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Original Article

# Evaluating phase angle in malnutrition risk assessment using nutritional screening tools

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SUMMARY

*Background & aims:* Malnutrition is a common complication in patients with breast cancer and is associated with adverse clinical outcomes. Phase angle (PhA), a parameter derived from bioelectrical impedance analysis (BIA) may reflect nutritional status, but its value versus standard tools remains unclear. This study aims to evaluate the utility of PhA in detecting malnutrition risk in breast cancer patients, compared with four validated screening tools.
*Methods:* This cross-sectional observational study included 98 female patients with breast cancer. Nutritional status was assessed using the Nutritional Risk Screening 2002 (NRS-2002), Patient-Generated Subjective Global Assessment Short Form (PG-SGA SF), Malnutrition Universal Screening Tool (MUST), and Malnutrition Screening Tool (MST). PhA was measured using single-frequency (50 kHz) BIA. Receiver Operating Characteristic (ROC) analysis was used to determine the optimal PhA cut-off for malnutrition risk. Associations between PhA and malnutrition risk were examined univariate and multivariate logistic regression analyses.
*Results:* PhA was significantly associated with nutritional risk across all four screening tools. The optimal PhA cut-off for malnutrition risk based on NRS-2002 was 5.04 degrees (AUC = 0.83), with 73% sensitivity and 87% specificity. In crude logistic regression, a PhA <5.04 degrees significantly increased malnutrition risk across all screening tools: NRS-2002 (OR = 0.178, $p < 0.001$), MUST (OR = 0.338, $p = 0.005$), MST (OR = 0.308, $p <$

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0.001), and PG-SGA SF (OR = 0.481, p = 0.037). These associations remained statistically significant after adjustment for age and fat mass index in three models (excluding PG-SGA SF).
*Conclusion:* PhA, appears to be a practical and supportive indicator for identifying malnutrition risk in breast cancer patients, particularly when used alongside validated screening tools. The identified cut-off value (5.04 degrees) may serve as a useful threshold in clinical practice.



## Introduction

Cancer remains a major global public health concern. According to GLOBOCAN 2022 data from the International Agency for Research on Cancer (IARC), breast cancer is the most frequently diagnosed malignancy and the leading cause of cancer-related mortality among women worldwide [1]. Malnutrition is a common condition in cancer patients, particularly in those with advanced disease stages, and is known to negatively affect treatment outcomes, increase morbidity, and contribute to mortality. Notably, alterations in the electrical properties of body tissues can precede the clinical signs of malnutrition in cancer patients [2]. Therefore, early and accurate assessment of nutritional status is critical to ensure appropriate clinical management. Nutritional screening plays a key role in identifying patients at risk and allows for timely interventions to prevent or mitigate malnutrition-related complications [3].

Comprehensive nutritional assessment should be qualitative and quantitative, incorporate subjective and objective parameters and be simple, rapid, reproducible and numerically interpretable for routine clinical application [4]. Despite the availability of numerous validated screening and assessment tools, there is currently no universally accepted gold standard for evaluating nutritional status in oncology patients [5].

Bioimpedance analysis (BIA) is a non-invasive, cost-effective, and reproducible technique for assessing body composition and nutritional status. PhA, a parameter derived from BIA by calculating the ratio of reactance (Xc) to resistance (R), reflects cell membrane integrity and body cell mass. It has been increasingly recognized as a valuable prognostic marker for malnutrition and overall health status in various clinical populations [2,6,7].

According to the 2017 European Society of Clinical Nutrition and Metabolism (ESPEN) consensus on clinical nutrition terminology, PhA provides meaningful insight into body composition and may serve as a useful prognostic tool [8]. In patients with advanced cancer, lower PhA values have been consistently associated with poorer nutritional status and reduced survival [9]. Notably, studies have shown that PhA tends to decrease following chemotherapy in breast cancer patients, with persistently low values unless nutritional support is provided. Conversely, targeted interventions such as individualized nutritional optimization (including high-protein medical nutrition therapy) and structured resistance training have been shown to stabilize or even improve PhA in breast cancer patients undergoing chemotherapy [10–12].

Despite these findings, routine clinical implementation of PhA remains limited, partly due to variability in cut-off values stemming from differences in measurement techniques, electrode placement, and patient characteristics [13,14]. Therefore, more research is needed to establish standardized reference values and clarify its role in specific populations.

This study aimed to explore the potential role of PhA in indicating malnutrition risk among breast cancer patients. Additionally, its diagnostic performance was compared to four widely used and validated nutritional screening tools: NRS-2002, PG-SGA SF, MUST, and MST.

## Material and methods

### *Study setting and design*

This observational, cross-sectional study was conducted at Medicana Hospital in Istanbul, Turkey, between June and December 2019. The research protocol was approved by the Ethics Committee of Istanbul Bilgi University under the reference number 2019-20016-28. Written informed consent was obtained from all participants prior to enrolment.

