Phase angle as a predictor of outcomes in chronic kidney disease: an integrative review

Doracy Lovasz Dantas[1]

[1] Pontifical Catholic University of Rio Grande do Sul (PUCRS), Porto Alegre, RS, Brazil.

Open Access

Corresponding author:
Doracy Lovasz Dantas (dylz1968@gmail.com)
Pontifical Catholic University of Rio Grande do Sul (PUCRS)

Published: November 8, 2025

Nutrition and Metabolism Journal: Clinical and Experimental: *2025, Volume 1 (Issue 1)*

Highlights

- Chronic kidney disease is a global public health problem.
- Gathering relevant information improves patient care and treatment outcomes.
- Phase angle is portrayed as a prognostic tool in several clinical conditions.
- There is a strong association between nutritional status and the phase angle.

Abstract

Introduction: Considered a global health problem, chronic kidney disease progresses silently, leading to nutritional disorders that have negative repercussions on body composition, prognosis and life expectancy. The need to quickly identify whether nutritional intake is adequate or whether it needs to be revised has led researchers to investigate the usefulness of phase angle (PA) as an indicator of muscle quality. From this perspective, this research aimed to determine whether PA is an adequate predictor of clinical outcomes for mortality and/or readmission in patients with chronic kidney disease.
Methods: Integrative review with an exploratory bias, conducted according to a protocol previously orderly and registered in the Open Science Framework (OSF). Through the Virtual Health Library (BVS), the MEDLINE, IBECS, LILACS and WPRIM databases were accessed; the Cochrane Library was accessed through the collection of the Coordination for the Improvement of Higher Education Personnel (CAPES), and the SciELO scientific library was accessed through its virtual address. The search was limited to articles published between 2019 and 2024, in Portuguese, English or Spanish.
Results: Of the total of 392 publications screened, 5 were eligible for detailed analysis criteria.
Conclusions: Considering the small number of articles produced in recent years, as well as the small number of evidence on clinically relevant results to correlate PA and mortality in the CKD population, it is concluded that it is not possible to use PA as a predictor of mortality or readmission.

Keywords: Phase Angle; Electrical Impedance; Chronic Kidney Disease

Introduction

The year was 1836, and Richard Bright was already studying the morphological changes in a kidney that had belonged to a hypertensive patient. At Guy's Hospital in England, the prominent physician was pioneering the study of what later became a global health problem: Chronic Kidney Disease (CKD). CKD is defined here as a lesion that persistently and silently affects kidney structure or function, progressively and irreversibly decreasing glomerular filtration rate[1].

In the centuries following Bright's discoveries, the scientific community expanded its knowledge of kidney disease as rapidly as the number of people affected by the condition grew. Particularly in the last decade, a significant increase in the number of kidney disease cases has mobilized organizations worldwide. Unfortunately, the search for effective measures to control such a complex situation was seriously hampered by the arrival of COVID-19. Infected patients presented a wide range of kidney alterations directly linked to increased mortality. Furthermore, the SARS-CoV-2 virus has been shown to potentially trigger kidney complications in patients with previously compromised kidney function[2].

In Brazil, economic, social, and demographic disparities, combined with the high prevalence of chronic diseases, a sedentary lifestyle, and frequent adoption of risky behaviors, have made CKD one of the biggest public health problems today. Deaths from kidney failure, which had already been rising over the past few decades, increased significantly in 2020 when the SARS-CoV-2 virus reached the country. However, widespread vaccination coverage and the subsequent decline in COVID-19 cases contributed to a decrease in mortality in 2022, according to data from the Brazilian Dialysis Census. 3 Even so, the complexity and high cost of treatment overburden the healthcare system, impact the national economy, and reduce the population's quality of life.

Even if it's imperceptible at first, when the renal parenchyma is damaged, organic homeostasis is compromised. This happens because the kidneys are directly or indirectly responsible for elementary activities. Among the numerous factors that lead to damage, two stand out for their close relationship with kidney function: systemic arterial hypertension (SAH) and type 2 diabetes mellitus (T2DM)[4].

In an attempt to regulate systemic blood pressure, endothelins, atrial natriuretic peptide, eicosanoids, and reactions triggered by renin-angiotensin interaction and nitric oxide (NO) play a role. The simultaneous action of these mediators results in the expansion of intravascular volume, causing an increase in renal perfusion with subsequent autoregulation and a reduction in perfusion pressure. This mechanism is exacerbated by T2DM and its persistent hyperglycemia, which trigger a cascade of events that lead to endothelial dysfunction and affect glomerular filtration capacity[5].

Changes in renal hemodynamics and the related oxidative stress promote changes in the glomeruli, leaving the basement membrane denser and expanding mesangial cells. With the remodeled mesangial endothelium, there is an increase in glomerular pressure and subsequent enlargement of membrane pores, causing a rupture that allows the passage of molecules with higher atomic mass, such as proteins[6].

Glomeruli are fragile structures, susceptible to increased pressure. Faced with this injury, the immune system is stimulated, and inflammatory responses exacerbate the lesions, rapidly reducing the number of nephrons. Resistant nephrons become hyperplastic, further increasing glomerular permeability. Similarly affected, the tubules also reorganize, seeking a compensatory response that maintains normal excretion. However, this adaptation does not last indefinitely, leading to increased inflammation, hypoxia, cellular necrosis, and tubulointerstitial fibrosis[5].

Uncontrolled hypertension and type 2 diabetes are not the only etiological agents. Damage to renal structures can result from a multitude of factors, ranging from autoimmune and/or hereditary diseases, recurrent urinary tract infections, various illnesses, nephrotoxic substances, alcoholism, senescence, cardiovascular and endocrine dysfunctions, and even undetermined or idiopathic damage[5].

