

# **Brazilian Reference Percentiles for Bioimpedance Phase Angle of Healthy Individuals**

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**Objectives:** The present study was designed to estimate phase angle percentile curves for a broad age range of healthy individuals.

**Methods:** This is a cross-sectional study of healthy Brazilian individuals aged five to 80. InBodyS10 was used to assess phase angle. Reference curves were stratified by sex and estimated using Generalized additive models for location, scale, and shape as a continuous function of age. The phase angle determinants analyzed were physical activity, age, BMI, and SES variables.

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Mattiello R, Mundstock E and Ziegelmann PK (2022) Brazilian Reference Percentiles for Bioimpedance Phase Angle of Healthy Individuals. Front. Nutr. 9:912840. doi: 10.3389/fnut.2022.912840 **Results:** Data were analyzed from 2,146 individuals, 1,189 (55.2%) of whom were female. In both sexes, the phase angles showed a similar pattern (an increasing trend from childhood to the teenage phase, followed by stabilization during adult ages and a decrease in old adults). In female, the relationship between phase angle and age were associated with BMI and family income. In the male, the relationship between phase angle and age were angle and age were associated with skin color and family income.

**Conclusions:** To the best of our knowledge, it is the first attempt to apply the GAMLSS technique to estimate phase angle percentiles in a healthy population covering most of the life cycle. We also showed that there are different phase angle determinants according to sex.

Keywords: bioimpedance (BIA), phase angle (PA), reference values, percentiles, determinants

## INTRODUCTION

Phase angle (PA) from bioimpedance is measured by the potential difference of a low voltage alternating electric current introduced into the body. It is dependent on the resistive behavior and the capacitive effect on the cell membrane and other interfaces (1). PA has been proposed to indicate cellular health, where higher values reflect higher cellularity, cell membrane integrity, and better cell function (1). For this reason, it has been used as a health status tool and an important predictor of disease severity and survival in different medical conditions (2–6). However, the cut-offs used in the literature are not necessarily transferable to other populations and might thus not be applicable in the general clinical setting. This is because the cut-offs are generated primarily using the median or lowest quantile from a specific population without considering the determinants of phase angle. Phase angle reference values are still scarce, especially PA percentile curves (2).

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According to one recent meta-analysis involving more than 250,000 healthy subjects, age, sex, and BMI seem to be main independent determinants of phase angle (7). Another meta-analysis showed that physical activity also influences PA values, especially in individuals with chronic diseases, indicating that it should be considered as an associated variable (8).

Therefore, the present study was designed to estimate phase angle percentile curves for a broad age range of healthy individuals stratified by sex and understand the relationship between phase angle and physical activity, age, BMI, skin color, and family income.

## MATERIALS AND METHODS

#### **Study Design**

This was a cross-sectional study that followed the STROBE statement guidelines for reporting observational studies (9).

#### **Setting and Participants**

Healthy community-dwelling individuals aged five to 80 years old, of both sexes, were invited to participate in the study. The exclusion criteria were contraindications against bioimpedance measurements, such as diseases affecting the skin's electrical resistance, pregnancy, persons with an implanted pacemaker or cardioverter-defibrillator, and amputated persons using a prosthesis/orthosis. Participants were considered healthy if they had not been diagnosed with any chronic disease or were not on continuous medication. Data were collected from December 2015 to April 2019 in public and private schools, companies, and at events in cities in southern Brazil. Recruitment occurred through word of mouth.

#### **Data Measurements**

Sociodemographic variables were obtained through structured interviews. These included age (years), sex (male or female), self-reported skin color (categorized into white, black, or others—brown, Asian, and indigenous were grouped together to homogenize the size of the categories), and location of residence (rural or urban), defined according to the IBGE Brazilian demographic census (10). Income was categorized into low and high (according to whether the families earned more or less than the median income, calculated separately for the samples of men and women).

To assess the level of physical activity, the participants answered different validated questionnaires, according to their age. The children up to 10 years of age answered the Physical Activity Checklist (11), and participants over 10 years of age answered the short version of the International Questionnaire on Physical Activity (IPAQ) (12, 13). After that, the participants were classified as active or inactive according to their physical activity level. The cut-off points to be considered active was 300 min of moderate to vigorous physical activity (MVPA) per week for children and adolescents. For the adults (18 years and older), it was 150 min of MVPA, or 75 min of vigorous physical activity (VPA) per week. These cut-off points are the same ones suggested by the World Health Organization (14). Body mass was measured with the participants in a standing position, wearing the least possible amount of clothing and no shoes, using a calibrated digital scale (Charder MS6121). Height was measured with the participants standing barefoot with their feet parallel and heels together, arms along their body, and head in the Frankfurt plane, using a Sanny compact stadiometer and a tape measure to the nearest 0.1 cm (American Medical do Brazil Ltda, São Bernardo do Campo, Brazil). Body mass index was classified as underweight, normal weight, pre-obesity, and obesity according to the WHO BMI classification for children, adults, and the elderly (15).

Bioimpedance Multi-frequency InBodyS10 (Ottoboni, Rio de Janeiro, RJ, Brazil) was used to assess phase angle. The InBodyS10 showed excellent agreements with DEXA regarding to whole body lean mass, fat mass and percentage body fat (16). The applied current was 100  $\mu$ A (1 kHz) and 500  $\mu$ A and frequency was 50 kHz. The hand electrodes were attached to each thumb and middle finger, while the foot electrodes were positioned between the ankle bone and the heel, covering as much area as possible. The BIA was performed with the participants on a non-conductive surface in the standing position, with their legs apart and arms held away from their body and wearing the least amount of clothing possible and no metal jewelry. The standard guidelines were followed to instruct regarding fasting state of the subjects before the BIA (17). All measurements were performed by one of the four experienced researchers according to the manufacturer's instructions using a standardized technique. All the participants completed three evaluations, and the average of the three values was considered as their result.

#### **Statistical Analysis**

The data were expressed as mean (SD) or median and interquartile range (IQR, 25th–75th percentiles) for the continuous variables and absolute and relative frequencies for the categorical variables.

Generalized additive models for location, scale, and shape (GAMLSS) were used to estimate age-related phase angles and determine phase angle predictors. These models are more flexible than linear or generalized linear models. They let the data determine the relationship between the predictor and the covariables rather than enforcing a linear (or polynomial) relationship. It is also possible to use smoothing techniques and allow the covariables to model variability and shape besides the median values (18, 19).

First, the LMS R function was used to estimate the power value, possible transformation of age and select the distribution family (among BCCGo, BCPEo, and BCT families). To identify the models' optimum number of effective degrees of freedom (edf), the automated "pb" function was implemented. Models were also tested with and without age transformation, different degrees of freedom, and cubic smoothing. The models were compared using GAIC (generalized Akaike information criterion) (19, 20).