### *Participants*

The study included breast cancer patients who applied to the departments of medical oncology and radiation oncology at Medicana Hospital and agreed to participate. The required sample size was calculated using G*Power statistical analysis software. An a priori power analysis, based on an independent samples t-test with an alpha level of 0.05, an effect size of 0.33, and a statistical power of 90%, indicated a minimum sample size of 90 participants. To account for potential dropouts, 100 patients were recruited (50 from each department). The flow of participant recruitment and study completion is presented in Figure 1.

Inclusion criteria were: (1) age $\geq$18 years, (2) a confirmed diagnosis of breast cancer, and (3) provision of written informed consent. Exclusion criteria included: (1) communication impairments (e.g., severe cognitive dysfunction), (2) lymphedema in the upper or lower limbs, (3) history of edema-related diseases (e.g., heart or liver failure), (4) use of diuretics, (5) presence of ascites, pleural

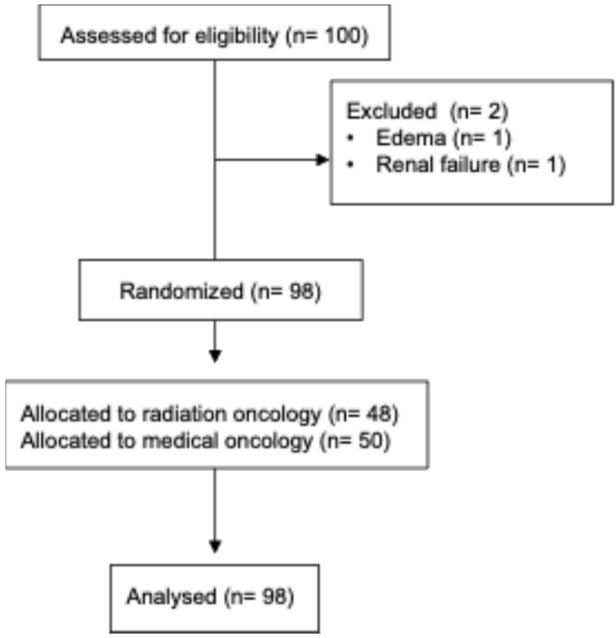


**Figure 1.** Consort flow diagram of the study.

effusion, or pericardial effusion, and (6) the presence of pacemakers, metal implants, or limb amputations due to potential interference with BIA measurements.

*Study measurements*

Data on age, sex, primary cancer diagnosis and treatment type (e.g., chemotherapy, radiotherapy) were obtained from medical records. Additional demographic data were collected via face-to-face interviews.

Although there is no universally accepted gold standard for malnutrition screening, several tools validated by ESPEN [15], American Society for Parenteral and Enteral Nutrition (ASPEN) [16], and British Association for Parenteral and Enteral Nutrition (BAPEN) [17] were used: PG-SGA SF [18], NRS-2002 [19,20], MUST [21,22], and MST [23].

Height and body weight were measured using a calibrated clinical scale. Body mass index was calculated by dividing body weight by the square of height (BMI = weight [kg]/height [$m^2$]). Body composition and PhA were assessed using BIA. All measurements were performed in the morning after a minimum of six hours of fasting. A single-frequency (50 kHz) Premium BIA600 Nutribox Rev. 1.0 (Juwell Medical Gmbh, Rheine, Germany) device was used, which generates an alternating electric current through the body. Before measurement, skin was cleaned with 70% ethanol. Electrodes were placed on the dorsal side of the right hand, right wrist, right foot, and right ankle according to manufacturer guidelines. Patients were measured in the supine position. Measurement data, including R, Xc and PhA, as well as demographic data (e.g., name, gender, height, weight, date of birth), were entered into the BodyExplorer 3.0.2 Premium Health 16 software (Juwell Medical Gmbh, Rheine, Germany). The following BIA parameters were recorded: fat mass (FM), fat mass index (FMI), fat-free mass (FFM), fat-free mass index (FFMI), extracellular mass (ECM), body cell mass (BCM), ECM/BCM ratio, PhA, and nutritional index. The nutritional index, derived from BIA measurements, reflects the relationship between Xc and R, thereby providing information on cell membrane integrity and overall nutritional and metabolic status.

*Statistical analysis*

This observational, descriptive, cross-sectional study used means ± standard deviations (SD) for continuous variables and frequencies (n, %) for categorical variables. Normality was assessed using the Kolmogorov-Smirnov test. The Chi-square test was applied to compare categorical variables, and Student's t-test was used for continuous variables. A p-value of $<0.05$ was considered statistically significant. ROC analysis was performed to determine the optimal PhA cut-off for predicting risk of malnutrition. Logistic regression analyses (univariate and multivariate) were conducted to examine the association between PhA and malnutrition risk. Multivariate models was performed with adjustments for age and FMI. Odds ratio (OR) were reported for each 1 degrees decrease in PhA to indicate the corresponding rise in malnutrition risk. All statistical analyses were performed using SPSS version 30.0 (IBM Corp., Armonk, NY, USA).