Regardless of the etiology, in the face of irreversible and prolonged damage, there will be a progressive decrease in the glomerular filtration rate (GFR). Scenarios in which the GFR remains below 60 mL/min per 1.73 m² of body surface area, with or without any evidence of structural injury, for a period of more than 3 months constitutes established CKD[4].

Loss of kidney function accompanies a depletion of the body's energy and protein reserves, which can be aggravated by pre-existing comorbidities and the aging process. The reasons are multiple: elevated levels of pro-inflammatory cytokines stimulate acute-phase proteins, leading to increased proteolysis; insulin resistance and acidosis, combined with uremic syndrome, increase chronic inflammation, further driving protein breakdown; and pharmacotherapy associated with altered metabolism and imposed dietary restrictions predisposes to loss of appetite. And as CKD progresses, the condition can worsen. Patients using renal replacement therapy (RRT) increase the risk of complications due to infection, especially in the catheter area, contributing to the increase in nutritional disorders. Furthermore, peritoneal dialysis (PD) can lead to hypertriglyceridemia, dyslipidemia, and obesity, resulting from the daily absorption of glucose present in the dialysate (the volume absorbed can vary from 100 to 200g/day). on the other hand, hemodialysis patients experience significant loss of amino acids and other nutrients in the intradialytic process, significantly reducing nutritional intake[6,7,8].

Additionally, the limitations imposed by the rigid treatment negatively impact emotional well-being, leading to episodes of depression and prostration. This contributes to this population's low adherence to physical exercise and an active lifestyle. Reduced physical activity significantly impairs nutritional status, favoring the emergence of aggravating factors such as protein-energy malnutrition, sarcopenia, sarcopenic obesity, and frailty syndrome[9].

In this scenario, body composition changes. The restrictions and complications associated with the disease lead to nutritional disorders with negative repercussions on prognosis and life expectancy. Routine monitoring of body composition is necessary to determine whether the nutritional intake provided is adequate or, on the contrary, urgently

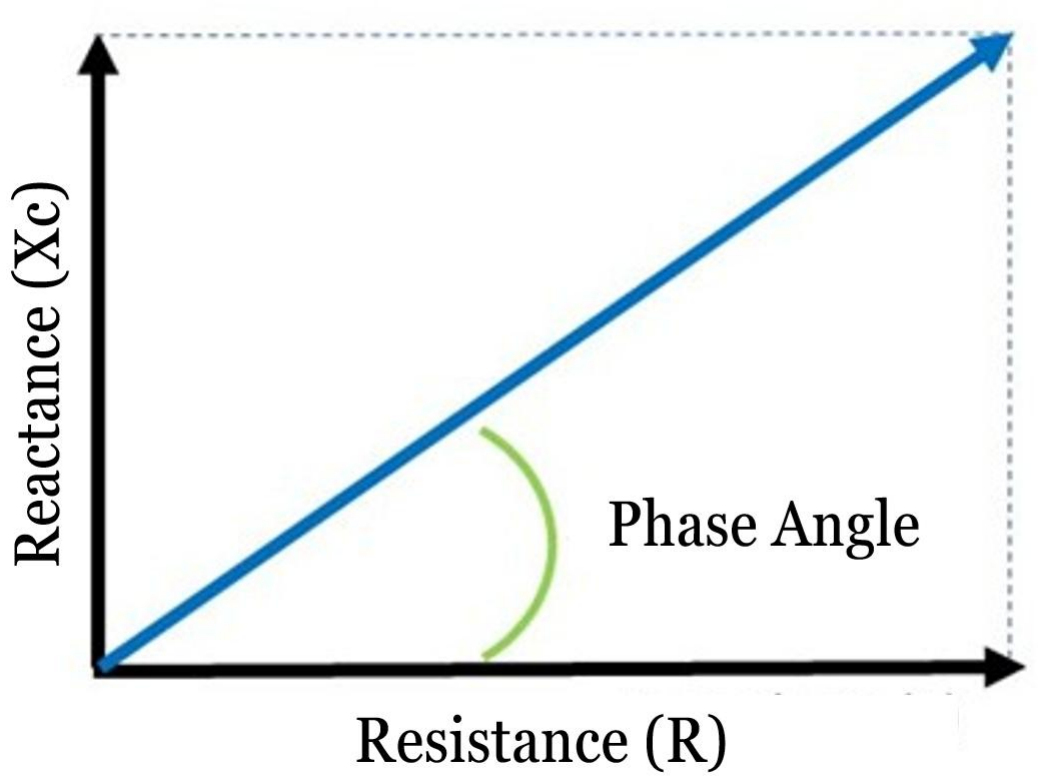
needs to be revised. This urgency in decision-making and the high costs associated with treatment require the use of an effective tool that does not cause major discomfort to the patient and does not overburden the process[10].

A tool that has been widely used in assessing body composition is bioelectrical impedance analysis (BIA). This device can estimate body composition based on the resistance that biological tissues offer to the flow of an alternating current. Electrodes placed at the ends of the analyzed tissue section record changes in electrical conductivity. In the presence of muscle tissue, the current passes easily, while adipose and bone tissue offer greater resistance. This occurs because fat-free mass contains more body fluids and, therefore, a greater amount of electrolytes, allowing electricity to flow easily through the ions present in this aqueous medium. Fat mass, on the other hand, repels water (with the ions), and bone mass acts as an electrical insulator[11].

Impedance derives from the relationship between resistance (R) and reactance (Xc), that is, the relationship between how a body opposes the passage of electric current (resistance) and how that electricity is retained, resulting from the insulation potential of the cell membrane (reactance). What allows for insulation is the membrane's lipid structure. This means that an intact membrane provides better insulation, indicating good cell mass quality, which in turn is associated with good individual health[11, 12].

When it encounters the membrane, the speed of the electric current decreases, as some of the energy is retained there for a short period. The result is a drop in voltage that gives rise to a phase shift, forming a tangent arc between resistance (R) and reactance (Xc). The angle that is established is called the phase angle (PA) and can be geometrically represented as in **Figure 1**[13]:

Figure 1: Phanse angle.



