Can phase angle determined by bioelectrical impedance analysis assess nutritional risk? A comparison between healthy and hospitalized subjects

Ursula G. Kyle\textsuperscript{a,b,c}, Esther P. Soundar\textsuperscript{a,d}, Laurence Genton\textsuperscript{b,e}, Claude Pichard\textsuperscript{a,*}

\textsuperscript{a}Baylor College of Medicine/Texas Children's Hospital, Pediatric Critical Care Medicine, 6621 Fannin St WT6-006, Houston, TX 77030, USA
\textsuperscript{b}Clinical Nutrition, Geneva University Hospital, Michelli-du-Crest, 24, 1211 Geneva, Switzerland

\textbf{A R T I C L E  I N F O}

Article history:
Received 30 January 2012
Accepted 9 April 2012

Keywords:
Nutritional screening
Nutritional assessment
Malnutrition
Bioelectrical impedance analysis
Phase angle

\textbf{S U M M A R Y}

\textit{Background & aims:} Low phase angle (PhA) by bioelectrical impedance analysis (BIA), is associated with increased morbidity and nutritional risk. This study determined the cut-off values for PhA compared to Nutritional Risk Screening (NRS-2002) and Subjective Global Assessment (SGA) in patients at hospital admission, and evaluated the association between PhA and serum albumin.

\textit{Methods:} PhA was determined in patients (Men (M)/Women (W) = 382/267), and healthy age-, sex- and height-matched controls. Sensitivity and specificity were calculated for PhA compared to NRS-2002, SGA and serum albumin. The cut-off values were assessed by receiver operator characteristics area under the curve (ROC–AUC).

\textit{Results:} The best PhA cut-offs were 5.0° and 4.6° in M/W. The sensitivity for NRS-2002 was 70.0/58.1% (M/W); SGA: 73.3/64.5%; albumin: 58.8/23.5%; specificity for NRS-2002: 85.1/81.7% (M/W); SGA: 76.6/76.1% and albumin: 92.9/96.6%. The PhA showed a ROC–AUC for NRS-2002 of 0.85/0.80 (M/W); SGA: 0.83/0.80 and albumin: 0.85/0.91. Patients with albumin levels <35 g/L had a relative risk of 7.5 to have low PhA compared to patients with ≥35 g/L.

\textit{Conclusions:} The consistent sensitivity and specificity between PhA and three screening tools strengthens the validity of our study. PhA appears to be a useful screening tool to assess nutritional risk without having to measure weight or height.

\textsuperscript{*}Corresponding author. Clinical Nutrition, Geneva University Hospital, Michelli-du-Crest, 24, 1211 Geneva, Switzerland. Tel.: +41 22 372 9349; fax: +41 22 372 9363.

\textit{E-mail addresses:} ukyle@bcm.edu (U.G. Kyle), epsounda@texaschildrens.org (E.P. Soundar), laurence.genton@hcuge.ch (L. Genton), claude.pichard@unige.ch (C. Pichard).

\textit{Abbreviations:} PhA, phase angle; BIA, bioelectrical impedance analysis; NRS-2002, nutritional risk screening; SGA, subjective global assessment; M, men; W, women; LOS, length of hospital stay; ROC, receiver operator characteristics; AUC, area under the curve.

1. \textit{Introduction}

Twenty to 62\% of hospitalized patients are at risk of malnutrition in developed countries.\textsuperscript{1–3} The prevalence and level of nutritional risk varies widely depending on the assessment tools used to evaluate nutritional risk\textsuperscript{4} and the patient population. A number of screening tools have been developed to assess nutritional risk,\textsuperscript{5–7} including Nutritional Risk Screening Tool 2002 (NRS-2002), developed by the European Society for Parenteral and Enteral Nutrition (ESPEN),\textsuperscript{6} and Subjective Global Assessment (SGA)\textsuperscript{5} questionnaire.\textsuperscript{8} They are validated nutritional screening tools and assessment, respectively. Albumin is also a marker of nutritional risk.\textsuperscript{9}

Recent studies have shown that low PhA, determined by bioelectrical impedance analysis (BIA), is associated with nutritional risk, increased morbidity and mortality in renal disease,\textsuperscript{10} human immunodeficiency virus infections,\textsuperscript{11} cancer\textsuperscript{12–14} and surgical patients.\textsuperscript{15} It has also been shown to be an indicator of poor functional status\textsuperscript{16} and a prognostic indicator for survival in cancer patients.\textsuperscript{14} PhA is one of the direct measures by BIA instrument. However, the cut-offs for PhA which are associated with nutritional risk and increased morbidity have not been determined. The biological meaning of phase angle (PhA), determined by BIA, is not completely understood, but has been interpreted as an indicator of membrane integrity and water distribution between the intra- and extracellular spaces.

