed that AMC was significantly higher in male patients as compared to female patients. To make any conclusions about these differences in anthropometric parameters in HD patients the values of these parameters in the general population and for each gender need to be known. Anthropometric indices, especially BMI, are easily applied in clinical practice at dialysis units. According to the World Health Organization [25], the diagnosis of MN would apply to patients of the general population with a BMI lower than 18.5 kg/m$^2$. In the present study, the mean BMI was 23.2±3.4 kg/m$^2$ and no significant difference was observed between the

**Table 3: Correlation between some biochemical nutritional parameters and anthropometric, bioelectrical impedance nutritional parameters**

| Anthropometrics parameters | Albumin | | Prealbumin | |
|---|---|---|---|---|
| | r | p | r | p |
| BMI | -0 .18 | 0.25 | -0.14 | 0.38 |
| AC | 0.003 | 0.98 | 0.15 | 0.33 |
| AMC | 0.08 | 0.60 | 0.33 | 0.034 |
| TSF | -0.09 | 0.55 | -0.22 | 0.15 |
| **BEI parameters** | | | | |
| LTI | 0.37 | 0.018 | 0.53 | <0.001 |
| FTI | -0.25 | 0.11 | -0.35 | 0.026 |

BMI: body mass index; AC: arm circumference; AMC: arm muscle circumference; TSF: triceps skin fold thickness; BEI: bioelectrical impedance; LTI: lean tissue index; FTI: fat tissue index

**Table 4: Correlation between anthropometrics nutritional parameters and the bioelectrical impedance nutritional parameters**

| Anthropometrics parameters | LTI | | FTI | |
|---|---|---|---|---|
| | r | p | r | p |
| BMI | -0.16 | 0.30 | 0.59 | <0.001 |
| AC | 0.037 | 0.82 | 0.44 | 0.004 |
| AMC | 0.39 | 0.012 | -0.009 | 0.95 |
| TSF | -0.47 | 0.002 | 0.61 | <0.001 |

BMI: body mass index; AC: arm circumference; AMC: arm muscle circumference; TSF: triceps skin-fold thickness; LTI: lean tissue index; FTI: fat tissue index

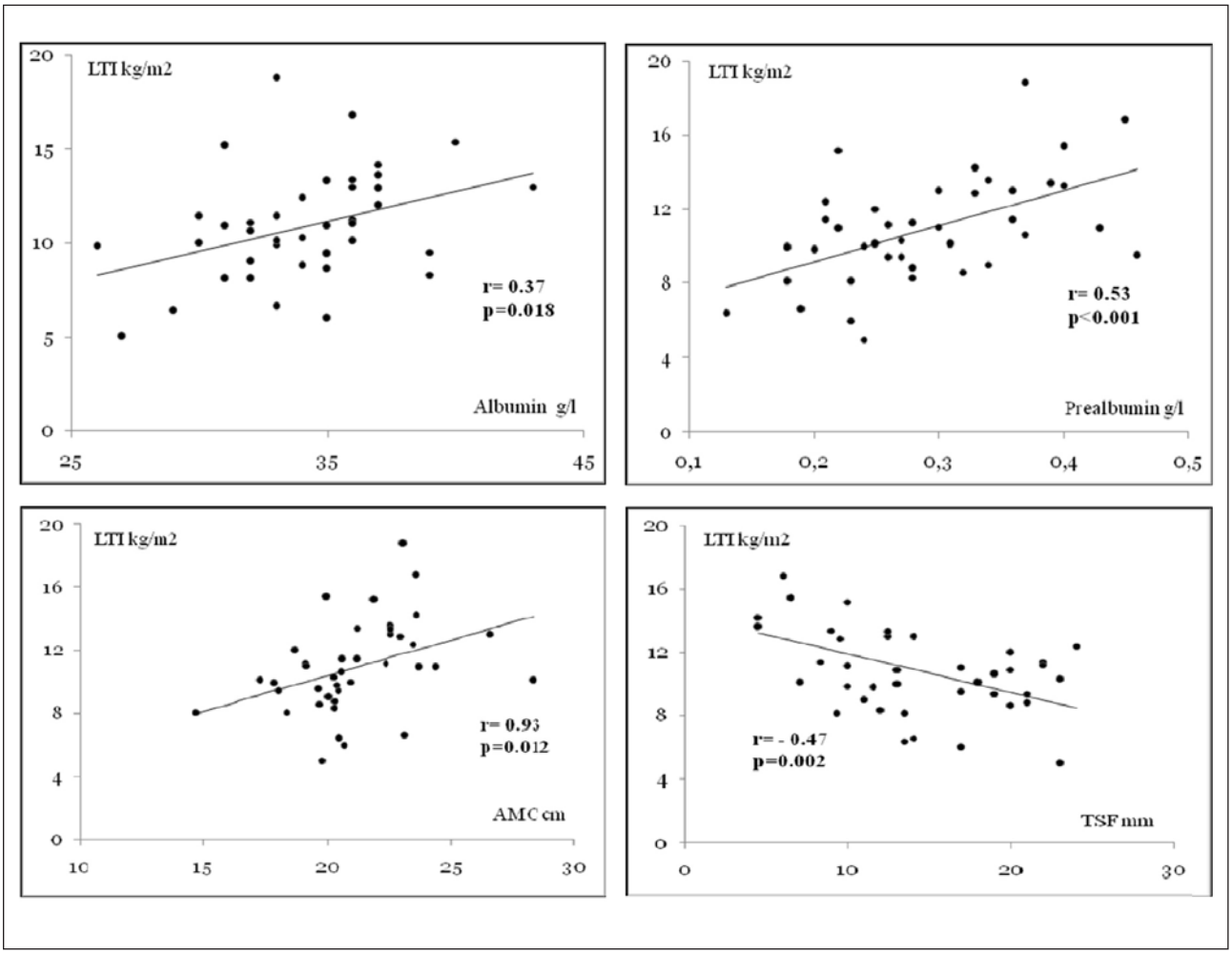
two genders. When adopting this limit, the prevalence of MN was 12.5%. This value was similar to results of previously reported studies [5, 26]. The choice of a BMI cut-off point of 18.5 kg/m$^2$ for the dialysis population can be questioned because patients with a BMI lower than 22 kg/m$^2$ already seem to be at a risk of mortality. Some studies have found that, in dialysis, a high BMI associates with a better prognosis [5, 27]. Leavey *et al* [28] have reported that a BMI lower than 23.9 kg/m$^2$ was associated with an increase in the mortality rate. Tokunaga *et al* [29] have reported that the BMI cut-off associated with lower morbidity was 22.2 kg/m$^2$ for men and 21.9 kg/m$^2$ for women, and have suggested that the ideal body weight would be the one associated with a BMI of 22 kg/m$^2$.