In this context, several studies have focused on the usefulness of phase angle (FA) as an indicator of muscle quality and its relationship with prognosis in various pathologies. It has shown promising results not only in its association with clinical outcome and survival time, but also in monitoring disease progression and treatment effectiveness[14, 15, 16, 17]. This is because reactance (Xc) and resistance (R) are factors dependent on the quantity and quality of muscle mass. As the inflammatory process increases, catabolism increases, reducing reactance (Xc) and consequently the degree of the phase angle (PA)[12].

It is known that patients with CKD present marked muscle catabolism due to metabolic changes arising from chronic inflammation associated with clinical conditions underlying CKD, such as acidosis resulting from a drop in GFR, uremic syndrome and anemia, among other factors[5]. These conditions favor the use of PA to monitor the nutritional status of these patients, as the greater the loss of muscle mass and inflammation in individuals with CKD, the lower the PA.

Furthermore, this characteristic catabolism is accompanied by muscle weakness that sometimes progresses to sarcopenia, a condition that favors and increases the risk of mortality[8]. Patients in these conditions have presented a low degree of AF, which corroborates the idea that AF can be used to predict an outcome of readmission or death, since the lower the degree of AF, the greater the severity of the disease, which in turn triggers cardiometabolic complications, increasing the chances of hospitalization and mortality[15].

Although it has potential for use in the CKD population, PA is not considered a reference method for assessing body composition and nutritional status. The Kidney Disease Outcomes Quality Initiative (KDOQI) clinical practice guideline for nutrition in CKD, published in 2020, states that there is no single method or instrument that provides complete knowledge of body composition and nutritional status, and that a combination of more than one method is recommended for a reliable patient assessment[32]. Methods such as dual energy X-ray absorptiometry (DXA), magnetic resonance imaging and computed tomography (CT) are recommended for their good accuracy and applicability when it comes to patients with kidney disease. However, the high cost limits the routine use of these devices, making anthropometry one of the most used methods due to its affordable price[33].

Regarding the cutoff points for the use of AF, there is no consensus. The multiple variables involved (target population characteristics, pathology of interest, study design) present a heterogeneity that makes standardization difficult. What we observe are reference values adjusted from average values of healthy populations, considering sex, age, and ethnicity, or from the association with length of hospital stay or clinical outcome[11].

Despite the multiplicity of factors that make standardizing AF a challenge, there is agreement among authors regarding its superiority in identifying nutritional impairment and subsequent consequences, making it a better option than DXA or CT for monitoring nutritional status[11,14,16,18].

Therefore, the purpose of this research is not to question its effectiveness. Rather, we propose to investigate, through an integrative literature review, whether PA is an adequate predictor of clinical outcomes for mortality and/or readmission in patients with chronic kidney disease, given that this condition is characterized by fluid retention and fluid-electrolyte imbalance, factors that directly impact the achievement of reliable PA.

Methods

An Integrative Literature Review (IR) was carried out with the aim of investigating in scientific databases what has been published regarding the following research question: Is PA an adequate predictor of mortality and/or readmission when used in patients with CKD?

The study was structured according to the steps guided by Estrela (2018)[19] and based on the recommendations of a checklist adapted from the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)[20]. A protocol that describes in detail the six steps that comprise this work has been established and registered with the Open Science Framework (OSF). The protocol is available at: https://osf.io/jztp3/?view_only=3a357ec0b46446119bf6e314e1de5b2f.

The first stage involved determining the topic of interest and developing the research question, aiming to achieve the desired objectives. This IR included the following objectives: Primary objective: To evaluate the association between PA and all-cause mortality, as well as the association of PA with readmission in the adult and elderly population with CKD. Secondary objective: To determine whether mortality can be predicted in individuals with CKD using PA.

The second stage involved defining the eligibility criteria for article selection to ensure sample representativeness. Original, full-text, free-access articles published in Portuguese, English, or Spanish between 2019 and 2024 that addressed the use of PA in determining the nutritional status of adults and/or elderly people with chronic kidney disease and its correlation with mortality and/or readmission were excluded. Articles related to the pediatric population, literature reviews, case reports, and experience reports were excluded. The third stage involved searching for and identifying relevant papers; the search took place on April 10th and 11th, 2024. The data to be extracted from the selected articles were also defined.

The search process included the use of descriptors. Using the DeCS portal, descriptors that addressed the research question were searched, resulting in the selection of the following terms in Portuguese: "electrical impedance" and "chronic kidney disease," which were combined using the Boolean operator AND. No descriptor related to the term "phase angle" was found. Because it is a key term, it was placed at the top of the search expression, associated with the descriptor "electrical impedance" using the Boolean operator OR.

