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Phase Angle Reference Ranges from NHANES-III

Introduction

A Bioelectrical Impedance Analyzer (BIA) is a noninvasive, inexpensive, and portable tool that is commonly used for estimating body composition. RJL Systems' BIA devices use a 50 kHz signal to measure resistance (R) and reactance (X_C), which are the components of impedance (Z). Phase angle (PA) is generally reported in degrees, and is the measure of how much the signal is being delayed by the reactance. Mathematically, these four values (Z, R, X_C , and PA) are related to each other as follows:

$$Z = \sqrt{R^2 + X_C^2}$$

$$PA = \arctan\left(\frac{X_C}{R}\right) \times \left(\frac{180}{\pi}\right)$$

Many claims have been made by different individuals over the years as to the significance of phase angle measurements in a clinical setting. However, it is important to note that, at the time of this writing, the United States Food and Drug Administration has not evaluated any of these claims and does not currently recognize any clinical utility of the measurement.

The goal of this document is to present average ranges of phase angle for the American population by sex and age. RJL Systems makes no claims as to any prognostic or diagnostic utility of phase angle, and places no significance in whether any given phase angle value is below, within, or above the average range.

Methods and Discussion

In the United States, the Centers for Disease Control (CDC) have an ongoing series of studies called the National Health and Nutrition Examination Survey, or NHANES¹. The third NHANES survey (commonly abbreviated NHANES-III) collected data from 1988 - 1994, and was the first NHANES to include BIA data.²

The NHANES-III data set contains records for 33,994 individuals, although not all participants took part in every section of the survey. Eliminating all records that do not have BIA data reduces the data pool to 17,660 records.

1 "About the National Health and Nutrition Examination Survey"
https://www.cdc.gov/nchs/nhanes/about_nhanes.htm - referenced 2018-08-29.

2 "Data Files" <https://www.cdc.gov/nchs/nhanes/nhanes3/DataFiles.aspx> - referenced 2018-08-29.

The NHANES surveys used a different manufacturer's BIA devices, but published equations exist to compensate for the difference in calibration methods to convert the resistance and reactance measurements reported by those devices to the equivalent values that would have been reported using an RJL BIA.³

After applying the conversion equations, the data was separated according to sex and ten-year age range. (10-19, 20-29, etc.) Within each subgroup, mean average and standard deviation were calculated for both phase angle and age. The resulting average ranges and the number of people in each subgroup can be seen in the tables below. Because of the nature of a standard distribution, it can be assumed that approximately 68% of the individuals within each subgroup fall within the average ranges.