## Results

After excluding two participants because of edema and renal failure, a total of 98 female patients with breast cancer were included and completed the study. Descriptive data, including age, anthropometric measurements, disease stage, treatment methods and nutritional screening tool outcomes, are summarized in Table 1. The mean age of the participants was 54.51 ± 12.69 years. The average BMI and PhA were 29.14 ± 5.12 kg/$m^2$ and 5.23 ± 0.73 degrees, respectively. The mean phase angle did not differ significantly by disease stage (Stage 1: 5.67 ± 0.55; Stage 2: 5.16 ± 0.82; Stage 3: 5.27 ± 0.52; Stage 4: 5.02 ± 0.86; $p = 0.061$) or treatment method (radiotherapy: 5.34 ± 0.72 vs. chemotherapy: 5.13 ± 0.74; $p = 0.167$), as shown in Table 2.

In the study, an attempt was made to obtain the cut-off values of the PhA using ROC curves from each malnutrition screening tool such as NRS-2002, PG-SGA SF, MUST, and MST (Table 3 and Figure 2). We calculated the area under the ROC curve 0.83 with a standard error of 0.05. Since the area under

**Table 1**
Baseline characteristics of patients

| Parameters | n=98 |
|---|---|
| | $\bar{x} \pm SD$ |
| Age | 54.51 ± 12.69 |
| Body weight (kg) | 74.29 ± 12.88 |
| Height (cm) | 159 ± 0.07 |
| BMI (kg/m$^2$) | 29.14 ± 5.12 |
| Phase Angle (PhA, degrees) | 5.23 ± 0.73 |
| ECM[a] (kg) | 23.52 ± 4.20 |
| BCM[b] (kg) | 21.05 ± 2.97 |
| ECM/BCM Index | 1.13 ± 0.25 |
| Body fat (kg) | 29.72 ± 8.40 |
| FFM[c] (kg) | 44.27 ± 5.40 |
| FMI[d] (kg/m$^2$) | 11.67 ± 3.34 |
| FFMI[e] (kg/m$^2$) | 17.46 ± 2.07 |
| Nutritional Index | 91.72 ± 12.95 |
| Disease Stage | **n (%)** |
| Stage 1 | 14 (14,3) |
| Stage 2 | 30 (30,6) |
| Stage 3 | 30 (30,6) |
| Stage 4 | 24 (24,5) |
| Treatment Method | **n (%)** |
| Radiotherapy | 48 (49) |
| Chemotherapy | 50 (51) |
| Nutritional Screening Tools | **n (%)** |
| PG-SGA SF | |
| Normal | 37 (37.8) |
| Malnutrition risk | 61 (62.3) |
| MUST | |
| Normal | 79 (80.6) |
| Malnutrition risk | 19 (19.4) |
| MST | |
| Normal | 58 (59.2) |
| Malnutrition risk | 40 (40.8) |
| NRS-2002 | |
| Normal | 82 (83.7) |
| Malnutrition risk | 16 (16.3) |

[a] ECM; Extracellular mass.
[b] BCM; Body cell mass.
[c] FFM; Fat free mass.
[d] FMI; Fat mass index.
[e] FFMI; Fat free mass index.

the curve was the highest according to NRS-2002, the cut-off point was determined according to this screening method. According to the NRS-2002 screening method, the cut-off point value of the PhA was determined as 5.04 degrees with 73% sensitivity and 87% specificity. Based on the PhA cut-off point, it was determined that 36.7% of the patients in our study had a PhA value of <5.04 degrees, indicating a risk of malnutrition, while 63.3% had a PhA value of ≥5.04 degrees, indicating no risk of malnutrition.

Differences between PhA cut-off point with nutritional screening tools are shown in Figure 3. The PhA cut-off value is statistically significantly associated with all malnutrition risk assessment tools used in this study.

We found that patients with <5.04 degrees PhA had higher ECM and ECM/BCM index, and lower BCM and nutritional index and these differences were statistically significant ($p$ <0.05). We did not find any statistically differences between FM, FFM, FFMI, FMI, and PhA cut-off points ($p$ >0.05) (Table 4).