Among the biochemical parameters, albumin is a marker of visceral protein storage. It is most frequently used to assess protein MN based on the concept that the level of serum albumin reflects the visceral protein status. However, this is only partly true, since there are many others factors that influence the generation, distribution, and catabolism of albumin degradation, albumin losses from the body, dilution by fluid overload and exchange between intravascular and extravascular compartments [30]. The ESRD Clinical Performance Measures Project [31] has defined that serum albumin lower than 3.5 g/dl by use of BCG and lower than 3.2 g/dl by use of bromcresol purple (BCP) indicate an inadequate serum albumin level, and values greater than 4.0 g/dl by use of BCG and 3.7 g/dl by use of BCP characterize an optimal serum albumin level. The International Society of Renal Nutrition and Metabolism recently included serum albumin <3.8 g/dl as one of three biochemical diagnostic criteria for protein energy wasting [32]. Valenzuela *et al* [33] studying 165 patients on dialysis have reported albumin levels lower than 3.5 g/dl (BCG method) in only 8% of the patients. On the other hand, Cabral *et al* [34] had reported that 54.1% and 94.6% of the patients had albumin lower than 3.5g/dL and 4.0 g/dL respectively by the BCG method. In the present study, the nutritional assessment through predialysis albumin detected 65% of malnourished patients according to the cut-off point (< 3.5 g/dl), and 95 % of patients had an albumin level less than 4.0 g/dl.

The K/DOQI [11] and the European [35] guidelines for HD patients recommend nPNA to be at least 1.0 g/kg day. More recently, Kalantar-Zadeh *et al* studied the relationship between nPNA and mortality in a U.S. cohort of almost 54 000 HD patients [36]. They noticed that a decrease in nPNA below 1.2 g/kg day during the first 6 months was followed by an increase in mortality in the following 18 months, whereas an increase in nPNA was associated with a reduction in death risk. In this study the mean nPNA was 1.06±0.15 g/kg day and there was no significant difference between males and females.

In regard to BEI, the values of reactance and phase angle have been recently shown to have a good correlation with nutritional markers, and clinical studies have associated the phase angle with morbidity and mortality of patients on HD [37]. In the present study, we found that the LTI was positively correlated with AMC, serum albumin and serum prealbumin, but negatively correlated with TSF. On the other hand, the FTI was positively correlated with BMI, AC and TSF, but negatively correlated with serum prealbumin.

**Figure 1: Correlation between lean mass index (LTI) and serum albumin, serum prealbumin, arm muscle circumference (AMC), triceps skin-fold thickness (TSF)**




Therefore, the K/DOQI guidelines do not recommend BEI as a valid method to estimate body composition in HD patients [11], although some authors have found significant correlations between BEI and reference methods like DEXA or NaBr [38].