GAMLSS models were also used to explore phase angle determinants. Physical activity, BMI, skin color, and family income were analyzed one by one in a bivariable model with age to test any possible interaction between age and the

Characteristics	Total sample	Male	Female
n (%)	2,122 (100.0)	951 (44.8)	1,171 (55.2)
Age (years), n (%)	2,122 (100.0)	951 (44.8)	1,171 (55.2)
5–12	901 (42.4)	398 (41.8)	503 (42.9)
13–15	222 (10.4)	95 (9.9)	127 (10.8)
16–18	81 (3.8)	40 (4.2)	41 (3.5)
19–28	222 (10.4)	102 (10.7)	120 (10.2)
29–38	262 (12.3)	119 (12.5)	143 (12.2)
39–48	239 (11.2)	102 (10.7)	137 (11.6)
49–58	128 (6.0)	67 (7.0)	61 (5.2)
> 59	67 (3.1)	28 (2.9)	39 (3.3)
Body mass index, n (%)	2,122 (100.0)	951 (44.8)	1,171 (55.2)
Under/Normal weight	979 (46.1)	400 (42.0)	579 (49.4)
Pre-obesity	665 (31.3)	340 (35.7)	325 (27.7)
Obesity	478 (22.5)	211 (22.1)	267 (22.8)
Skin color*, n (%)	1,611 (100.0)	751	820
White	724 (44.9)	360 (47.9)	364 (42.3)
Black	592 (36.7)	251 (33.4)	341 (39.6)
Others (brown, Asian, and indigenous)	295 (18.3)	140 (18.6)	115 (18.0)
Missing data	511 (24.0)	200 (21.0%)	311 (26.6)
Family monthly income	1,596 (100.0)	720	876
Low income	846 (53.2)	399 (55.4)	450 (38.4)
High income	747 (46.8)	321 (44.6)	426 (48.6)
Missing data	526 (24.8)	231 (24.3)	295 (25.2)
Residence area, n (%)	2,122 (100.0)	951	1,171
Urban	1,304 (61.5)	634 (66.8)	670 (57.3)
Missing data	5 (0.2)	3 (0.3)	2 (0.2)
Physical activity, n (%)	1,599 (100.0)	729	870
Inactive	1,078 (67.4)	440 (60.3)	638 (73.3)
Missing	523 (24.9)	222 (23.3)	301 (25.7)

\*Self-declared.

covariables. The covariables and interactions, significant at 5%, were maintained in the multivariable model.

All analyses were performed using the R software, version 3.2.3, with the "gamlss" package, version 5.1-5 (21).

The present study was part of an umbrella project and was conducted according to the Declaration of Helsinki (22). This project received the approval of the Research Ethics Committee of the Pontifical Catholic University of Rio Grande do Sul (permission 2.187.802). For adult participants, the Informed Consent Term (ICT) was signed. In the case of underage participants, the consent term was obtained, and ICT signature was acquired from their parents or guardians.

#### RESULTS

A total of 2,122 participants aged five up to 80 years old were evaluated. The majority were females (n = 1,171, 55.2%); were aged between five and 12 years (n = 901, 42.4%); were underweight/normal weight (n = 979, 46.1%); self-declared their skin color as white (n = 724, 44.9%); were living in an urban area (n = 1,304, 61.5%); were inactive according to their physical activity level (n = 1,078, 67.4%); and were classified as low income (n = 846, 53.2%) (**Table 1**).

#### **Phase Angle Centile Estimation**

**Women:** The final age-related model for centile estimation was adjusted using the Box-Cox Cole and Green orig family distribution (BCCGo); there was no age transformation; mu = 10, sigma = 4, and nu = 4, and these were all associated with age.

**Men:** The final age-related model for centile estimation was adjusted using the Box-Cox Power Exponential orig family distribution (BCPE); there was no age transformation; mu = 13, sigma = 4, nu = 4, tau = 2, and these were all associated with age.

The estimated phase angle percentiles showed for both sexes that the values increase through childhood, stabilize during most of adulthood, and decrease through late adulthood (Figure 1). The estimated percentiles and z-scores are shown in Table 2 for men and in Table 3 for women.



FIGURE 1 | Phase angle by age in healthy males' and female's individuals. Solid lines represent median estimates together with 25th and 75th centiles (dotted lines) and 5th and 95th centiles (dashed lines).

TABLE 2 | Men's phase angle percentiles and z-score.

TABLE 2 | (Continued)

