Is Phase Angle a Sensitive Biomarker for Overall Health Status?

Kara Poindexter, Madison D Dixon, and Sam R Emerson

Department of Nutritional Sciences, College of Human Sciences, Oklahoma State University, Stillwater, OK, USA

BACKGROUND

- Bioelectrical impedance analysis (BIA) is used as a non-invasive method of calculating body composition, such as body fat and fat-free mass. It works by transmitting electrical currents throughout the body and assessing resistance as the current passes through different body tissues.
- BIA can be used to calculate *Phase Angle*, which is calculated using body tissue *resistance* and cell membrane *reactance* (1).
- Phase Angle is thought to be an indicator of overall cellular health and nutritional quality of cells.
  - Phase Angle has been observed to be positively associated with survival in several clinical conditions, such as HIV AIDS, lung cancer, and patients undergoing hemodialysis (2).
  - However, Phase Angle is still a relatively new biomarker that needs to be further examined.
- Various lifestyle behaviors such as diet, physical activity, and stress are well-known risk factors of chronic disease development, which can be difficult to detect, especially during the beginning stages, and often take years to develop.
- It is unknown whether phase angle is associated with traditional lifestyle risk factors.
- The **purpose** of this study was to determine if there is a correlation between phase angle, a potentially underutilized assessment of overall health, and behavioral markers such as diet, exercise, and stress.
- We **hypothesized** that higher levels of antioxidant nutrients and physical activity as well as lower levels of stress would be associated with a higher phase angle.

METHODS

Participants

We recruited 36 participants (14 men, 22 women).

Inclusion criteria:

- Healthy men and women
- Age: 18-30 years

Exclusion criteria:

- Having a current diagnosed disease or condition
- Having a pace-maker or other electrical implant
- Pregnancy
- Use of tobacco products

Figure 1. Bioelectrical Impedance Analysis Machine.

Data Collection

- Participants came to the lab a total of two times. The initial appointment consisted of answering surveys regarding physical activity and perceived stress level, as well as documenting the participants' blood pressure, height, weight, fat mass, fat free mass, and phase angle using the BIA machine (Figure 1).
- Following biochemical measurements, the participants were given a food log to track their diet for 3 days (including 2 weekdays, and 1 weekend day), and a physical activity tracker on their non-dominant wrist to wear for 5 days. At the follow-up appointment, participants returned the physical activity tracker and diet log back to the lab to be analyzed.
- Following all data collection, nutritional analysis of the 3 day diet was completed by a single investigator using a food analysis software.

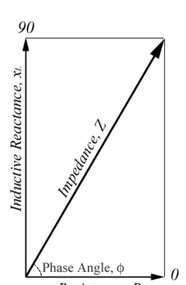
Seca mBCA 514 (Figure 1).

- A Seca medical body composition analyzer (mBCA) 514 was used to determine various body composition measurements such as weight, BMI, fat mass, fat free mass, and phase angle.
- The participant was required to stand on the machine barefoot, as well as remove all sources of metal such as earrings, watches, belts, etc.
- After manually inputting participant information such as height and waist circumference, the machine analyzes body composition in less than 20 seconds, and is completely non-invasive.

What is Phase Angle?

- The Seca mBCA 514 measures phase angle by transmitting an insensible electrical current through the body and measuring *resistance* and *reactance*.
  - **Resistance**: opposition by the body to the flow of an oscillating electrical current. Resistance is inversely associated with water and electrolyte content.
  - **Reactance**: the capacitance properties of the cell membrane. Variations in reactance occur depending on the function, composition, and integrity of cellular membrane.