Correlation analysis revealed that PhA was significantly associated with several clinical and nutritional parameters (Figure 4). A moderate negative correlation was observed between PhA and

**Table 2**
Phase angle distribution according to disease stage and treatment type

| | Phase angle | | $p^a$ |
|---|---|---|---|
| | n | $\bar{x}\pm SS$ | |
| **Disease Stage** | | | |
| Stage 1 | 14 | 5.67±0.55 | 0.061 |
| Stage 2 | 30 | 5.16±0.82 | |
| Stage 3 | 30 | 5.27±0.52 | |
| Stage 4 | 24 | 5.02±0.86 | |
| **Treatment Method** | | | |
| Radiotherapy | 48 | 5.34±0.72 | 0.167 |
| Chemotherapy | 50 | 5.13±0.74 | |

[a] $p$ values were calculated using Anova test ($p < 0.05$ statistically significant).

**Table 3**
Cut-off values for PhA were determined based on ROC curves and study parameters

| | PhA cut-off points (degrees) | Area under the curve | Sensitivity | Specificity | CI (95%) |
|---|---|---|---|---|---|
| NRS-2002 | 5.04 | 0.83 | 0.73 | 0.87 | 0.74–0.91 |
| PG-SGA SF | 5.27 | 0.68 | 0.70 | 0.64 | 0.54–0.82 |
| MUST | 5.18 | 0.75 | 0.64 | 0.84 | 0.63–0.88 |
| MST | 5.18 | 0.72 | 0.70 | 0.67 | 0.62–0.82 |