<b>Age</b> 5																					
5	P5	P25	P50	P75	P95	-2	-1	0	+ 1	+2	Age	P5	P25	P50	P75	P95	-2	-1	0	+ 1	+2
	3.28	3.63	4.03	4.56	5.54	3.18	3.49	4.03	4.86	5.99	58	5.19	5.86	6.24	6.62	7.32	4.91	5.65	6.24	6.83	7.62
	3.33	3.69	4.09	4.61	5.54	3.23	3.55	4.09	4.90	5.96	59	5.16	5.82	6.19	6.56	7.26	4.88	5.61	6.19	6.77	7.5
	3.38	3.75	4.15	4.67	5.56	3.28	3.61	4.15	4.95	5.95	60	5.13	5.77	6.14	6.51	7.19	4.85	5.57	6.14	6.72	7.4
	3.44	3.83	4.23	4.75	5.6	3.33	3.68	4.23	5.02	5.96	61	5.1	5.74	6.09	6.45	7.13	4.83	5.54	6.09	6.66	7.4
	3.52	3.92	4.33	4.84	5.67	3.41	3.77	4.33	5.10	6.00	62	5.07	5.71	6.05	6.41	7.08	4.81	5.51	6.05	6.61	7.3
	3.62	4.03	4.45	4.96	5.77	3.5	3.87	4.45	5.22	6.09	63	5.05	5.68	6.02	6.36	7.03	4.79	5.48	6.02	6.57	7.3
	3.74	4.18	4.61	5.12	5.91	3.62	4.01	4.61	5.38	6.22	64	5.03	5.65	5.98	6.32	6.98	4.77	5.46	5.98	6.52	7.2
	3.91	4.37	4.81	5.32	6.11	3.77	4.19	4.81	5.58	6.42	65	5.01	5.62	5.95	6.28	6.94	4.76	5.43	5.95	6.48	7.2
	4.11	4.60	5.05	5.58	6.37	3.96	4.41	5.05	5.84	6.67	66	4.99	5.59	5.91	6.24	6.88	4.74	5.41	5.91	6.43	7.
	4.34	4.86	5.34	5.88	6.68	4.18	4.67	5.34	6.14	6.97	67	4.97	5.56	5.87	6.19	6.83	4.71	5.38	5.87	6.38	7.
	4.59	5.15	5.65	6.2	7.01	4.42	4.94	5.65	6.47	7.31	68	4.94	5.52	5.82	6.13	6.77	4.69	5.34	5.82	6.32	7.0
	4.86	5.45	5.97	6.54	7.35	4.67	5.23	5.97	6.81	7.65	69 70	4.9	5.47	5.77	6.08	6.70	4.66	5.30	5.77	6.26	6.9
7 3	5.11 5.35	5.74 6.00	6.28 6.55	6.86 7.14	7.69 7.97	4.92 5.14	5.51 5.77	6.28 6.55	7.14 7.42	7.99 8.28	70 71	4.86 4.82	5.43 5.37	5.72 5.65	6.01 5.94	6.63 6.55	4.62 4.58	5.26 5.20	5.72 5.65	6.19 6.12	6.9 6.8
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9 )	5.66	6.35	6.91	7.5	8.32	5.43	6.11	6.91	7.78	8.62	73	4.77	5.24	5.51	5.78	6.37	4.55	5.08	5.51	5.95	6.6
1	5.74	6.45	7,00	7.59	8.39	5.43 5.51	6.20	7,00	7.86	8.68	73 74	4.71	5.24 5.17	5.43	5.69	6.27	4.48 4.43	5.08 5.01	5.43	5.95 5.86	6.5
2	5.74 5.79	6.5	7.05	7.62	8.41	5.55	6.25	7.05	7.89	8.69	75	4.05	5.10	5.35	5.60	6.17	4.43	4.95	5.35	5.76	6.4
3	5.81	6.52	7.06	7.62	8.39	5.56	6.27	7.06	7.88	8.67	76	4.53	5.03	5.27	5.52	6.07	4.31	4.88	5.27	5.67	6.0
4	5.8	6.52	7.05	7.6	8.35	5.56	6.27	7.05	7.86	8.62	77	4.47	4.96	5.19	5.43	5.97	4.26	4.81	5.19	5.59	6.
5	5.79	6.50	7.03	7.56	8.29	5.54	6.26	7.03	7.81	8.56	78	4.42	4.89	5.11	5.35	5.88	4.21	4.75	5.11	5.50	6.
6	5.77	6.48	7.00	7.52	8.23	5.52	6.24	7.00	7.76	8.49	79	4.36	4.82	5.04	5.27	5.79	4.15	4.68	5.04	5.41	6.
7	5.74	6.46	6.96	7.47	8.17	5.49	6.21	6.96	7.71	8.42	80	4.30	4.75	4.97	5.18	5.70	4.10	4.62	4.97	5.33	5.9
28	5.72	6.43	6.94	7.43	8.12	5.47	6.19	6.94	7.67	8.37											
29	5.71	6.42	6.92	7.41	8.09	5.45	6.18	6.92	7.64	8.33											
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34 35 36 37 38 39 40	5.72 5.73 5.72 5.71 5.68 5.66 5.63 5.61	6.47 6.48 6.47 6.45 6.42 6.39 6.37	6.94 6.97 6.97 6.96 6.93 6.90 6.87 6.85	7.42 7.43 7.44 7.44 7.43 7.4 7.37 7.34 7.31	8.09 8.11 8.12 8.13 8.12 8.10 8.07 8.04 8.02	5.44 5.44 5.43 5.41 5.39 5.36 5.33 5.30	6.21 6.22 6.23 6.23 6.22 6.2 6.17 6.15 6.12	6.94 6.96 6.97 6.96 6.93 6.90 6.87 6.85	7.64 7.66 7.67 7.66 7.63 7.60 7.57 7.54	8.33 8.35 8.37 8.38 8.37 8.35 8.33 8.30 8.28	incon M betw color <b>DIS</b> This	me (w [ale: ] een pl (with CU: study	ith a si In the hase a n a sign <b>SSIC</b> vused	ngle ar ignific e fina ngle a nifican <b>)N</b> a larg	ant int l mul nd age t inter	teracti tivaria e was a raction	on) ( <b>S</b> able n associa a) ( <b>Sup</b> ) healtl	upplen nodel, ated w pplem	h BMI menta the rith BM entary	I and f ry Tab relatio /II and Table indivi	am ole nsh l sk e 1)
34 35 36 37 38 39 40 41 42	5.72 5.73 5.72 5.71 5.68 5.66 5.63 5.61 5.59	6.47 6.48 6.47 6.45 6.42 6.39 6.37 6.35	6.94 6.97 6.97 6.96 6.93 6.90 6.87 6.85 6.82	7.42 7.43 7.44 7.43 7.4 7.37 7.37 7.34 7.31 7.29	8.09 8.11 8.12 8.13 8.12 8.10 8.07 8.04 8.02 8,00	5.44 5.44 5.43 5.41 5.39 5.36 5.33 5.30 5.28	6.21 6.22 6.23 6.22 6.2 6.17 6.15 6.12 6.10	6.94 6.97 6.97 6.96 6.93 6.90 6.87 6.85 6.82	7.64 7.66 7.67 7.66 7.63 7.60 7.57 7.54 7.52	8.33 8.35 8.37 8.38 8.37 8.35 8.33 8.30 8.28 8.26	incon M betw color <b>DIS</b> This aged	me (w [ale: ] een pl : (with CUS study five to	ith a si In the hase a n a sign <b>SSIC</b> used o 80 ye	ngle ar gnific e fina ngle a nifican <b>)N</b> a larg ears ol	ant int l mul nd age t inter ge sam d to es	teracti tivaria e was = caction ple of stimat	on) ( <b>S</b> able n associa h) ( <b>Sup</b> healtl e phas	upplen nodel, ated w opleme hy Bra	h BMI menta the rith BM entary zilian e, as n	I and f ry Tab relatio //I and / Table indivineasur	am <b>ble</b> nsh l sk <b>c 1</b> ) dua ed
34 35 36 37 38 39 40 41 42 43	5.72 5.73 5.72 5.68 5.66 5.63 5.61 5.59 5.57	6.47 6.48 6.47 6.45 6.42 6.39 6.37 6.35 6.33	6.94 6.96 6.97 6.96 6.93 6.90 6.87 6.85 6.82 6.8	7.42 7.43 7.44 7.43 7.4 7.37 7.37 7.34 7.31 7.29 7.27	8.09 8.11 8.12 8.13 8.12 8.10 8.07 8.04 8.02 8,00 7.98	5.44 5.44 5.43 5.41 5.39 5.36 5.33 5.30 5.28 5.27	6.21 6.22 6.23 6.22 6.2 6.17 6.15 6.12 6.10 6.09	6.94 6.96 6.97 6.96 6.93 6.90 6.87 6.85 6.82 6.8	7.64 7.66 7.67 7.66 7.63 7.60 7.57 7.54 7.52 7.5	8.33 8.35 8.37 8.38 8.37 8.35 8.33 8.30 8.28 8.26 8.26	incon M betw color <b>DIS</b> This aged BIA.	me (w [ale: ]] een pl (with CUS study five to The r	ith a si In the hase a n a sign <b>SSIC</b> used o 80 ye models	ngle ar gnific e fina ngle a nifican <b>DN</b> a large ears ol s used	ant int l mul nd age t inter ge sam d to es allow	teracti tivaria e was caction ple of stimat ed us	on) ( <b>S</b> ible n associa n) ( <b>Sup</b> healtl e phas to esti	upplem nodel, ated w ppleme hy Bra se angl mate s	h BMI menta the prith BM entary zilian e, as n smoot	I and f ry Tab relatio //I and / Table indivineasur	am <b>ble</b> nsh l sk <b>c 1</b> ) dua ed
34 35 36 37 38 39 40 41 42 43	5.72 5.73 5.72 5.68 5.66 5.63 5.61 5.59 5.57 5.56	6.47 6.48 6.47 6.45 6.42 6.39 6.37 6.35 6.33 6.33	6.94 6.96 6.97 6.96 6.93 6.90 6.87 6.85 6.82 6.8 6.8 6.8	7.42 7.43 7.44 7.43 7.4 7.37 7.34 7.31 7.29 7.27 7.26	8.09 8.11 8.12 8.13 8.12 8.00 8.07 8.04 8.02 8,00 7.98 7.98	5.44 5.44 5.43 5.41 5.39 5.36 5.33 5.30 5.28 5.27 5.26	6.21 6.22 6.23 6.22 6.2 6.17 6.15 6.12 6.10 6.09 6.08	6.94 6.96 6.97 6.96 6.93 6.90 6.87 6.85 6.82 6.8 6.8 6.8	7.64 7.66 7.67 7.66 7.63 7.60 7.57 7.54 7.52 7.5 7.49	8.33 8.35 8.37 8.38 8.37 8.35 8.33 8.30 8.28 8.26 8.26 8.26 8.26	incon M betw color <b>DIS</b> This aged BIA. curve	me (w lale: 1 een pl (with SCUS study five to The r es as v	ith a si In the hase a n a sign <b>SSIC</b> used o 80 ye nodels vell as	ngle ar gnific e fina ngle a nifican <b>DN</b> a larg ears ol s used z-scor	ant int l mul nd age t inter ge sam d to es allow res stra	teracti tivaria e was caction ple of stimat ed us	on) ( <b>S</b> uble n associa h) ( <b>Sup</b> healtl e phas to esti by age	upplem nodel, ated w pplem hy Brasse angl mate s and s	h BMI menta the prith BM entary azilian e, as n smootl ex.	I and f ry Tab relatio /II and / Table indivine asur h perc	am <b>ble</b> nsh l sk <b>c 1</b> ) dua ed ent