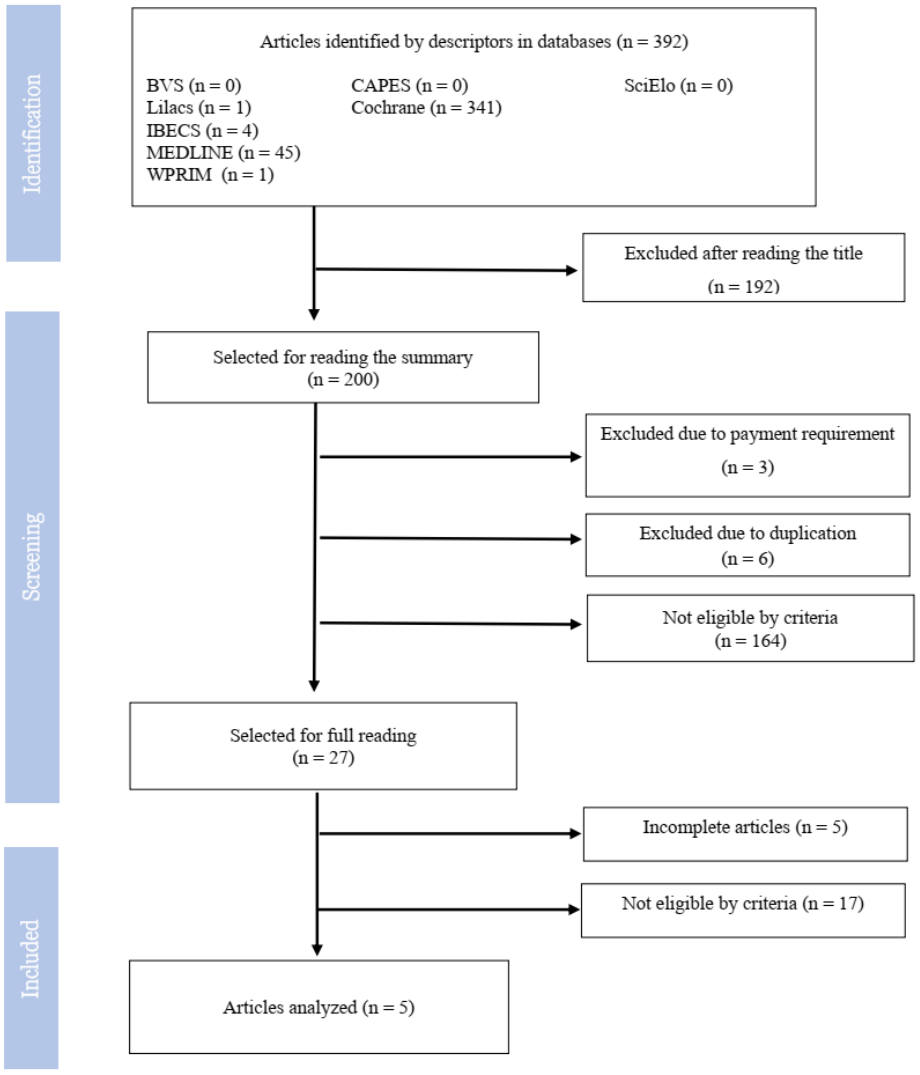
Article retrieval began with the advanced search tool of the Virtual Health Library (VHL). Two filters were used: "publication year range" was used to restrict studies published between 2019 and 2024, and "language" was used to

exclude studies not in Portuguese, English, or Spanish. As a result, 51 articles indexed in the MEDLINE, IBECS, LILACS, and WPRIM databases were obtained. Filters by time and language were also used in the Cochrane Library, resulting in 341 publications. SciELO found no documents in the search.

Of the 392 publications, 192 were found to be inappropriate after reading the title, 3 required payment, 6 were indexed in more than one database, and 164 did not meet the inclusion criteria after reading the abstract. Of the 27 selected for full-text reading, 5 were incomplete, and 17 were found to be ineligible based on the selection criteria.

The screening process can be viewed in the Article Selection Flowchart (**Figure 2**).

Figure 2: Article Selection Flowchart, adapted from the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA).



In extracting data from the selected articles, an instrument adapted from the questionnaire validated by Ursi (2006) was used[21]. Adaptation was necessary to adapt the questionnaire to the topic at hand. The next three stages of this integrative review included analysis and discussion of the data collected, interpretation of the results, and, finally, a complete and detailed presentation of the IR so that the reader could assess the applicability of the method in clinical practice.

Results

At the end of the screening, only five articles correlated low PA levels with a higher likelihood of death, and none investigated the association of PA with hospital readmission. All articles were from Medline and originally published in English. Most publications were from 2022, with only one from 2020.

The studies that gave rise to the published articles enrolled patients of varying ages, with the established cutoff point being 18 to 20 years of age; the exception was the study by Ruperto and Barril (2022)[22], which recruited exclusively elderly patients. The definition of elderly followed the criteria established by the UN at the World Assembly on Aging (1982), which considers people aged 60 or older in developing countries and 65 or older in developed countries[23]. There was no maximum age cutoff point in any of the studies.

Regarding CKD staging, all authors used the classification proposed by Kidney Disease Improving Global Outcomes – KDIGO[24]. Two studies were conducted with CKD patients undergoing conservative treatment: estimated GFR ≤ 45 mL/min/1.73 m² or stages G3b, G4–G5 (study conducted in Spain in 2022)[25]; estimated GFR 15–59 mL/min/1.73 m² or stages G3a, G3b, and G4 (Mexico, 2022)[26]. Another study focused on the population aged 65 years or older with estimated GFR ≤ 30 mL/min/1.73 m² or stages G4–G5, pre-dialysis (Spain, 2022)[22]. The last two studies were conducted with patients undergoing RRT: one included patients undergoing hemodialysis (HD) for a period of ≥ 6 months (Korea, 2022)[27]; the other included patients on continuous ambulatory peritoneal dialysis (CAPD), was conducted in China, and published in 2020[28]. General characteristics and a summary of each study are described in **Table 1**.

Table 1: General characteristics and summary of studies.