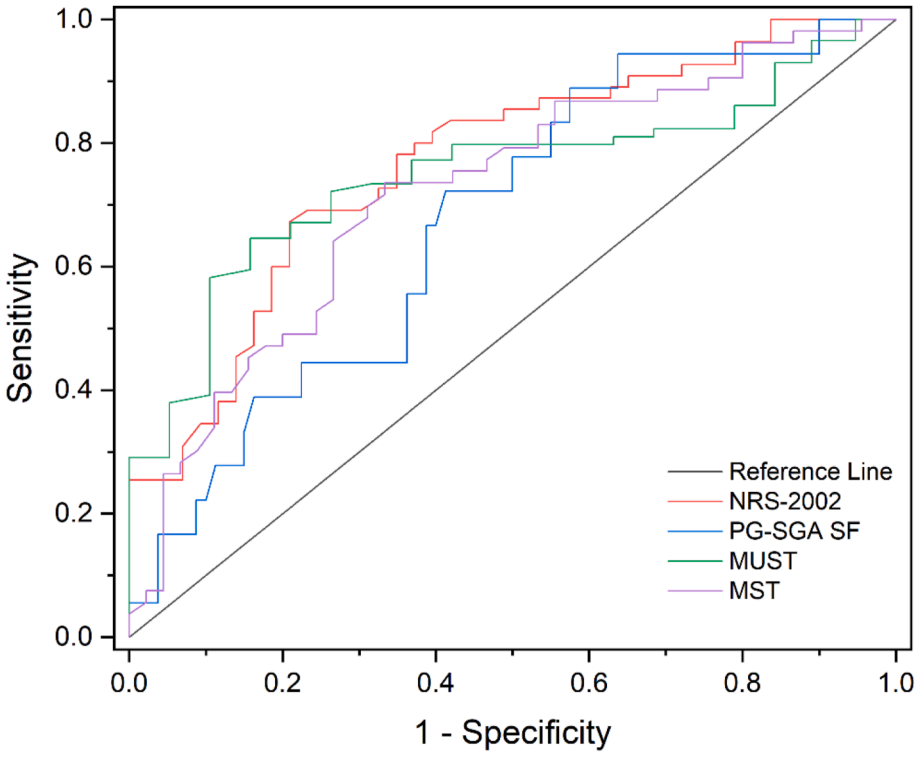


**Figure 2.** Phase angle cut off points ROC curve.

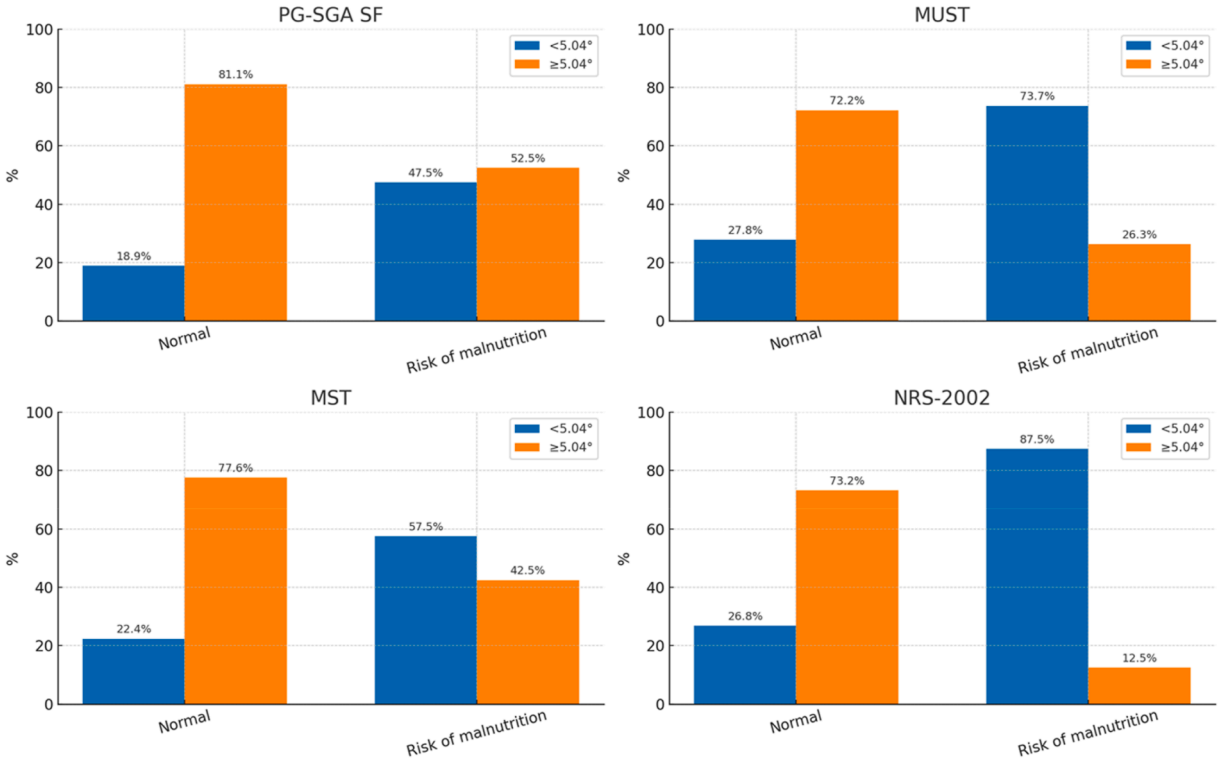


**Figure 3.** Evaluation of NRS-2002, PG-SGA SF, MUST and MST by PhA.

**Table 4**
BIA parameters values by phase angle

| | Phase angle cut off points | | *p** |
|---|---|---|---|
| | <5.04 (degrees) (n=36) | ≥5.04 (degrees) (n=62) | |
| | $\bar{x} \pm SD$ | $\bar{x} \pm SD$ | |
| ECM[a] (kg) | 24.74 ± 3.43 | 22.82 ± 4.47 | **0.029** |
| BCM[b] (kg) | 18.89 ± 2.03 | 22.30 ± 2.71 | **0.001** |
| ECM/BCM Index | 1.32 ± 0.20 | 1.03 ± 0.23 | **0.001** |
| Nutritional Index | 78.25 ± 8.01 | 99.55 ± 7.78 | **0.001** |
| Body fat (kg) | 30.94 ± 6.10 | 29.02 ± 9.47 | 0.279 |
| FFM[c] (kg) | 43.64 ± 4.66 | 45.12 ± 5.76 | 0.193 |
| FFMI[e] ($kg/m^2$) | 17.28 ± 1.89 | 17.57 ± 2.19 | 0.516 |
| FMI[d] ($kg/m^2$) | 12.23 ± 2.82 | 11.30 ± 3.59 | 0.141 |

*$p$ values were calculated using independent Student's $t$-test ($p < 0.05$ statistically significant).
Bold values indicate statistical significance at the $p$ <0.05 level.
[a] ECM; Extracellular mass.
[b] BCM; Body cell mass.
[c] FFM; Fat free mass.
[d] FMI; Fat mass index.
[e] FFMI; Fat free mass index.

age (r = –0.416, p < 0.001), indicating that PhA tends to decline as age increases. PhA was also negatively correlated with all four nutritional screening tools. The strongest negative association was with PG-SGA SF (r = –0.509, p < 0.001), followed by MST (r = –0.468, p < 0.001), NRS-2002 (r = –0.481, p < 0.001), and MUST (r = –0.303, p = 0.002). These results suggest that individuals with poorer nutritional status, as reflected by higher screening tool scores, tend to have lower phase angle values. Additionally, a weak but statistically significant negative correlation was observed between PhA and FMI (r = –0.203, p = 0.045). Importantly, a perfect positive correlation was observed between PhA and the Nutritional Index (r = 1.000, p < 0.001).

Logistic regression analyses were conducted to evaluate the association between PhA and the risk of malnutrition using four different screening tools: NRS-2002, MUST, MST, and PG-SGA SF (Table 5). In the crude models, lower PhA was significantly associated with increased risk of malnutrition across all tools. The odds ratios were as follows: 0.178 (95% CI: 0.070–0.453, p < 0.001) for NRS-2002, 0.338 (95% CI: 0.160–0.717, p = 0.005) for MUST, 0.308 (95% CI: 0.158–0.600, p < 0.001) for MST, and 0.481 (95% CI: 0.242–0.955, p = 0.037) for PG-SGA SF. After adjusting for age and FMI, the association between PhA and risk of malnutrition remained statistically significant for NRS-2002 (OR = 0.217, 95% CI: 0.081–0.577, p = 0.002), MUST (OR = 0.416, 95% CI: 0.186–0.930, p = 0.033), and MST (OR = 0.361, 95% CI: 0.177–0.736, p = 0.005). However, for PG-SGA SF, the association did not reach statistical significance after adjustment (OR = 0.501, 95% CI: 0.250–1.007, p = 0.052).