34 35 36 37 38 39 40 41 42 43 44	5.72 5.73 5.72 5.68 5.66 5.63 5.61 5.59 5.57 5.56 5.56	6.47 6.48 6.47 6.45 6.42 6.39 6.37 6.35 6.33 6.32 6.32	6.94 6.96 6.97 6.96 6.93 6.90 6.87 6.85 6.82 6.8 6.79 6.78	7.42 7.43 7.44 7.43 7.4 7.37 7.34 7.31 7.29 7.27 7.26 7.24	8.09 8.11 8.12 8.13 8.10 8.07 8.04 8.02 8.00 7.98 7.98 7.97	5.44 5.44 5.43 5.41 5.39 5.36 5.33 5.30 5.28 5.27 5.26 5.25	6.21 6.22 6.23 6.22 6.2 6.17 6.15 6.12 6.10 6.09 6.08 6.07	6.94 6.96 6.97 6.96 6.93 6.90 6.87 6.85 6.82 6.8 6.79 6.78	7.64 7.67 7.67 7.63 7.60 7.57 7.54 7.52 7.5 7.49 7.48	8.33 8.35 8.37 8.38 8.37 8.35 8.33 8.30 8.28 8.26 8.26 8.26 8.26 8.25	incon M betw color <b>DIS</b> This aged BIA. curve	me (w [ale: 1] een pl (with SCUS study five to The 1 es as v he esti	ith a si In the hase a n a sign SSIC used o 80 ye nodels vell as imateo	ngle ar ignific e fina ngle a nifican <b>DN</b> a larg ears ol s used z-scor l phas	ant int l mul nd age t inter ge sam d to es allow res stra e angle	teracti- tivaria e was a caction ple of stimat ed us tified e perc	on) ( <b>S</b> uble n associa h) ( <b>Sup</b> to esti by age entiles	upple nodel, ated w pplema hy Bra is angl mate s and s s show	h BMJ menta the prith BM entary entary exilian e, as n smootl ex. ed tha	I and f ry Tab relatio /II and Table indivine asur h perc t the v	am <b>ble</b> nsh l sk <b>c</b> 1) dua ed ent
34 35 36 37 38 39 40 41 42 43 44 45 46	5.72 5.73 5.72 5.68 5.66 5.63 5.61 5.59 5.57 5.56 5.56 5.54	6.47 6.48 6.47 6.45 6.42 6.39 6.37 6.35 6.33 6.32 6.32 6.3	6.94 6.96 6.97 6.96 6.93 6.90 6.87 6.85 6.82 6.8 6.79 6.78 6.76	7.42 7.43 7.44 7.43 7.4 7.37 7.34 7.31 7.29 7.27 7.26 7.24 7.22	8.09 8.11 8.12 8.13 8.12 8.00 8.04 8.02 8.00 7.98 7.98 7.97 7.95	5.44 5.44 5.43 5.41 5.39 5.36 5.33 5.30 5.28 5.27 5.26 5.25 5.24	6.21 6.22 6.23 6.22 6.2 6.17 6.15 6.12 6.10 6.09 6.08 6.07 6.06	6.94 6.96 6.97 6.96 6.93 6.90 6.87 6.85 6.82 6.8 6.79 6.78 6.76	7.64 7.67 7.67 7.66 7.63 7.60 7.57 7.54 7.52 7.5 7.49 7.48 7.46	8.33 8.35 8.37 8.38 8.37 8.35 8.33 8.30 8.28 8.26 8.26 8.26 8.26 8.25 8.24	incon M betw color DIS This aged BIA. curv Tincre	me (w [ale: 1] een pl (with SCUS study five to The r es as v he esticase th	ith a si In the hase a n a sign SSIC used o 80 ye nodels vell as imateo prough	ngle ar gnific e fina ngle a nifican <b>DN</b> a large ears ol s used z-scor l phas c child	ant int l mul nd age it inter ge sam d to es allow res stra e angle hood,	teracti tivaria e was caction ple of stimat ed us utified e perc stabili	on) ( <b>S</b> ible n associa h) ( <b>Sup</b> by age entiles ize du	upplen nodel, ated w ppleme hy Bran se angl mate se and s s show ring m	h BMJ menta the prith BM entary exilian e, as n smootl ex. ed tha nost of	I and f ry Tab relatio /I and Table indivi- neasur h perc t the v adult	am <b>ble</b> nsh l sk <b>c</b> 1) ddua ed ent valu hoc
34 35 36 37 38 39 40 41 42 43 44 45 46 47	5.72 5.73 5.72 5.68 5.66 5.63 5.61 5.59 5.57 5.56 5.56 5.54 5.52	6.47 6.48 6.47 6.45 6.42 6.39 6.37 6.35 6.33 6.32 6.32 6.32 6.3 6.32	6.94 6.96 6.97 6.96 6.93 6.90 6.87 6.85 6.82 6.8 6.79 6.78 6.76 6.72	7.42 7.43 7.44 7.43 7.4 7.37 7.34 7.31 7.29 7.27 7.26 7.24 7.22 7.18	8.09 8.11 8.12 8.13 8.12 8.00 8.04 8.02 8.00 7.98 7.98 7.97 7.95 7.91	5.44 5.43 5.43 5.41 5.39 5.36 5.33 5.30 5.28 5.27 5.26 5.25 5.24 5.22	6.21 6.22 6.23 6.22 6.2 6.17 6.15 6.12 6.10 6.09 6.08 6.07 6.06 6.03	6.94 6.96 6.97 6.96 6.93 6.90 6.87 6.85 6.82 6.8 6.79 6.78 6.76 6.72	7.64 7.66 7.67 7.66 7.63 7.60 7.57 7.54 7.52 7.5 7.49 7.48 7.46 7.41	8.33 8.35 8.37 8.38 8.37 8.35 8.33 8.30 8.28 8.26 8.26 8.26 8.26 8.25 8.24 8.24 8.20	incon M betw color DIS This aged BIA. curve Tincreand	me (w lale: 1 een pl (with SCUS five to The r es as v he esti- case th decrea	ith a si In the hase a n a sign SSIC used o 80 ye nodels vell as imatec urough ase the	ngle ar gnific e fina ngle a nifican <b>N</b> a large ears ol s used z-scor l phas child cough	ant int l mul nd age t inter ge sam d to es allow res stra e angle hood, late a	ple of stimat ed us tified e perc stabili dultho	on) ( <b>S</b> ible n associa h) ( <b>Sup</b> by age entiles ize du bod, w	upplen nodel, ated w plem hy Brass e angl mate s s show ring m vhich i	h BMJ menta the prith BM entary azilian e, as n smooth ex. ed tha nost of is consi	I and f ry Tab relatio /I and Table indivi- neasur h perc t the v adult sistent	am <b>ble</b> nsh l sk <b>e</b> 1) dua ed ent valu hoc wi
4 5 6 7 8 9 0 1 2 3 4 5 6 7 8	5.72 5.73 5.72 5.68 5.66 5.63 5.61 5.59 5.57 5.56 5.56 5.54 5.52 5.48	6.47 6.48 6.47 6.45 6.42 6.39 6.37 6.35 6.33 6.32 6.32 6.3 6.32 6.32 6.32	6.94 6.96 6.97 6.96 6.93 6.90 6.87 6.85 6.82 6.8 6.79 6.78 6.76 6.72 6.67	7.42 7.43 7.44 7.43 7.4 7.37 7.34 7.31 7.29 7.27 7.26 7.24 7.22 7.18 7.12	8.09 8.11 8.12 8.13 8.12 8.10 8.07 8.04 8.02 8.00 7.98 7.98 7.97 7.95 7.91 7.85	5.44 5.43 5.43 5.41 5.39 5.36 5.33 5.30 5.28 5.27 5.26 5.25 5.24 5.22 5.22 5.22	6.21 6.22 6.23 6.22 6.2 6.17 6.15 6.12 6.10 6.09 6.08 6.07 6.06 6.03 5.98	6.94 6.96 6.97 6.96 6.93 6.90 6.87 6.85 6.82 6.8 6.79 6.78 6.76 6.72 6.67	7.64 7.66 7.67 7.66 7.63 7.60 7.57 7.54 7.52 7.5 7.49 7.48 7.46 7.41 7.35	8.33 8.35 8.37 8.38 8.37 8.35 8.33 8.30 8.28 8.26 8.26 8.26 8.26 8.26 8.25 8.24 8.20 8.14	incon M betw color DIS This aged BIA. curve Tr increa and the p	me (w lale: 1 een pl (with SCUS study five to The r es as v he esti- ease th decrea- previou	ith a si In the hase a n a sign SSIC used o 80 ye models vell as imatec arough ase the usly pu	ngle ar gnific e fina ngle a nifican <b>N</b> a larg ears ol s used z-scor l phas a child rough ıblishe	ant int l mul nd age t inter d to es allow res stra e angle hood, late a ed met	ple of stimat e was caction ple of stimat ed us stified e perco stabili dultho ca-anal	on) ( <b>S</b> associant associant) ( <b>Sup</b> by ( <b>Sup</b> by age entiles ize dur bood, w lysis (7	upplen nodel, ated w plem by Brass e angl mate s e and s s show ring m vhich i 7). The	h BMJ menta the prith BM entary azilian e, as n smooth ex. red that host of is conse ese find	I and f ry Tab relatio /I and / Table indivi- neasur h perc t the v adult sistent dings r	am <b>ble</b> nsh l sk <b>c</b> 1) dua ed ent valu hoc wi refle
44 35 36 37 38 39 40 41 42 33 44 45 56 37 48 39 44 45 56 37 48 39 49 49 57 49 59 49 50 50 50 50 50 50 50 50 50 50 50 50 50	5.72 5.73 5.72 5.68 5.66 5.63 5.61 5.59 5.57 5.56 5.54 5.54 5.52 5.48 5.43	6.47 6.48 6.47 6.45 6.42 6.39 6.37 6.35 6.33 6.32 6.32 6.32 6.32 6.27 6.22 6.16	6.94 6.96 6.97 6.96 6.93 6.90 6.87 6.85 6.82 6.8 6.79 6.78 6.76 6.72 6.67 6.61	7.42 7.43 7.44 7.43 7.4 7.37 7.34 7.31 7.29 7.27 7.26 7.24 7.22 7.18 7.12 7.05	8.09 8.11 8.12 8.13 8.12 8.00 8.04 8.02 8.00 7.98 7.98 7.95 7.91 7.85 7.78	5.44 5.43 5.43 5.41 5.39 5.36 5.33 5.30 5.28 5.27 5.26 5.25 5.24 5.22 5.24 5.22 5.18 5.14	6.21 6.22 6.23 6.22 6.2 6.17 6.15 6.12 6.10 6.09 6.08 6.07 6.06 6.03 5.98 5.93	6.94 6.96 6.97 6.96 6.93 6.90 6.87 6.85 6.82 6.8 6.79 6.78 6.76 6.72 6.67 6.61	7.64 7.66 7.67 7.66 7.63 7.60 7.57 7.54 7.52 7.5 7.49 7.48 7.46 7.41 7.35 7.28	8.33 8.35 8.37 8.38 8.37 8.35 8.33 8.30 8.28 8.26 8.26 8.26 8.26 8.25 8.24 8.20 8.14 8.07	incon M betw color DIS This aged BIA. curve This increated and the p	me (w lale: 1 een pl (with study five to The r es as v he esti- case th decrea- previou- hysiol	ith a si In the hase a n a sign SSIC used o 80 ye models vell as imatec urough ase the usly pulogical	ngle ar gnific e fina ngle a nifican <b>N</b> a larg ears ol s used z-scor l phas child rough ublishe chang	ant int l mul nd age t inter e sam d to es allow res stra e angle hood, late a ed met ges tha	ple of stimat e was caction ple of stimat ed us atified e perc stabili dultho ca-anal t occu	on) ( <b>S</b> associant associant) ( <b>Sup</b> b) ( <b>Sup</b> b) ( <b>Sup</b> b) ( <b>Sup</b> b) ( <b>Sup</b> b) ( <b>Sup</b> b) ( <b>Sup</b> b) ( <b>Sup</b>	upplen nodel, ated w pplem by Brass e angl mate s and s s show ring m rhich i 7). The ughou	h BMJ menta the prith BM entary azilian e, as n smooth ex. ed that host of is conse ese find t life. (	I and fi ry Tab relation /II and Table indivine asur h percont t the w adult sistent dings r Consid	am <b>ble</b> nsh l sk <b>c</b> <b>c</b> <b>c</b> <b>c</b> <b>c</b> <b>c</b> <b>c</b> <b>c</b>