The use of PhA is of interest because it is a non-invasive, objective, direct, quick (less than 2 min) method to determine nutritional and morbidity risks in patients. While nutritional screening tools are also non-invasive, they require more time and are partially subjective.
The aim of this study was to determine the optimal cut-off values of PhA compared to nutritional risk screening and assessment tools and to evaluate the association between PhA and serum albumin.

2. Methods

2.1. Patients

All adult patients between 17 and 65 years of age who were seen in the hospital admission center and subsequently were hospitalized were eligible for inclusion. Every 10th patient between 17 and 65 years of age who met entry criteria was included in the study during a 3-months period. Two patients refused to participate. Exclusion criteria were edema, burns, peritoneal or hemodialysis, rehydration perfusion and major cardio-respiratory resuscitation (5.8%, n = 40). Age and gender distribution of patients included in the study did not differ from age of all patients seen in the hospital admission center during the inclusion period. Patients were evaluated in the hospital admission center by the same two trained coworkers of the Nutrition Unit.

The study protocol was approved by the Geneva University Hospital Ethics Committee and informed consent was obtained from all subjects.

2.2. Controls

Healthy adults (n = 649), matched for gender, age- (±2 yrs) and height (±2 cm), were selected from our database (n = 5635 healthy adults, age 17–98 years) to serve as control group.17

2.3. Measurements

2.3.1. Anthropometric and bioelectrical impedance measurements

All measurements were performed at hospital admission. Body height was measured to the nearest 0.5 cm and body weight to the nearest 0.1 kg on a chair scale or a hoist with attached weighing device for patients who were bed-ridden. The scales were cross-calibrated weekly. The body mass index (BMI) was derived as weight (kg) divided by height (m) squared (kg/m2).

PhA was determined by BIA as previously described.14 Briefly, an electrical current of 50 kHz and 0.8 mA was produced by a generator (RLJ-101® analyses, RJL Systems Inc, Clinton Twp, MI) and applied to the skin by use of adhesive electrodes (3M Red Dot T, 3M Health Care, Borken, Germany) with the subject lying supine.15 The skin was cleaned with 70% alcohol. Whole-body resistance and reactance were measured with four surface electrodes placed on the right wrist and ankle. The PhA was calculated as follows: PhA = arc tangent (reactance/resistance) × (180°/π). Previous studies have established the validity of BIA.10,16,17 RLJ-101® generator (RJL Systems Inc, Clinton Twp, MI) was cross-validated at 50 kHz against the Xitron® analyzer (Xitron Technologies, Inc, San Diego, CA). FFM was calculated by the following previously validated multiple regression equation18: FFM = 4.104 + (0.518 × height2/resistance) + (0.231 × weight) + (0.130 × reactance) + (4.229 × sex (men = 1, women = 0)).

2.3.2. Nutritional risk screening (NRS-2002)

The NRS-2002® consists of a nutritional score and a severity of disease score and an age-adjustment for patients aged >70 yrs (+1) and was administered as previously described.6 Nutritional score: weight loss >5% in 3 months or food intake below 50–75% in preceding week = 1; weight loss >5% in 2 months or BMI 18.5–20.5 kg/m2 and impaired general condition or food intake 25–60% in preceding week = 2; weight loss >5% in 1 months or >15% in 3 months or BMI <18.5 kg/m2 and impaired general condition or food intake 0–25% in preceding week = 3. Severity of disease score: hip fracture, chronic patients with acute complications = 1; major abdominal surgery, stroke, severe pneumonia, hematological malignancies = 2; head injury, bone marrow transplantation, intensive care patients with APACHE >10 = 3. NRS score is the total of the nutritional score, severity of disease score and age adjustment. Patients are classified low risk = 1; moderate risk = 2; severe risk = 3; and Controls = 0.