Phase angle = arc-tangent reactance/resistance x 180°/π



RESULTS

- ***Our sample consisted of healthy college-aged individuals. Men and women differed in weight, height, systolic BP, fat mass, fat-free mass, and phase angle (Table 1).***

	Total	Men	Women	*p*-value
Age (years)	23.5±5.2	24.8±5.5	22.7±4.9	0.25
Weight (kg)	72.4±15.1	81.0±10.9	66.7±15.0	0.004
Height (m)	1.7±0.09	1.77±0.09	1.66±0.06	0.0003
BMI (kg/m²)	25±5.2	26.1±3.9	24.4±5.9	0.35
Systolic BP (mmHg)	114.9±11.8	121.0±9.5	110.9±11.6	0.01
Diastolic BP (mmHg)	74.6±9.6	72.6±9.5	75.8±9.7	0.37
Fat Mass (%)	27.1±8.7	21.7±7.6	30.7±7.6	0.002
Fat-Free Mass (%)	72.8±8.7	78.3±7.5	69.2±7.6	0.002
Phase Angle (degrees)	5.7±0.6	6.2±0.7	5.4±0.3	0.0001
MVPA (minutes)	194.4±61.2	177.4±62.4	206.4±58.9	0.18
Steps/day	11280.8±2956.3	11439.9±2956.3	11169.5±3033.6	0.80

Table 1. Participant characteristics. Statistical results for each variable represent findings of an unpaired *t*-test. Data are presented as Mean ± SD. * Men and women significantly different ($p < 0.05$). Age, Weight (kg), Height (m), BMI, Systolic Blood Pressure, Diastolic Blood Pressure, Fat Mass, Fat Free Mass, Phase Angle, MVPA (Moderate to Vigorous Physical Activity), Steps per day.

- ***Men were found to have a significantly greater phase angle than women (Figure 2).***

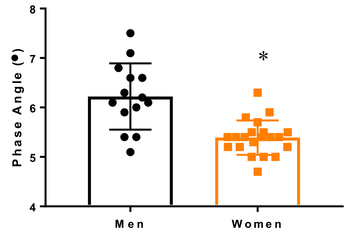


Figure 2. Comparison of phase angle in men and women. Data were divided into men and women and compared using an unpaired *t*-test. Men were observed to have a significantly greater phase angle than women ($p < 0.0001$). Data are Mean ± SD with individual data points visible.

- ***Age and diastolic BP were not significantly correlated with phase angle, but systolic BP was positively associated with phase angle (Figure 3).***

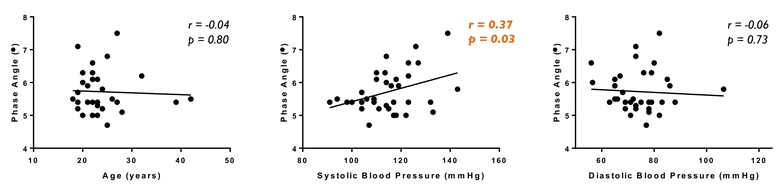


Figure 3. Correlations between phase angle and age, systolic blood pressure, and diastolic blood pressure. Pearson correlations were used to test the association between phase angle and age and blood pressure. The only result that showed a statistically significant correlation was systolic blood pressure, which was a positive correlation.

- ***Phase angle was not significantly correlated with body mass index, but there was a strong positive correlation with fat-free mass percentage, as well as an inverse association with fat mass percentage (Figure 4).***

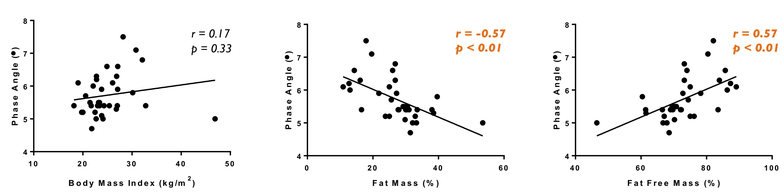


Figure 4. Correlations between phase angle and body mass index, fat mass percentage, and fat-free mass percentage. Pearson correlations were used to test the association between phase angle and body composition outcomes. Although phase angle did not show a significant correlation with body mass index in participants, there was a strong association with fat mass and fat free mass. A higher phase angle was inversely associated with fat mass percentage, which indicates higher overall cellular health in people with more lean body mass.

