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Original Article

Phase angle as a prognostic factor for one-year mortality in geriatric health service facility residents

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Abstract. [Purpose] The present study aimed to investigate the association of phase angle with the continuing activities of residents in a geriatric health service facility for one year. We compared the phase angle among current residents in a geriatric health service facility with those who died within one year. [Participants and Methods] This one-year prospective observational study included 149 residents who entered a geriatric health service facility. We divided participants into two groups: an over one-year survival group and a death within one year group. The receiver operating characteristic curves were created to determine the sensitivity and specificity for predicting one-year mortality based on the phase angle. [Results] The phase angle was significantly higher in the one-year survival group than in the death within one year group and was independently and significantly associated with one-year mortality using binomial logistic regression analysis. The phase angle was shown to have predictive power (based on the area under the receiver operating characteristic curve). Based on the calculation for identifying one-year survival, the optimal cut-off value for the phase angle was 2.95° (area under the receiver operating characteristic curve=0.76, sensitivity 55.6%, specificity 83.3%). [Conclusion] The phase angle may contribute to the prognosis of one-year mortality for residents of geriatric health service facilities.

Key words: Phase angle, Mortality, Geriatric health service facility

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INTRODUCTION

Bioelectric Impedance Analysis (BIA) can assist an assessment of body composition, including muscle condition. BIA is a safe, noninvasive, and objective bed side method to measure body composition. The phase angle (PhA), which is one of the body composition indices, may have broad potential in assessing the nutritional status and stage of the disease, as well as in estimating the risk of postoperative complications, disability, and even mortality[1)]. Furthermore, PhA may be a potential screening tool in clinical practice to evaluate different biomarkers, cardiovascular risk, and nutritional diagnosis in metabolic diseases in adults[2)], and reacts to physical training and detraining[3)]. Therefore, PhA is a feasible evaluation for assessing cellar health and could be a potential marker of inflammation and oxidative stress[4)]. Our previous study indicated that PhA is an indicator of physical condition associated with aging even in nursing home residents aged 75 to 100 years for female[5)].

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The PhA is a useful postoperative prognostic marker for patients with gastrointestinal and hepatobiliary-pancreatic cancers[6)]. Recent research has evaluated the association between PhA and mortality in patients with cancer and reported that low PhA and rectus femoris cross-sectional area values are significant independent predictors of mortality[7)]. However, the prognostic value of the PhA for residents of Japanese geriatric health service facilities is still unclear.

Therefore, the aim of the present study was to investigate the association of PhA with the continuing activities of residents in a geriatric health service facility over the course of one year. We compared the PhA among current residents in a geriatric health service facility with those who died within one year.

PARTICIPANTS AND METHODS

This single-facility, one-year prospective observational study was conducted between October 2021 and October 2022. This study included 149 residents who entered a geriatric health service facility in the northern part of Tochigi prefecture, Japan. After excluding 53 residents, 96 were included in this analysis (Fig. 1). They had no history of replacement arthroplasty or current use of an artificial pacemaker.

The study protocol was approved by the Ethics Committee of the International University of Health and Welfare (Otawara-shi, Tochigi, Japan: Approval No. 21-Io-13), and all participants (or their family members) provided signed informed consent.

The primary outcome was death within one year after BIA measurement, assessed using the PhA. We divided participants into two groups: an over one-year survival group (SG) and a death within one year group (DG). After performing the binomial logistic regression analysis, the area under the curve (AUC) analysis was also conducted.

PhA, skeletal muscle mass index (SMI), and fat mass were measured using a portable, noninvasive, multifrequency bioimpedance device (In Body S10; In Body, Tokyo, Japan). The device can be measured while the resident is supine and sitting, which is useful for residents who cannot stand or sit due to serious dysfunction or are bedridden. Researches using this device have already been reported from the sports field to the clinical research field[6, 8–12)]. In addition, since reproducibility has been reported with the same series of device, measurements were taken once[13)].

Body weight was measured 1–2 days before PhA measurement. Height was calculated using an estimation formula[14)]. The body mass index (BMI) was calculated from this weight and height.

The phase angle was calculated using the equation: phase angle=arctangent (Xc/R) £ (180/p), where R is the resistance of the right half of the body and Xc is the reactance measured at 50 kHz.

The morbidity had complete information available from the medical records of institution.