## Discussion

Breast cancer remains the most commonly diagnosed cancer among women globally [1]. Malnutrition is frequently observed in cancer patients and is characterized by disturbances in cellular membrane stability and fluid balance. Consequently, body composition analysis is an essential component of comprehensive nutritional assessment in cancer patients [2].

BIA is a practical and widely used non-invasive method for evaluating body composition. PhA, a novel quantitative parameter derived from BIA, has been shown to correlate positively with nutritional status and clinical outcomes in cancer patients. Recent studies have demonstrated its potential as a useful marker of malnutrition [7].

Our findings showed that PhA was significantly associated with malnutrition risk across all screening tools (NRS-2002, MUST, MST, PG-SGA SF). The optimal PhA cut-off point determined by ROC analysis was 5.04 degrees, based on the highest AUC observed using the NRS-2002 tool (AUC = 0.83).

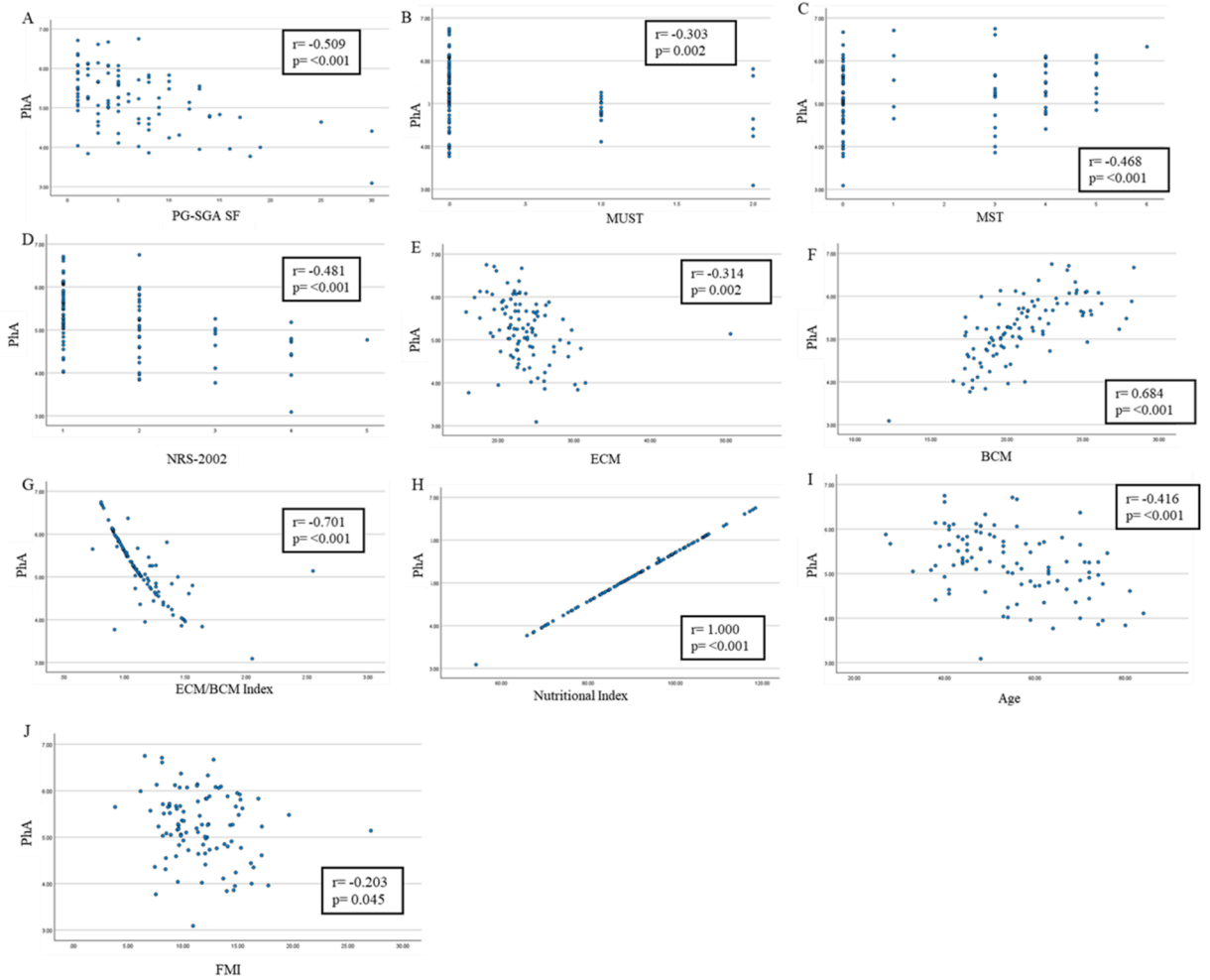


**Figure 4.** The Person correlation analysis of PhA and with malnutrition screening tools and various BIA parameters. (A) PG-SGA SF, (B)MUST, (C) MST, (D) NRS-2002, (E) ECM, (F) BCM, (G) ECM/BCM Index, (H) Nutritional Index, (I) Age and (J) FMI.

**Table 5**
Multivariate logistic regression analysis of phase angle in predicting risk of malnutrition across four screening tools

| | Model 1 | | Model 2 | | Model 3 | | Model 4 | |
|---|---|---|---|---|---|---|---|---|
| | OR (95% CI) | P | OR (95% CI) | P | OR (95% CI) | P | OR (95% CI) | P |
| Crude model | 0.178 (0.070–0.453) | **<0.001** | 0.338 (0.160–0.717) | **0.005** | 0.308 (0.158–0.600) | **<0.001** | 0.481 (0.242–0.955) | **0.037** |
| Adjusted model | 0.217 (0.081–0.577) | **0.002** | 0.416 (0.186–0.930) | **0.033** | 0.361 (0.177–0.736) | **0.005** | 0.501 (0.250–1.007) | 0.052 |

Logistic regression analysis was performed separately for each screening tool as the dependent variable (Model 1: NRS-2002, Model 2: MUST, Model 3: MST, Model 4: PG-SGA SF), with phase angle (PhA) as the primary independent variable. All models were adjusted for age and fat mass index (FMI). OR: Odds Ratio, CI: Confidence Interval. ($p < 0.05$ statistically significant).

This cut-off demonstrated a sensitivity of 73% and specificity of 87%, indicating strong discriminative power (Table 3, Figure 2). Previous studies have reported varying PhA cut-off points for different cancer types. For example, Motta *et al.* reported a PG-SGA–based cut-off of 5.4 degrees among cancer patients [24]. In another study involving 259 breast cancer patients, the average PhA was 5.6 degrees, and lower values were associated with reduced survival [2]. Similar findings were reported in pancreatic cancer (5.45 degrees), gastric and colorectal cancers (5.1 degrees), and breast cancer (5.2 degrees) [25–27]. Our study identified a cut-off of <5.04 degrees for malnutrition risk, consistent with these prior results. On the other hand, Yang *et al.