Authors	Title	Journal / Year / Country	Study Design	Study Synthesis
Barril, G. et al.	Nutritional predictors of mortality after 10 years of follow-up in patients with chronic kidney disease at a multidisciplinary unit of advanced chronic kidney disease	Nutrients / 2022 / Spain	Observational study, retrospective	To identify mortality risk factors in CKD, patients eligible by criteria were grouped into one of three groups: survivors (n = 161) and censored (n = 84). The "non-survivor" group consisted of patients who died from various pathologies; the "censored" group consisted of patients who were withdrawn from the study. Biochemical, anthropometric, and other data were collected and analyzed.
Alatriste, P.V.M. et al.	Hydration status according to impedance vectors and its association with clinical and biochemical outcomes and mortality in patients with chronic kidney disease	Nutrición Hospitalaria / 2022 / Mexico	Observational study	To determine the association between hydration status measured by BIVA, biochemical and clinical parameters with mortality in patients with CKD in stages G3a, G3b and G4, a subanalysis of data collected in two previous studies was performed: 1st cross-sectional study with 81 patients from INCMNSZ in 2004 to assess hydration status through BIVA and identify its associations with anthropometric, clinical and biochemical variables; 2nd blinded randomized clinical trial with 57 patients from INCMNSZ in 2015, who underwent clinical and nutritional assessments, including BIVA.
Ruperto, M.; Barril, G.	Nutritional status, body composition, and inflammation profile in older patients with advanced chronic kidney disease stage 4–5: a case-control study	Nutrients / 2022 / Spain	Case-control	Elderly individuals (n = 150) were allocated into 2 groups: 75 with CKD (stages 4-5) individually matched with controls (without CKD or other pathology that influenced nutritional and inflammatory status) registered in the community, in a 1:1 ratio for age and sex. Several parameters were assessed, including body composition and hydration by BIVA.
Kang, S.H. et al.	Impedance-derived phase angle is associated with muscle mass, strength, quality of life, and clinical outcomes in maintenance hemodialysis patients	PLoS One / 2022 / South Korea	Observational study	Eighty-three patients eligible by criteria and on HD (3x/week) were divided into tertiles based on the phase angle value as follows: low tertile, medium tertile, and high tertile. On the day after the second HD of the week, measurements were performed (BIVA, MM, strength, physical performance, among others). The association between the phase angle and MM, strength, and QOL was investigated.
Huang, R. et al.	Lower phase angle measured by bioelectrical impedance analysis is a marker for increased mortality in incident continuous ambulatory peritoneal dialysis patients	Journal of Renal Nutrition / 2020 / China	Prospective study	760 patients using CAPD for more than 3 months underwent BIVA measurement at some point between the 1st and 3rd month of starting CAPD (among other criteria) and had their data analyzed to verify the association of BP with the risk of death from all causes and, mainly, cardiovascular death.

Legend: ACKD = Advanced Chronic Kidney Disease Unit; RRT = Renal Replacement Therapy; HD = hemodialysis; BIVA = electrical impedance vector analysis; INCMNSZ = Salvador Zubirán National Institute of Medical Sciences and Nutrition; DRC = chronic kidney disease; MM = muscle mass; QOL = quality of life; CAPD = continuous ambulatory peritoneal dialysis.

As shown in **Table 1**, in addition to the small number, there is a lack of homogeneous distribution of publications over the last six years, and none were authored by Brazilians. This finding identifies a gap, considering that this is a country with a recent increase in the prevalence of chronic dialysis patients, with an incidence of approximately 214 patients per million (ppm)[3]. With an estimated mortality rate of 17.1% and a small participation (28%) of dialysis centers in the data collection for the national census, expanding knowledge on this topic is crucial to improving these rates.

This problem is not exclusive to developing countries like Brazil. Epidemiological statistics demonstrate that CKD severely impacts the healthcare system in developed countries, which have seen a significant increase in CKD incidence[29] and prevalence rates. Therefore, expanding the scope of research in this area is essential for the international scientific community and global public health.

In the five studies, patients with lower PA values were older, had a higher inflammatory profile, and lower albumin levels. Barril et al. (2022) demonstrated that the PA values of the survivor group differed significantly from those of the non-survivors. The median PA value for the total number of study participants was 4.10 ± 1.16, with a PA ≥ 4° present in 53.40% of the survivor group, while 58.10% of the non-survivors had a PA < 4°. Furthermore, Kaplan-Meier survival analysis showed a longer survival in months for the study population with AF > 4°.

The findings of Alatriste et al. (2022) corroborate the idea that lower PA is associated with higher mortality rates. Of the 138 patients in the study sample, 8.7% died within a median time of 52.2 months, with the mean follow-up period for the group being 119.6 months (median of 65.5 months). As the study's objective was to determine whether hydration status is related to mortality, the relationship between blood volume and complications resulting from the fluid changes experienced by the patients was investigated. This investigation confirmed the association of PA with fluid overload.

Electric impedance vector analysis (BIVA) allows hydration to be quantified by the length of the vector: excess body fluids generate less resistance, producing shorter vectors, which form shorter PA, demonstrating compromised nutritional status. Thus, impedance analysis identified fluid retention and separated normally hydrated from overhydrated patients. The group with overhydration and lower PA had a four-fold increased risk of mortality according to multivariate Cox proportional hazards regression. The PA values measured ranged from 4.1° to 6.5°. At the end of the study, BIVA proved useful in assessing body composition and hydration status in patients with CKD stages G3 and G4 not on dialysis, and the derived PA proved to be an important predictor of clinical outcomes.

Ruperto and Barril (2022) also identified PA as a reliable tool in detecting clinical outcomes and a higher likelihood of long-term death. The analysis that led to the correlation of nutritional status with BIA measurements (and among these, I highlight PA) showed significant differences between the case and control groups, validating the assumption that lower PA increases the likelihood of nutritional risk. PA ≥4° was positively associated with a higher percentage of muscle mass (MM), both by univariate and multivariate analysis. This value may also be associated with better preserved nutritional status in both groups. Overall, the CKD group expressed lower PA compared to the control group. Intracellular water was also positively associated with higher PA, while extracellular mass and C-reactive protein (CRP), a strong inflammatory marker, were inversely correlated. At the end of the study, nutritional indicators, body composition measures, and inflammatory markers were significant risk predictors in CKD patients compared to age- and sex-matched controls, and PA <4° was shown to be an independent predictor of long-term mortality.