For statistical analysis, the difference between the SG and DG were analyzed using a t-test for continuous variables, and the chi-squared test for categorical variables such as comorbidities. In the binomial logistic regression analysis, one-year mortality was used as the dependent variables. Variables with $p<0.05$ in the t-test were used as independent variables. The receiver operating characteristic (ROC) curves were then created to determine the sensitivity and specificity for predicting the one-year mortality based on the PhA. The AUC, sensitivity and specificity were calculated using the Youden index to determine the optimal cut-off point. AUC values >0.9 represent high precision, values ranging from 0.7 to 0.9 represent medium precision, and values <0.7 represent low precision[15)].

All statistical analyses were performed using SPSS Statistics version 27.0 (IBM Corp., Armonk, NY, USA). Statistically significant was set at $p<0.05$.

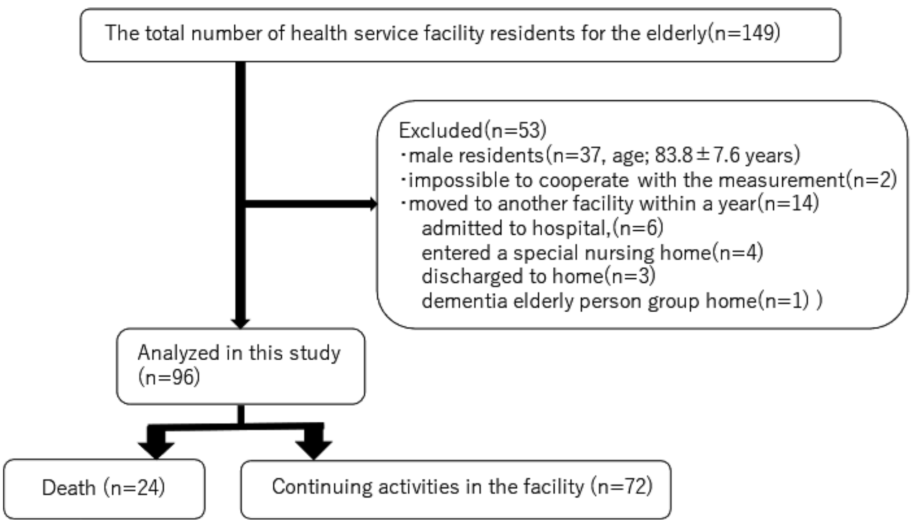

Fig. 1. Flow chart of participant selection.

RESULTS

Table 1 shows the comparison of basic attributes of the SG and DG. Significant differences were observed in age, height, PhA, and SMI. The PhA was significantly higher in the SD than in the DG.

Binomial logistic regression analysis showed that PhA was independently and significantly associated with one-year mortality (Table 2).

Table 3 shows the ROC analysis for survivors as identified by the PhA. The PhA was shown to have predictive power (based on the AUC). Based on the calculation for identifying one-year survival, the optimal cut-off value for the PhA was 2.95° (AUC=0.76, sensitivity 55.6%, specificity 83.3%) (Fig. 2).

Table 1. Comparison of basic attributes of over 1 year survival group and within 1 year death group

	All	Over 1 year survival group	Within 1 year death group
	(n=96)	(n=72)	(n=24)
Age (years)**	90.5 ± 5.7	89.2 ± 5.5	94.2 ± 4.6
Height (cm)*	152.6 ± 5.2	153.3 ± 4.8	150.3 ± 5.9
Weight (kg)	42.9 ± 7.2	43.7 ± 7.1	40.5 ± 7.1
BMI (kg/m^2)	18.4 ± 3.0	18.6 ± 2.9	18.0 ± 3.2
PhA (°)**	3.03 ± 0.70	3.19 ± 0.70	2.55 ± 0.46
SMI (kg/m^2)*	4.6 ± 0.9	4.7 ± 0.8	4.2 ± 0.9
Fat mass (%)	25.4 ± 10.7	25.1 ± 9.8	26.4 ± 13.4
Comorbidities			
Cardiovascular disease, n (%)	32 (33.3%)	22 (30.6%)	10 (41.7%)
Respiratory disease, n (%)	6 (6.3%)	4 (5.6%)	2 (8.3%)
Cerebrovascular disease, n (%)	30 (31.3%)	21 (29.2%)	9 (37.5%)
Orthopedic disease, n (%)	60 (62.5%)	49 (68.1%)	11 (45.8%)
Malignant tumor*, n (%)	8 (8.3%)	3 (4.2%)	5 (20.8%)
Osteoprosis, n (%)	8 (8.3%)	8 (11.1%)	0 (0%)
Diabetes mellitis, n (%)	16 (16.7%)	13 (18.1%)	3 (13.0%)
Hypertension, n (%)	40 (41.7%)	32 (44.4%)	8 (33.0%)

*p<0.05, **p<0.01.
The data are presented as the mean ± standard deviation or number (%). The differences between the two groups were analyzed using unpaired t-test for continuous variables and the χ^2 test for categorical variables.
BMI: body mass index; PhA: phase angle; SMI: skeletal muscle mass index.