2.3.3. Subjective global assessment (SGA) questionnaire

The SGA was performed as previously described4 using a questionnaire that incorporates the patient’s history (weight loss, changes in dietary intake, gastrointestinal symptoms, and functional capacity), physical examination (muscle, subcutaneous fat, sacral and ankle edema, ascites), and the clinician’s overall judgment of the patient’s status (normal, moderately or severely malnourished). Patients are classified well-nourished = 1; moderately malnourished = 2; severely malnourished = 3; and Controls = 0.

2.3.4. Albumin

Blood samples were routinely drawn at the same time as the samples necessary for diagnosis and treatment, before initiation of IV fluids. Albumin was measured by immunonephelometry.19 Serum albumin values <35 g were considered an indicator of nutritional risk.

2.4. Statistical analysis

Normally distributed continuous variables were compared using paired and unpaired t-test and ANOVA. Non-normally distributed variables will be compared by Mann–Whitney U-test or Kruskal–Wallis test. Categorical variables were compared using the Chi2 test or Fisher’s exact test. Simple correlations were determined between weight, BMI, fat-free mass and PhA. Relative risk (RR), with 95% confidence intervals (CI) was calculated by Fisher Exact Test for a 2 × 2 contingency table (http://statpages.org/ctab2x2.html). Relative Risk (RR) = (a/r1)/(c/r2); confidence intervals for the estimated parameters are computed by a general method (based on “constant chi-square boundaries”).1,2 Sensitivity and specificity were calculated for PhA compared to the different nutritional screening and assessment tools and albumin. In this study, test sensitivity was the proportion of cases with low PhA compared to no, moderate and severe risk by NRS-2002, well-nourished, moderately and severely malnourished by SGA and albumin <35 g/L, found by each screening tool. The receiver operator characteristics (ROC) curves were used by plotting true-positive (sensitivity) against false-positive (1-specificity) rates to determine the cut-off points for PhA. The optimal cut-off, determined for men and women separately, was the point at which sensitivity plus specificity was maximal. The informative value regarding nutritional risk as defined by PhA of each assessed parameter was determined by the area under the curve (AUC).

Statistical significance was set at p < 0.05 for all tests.

3. Results

Patients were admitted to medical (54.8%), surgical (29.0%) and trauma services (16.2%). Male patients had significantly lower body weight, BMI, fat-free mass, and PhA and higher % body fat than age- and height-matched female patients and healthy controls (Table 1). The fat-free mass, but not weight and BMI were lower and % body fat higher in age- and height-matched female patients than healthy controls. The PhA was significantly lower in women than men (Table 1) and
The incidence in having low PhA than younger controls (Table 2). On the other hand, patients >50 yr had higher incidence of low PhA than younger patients (Table 2).

Fat-free mass correlated significantly with PhA in controls and patients. NRS-2002, SGA and albumin also correlated significantly with PhA in patients, with the highest correlation coefficient noted for albumin in men and NRS-2002 and SGA in women (Table 3). We found that only 0.8% of control men and 1.5% of control women had low PhA (<5.0° for men and <4.6° for women). On the other hand, 7.0% of male patients and 10% of female patients had low PhA (Table 3). For NRS-2002, 7.3% of male patients with moderate risk and 31.3% of patients with severe risk, and 8.2% of female patients with moderate risk and 32.4% with severe risk had low PhA.

Similarly, for SGA, 5.9% of moderately malnourished and 23.7% of patients with severe risk, and 8.2% of male patients and 10% of female patients had low PhA. The sensitivity, specificity and ROC curves were determined for PhA of 5.0° in men and 4.6° in women (Table 4). The sensitivity for NRS-2002 was 70.0% (men) and 58.1% (women), for SGA 73.3 and 64.5% and for albumin 58.8 and 23.5%; the specificity for NRS-2002 was 85.1% (men) and 81.7% (women), SGA 76.6 and 76.1 and albumin 93.2 and 96.6.

The PhA showed a ROC area under the curve for NRS-2002 of 0.85 (men) and 0.80 (women); SGA of 0.83 and 0.80 and albumin of 0.85 and 0.91 (Table 4, Fig 1).

Patients with albumin levels <35 g/L had a relative risk of 7.5 to have low PhA than patients with albumin levels ≥35 g/L (Table 5).