33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51	5.72 5.73 5.72 5.68 5.66 5.63 5.61 5.59 5.57 5.56 5.54 5.54 5.52 5.48 5.43 5.43 5.39	6.47 6.48 6.47 6.45 6.42 6.39 6.37 6.35 6.33 6.32 6.32 6.32 6.32 6.27 6.22 6.16 6.11	6.94 6.96 6.97 6.96 6.93 6.90 6.87 6.85 6.82 6.8 6.79 6.78 6.76 6.72 6.67 6.61 6.55	7.42 7.43 7.44 7.43 7.4 7.37 7.34 7.31 7.29 7.27 7.26 7.22 7.26 7.24 7.22 7.18 7.12 7.05 6.98	8.09 8.11 8.12 8.13 8.12 8.00 8.04 8.02 8.00 7.98 7.98 7.95 7.91 7.85 7.78 7.71	5.44 5.43 5.43 5.41 5.39 5.36 5.33 5.30 5.28 5.27 5.26 5.25 5.24 5.22 5.24 5.22 5.18 5.14 5.10	6.21 6.22 6.23 6.22 6.2 6.17 6.15 6.12 6.10 6.09 6.08 6.07 6.06 6.03 5.98 5.93 5.88	6.94 6.96 6.97 6.96 6.93 6.90 6.87 6.85 6.82 6.8 6.79 6.78 6.76 6.72 6.67 6.61 6.55	7.64 7.66 7.67 7.66 7.63 7.60 7.57 7.54 7.52 7.5 7.49 7.48 7.46 7.41 7.35 7.28 7.21	8.33 8.35 8.37 8.38 8.37 8.35 8.33 8.30 8.28 8.26 8.26 8.26 8.26 8.26 8.25 8.24 8.20 8.14 8.07 8,00	incon M betw color DIS This aged BIA. curve This increated and the p the p that	me (w lale: 1 een pl (with study five to The r es as w he esti- decrea- previou- hysiol phase	ith a si In the hase a n a sign <b>SSIC</b> used o 80 ye nodels vell as imateo ase the usly pulogical e angle	ngle ar gnific e fina ngle a hifican <b>DN</b> a large ears ol s used z-scor l phas child rough iblishe change e is a	ant int l mul nd age t inter ge sam d to es allow res stra e angle hood, late a ed met ges tha n indi	ple of stimat e was caction ple of stimat ed us tified dultho ca-anal t occu icator	on) ( <b>S</b> associant associant associant ( <b>Sup</b> ) ( <b>Sup</b> ) ( <b>Sup</b> )	upplen nodel, ated w pplem by Bras e angl mate s and s s show ring m rhich i r/). The ughou ll fund	h BMI menta the prith BM entary vith BM entary entary entary ex. ed that host of is con- ese find t life. C ction	I and fire a	ami <b>ole</b> 1 nsh l sk <b>e</b> 1).
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4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3	5.72 5.73 5.72 5.71 5.68 5.66 5.63 5.59 5.57 5.56 5.56 5.54 5.52 5.48 5.43 5.39 5.33 5.33 5.31	6.47 6.48 6.47 6.45 6.42 6.39 6.37 6.35 6.33 6.32 6.32 6.32 6.32 6.32 6.27 6.22 6.16 6.11 6.07 6.04 6.01	6.94 6.96 6.97 6.96 6.93 6.90 6.85 6.82 6.8 6.79 6.78 6.76 6.72 6.67 6.61 6.55 6.5 6.46 6.42	7.42 7.43 7.44 7.43 7.4 7.37 7.34 7.29 7.27 7.26 7.24 7.22 7.18 7.12 7.05 6.98 6.93 6.88 6.84	8.09 8.11 8.12 8.13 8.12 8.00 7.98 7.98 7.97 7.95 7.91 7.85 7.71 7.65 7.60 7.56	5.44 5.43 5.41 5.39 5.36 5.33 5.30 5.28 5.27 5.26 5.25 5.24 5.22 5.18 5.14 5.10 5.06 5.04 5.02	6.21 6.22 6.23 6.22 6.2 6.17 6.15 6.12 6.10 6.09 6.08 6.07 6.06 6.03 5.98 5.93 5.88 5.84 5.81 5.79	6.94 6.96 6.97 6.96 6.93 6.90 6.85 6.82 6.8 6.79 6.78 6.72 6.67 6.61 6.55 6.5 6.46 6.42	7.64 7.67 7.67 7.63 7.60 7.57 7.54 7.52 7.5 7.49 7.48 7.46 7.41 7.46 7.41 7.35 7.28 7.21 7.16 7.11 7.07	8.33 8.35 8.37 8.38 8.37 8.35 8.33 8.30 8.28 8.26 8.26 8.26 8.26 8.26 8.26 8.25 8.24 8.20 8.14 8.07 8.00 7.95 7.90 7.86	incon M betw color <b>DIS</b> This aged BIA. curv. T: increand the p that these mech adult	me (w lale: 1 een pl (with SCUS study five to The r es as v he esti- ease th decrea phase e findi- nanisn t age b	ith a si In the hase a n a sign SSIC used o 80 ye nodels vell as imated ase the usly pulogical e angle ngs re ns invo	ngle ar gnific e fina ngle a hifican <b>DN</b> a large ears ol s used z-scor l phas child cough iblishe e is a flect tl plved i eriora	ant int I mul nd age it inter ge sam d to es allow res stra e angle hood, late a ed met ges tha n indi he diff n the o	ple of stimat e was caction ple of stimat ed us tified e perc stabili dultho a-anal t occu icator erent cell me ing the	on) ( <b>S</b> ble n associa h) ( <b>Sup</b> b) ( <b>Sup</b> b) ( <b>Sup</b> c)	upplem nodel, ated w pplem by Brass e angle mate se and se show ring m rhich in 7). The ughou Il fund ellular ne, wh tages of	h BMI menta the prith BM entary exith BM entary exit and a smooth ex. ed that host of is consistent t life. ( ction a and fui ich im of life (	I and firy Tab relation /II and Table indivine asur h perconst adult sistent dings r Consid and h unction prove (7, 23)	am <b>ble</b> nsh l sk e 1) dua ed ent value hoc wi refle lerin up
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34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51	5.72 5.73 5.72 5.71 5.68 5.66 5.63 5.59 5.57 5.56 5.56 5.54 5.52 5.48 5.43 5.39 5.33 5.33 5.31	6.47 6.48 6.47 6.45 6.42 6.39 6.37 6.35 6.33 6.32 6.32 6.32 6.32 6.32 6.27 6.22 6.16 6.11 6.07 6.04 6.01	6.94 6.96 6.97 6.96 6.93 6.90 6.85 6.82 6.8 6.79 6.78 6.76 6.72 6.67 6.61 6.55 6.5 6.46 6.42	7.42 7.43 7.44 7.43 7.4 7.37 7.34 7.29 7.27 7.26 7.24 7.22 7.18 7.12 7.05 6.98 6.93 6.88 6.84	8.09 8.11 8.12 8.13 8.12 8.00 7.98 7.98 7.97 7.95 7.91 7.85 7.71 7.65 7.60 7.56	5.44 5.43 5.41 5.39 5.36 5.33 5.30 5.28 5.27 5.26 5.25 5.24 5.22 5.18 5.14 5.10 5.06 5.04 5.02	6.21 6.22 6.23 6.22 6.2 6.17 6.15 6.12 6.10 6.09 6.08 6.07 6.06 6.03 5.98 5.93 5.88 5.84 5.81 5.79	6.94 6.96 6.97 6.96 6.93 6.90 6.85 6.82 6.8 6.79 6.78 6.72 6.67 6.61 6.55 6.5 6.46 6.42	7.64 7.67 7.67 7.63 7.60 7.57 7.54 7.52 7.5 7.49 7.48 7.46 7.41 7.35 7.21 7.28 7.21 7.16 7.11 7.07	8.33 8.35 8.37 8.38 8.37 8.35 8.33 8.30 8.28 8.26 8.26 8.26 8.26 8.26 8.26 8.25 8.24 8.20 8.14 8.07 8.00 7.95 7.90 7.86	incon M betw color DIS This aged BIA. curve This aged BIA. curve This increa and the p that these mech adult W on s	me (w lale: 1 een pl (with SCUS study five to The r es as v he esti- case th decrea phase e findi nanism t age b Ve also ex. In	ith a si In the hase a n a sign SSIC used o 80 ye nodels vell as imated ase the usly pulogical e angle ngs re ns inver- out det o foun- both	ngle ar gnific e fina ngle a hifican <b>N</b> a large ears ol s used z-scor l phas child rough iblishe chang e is a flect th olved i eriora d diffe sexes	ant int nd age it inter ge sam d to es allow res stra e angle hood, late a ed met ges tha n indi he diff n the c te durie	ple of stimat ed us tified e perc stabili dultho a-anal t occu icator erent cell me ohase a e angle	on) ( <b>S</b> bble n associa b) ( <b>Sup</b> b) ( <b>Sup</b> b) ( <b>Sup</b> c)	upplem nodel, ated w plem by Bran se angl mate se and s s show ring m rhich i 7). The ughou II fund ellular ne, wh tages of leterm ssocia	h BMI menta the prith BM entary exith BM entary exit and a smooth ex. ed that host of is consistent t life. ( ction a and fui ich im of life (	I and firy Tab relation /I and Table indivi- neasur h perconduction isstent dings r Consida and h unction prove (7, 23) i depen- ith age	ami <b>ble</b> I nsh l sk <b>2</b> 1). ddua ed I enti valu hood wi refle lerin ealt nali up nding a