Table 2. Association between one-year mortality and phase angle based on binominal logistic regression

	OR	95% CI
PhA (°)*	0.232	0.065–0.827
Age (years)	1.117	0.980–1.272
SMI (kg/m^2)	1.029	0.477–2.219
Hight (cm)	0.900	0.806–1.005

*p<0.05. Nagalkerke R^2=0.357. OR: odds ratio; 95% CI: 95 confidence interval; PhA: phase angle; SMI: skeletal muscle mass index.

Table 3. Receiver operating characteristic curve analysis for survivor identification by phase angle

	AUC**	95% CI	Cut-off	Sensitivity	Specificity
PhA	0.76	0.658–0.862	2.95°	55.6%	83.3%

**p<0.01. AUC: area under the curve; 95% CI: 95 confidence interval; PhA: phase angle.

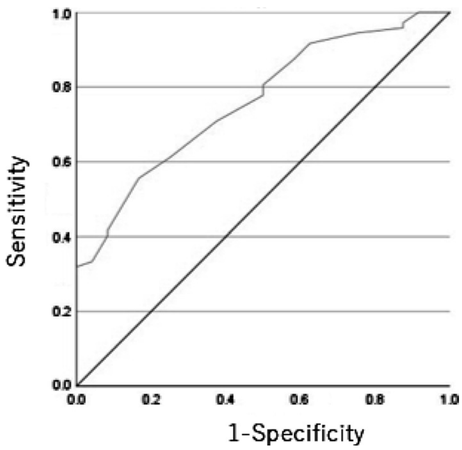

Fig. 2. Optimal cut-off value by Youden index and receiver operating characteristic curve showing specificity and sensitivity of cut-off value.

DISCUSSION

This report compares the phase angle between the SD and DG in female residents of a Japanese geriatric health service facility and the optimal PhA cur-off point for determining the one-year mortality. The PhA has been reported to be an indicator of physical condition associated with aging for nursing home residents with various diseases[5)]. In this study, patients in the DG were significantly older, and had significantly more malignant tumors, than those in the SG. These factors may be related to lower PhA values.

A systematic review previously summarized the findings of studies of the association between PA and mortality[16)]. The authors reported that 42 of 48 studies showed a correlation between PhA and mortality. The PhA cut-off points, which increased the risk of death, varied among diseases and studies. Cut-off points ranged from 3.6° to ≤8.0° in patients with kidney disease, 4.2° to <5.5° in patients with heart disease, 4.4° to <5.8° in patients with cancer, and 4.1° to <6.0° in patients who were critically ill. The present study identified a cut-off value from the ROC curve that allowed the estimation of one-year mortality using PhA. The results indicated that the optimal PhA cut-off value for identifying one-year survival for female residents of a Japanese geriatric health service facility was 2.95°, which was lower than the previously published cut-off for chronic and critical illness. The one-year mortality prediction using PhA showed a medium precision AUC value (0.76). Therefore, we suggest that a PA value 2.95° can be a convenient screening tool for mortality in residents of geriatric health service facilities.

This study has two major limitations. First, the results of this study are based on a small sample size from only one institution. Control measure for COVID-19 made it difficult to conduct studies at additional facilities, and the results cannot be generalized to include all geriatric health service residents. However, in our previous study for female nursing home residents, the PhA of females aged ≥75 years was 3.2°, and it was 2.6° for residents aged ≥90 years[5)]; These results are similar to those in present study because the mean age of the subjects was also approximately 90 years old. The second limitation was that subjects were limited to females because there were small number of male residents. The PhA is generally higher in male than in females, decreases with age, and varies among races[17)]. Therefore, further studies are needed to support these generalizations.

In conclusion, the PhA may contribute to the prognosis of one-year mortality for residents of geriatric health service facilities.

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Conflict of interest

The authors declare no conflicts of interest in this work.

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