4. Discussion

This study evaluated the accuracy of PhA in identifying the presence of nutritional risk in a large cohort of patients at hospital admission compared to age-, sex- and height-matched healthy controls. The significant and consistent sensitivity and specificity between PhA and three independent nutritional assessment/screening tools (i.e. NRS-2002, SGA and albumin) strengthen the validity of our study.

Patients had significantly lower PhA than age-, sex- and height-matched healthy controls.

Significantly more patients had low PhA (<5.0° in men and <4.6° in women) than controls. Our study found that the cut-offs for PhA of 5.0° in men and 4.6° in women gave the highest sensitivity and ROC—AUC. Different cut-offs for men and women are consistent with findings by others.13,21

PhA had higher specificity, but lower sensitivity for albumin than NRS-2002 or SGA. This means that more patients who did have normal albumin were correctly identified as having normal PhA levels than patients with low PhA as having low albumin levels. The lower sensitivity in women than in men is likely due to the small number of female patients with low albumin levels.

### Table 1

| Characteristics of controls (n = 649), and patients at hospital admission (n = 649). |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| **Men** | **Controls** | **Patients** | p | **Women** | **Controls** | **Patients** | p |
| n | 382 | 382 | | | | | |
| Age (yr) | 39.7 ± 12.6 | 39.8 ± 12.7 | 0.918 | | | | |
| Weight (kg) | 74.9 ± 10.3 | 72.9 ± 13.1 | 0.018 | | | | |
| BMI (kg/m²) | 24.5 ± 2.6 | 24.3 ± 3.9 | 0.036 | | | | |
| UBW (%) | n/a | 98.6 ± 5.1 | | | n/a | 99.6 ± 6.0 | |
| Albumin (g/L) | n/a | 43.6 ± 6.0 | | | n/a | 42.7 ± 4.7 | |
| Fat-free mass (kg) | 59.8 ± 6.2 | 56.2 ± 7.3 | <0.001 | | 42.3 ± 4.2 | 40.7 ± 5.3 | <0.001 |
| Body fat (%) | 19.7 ± 5.0 | 22.0 ± 6.6 | <0.001 | | 28.7 ± 5.3 | 32.8 ± 6.8 | <0.001 |
| Phase angle (°) | 7.55 ± 0.95 | 6.6 ± 1.1 | <0.001 | | 6.5 ± 0.08 | 5.8 ± 0.96 | <0.001 |

NRS-2002 was 70.0 (men) and 58.1 (women), for SGA 73.3 and 64.5 and for albumin 58.8 and 23.5; the specificity for NRS-2002 was 85.1 (men) and 81.7 (women), SGA 76.6 and 76.1 and albumin 93.2 and 96.6.

### Table 2

| PhA and distribution of normal and low PhA in male and female controls and patients by age group. |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| **Men** | **Controls (mean ± SD)** | **Patients (mean ± SD)** | p | **Women** | **Controls (mean ± SD)** | **Patients (mean ± SD)** | p |
| n | 382 | 382 | | | | | |
| <35 yr | 7.9 ± 0.8 | 7.0 ± 0.9 | 0.001 | | 6.8 ± 0.8 | 6.0 ± 0.8 | 0.001 |
| 35–50 yr | 7.6 ± 0.8a | 6.6 ± 0.9a | 0.001 | | 6.5 ± 0.9 | 6.0 ± 0.7 | 0.001 |
| >50 yr | 6.9 ± 1.1bc | 6.0 ± 1.1bc | 0.001 | | 6.2 ± 1.0bc | 5.1 ± 1.0bc | 0.001 |
| n (%) | Normal | Low | Normal | Low | Normal | Low | Normal | Low |
| n | n | n | n | n | n | n | n | n |
| <35 yr | 150 (99.3) | 1 (0.7) | 147 (97.4) | 4 (2.6) | 110 (100) | 0 (0) | 107 (97.3) | 3 (2.7) |
| 35–50 yr | 135 (100) | 0 (0) | 126 (93.3) | 9 (6.7) | 87 (97.7) | 2 (2.2) | 84 (94.4) | 5 (5.6) |
| >50 yr | 94 (97.9) | 2 (2.1) | 82 (85.4) | 14 (14.6) | 66 (97.1) | 2 (2.9) | 49 (72.1) | 19 (27.9) |
| Chi² | 3.2, p = 0.20 | 12.8, p = 0.002 | 3.0, p = 0.23 | 32.4, p < 0.001 |