TABLE 3 | Women's phase angle means estimates and z-score.

TABLE 3   Women's phase angle means estimates and z-score.												
Age	P5	P25	P50	P75	P95	-2	-1	0	+1	+2		
5	3.2	3.58	3.92	4.36	5.28	3.08	3.44	3.92	4.62	5.76		
6	3.26	3.65	3.99	4.43	5.29	3.14	3.5	3.99	4.68	5.72		
7	3.32	3.72	4.07	4.5	5.33	3.19	3.58	4.07	4.75	5.72		
8	3.39	3.81	4.17	4.59	5.39	3.26	3.66	4.17	4.83	5.75		
9	3.48	3.92	4.28	4.7	5.47	3.35	3.76	4.28	4.94	5.81		
10	3.58	4.03	4.4	4.83	5.58	3.44	3.87	4.4	5.06	5.9		
11	3.7	4.16	4.54	4.97	5.71	3.55	4.00	4.54	5.2	6.02		
12	3.82	4.31	4.7	5.13	5.86	3.67	4.14	4.7	5.36	6.16		
13	3.96	4.46	4.86	5.3	6.03	3.79	4.29	4.86	5.54	6.33		
14	4.1	4.62	5.03	5.48	6.21	3.93	4.44	5.03	5.71	6.5		
15	4.23	4.78	5.19	5.65	6.38	4.05	4.59	5.19	5.88	6.67		
16	4.36	4.91	5.34	5.80	6.53	4.17	4.72	5.34	6.04	6.82		
17	4.46	5.03	5.46	5.93	6.66	4.26	4.83	5.46	6.16	6.94		
18	4.54	5.12	5.56	6.03	6.76	4.34	4.92	5.56	6.27	7.05		
19	4.61	5.2	5.65	6.12	6.85	4.41	5.00	5.65	6.35	7.13		
20	4.67	5.27	5.71	6.19	6.91	4.46	5.06	5.71	6.42	7.19		
21	4.71	5.32	5.77	6.24	6.97	4.50	5.11	5.77	6.48	7.25		
22	4.75	5.36	5.81	6.28	7.01	4.53	5.15	5.81	6.52	7.29		
23	4.77	5.38	5.84	6.31	7.04	4.56	5.17	5.84	6.55	7.32		
24	4.78	5.4	5.85	6.33	7.06	4.57	5.19	5.85	6.57	7.34		
25	4.78	5.4	5.86	6.34	7.07	4.57	5.19	5.86	6.58	7.35		
26	4.78	5.4	5.86	6.34	7.07	4.56	5.19	5.86	6.58	7.35		
27	4.76	5.39	5.85	6.33	7.06	4.55	5.17	5.85	6.57	7.34		
28	4.74	5.37	5.83	6.31	7.04	4.52	5.15	5.83	6.55	7.32		
29	4.72	5.34	5.81	6.29	7.02	4.50	5.13	5.81	6.53	7.30		
30	4.68	5.31	5.78	6.26	7.00	4.46	5.10	5.78	6.5	7.28		
31	4.65	5.28	5.74	6.23	6.97	4.43	5.06	5.74	6.47	7.25		
32	4.61	5.24	5.71	6.20	6.94	4.39	5.03	5.71	6.44	7.22		
33	4.57	5.21	5.68	6.17	6.91	4.35	4.99	5.68	6.41	7.19		
34	4.54	5.18	5.65	6.14	6.89	4.32	4.96	5.65	6.39	7.17		
35	4.51	5.15	5.62	6.12	6.87	4.29	4.93	5.62	6.37	7.16		
36	4.49	5.13	5.61	6.10	6.87	4.26	4.91	5.61	6.35	7.16		
37	4.47	5.12	5.59	6.10	6.87	4.25	4.89	5.59	6.35	7.16		
38	4.46	5.11	5.59	6.10	6.88	4.24	4.89	5.59	6.35	7.18		
39	4.46	5.11	5.59	6.11	6.9	4.23	4.88	5.59	6.37	7.2		
40	4.46	5.11	5.6	6.12	6.93	4.24	4.89	5.6	6.39	7.24		
41	4.47	5.12	5.62	6.14	6.96	4.24	4.9	5.62	6.41	7.28		
42	4.48	5.13	5.63	6.17	7.00	4.25	4.91	5.63	6.44	7.32		
43	4.49	5.15	5.65	6.19	7.04	4.26	4.92	5.65	6.46	7.37		
44	4.49	5.16	5.66	6.21	7.07	4.27	4.92	5.66	6.49	7.41		
45	4.5	5.16	5.67	6.22	7.09	4.28	4.93	5.67	6.50	7.44		
46	4.49	5.15	5.66	6.22	7.10	4.27	4.92	5.66	6.50	7.46		
47	4.48	5.13	5.64	6.2	7.1	4.26	4.91	5.64	6.49	7.45		
48	4.46	5.11	5.62	6.17	7.07	4.24	4.88	5.62	6.46	7.44		
49	4.43	5.08	5.58	6.14	7.04	4.21	4.85	5.58	6.43	7.40		
50	4.4	5.04	5.54	6.10	7.00	4.19	4.81	5.54	6.38	7.36		
51	4.36	5.00	5.50	6.05	6.95	4.15	4.78	5.50	6.34	7.31		
52	4.33	4.96	5.46	6.00	6.90	4.12	4.74	5.46	6.29	7.26		
53	4.3	4.93	5.42	5.96	6.85	4.09	4.71	5.42	6.24	7.21		
54	4.28	4.90	5.38	5.92	6.81	4.07	4.68	5.38	6.21	7.16		
55	4.26	4.87	5.36	5.90	6.77	4.05	4.66	5.36	6.17	7.12		
56	4.24	4.86	5.34	5.87	6.74	4.04	4.64	5.34	6.15	7.09		
00												