- ***There were no significant correlations between phase angle and physical activity or perceived stress (Figure 5).***

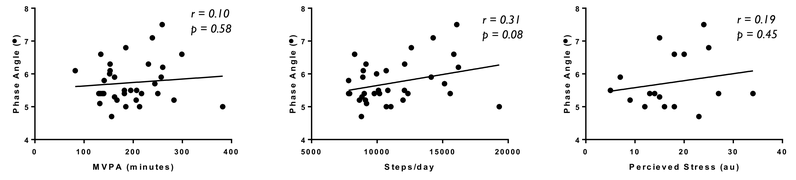


Figure 5. Correlations between phase angle and MVPA, steps/day, and perceived stress. There was not a significant correlation between phase angle and physical activity, measured as moderate- to vigorous-intensity physical activity (MVPA) and overall steps per day. There also was not an association between perceived stress levels and phase angle.

- ***In general, phase angle was positively associated with increased food intake, but was not associated with fiber or certain antioxidant vitamins (Figure 6).***

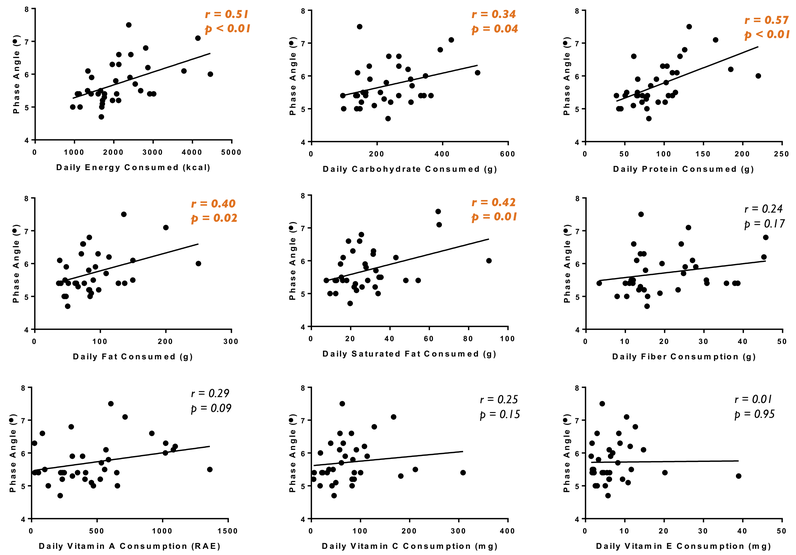


Figure 6. Correlations between phase angle and various nutritional indicators. There was a positive association between phase angle and total energy consumed, which includes carbohydrates, protein, and fat. Antioxidant vitamins A, C, and E were not significantly correlated with phase angle. Fiber was also not associated with phase angle.

SUMMARY

- There was a strong correlation between body composition and phase angle, which makes sense as *resistance* and *reactance* are used by BIA to calculate phase angle, fat mass, and fat-free mass.
- However, phase angle was not significantly associated with age, physical activity, stress, or certain antioxidant vitamins, and was positively associated with systolic blood pressure.
- Our data does not support phase angle as a sensitive marker of overall health in young disease-free individuals, as it did not correlate with key risk factors, such as age, physical activity, stress, or antioxidant intake.
- Future research should investigate the relationship between phase angle and lifestyle factors in a larger sample that includes a wider spectrum of chronic disease risk.

REFERENCES

1. Bosy-Westfal, A., Danielzik, S., Dörhöfer, R., Later, W., Wiese, S., & Müller, M.J. (2006). Phase Angle From Bioelectrical Impedance Analysis: Population Reference Values by Age, Sex, and Body Mass Index. Journal of Parental and Enteral Nutrition. 30(4), 309-316.

2. Barbosa-Silva MC, Barros AJ, Wang J, Heymsfield SB, Pierson Jr RN. Bioelectrical impedance analysis: population reference values for phase angle by age and sex–. The American Journal of Clinical Nutrition. 2005;82(1):49-52.