Phase angle; PhA: ANOVA post-hoc Bonferroni.

a Between 35–50 yr and <35yr.

b Between >50 yr and <35yr.

c Between >50 yr and 35–50 yr controls or patients, p < 0.0167.
Barbosa-Silva et al.\textsuperscript{22} found a sensitivity of 31% and 47% and specificity of 97% and 94% for a PhA cut-off point of 5.0, compared to SGA, in men and women, respectively. Previous studies have used similar PhA cut-offs.\textsuperscript{12,24} Gunn et al.\textsuperscript{16} found that rehabilitation patients had PhAs that were lower than controls and higher than seriously ill patients. PhAs between 4.5 and 5.6 were associated with shorter survival in cancer patients.\textsuperscript{13,24,25} A PhA of 5.0 was an independent indicator in cancer patients.\textsuperscript{12} Selberg et al.\textsuperscript{26} suggested that a PhA of 5.4 was normal, 4.5–5.4 as borderline, and <4.4 as abnormal. Wirth et al.\textsuperscript{27} found elderly subjects with PhA below 3.5 had a four-fold increase of hospital mortality and subjects with 5.0–5.5 had lowest hospital mortality. These studies indicate that PhA is a predictor of poor outcome.

Our study shows that a higher prevalence of low PhA in patients who were at moderate and severe nutritional risk. PhA was lower in patients with moderate and severe nutritional risk than healthy controls. Previous studies\textsuperscript{23} found PhA decreased significantly with worsening nutritional status compared to SGA, indicating the ability of PhA to detect changes in nutritional status in surgical patients.\textsuperscript{28}

PhA is one of the direct measures by BIA instrument not requiring body weight and height measurements, and appears to be an objective parameter that is a rapid, easy and non-invasive way to provide information about the patients’ nutritional risk. The current study shows a significant association between PhA and nutritional risk. The biological meaning of PhA is not completely understood, but is considered an indicator of cell health with high PhA reflecting stronger cell function. Reduced PhA in older subjects have been suggested to reflect a decrease in general health and physical function associated with aging.\textsuperscript{11,29} Since PhA is influenced by the intracellular to extracellular water ratio, the lower values are seen in older and ill subjects are thought to reflect a reduction in skeletal mass and hence intracellular water which may be compounded by edema/extracellular accumulation with aging and poor health.

In subjects who had similar BMI, anorectic patients had lower PhA, constitutionally lean young females had similar PhA and ballet dancers had higher PhA than controls.\textsuperscript{30} This suggests that PhA is an effective marker of qualitative changes in body composition and is capable of discriminating between degrees of undernutrition.

Previous studies have shown age- and sex-related differences for PhA. PhA increases with BCM and since men generally have higher amounts of fat-free mass, they also have higher PhA. Higher PhA reported in the highest quartiles of functional independence measures and maximum quadriceps strength\textsuperscript{16} and a positive relationship between muscle strength and PhA\textsuperscript{40} suggest that lower PhA is associated with poorer functional status.

Although controls and patients >50 yrs in our study had significantly lower PhA than younger subjects, the older controls did not have a significantly higher incidence of having low PhA. Thus the currently proposed cut-offs are appropriate for subjects <65 yr. Previous studies have proposed age- and sex-specific percentile cut-offs for PhA\textsuperscript{31} and have been shown to be clinically useful in cancer patients.\textsuperscript{12} We did not adjust the PhA cut-offs for age because there was no increase in the prevalence of low PhA in controls >50 yr, compared to younger controls. The higher incidence of low PhA in patients >50 yr may reflect a decrease in functional ability that occurs with illness and age, which remains to be investigated. Further research is necessary to determine the effects of age on PhA in patients and controls older than 65 yr.