* reported a lower threshold (4.65 degrees) in gastric cancer patients, highlighting that variations in patient population, cancer type, stage, and methodology may contribute to differences across studies [28]. These discrepancies likely reflect disease-specific factors such as tumor location and related inflammation, differences in body composition changes (muscle wasting, fluid shifts), and treatment modalities, all of which can influence cell membrane integrity and therefore phase angle values [29].

Correlation analyses showed moderate negative correlations between PhA and PG-SGA SF ($r = –0.509$), NRS-2002 ($r = –0.481$), MST ($r = –0.468$), and a weaker correlation with MUST ($r = –0.303$). These findings suggest that lower PhA values are associated with higher malnutrition risk. Our results align with studies by Kyle *et al.* [9], who found lower PhA values in malnourished patients compared to well-nourished controls, and similar studies using SGA and other tools [24,30–33].

Our data showed that patients with PhA <5.04 degrees had higher ECM, lower BCM, and higher ECM/BCM index compared to those with PhA ≥5.04 degrees, and these differences were statistically significant ($p < 0.05$). Correlation analyses further revealed a strong positive correlation between PhA and BCM ($r = 0.684$), and strong negative correlation with ECM/BCM ratio ($r = –0.701$), consistent with other reports in head and neck, lung, and liver cancer patients [34–37].

We found a significant weak negative correlations between PhA and FMI. Some studies have suggested that FMI and FFMI may better reflect malnutrition than BMI, as cancer patients can have a high BMI despite being malnourished especially in cases of sarcopenic obesity, where fat mass increases while muscle mass decreases [38–40]. Post-menopausal hormonal changes and treatment side effects may exacerbate this phenomenon, emphasizing the need for individualized nutrition and exercise plans in breast cancer patients [41]. This relationship is further supported by evidence linking phase angle directly to skeletal muscle mass. Furthermore, phase angle is closely linked to skeletal muscle mass, as it reflects cell membrane integrity and body cell mass. Exercise oncology interventions aimed at increasing muscle hypertrophy have been shown to improve phase angle values, supporting the concept that higher muscle mass contributes to better cellular health and nutritional status. In breast cancer patients, substantial treatment-related muscle loss, particularly during chemotherapy or antiestrogen therapy, may therefore lead to lower phase angle values and increased malnutrition risk [42].