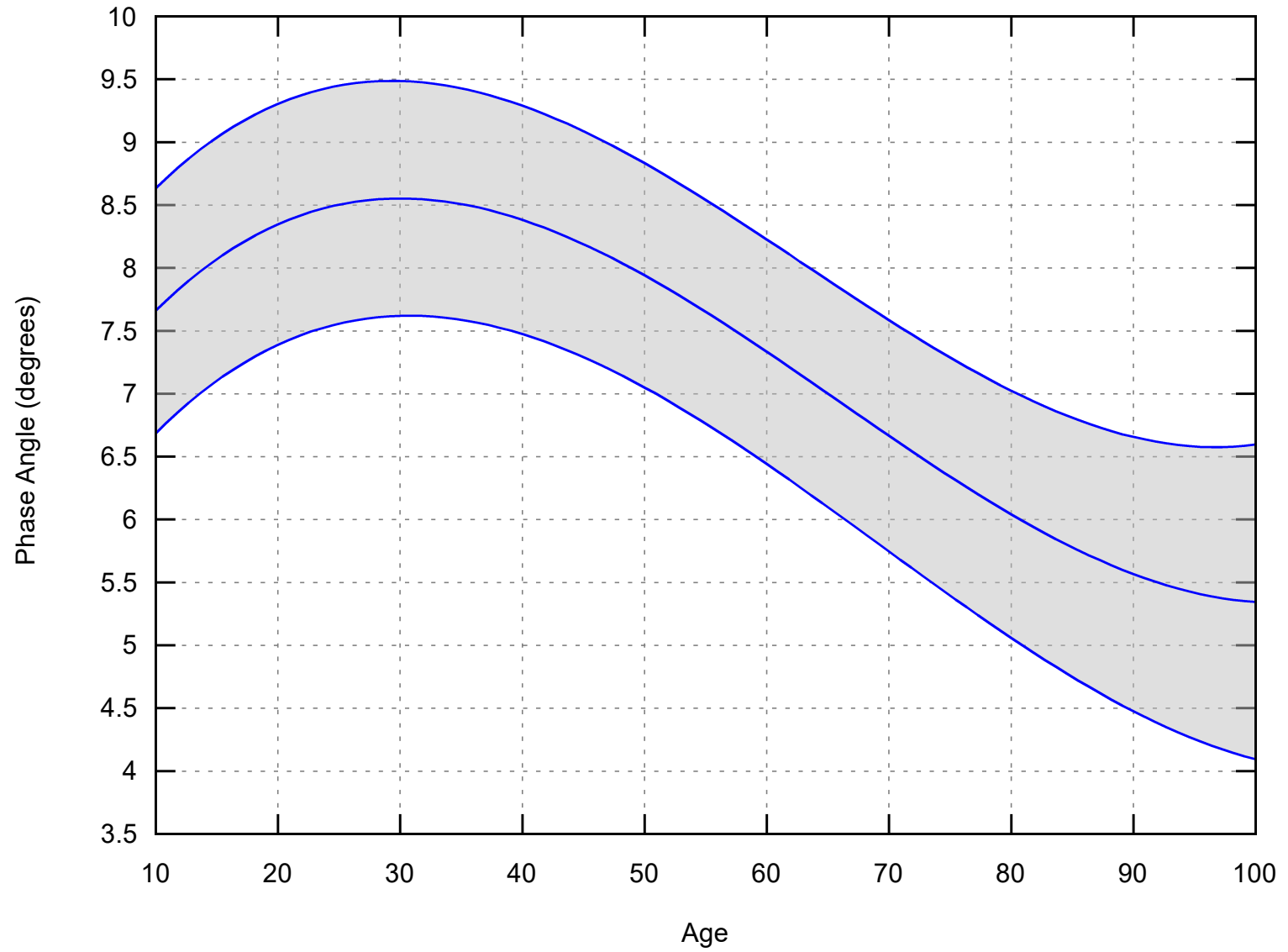
Males									
Age Group	10 - 19	20 - 29	30 - 39	40 - 49	50 - 59	60 - 69	70 - 79	80 - 89	90 - 99
Phase Angle	8.0 ± 1.0	8.7 ± 0.9	8.5 ± 0.9	8.2 ± 1.0	7.6 ± 0.9	7.1 ± 0.9	6.4 ± 1.0	5.7 ± 0.9	5.4 ± 1.2
Age	15.4 ± 2.3	24.5 ± 2.8	34.3 ± 2.8	43.9 ± 2.8	54.4 ± 2.8	64.3 ± 2.9	73.6 ± 2.6	82.8 ± 2.5	90.0 ± 0.0
(n)	1379	1553	1383	1155	792	1055	724	472	32

Females									
Age Group	10 - 19	20 - 29	30 - 39	40 - 49	50 - 59	60 - 69	70 - 79	80 - 89	90 - 99
Phase Angle	7.5 ± 0.8	7.8 ± 0.8	7.7 ± 0.9	7.6 ± 0.8	7.1 ± 0.9	6.7 ± 0.9	6.2 ± 1.0	5.6 ± 0.9	5.0 ± 0.7
Age	15.3 ± 2.3	24.5 ± 2.9	34.5 ± 2.9	43.8 ± 2.8	54.3 ± 2.8	64.3 ± 2.8	73.9 ± 2.8	83.0 ± 2.6	90.0 ± 0.0
(n)	1448	1511	1632	1248	907	1031	817	477	44

To further facilitate easy understanding, we have created a pair of graphs. The means and both bounds of the average ranges for phase angle in each subgroup were plotted using the mean age for that subgroup as the X-coordinate. Once all of the points were plotted, cubic splines were fitted to each of the traces, and the region comprising the average band was shaded. Those graphs can be found on the following pages.

³ Body composition estimates from NHANES-III bioelectrical impedance data. WC Chumlea, SS Guo, et. al. International Journal of Obesity (2002) 26, 1596-1609

Phase Angle Averages for Males



Phase Angle Averages for Females