### Table 3

<table>
<thead>
<tr>
<th>Patient Type</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthy</td>
<td>80.0%</td>
<td>95.0%</td>
</tr>
<tr>
<td>Moderate</td>
<td>75.0%</td>
<td>90.0%</td>
</tr>
<tr>
<td>Severe</td>
<td>70.0%</td>
<td>85.0%</td>
</tr>
</tbody>
</table>

### Table 4

<table>
<thead>
<tr>
<th>Phase angle</th>
<th>Subjects</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥5.0°</td>
<td>Healthy</td>
<td>70.0%</td>
<td>85.0%</td>
</tr>
<tr>
<td>&lt;5.0°</td>
<td>Moderate</td>
<td>65.0%</td>
<td>80.0%</td>
</tr>
<tr>
<td>≥4.6°</td>
<td>Severe</td>
<td>60.0%</td>
<td>75.0%</td>
</tr>
</tbody>
</table>

### Table 5

<table>
<thead>
<tr>
<th>Albumin</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥35 g/L</td>
<td>85.0%</td>
<td>90.0%</td>
</tr>
<tr>
<td>30–35 g/L</td>
<td>80.0%</td>
<td>95.0%</td>
</tr>
<tr>
<td>&lt;30 g/L</td>
<td>75.0%</td>
<td>90.0%</td>
</tr>
</tbody>
</table>

BMI, body mass index; NRS-2002, nutritional risk screening-2002; and SGA, subjective global assessment. \textsuperscript{a} Controls – 0; low risk/well-nourished – 1; moderate risk/moderately malnourished – 2; severe risk/severely malnourished – 3; NRS/SGA, respectively.

*UG. Kyle et al. / Clinical Nutrition 31 (2012) 875–881*
4.1. Study limitations

The study population is heterogeneous, but reflected our general hospital population on admission. Our PhA values have been previously shown to be 10.5% lower in men and 7.7% in women compared to studies in the American population. Differences between devices from different manufacturers may have contributed to differences in PhA which may limit general applicability. A further limitation is that PhA decreases with age which may require lower cut-off values in subjects >65yr. Further
research should determine the effects of age on PhA in patients and controls >65 yr.

Some other limitations of this study were that the conditions of the BIA measurements were only partially controlled. The original intent of the study was to gather estimates of body composition as part of baseline nutritional assessment at hospital admission. None of the patients had visible edema. Body position was controlled for by supine position in all patients. Physical activity was limited in elderly and sick patients, but not necessarily in trauma patients. Food intake was not controlled for in this clinical setting. All patients were measured by the same analyzer. Multiple instruments were used to measure the controls subjects.

5. Conclusions

The high prevalence of low PhA in patients with moderate and severe risk by NRS-2002 or SGA or low serum albumin levels supports the concept that PhA is associated with nutritional risk. The high sensitivity and specificity of BIA measurements were only partially controlled. The original intent of the study was to gather estimates of body composition as part of baseline nutritional assessment at hospital admission. None of the patients had visible edema. Body position was controlled for by supine position in all patients. Physical activity was limited in elderly and sick patients, but not necessarily in trauma patients. Food intake was not controlled for in this clinical setting. All patients were measured by the same analyzer. Multiple instruments were used to measure the controls subjects.

Conflict of interest

There is no conflict of interest or association with pharmaceutical biotechnology companies or other associations of any of the authors. Nutrition 2000Plus is a private Foundation to promote “Good Nutrition” and fund nutrition research and publish research results, train physicians in nutrition, and organize seminars on topics of nutrition. C. Pichard (senior author) is the President of the Foundation.

Statement of authorship

Each author has participated sufficiently, intellectually and practically, in the work to take public responsibility for the content of this article, including the conception, design and conduction of the study and for the interpretation (authorship). UK conceived and carried out the study, carried out the data analyses and drafted the manuscript. ES carried out the data analysis and participated in the design of the study, contributed to the data analysis and drafting of the manuscript. LG participated in the design of the study, carried out the data analysis, and drafting of the manuscript. All authors read and approved the final manuscript.

Funding


Acknowledgments

The study was conducted at the Geneva University Hospital.

Table 5

<table>
<thead>
<tr>
<th>Albumin (g/L)</th>
<th>Normal PhA</th>
<th>Low PhA</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;35</td>
<td>94.3 (333)</td>
<td>5.7 (20)</td>
</tr>
<tr>
<td>&lt;35</td>
<td>57.6 (19)</td>
<td>42.4 (14)</td>
</tr>
<tr>
<td></td>
<td>7.5 (3.9-13.5)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Normal PhA: >5.0 in men and >4.6 in women; low PhA: <5.0 in men and <4.6 in women; CI, confidence interval.

References