Kang, Do, and Kim (2022) evaluated 83 patients on hemodialysis (HD) for at least 6 months. Based on individual PA, patients were grouped into low, medium, and high tertiles. With a broad objective, the authors tested the hypothesis that PA is associated with several factors, such as muscle mass and strength, physical activity performance, mood and quality of life scales, and hospitalization-free survival rates. Ultimately, the study demonstrated a strong association between PA and muscle mass, strength, physical performance, and quality of life assessed by the Korean version of the Kidney Disease Quality of Life Short Form (KDQOL-SF). The KDQOL-SF is a scale specifically used to measure quality of life in kidney patients. It is a 36-item questionnaire that quantifies and analyzes the impact of kidney disease based on the patient's perception. One of the study's interesting findings was the finding that depressive mood and anxiety increase as PA decreases. Kaplan-Meier analysis showed that survival in the high tertile was significantly better than in the low tertile (P = 0.165 for low tertiles compared to medium tertiles and P = 0.046 for low tertiles compared to high tertiles). Hospitalization-free survival was also proportionally higher in the higher tertiles (P = 0.003 for low versus middle tertiles and P = 0.006 for low versus high tertiles). The mean follow-up duration was 596 ± 338 days. Thus, the analysis showed that hospitalization-free survival was better in the middle tertile, while patient survival was better in the upper tertile.

The final article is the study by Huang et al. (2020), which identified that lower PA significantly correlates with cardiovascular mortality and all-cause mortality in patients treated for CKD with continuous ambulatory peritoneal dialysis (CAPD). CAPD is a well-established treatment for managing CKD in patients with cardiovascular disease or when there is difficulty establishing vascular access. The sample population consisted of 760 patients using CAPD. Baseline PA measured at baseline, and 381 patients had PA <4.59° and 379 patients had PA ≥4.59°. With a median follow-up of 42 months, a total of 125 patients died: 16.4% from various causes, of which 8.9% died due to cardiovascular disease. The analysis showed that 13.6% of patients who died had baseline AF <4.59°, while 2.9% had AF ≥4.59°. **Table 2** highlights the objectives of each study, the sample characteristics, and identifies the results found that relate to the research question of interest.

Table 2: Objectives, population, results of interest.

Authors	Aims of the Study	Study Sample	Results of Interest
Barril, G. et al.	To identify mortality risk factors in chronic kidney patients undergoing nutritional monitoring at the ACKD multidisciplinary unit.	307 patients, age ≥ 18 years, CKD stage 3b, 4-5 or GFR ≤ 45 mL/min/1.73m2. Inclusion criteria: at least 3 months of ACKD, no exacerbation (sepsis, etc.), no major surgery in the last three months, no lower limb acuity, no malignant tumor, no use of NGT, GTT or PN, life expectancy > 3 months.	Significantly different PA values were found between the survivor and non-survivor groups. Higher PA values were present in the survivor group. Kaplan-Meier survival analysis revealed that patients with PA > 4° had significantly longer survival.
Alatriste, P.V.M. et al.	Hydration status according to impedance vectors and its association with clinical and biochemical outcomes and mortality in patients with chronic kidney disease	Nutrición Hospitalaria / 2022 / Mexico	To determine the association between hydration status measured by EIVA, biochemical and clinical parameters with mortality in patients with CKD in stages G3a, G3b and G4, a subanalysis of data collected in two previous studies was performed: 1st cross-sectional study with 81 patients from INCMNSZ in 2004 to assess hydration status through EIVA and identify its associations with anthropometric, clinical and biochemical variables; 2nd blinded randomized clinical trial with 57 patients from INCMNSZ in 2015, who underwent clinical and nutritional assessments, including EIVA.
Ruperto, M.; Barril, G.	Nutritional status, body composition, and inflammation profile in older patients with advanced chronic kidney disease stage 4–5: a case-control study	Nutrients / 2022 / Spain	Elderly individuals (n = 150) were allocated into 2 groups: 75 with CKD (stages 4-5) individually matched with controls (without CKD or other pathology that influenced nutritional and inflammatory status) registered in the community, in a 1:1 ratio for age and sex. Several parameters were assessed, including body composition and hydration by EIVA.
Kang, S.H. et al.	Impedance-derived phase angle is associated with muscle mass, strength, quality of life, and clinical outcomes in maintenance hemodialysis patients	PLoS One / 2022 / South Korea	Eighty-three patients eligible by criteria and on HD (3x/week) were divided into tertiles based on the phase angle value as follows: low tertile, medium tertile, and high tertile. On the day after the second HD of the week, measurements were performed (EIVA, MM, strength, physical performance, among others). The association between the phase angle and MM, strength, and QOL was investigated.
Huang, R. et al.	Lower phase angle measured by bioelectrical impedance analysis is a marker for increased mortality in incident continuous ambulatory peritoneal dialysis patients	Journal of Renal Nutrition / 2020 / China	760 patients using CAPD for more than 3 months underwent EIVA measurement at some point between the 1st and 3rd month of starting CAPD (among other criteria) and had their data analyzed to verify the association of BP with the risk of death from all causes and, mainly, cardiovascular death.

Legend: ACKD = Advanced Chronic Kidney Disease Unit; CAPD = continuous ambulatory peritoneal dialysis; CKD = chronic kidney disease; EIVA = electrical impedance vector analysis; GFR = glomerular filtration rate; GTT = gastrostomy; HD = hemodialysis; INCMNSZ = Salvador Zubirán National Institute of Medical Sciences and Nutrition; LL = lower limbs; MM = muscle mass; NGT = nasogastric tube; PA = phase angle; PN = parenteral nutrition; QOL = quality of life.

As can be observed in **Table 2**, although the objectives of each study differed, all authors at some point focused on analyzing the relationship between AF and mortality. This analysis allowed the identification of information of interest to answer the research question that was proposed.