(Continued)

	<b>.E 3</b> ] (C	ontinue	iu)							
Age	P5	P25	P50	P75	P95	-2	-1	0	+1	+2
58	4.23	4.85	5.33	5.85	6.70	4.03	4.63	5.33	6.13	7.04
59	4.23	4.85	5.33	5.85	6.69	4.03	4.64	5.33	6.12	7.02
60	4.24	4.86	5.33	5.85	6.67	4.03	4.64	5.33	6.12	7.00
61	4.24	4.86	5.34	5.85	6.66	4.02	4.64	5.34	6.11	6.97
62	4.23	4.86	5.34	5.84	6.64	4.02	4.64	5.34	6.10	6.94
63	4.22	4.85	5.33	5.83	6.60	4.00	4.64	5.33	6.08	6.90
64	4.21	4.84	5.31	5.81	6.56	3.99	4.62	5.31	6.06	6.85
65	4.18	4.82	5.29	5.78	6.52	3.96	4.60	5.29	6.02	6.79
66	4.15	4.8	5.26	5.74	6.45	3.92	4.58	5.26	5.98	6.72
67	4.11	4.76	5.22	5.69	6.39	3.88	4.54	5.22	5.92	6.64
68	4.07	4.72	5.18	5.64	6.31	3.83	4.50	5.18	5.86	6.55
69	4.02	4.68	5.13	5.58	6.23	3.78	4.46	5.13	5.80	6.46
70	3.96	4.62	5.07	5.51	6.14	3.72	4.41	5.07	5.72	6.36
71	3.91	4.57	5.01	5.44	6.05	3.65	4.35	5.01	5.65	6.26
72	3.84	4.51	4.95	5.37	5.95	3.58	4.29	4.95	5.57	6.16
73	3.78	4.46	4.89	5.30	5.86	3.51	4.24	4.89	5.49	6.06
74	3.71	4.4	4.83	5.23	5.77	3.44	4.18	4.83	5.41	5.96
75	3.64	4.34	4.76	5.16	5.68	3.36	4.12	4.76	5.34	5.86
76	3.57	4.28	4.70	5.08	5.58	3.28	4.06	4.70	5.26	5.76
77	3.5	4.22	4.63	5.01	5.49	3.19	3.99	4.63	5.18	5.66
78	3.43	4.15	4.57	4.93	5.4	3.11	3.93	4.57	5.10	5.56
79	3.36	4.09	4.50	4.86	5.31	3.03	3.87	4.5	5.02	5.46
80	3.29	4.03	4.44	4.78	5.22	2.95	3.81	4.44	4.94	5.36

TABLE 3 | (Continued)

and their interaction. However, in women there is an additional association with family income, with an age interaction; while in men there is an additional association with skin color, also with an age interaction. The comparison with the reference values already available was limited, since the statistical models, age groups and determinants were not differentiated between the studies (7, 24).

The causes of the differences observed between the sexes may include health status, cultural patterns, and biological and hormonal differences between men and women. As national economies progress, individuals with increased socioeconomic status may start taking a greater interest in their health, whereas people with a lower socioeconomic status may continue to struggle for calories. In this sense, the differences found between the determinants of phase angle in the different sexes may reflect the health inequalities still found between sexes and races (25–27).

Previous studies have shown an association between the level of physical activity and phase angle; however, we did not find this association (8). One possible explanation for our different results could be that most studies have included individuals diagnosed with a disease and they have not presented phase angle percentiles adjusted for sex and age.

This study is not free of limitations. A temporal relationship could not be defined due to the study's cross-sectional design. This article included a convenience sample of participants from only one (South) of the five regions of Brazil. However, when the study data are compared with the latest national health surveys (28, 29), we observe that these are similar in the distribution of sex, skin color, BMI, and level of physical activity. Our study included a greater number of younger and fewer elderly individuals than the percentages in these age groups of the Brazilian population. The primary justification for including more young participants is that the data presented in this paper are part of an umbrella project with other objectives. There is a scarcity of studies that present phase angle values that include the elderly. One of the main limitations of including participants in this age group is that most have a chronic disease diagnosis. Despite the differences in the distribution of age groups, the uncertainties related to these data were expressed in confidence intervals.

To the best of our knowledge, it is the first attempt to apply the GAMLSS technique to predict future PA distributions using a healthy population and to cover most of the life cycle. In general, GAMLSS offers a flexible approach due to a large number of implemented distribution families. With GAMLSS, it is possible to assess the effect of specific parameters on the outcome variable distribution. The WHO has adopted the GAMLSS methodology for creating reference growth curves (30). The reference values in this study can be used more comprehensively in clinical practice for populations with mixed SES.