The nutritional index, another BIA-derived parameter, reflects cellular health. In our study, patients with low PhA also had significantly lower nutritional index values, similar to findings reported by Emir *et al.* in head and neck cancer patients [35]. Although research in this area is limited, our results support the idea that PhA is a useful indicator of cell health and overall nutritional status [2].

The logistic regression analysis reinforced the clinical utility of PhA as a biomarker for malnutrition risk. In the unadjusted models, lower PhA values were consistently associated with higher odds of being classified as at risk of malnutrition across all four screening tools. After adjustment for confounding variables such as age and FMI, these associations remained statistically significant for NRS-2002, MUST, and MST, but not for PG-SGA SF. These results indicate that PhA may be a particularly effective complementary parameter when used alongside specific screening tools like NRS-2002, MUST, and MST. These findings underscore the value of PhA as a complementary, objective marker within a multidimensional nutritional assessment strategy. Importantly, similar associations between low PhA and malnutrition risk have been demonstrated in other clinical populations, including patients with gastrointestinal cancers and those undergoing hemodialysis. In those studies, PhA cut-off values were shown to be predictive of poor nutritional status, though influenced by other clinical parameters [27,43].

### *Strengths*

This study is one of the few to evaluate PhA in relation to multiple validated malnutrition screening tools in breast cancer patients. The use of four different tools enhanced comparability, and the identification of a practical PhA cut-off (5.04 degrees) adds clinically relevant data. Additionally, the integration of body composition parameters strengthens the assessment of PhA as a supportive, non-invasive nutritional marker. Furthermore, the use of both body composition metrics and functional indices enhances the multidimensional approach to nutritional status evaluation.

### *Limitations*

This study has some limitations that should be considered when interpreting the findings. First, the sample size was relatively small and limited to a single center, which may affect the generalizability of the results. Second, the use of a single-frequency BIA device, rather than a multi-frequency or segmental analyzer, may limit the accuracy of body composition measurements. Future studies with larger, more diverse populations and longitudinal follow-up are needed to confirm these findings and explore the clinical utility of PhA in routine oncology practice.

### *Clinical implications*

The integration of PhA into routine nutritional assessment protocols may offer a practical and objective means to complement traditional screening tools in oncology settings. Its rapid, non-invasive application allows for bedside use, making it suitable for both inpatient and outpatient care. Particularly in resource-limited settings where comprehensive assessments may not be feasible, PhA could support early nutritional risk identification and guide the allocation of individualized interventions. Establishing standardized guidelines for PhA use in clinical practice may improve consistency in malnutrition screening and support multidisciplinary decision-making. PhA may therefore serve as a valuable component in streamlining nutritional care pathways and improving patient outcomes in oncology settings.

## Conclusion

This study demonstrated that PhA may serve as a robust biomarker for assessing malnutrition risk in patients with breast cancer. The cut-off value identified through ROC analysis showed strong agreement with multiple validated screening tools, supporting the diagnostic utility of PhA. These findings suggest that incorporating PhA into clinical nutrition assessments could enhance early detection and intervention strategies. Moving forward, large-scale, multicenter, prospective studies with longitudinal designs are warranted to establish cancer type and stage-specific reference ranges and validate the clinical applicability of PhA across diverse patient populations.

## Author contributions

D.Z.B and S.A conceptualized and designed the study. D.Z.B was responsible for data collection. D.Z.B and N.E performed the data analysis and interpretation. D.Z.B and N.E conducted the investigation and drafted the manuscript. D.Z.B and N.E had primary responsibility for the final content. All authors critically reviewed the manuscript and approved the final version for submission.

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## Declaration of competing interest

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

## List of abbreviations

| | |
|---|---|
| ASPEN | American Society for Parenteral and Enteral Nutrition |
| BAPEN | British Association for Parenteral and Enteral Nutrition |
| BCM | Body Cell Mas |
| BMI | Body Mass Index |
| CI | Confidence Interval |
| ECM | Extracellular Mass |
| ESPEN | European Society of Clinical Nutrition and Metabolism |
| FFM | Fat Free Mass |
| FFMI | Fat Free Mass Index |
| FM | Fat Mass |
| FMI | Fat Mass Index |
| IARC | International Agency for Research on Cancer |
| MST | Malnutrition Screening Tool |
| MUST | Malnutrition Universal Screening Tool |
| NRS-2002 | Nutritional Risk Screening 2002 |
| OD | Odds Ratio |
| PG-SGA SF | Patient-Generated Subjective Global Assessment Short Form |
| PhA | Phase Angle |
| R | Resistance |
| ROC | Receiver Operating Characteristic |
| Xc | Reactance |

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