All the studies developed corroborate the idea that AF is an efficient instrument for determining the probability of the mortality outcome in patients from stage G3a to stage G5, whether or not the patient is undergoing renal replacement therapy. However, it should be noted that this systematic review has several limitations. The small number of articles screened may be insufficient to represent a consistent pattern of results. In addition, the number of deaths was calculated from information extracted from clinical records, which leads to considering the possibility of underreporting, since death outside the hospital is not always recorded in the patient's medical record. The total number of measurements in each study varied from 1 to a maximum of 3 times, making it impossible to ascertain changes in AF over time and its relationship with the clinical outcome. The cutoff points for AF associated with mortality differ slightly from each other and differ even more from previous studies, such as the cutoff point established by Bansal et al (2018)[31], which was 5.59°,

and this makes it difficult to establish a value to be adopted in clinical practice. Finally, we have a variety of BIA devices, employing different numbers of electrodes, not always evaluating the same tissue segment, also differing in the frequency used, and some without reporting the protocol applied.

Conclusions

Therefore, further studies are needed to assess the correlation between bioelectrical impedance analysis (BIA) and mortality in the population with chronic kidney disease (CKD). With few studies found, as mentioned, it is not possible to conclude that BIA is a predictor of mortality or rehospitalization. However, a strong association is observed between nutritional status and measured BIA, showing that it is a valid method for estimating body composition and nutritional status in patients even in the presence of changes in volume status. Therefore, BIA is a tool with the potential to quickly assist in decision-making regarding the nutritional management to be adopted. However, efforts need to be made to develop intervention studies that lead to a better understanding of the potential use of BIA and enable the standardization of protocols, as well as the establishment of reference values for this population. By expanding the scope of research, it will be possible to assess whether BIA is a good predictor of mortality and/or hospital readmission.

References

1. Silva FSL, Da Cruz FC, Pinheiro DM, Campelo EM, Cardoso JA, Rodrigues SP de M, et al. Mortalidade por doença renal crônica no Brasil: revisão integrativa / Cronic kidney disease mortality in Brazil: an integrative review. Brazilian Journal of Health Review. 2021;4(5):19900–10. Available from: https://ojs.brazilianjournals.com.br/ojs/index.php/BJHR/article/view/36292

2. Obrişcă B, Mocanu V, Vornicu A, Jurubiţă R, Sorohan B, Dimofte G, et al. The impact of SARS-CoV-2 infection on renal function in patients with biopsy-proven kidney diseases. PLoS One. 2023;18(12):e0296168. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10745175/#pone.0296168.ref002

3. Nerbass FB, Lima H do N, Moura-Neto JA, Lugon JR, Sesso R. Censo Brasileiro de Diálise 2022. Brazilian Journal of Nephrology. 2023;46(2):e20230062. Available from: https://www.scielo.br/j/jbn/a/RfV3vq5MYQxMdmzKmrPW7Hz/abstract/?lang=pt

4. Tortora GJ, Derrickson B. Princípios de Anatomia e Fisiologia. 16 ed. Rio de Janeiro: Guanabara Koogan; 2023. p.1288

5. Rosa, COB; Hermsdorff, HHM. Fisiopatologia da nutrição e dietoterapia. 1 ed. Rio de Janeiro: Rubio, 2021, 688p.

6. Murray I, Paolini MA. Histology, Kidney and Glomerulus [Internet]. PubMed. Treasure Island (FL): StatPearls Publishing; 2020. Available from: https://www.ncbi.nlm.nih.gov/books/NBK554544/

7. Shlipak MG, Tummalapalli SL, Boulware LE, Grams ME, Ix JH, Jha V, et al. The Case for Early Identification and Intervention of Chronic Kidney Disease: Conclusions from a Kidney Disease: Improving Global Outcomes (KDIGO) Controversies Conference. Kidney International. 2020;99(1). Available from: https://www.kidney-international.org/article/S0085-2538(20)31210-2/fulltext

8. Hanna Ramy M, Ghobry L, Wassef O, Rhee Connie M, Kalantar-Zadeh K. A Practical Approach to Nutrition, Protein-Energy Wasting, Sarcopenia, and Cachexia in Patients with Chronic Kidney Disease. Blood Purification. 2019;49(1-2):202–11. Available from: https://pubmed.ncbi.nlm.nih.gov/31851983/

9. Rodrigues KA, Silva EM da, Barbosa LD da C e S. Repercussões biopsicossociais em pacientes submetidos a tratamento hemodialítico. Research, Society and Development. 2020;9(7):e814974931. Available from: https://rsdjournal.org/index.php/rsd/article/view/4931

10. Pretto CR, Winkelmann ER, Hildebrandt LM, Barbosa DA, Colet C de F, Stumm EMF, et al. Calidad de vida de pacientes renales crónicos en hemodiálisis y factores relacionados. Revista Latino-Americana de Enfermagem. 2020;28. Available from: https://www.scielo.br/scielo.php?pid=S0104-11692020000100372&script=sci_arttext&tlng=es

11. Ward LC. Bioelectrical impedance analysis for body composition assessment: reflections on accuracy, clinical utility, and standardisation. European Journal of Clinical Nutrition. 2018;73(2):194–9. Available from: https://www.nature.com/articles/s41430-018-0335-3

12. Ram JL, P Michael Conn. Conn's handbook of models for human aging. London, United Kingdom: Elsevier Ltd; 2018.

13. Sardinha LB. Physiology of exercise and phase angle: another look at BIA. European Journal of Clinical Nutrition. 2018;72(9):1323–7. Available from: https://www.nature.com/articles/s41430-018-0215-x

14. Mundi MS, Patel JJ, Martindale R. Body Composition Technology: Implications for the ICU. Nutrition in Clinical Practice. 2018;34(1):48–58. Available from: https://aspenjournals.onlinelibrary.wiley.com/doi/full/10.1002/ncp.10230

15. Rimsevicius L, Gincaite A, Vicka V, Sukackiene D, Pavinic J, Miglinas M. Malnutrition Assessment in Hemodialysis Patients: Role of Bioelectrical Impedance Analysis Phase Angle. Journal of Renal Nutrition: The Official Journal of the Council on Renal Nutrition of the National Kidney Foundation. 2016;26(6):391–5. Available from: https://pubmed.ncbi.nlm.nih.gov/27450205/