## Conclusion

In summary, the nutritional assessment methods commonly used in clinical practice are subject to restrictions when applied to dialysis populations, considering the different percentages obtained with the different methods. Our data suggest that BEI analysis provides a useful means of assessing nutritional status and was correlated with anthropometrics and biochemical findings. Thus, BEI is helpful in identifying patients with increased risk of morbidity and mortality in the setting of dialysis. Further studies are required to assess the sensitivity to changes and association with survival, hospitalization, and functional status, and for better defining the role played by BEI.

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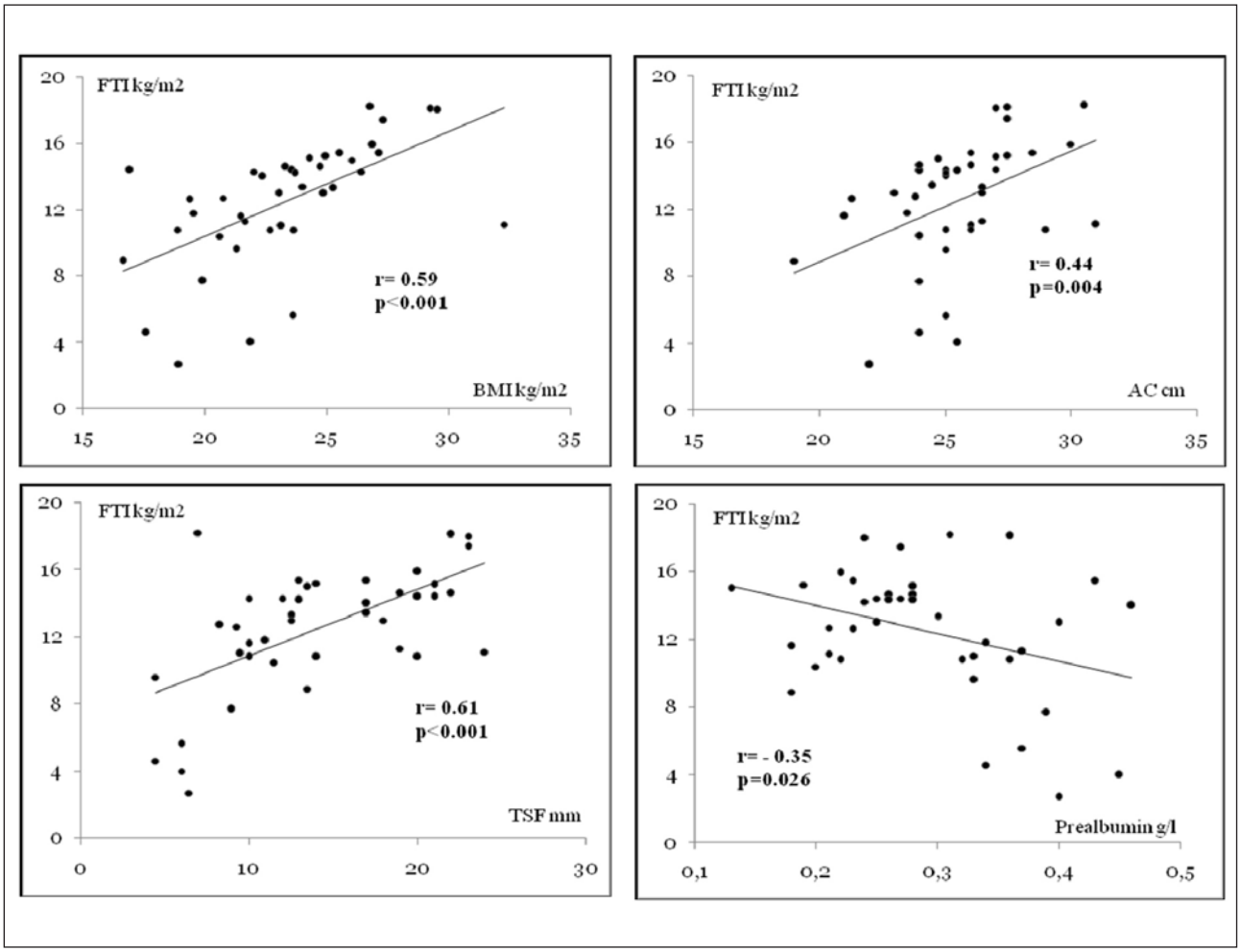
**Figure 2: Correlation between fat mass index (FTI) and body mass index (BMI), arm circumference (AC), triceps skin-fold thickness (TSF) and serum prealbumin,**

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