16. Stuqui M, Marinilza Beccaria L, Albertini SM, Fernandes de Godoy M. Ângulo de fase como potencial marcador do estado nutricional de pacientes em terapia intensiva. Cogitare Enfermagem. 2022;(27):1–11. Available from: https://www.scielo.br/j/cenf/a/BjTKgmMh5bpM4ZJ6Bf48VkH/?lang=pt#

17. Thibault R, Makhlouf AM, Mulliez A, Cristina Gonzalez M, Kekstas G, Kozjek NR, et al. Fat-free mass at admission predicts 28-day mortality in intensive care unit patients: the international prospective observational study Phase Angle Project. Intensive Care Medicine. 2016;42(9):1445–53. Available from: https://link.springer.com/article/10.1007/s00134-016-4468-3

18. Martins PC, de Lima LRA, Berria J, Petroski EL, da Silva AM, Silva DAS. Association between phase angle and isolated and grouped physical fitness indicators in adolescents. Physiology & Behavior. 2020; 217:112825. Available from: https://www.sciencedirect.com/science/article/pii/S0031938419313587

19. Estrela, C. Metodologia Científica: Ciência, Ensino, Pesquisa. 3. ed. Porto Alegre: Artes Médicas, 2018, p. 706

20. Peters MDJ, Godfrey C, McInerney P, Khalil H, Larsen P, Marnie C, et al. Best Practice Guidance and Reporting Items for the Development of Scoping Review Protocols. JBI Evidence Synthesis. 2022. Available from: https://journals.lww.com/jbisrir/fulltext/2022/04000/best_practice_guidance_and_reporting_items_for_the.3.aspx

21. Ursi ES, Gavão CM. Prevenção de lesões de pele no perioperatório: revisão integrativa da literatura. Revista Latino-Americana de Enfermagem. 2006;14(1):124–31. Available from: https://www.scielo.br/j/rlae/a/7hS3VgZvTs49LNX9dd85VVb

22. Ruperto M, Barril G. Nutritional Status, Body Composition, and Inflammation Profile in Older Patients with Advanced Chronic Kidney Disease Stage 4–5: A Case-Control Study. Nutrients. 2022;14(17):3650. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9460397/

23. UN – United Nations. Plano de Ação Internacional de Viena Sobre o Envelhecimento, 1982. tradução de Arlene Santos. Brasília: Secretaria Especial dos Direitos Humanos, 2003. 49 p.

24. Levey AS, Eckardt KU, Dorman NM, Christiansen SL, Hoorn EJ, Ingelfinger JR, et al. Nomenclature for kidney function and disease: report of a Kidney Disease: Improving Global Outcomes (KDIGO) Consensus Conference. Kidney International. 2020;97(6):1117–29. Available from: https://www.sciencedirect.com/science/article/pii/S0085253820302337

25. Barril G, Nogueira A, Alvarez-García G, Núñez A, Sánchez-González C, Ruperto M. Nutritional Predictors of Mortality after 10 Years of Follow-Up in Patients with Chronic Kidney Disease at a Multidisciplinary Unit of Advanced Chronic Kidney Disease. Nutrients. 2022;14(18):3848. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9504469/

26. Alatriste PVM, Espinosa-Cuevas Á, Ramírez EC, Carsi XA, Cruz-Rivera C. Hydration status according to impedance vectors and its association with clinical and biochemical outcomes and mortality in patients with chronic kidney disease. Nutrición Hospitalaria. 2022;39(5):1037-1046. Available from: https://www.nutricionhospitalaria.org/articles/03970/show

27. Kang SH, Do JY, Kim JC. Impedance-derived phase angle is associated with muscle mass, strength, quality of life, and clinical outcomes in maintenance hemodialysis patients. PLoS One. 2022;17(1):e0261070. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8754345/

28. Huang R, Wu M, Wu H, Ye H, Peng Y, Yi C., et al. Lower Phase Angle Measured by Bioelectrical Impedance Analysis Is a Marker for Increased Mortality in Incident Continuous Ambulatory Peritoneal Dialysis Patients.

Science Direct. Elsevier; 2020; 30(2). Available from: https://www.sciencedirect.com/science/article/pii/S1051227619302638?via%3Dihub

29. Jager KJ, Kovesdy C, Langham R, Rosenberg M, Jha V, Zoccali C. A single number for advocacy and communication—worldwide more than 850 million individuals have kidney diseases. Nephrology Dialysis Transplantation. 2019;34(11):1803–5. Available from: https://academic.oup.com/ndt/article/34/11/1803/5574389

30. Yangöz, Şefika Tuğba, Turan Kavradim, S., Özer, Z., & Boz, İ. Psychometric properties of the Kidney Disease Quality of Life-36 instrument: A systematic review using COSMIN methodology. Nursing & Health Sciences. 2021; 23(4), 792–806. Availablefrom: https://onlinelibrary.wiley.com/doi/10.1111/nhs.12877

31. Bansal N, Zelnick LR, Himmelfarb J, Chertow GM. Bioelectrical Impedance Analysis Measures and Clinical Outcomes in CKD. American Journal of Kidney Diseases: The Official Journal of the National Kidney Foundation. 2018;72(5):662–72. Available from: https://pubmed.ncbi.nlm.nih.gov/29885923/

32. Ikizler, TA et al. KDOQI Clinical Practice Guideline for Nutrition in CKD: 2020 Update. Am J Kidney Dis. v. 76, n. 3, p. S1–S107, 2020. Available from: https://www.sciencedirect.com/science/article/pii/S0272638620307265

33. Ceniccola, GD et al. Current technologies in body composition assessment: advantages and disadvantages. Nutrition. v. 62, p. 25-31, 2019. Available from: https://www.sciencedirect.com/science/article/pii/S0899900718313182