This study estimated a useful table of phase angle percentiles stratified by sex and age. To the best of our knowledge, it is the first attempt to apply the GAMLSS technique to estimate phase angle percentiles in a healthy population, covering most of the life cycle. We also showed that there are different phase angle determinants according to sex.

## DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

#### REFERENCES

- de Borba EL, Ceolin J, Ziegelmann PK, Bodanese LC, Gonçalves MR, Cañon-Montañez W, et al. Phase angle of bioimpedance at 50 kHz is associated with cardiovascular diseases: systematic review and meta-analysis. *Eur J Clin Nutr.* (2022). doi: 10.1038/s41430-022-01131-4
- Norman K, Stobaus N, Pirlich M, Bosy-Westphal A. Bioelectrical phase angle and impedance vector analysis–clinical relevance and applicability of impedance parameters. *Clin Nutr.* (2012) 31:854–61. doi: 10.1016/j.clnu.2012. 05.008
- de Azevedo ZMA, Santos Junior BD, Ramos EG, Salú MDS, Mancino da Luz Caixeta D, Lima-Setta F, et al. The importance of bioelectrical impedance in the critical pediatric patient. *Clin Nutr.* (2020) 39:1188–94. doi: 10.1016/j.clnu. 2019.05.005
- de Blasio F, Scalfi L, Di Gregorio A, Alicante P, Bianco A, Tantucci C, et al. Raw bioelectrical impedance analysis variables are independent predictors of early all-cause mortality in patients with COPD. *Chest.* (2019) 155:1148–57. doi: 10.1016/j.chest.2019.01.001
- Marino LV, Meyer R, Johnson M, Newell C, Johnstone C, Magee A, et al. Bioimpedance spectroscopy measurements of phase angle and height for age are predictive of outcome in children following surgery for congenital heart disease. *Clin Nutr.* (2017) 17:S0261–5614. doi: 10.1016/j.clnu.2017.06.020
- Pereira MME, Queiroz MDSC, de Albuquerque NMC, Rodrigues J, Wiegert EVM, Calixto-Lima L, et al. The prognostic role of phase angle in advanced cancer patients: a systematic review. *Nutr Clin Pract.* (2018) 33:813–24. doi: 10.1002/ncp.10100

### **ETHICS STATEMENT**

The studies involving human participants were reviewed and approved by Comitê de Ética em Pesquisas da PUCRS. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

#### **AUTHOR CONTRIBUTIONS**

RM: conception and design of the work, data collection, data analysis, interpretation, drafting the article, critical revision of the article, and final approval of the version to be published. PZ: conception and design of the work, data analysis, and interpretation, drafting the article, critical revision of the article, and final approval of the version to be published. EM: data collection, critical revision of the article, and final approval of the version to be published. All authors contributed to the article and approved the submitted version.

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## SUPPLEMENTARY MATERIAL

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- Mattiello R, Amaral MA, Mundstock E, Ziegelmann PK. Reference values for the phase angle of the electrical bioimpedance: systematic review and metaanalysis involving more than 250,000 subjects. *Clin Nutr.* (2020) 39:1411–7. doi: 10.1016/j.clnu.2019.07.004
- Mundstock E, Amaral MA, Baptista RR, Sarria EE, dos Santos RRG, Filho AD, et al. Association between phase angle from bioelectrical impedance analysis and level of physical activity: systematic review and meta-analysis. *Clin Nutr.* (2019) 38:1504–10. doi: 10.1016/j.clnu.2018.08.031
- von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. J Clin Epidemiol. (2008) 61:344–9. doi: 10.1016/j.jclinepi.2007.11.008
- IBGE. Classificação e Caracterização dos Espaços Rurais e Urbanos do Brasil: Uma Primeira Aproximação. Rio de Janeiro: IBGE (2017). p. 84.
- Adami F, Bergamaschi D, Hinnig P, Oliveira N. Validity study of the "physical activity checklist" in children. *Rev Saúde Pública*. (2013) 47:1–9. doi: 10.1590/ S0034-8910.2013047004018
- Guedes DP, Lopes CC, Guedes JERP. Reprodutibilidade e validade do questionário internacional de atividade física em adolescentes. *Rev Bras Med do Esporte.* (2005) 11:151–8. doi: 10.1590/S1517-86922005000200011
- Matsudo S, Araújo T, Matsudo V, Andrade D, Andrade E, Oliveira LCC, et al. Questionário internacional de atividade física (Ipaq): estupo de validade e reprodutibilidade no Brasil. *Rev Bras Atividade Física Saúde*. (2012) 6:5–18. doi: 10.12820/rbafs.v.6n2p5-18
- Bull FCC, Al-Ansari SSS, Biddle S, Borodulin K, Buman MPP, Cardon G, et al. World health organization 2020 guidelines on physical activity and sedentary

behaviour. Br J Sports Med. (2020) 54:1451-62. doi: 10.1136/bjsports-2020-102955

- Word Health Organization. Obesity and Overweight. (2021). Available online at: https://www.who.int/news-room/fact-sheets/detail/obesity-andoverweight (accessed April 26, 2022).
- Ling CHY, de Craen AJM, Slagboom PE, Gunn DA, Stokkel MPM, Westendorp RGJ, et al. Accuracy of direct segmental multi-frequency bioimpedance analysis in the assessment of total body and segmental body composition in middle-aged adult population. *Clin Nutr.* (2011) 30:610–5. doi: 10.1016/j.clnu.2011.04.001
- Kyle UG, Bosaeus I, De Lorenzo AD, Deurenberg P, Elia M, Manuel Gómez J, et al. Bioeletrical impedance analysis – partII: utilization in clinical practice. *Clin Nutr.* (2004) 23:1430–53. doi: 10.1016/j.clnu.2004. 09.012
- Faul F, Erdfelder E, Lang A-G, Buchner A. G\*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behav Res Methods*. (2007) 39:175–91. doi: 10.3758/bf0319 3146
- Stasinopoulos M, Rigby B, Voudouris V, Akantziliotou C, Enea M, Kiose D. Package 'gamlss'. (2020). Available online at: https://cran.r-project.org/web/ packages/gamlss/index.html (accessed July 15, 2021).
- Stasinopoulos MD, Rigby RA, Heller GZ, Voudouris V, De Bastiani F. Flexible Regression and Smoothing: Using GAMLSS in R. 1st ed. London: Chapman and Hall/CRC (2020). p. 571.
- 21. Rigby RA, Stasinopoulos DM. Generalized additive models for location, scale and shape (with discussion). J R Stat Soc Ser C Appl Stat. (2005) 54:507–54. doi: 10.1111/j.1467-9876.2005.00510.x
- World Medical Association. Declaration of Helsinki, Ethical Principles for Scientific Requirements and Research Protocols. Ferney-Voltaire: World Medical Association (2013).
- Schmidt SC, Bosy-Westphal A, Niessner C, Woll A. Representative body composition percentiles from bioelectrical impedance analyses among children and adolescents. The MoMo study. *Clin Nutr.* (2019) 38:2712–20. doi: 10.1016/j.clnu.2018.11.026
- Barbosa-Silva MC, Barros AJ. Bioelectrical impedance analysis in clinical practice: a new perspective on its use beyond body composition equations. *Curr Opin Clin Nutr Metab Care.* (2005) 8:311–7. doi: 10.1097/01.mco. 0000165011.69943.39

- Goryakin Y, Suhrcke M. Economic development, urbanization, technological change and overweight: what do we learn from 244 demographic and health surveys? *Econ Hum Biol.* (2014) 14:109–27. doi: 10.1016/j.ehb.2013.11.003
- Basto-Abreu A, Barrientos-Gutiérrez T, Zepeda-Tello R, Camacho V, Gimeno Ruiz de Porras D, Hernández-Ávila M. The relationship of socioeconomic status with body mass index depends on the socioeconomic measure used. *Obesity.* (2018) 26:176–84. doi: 10.1002/oby.2 2042
- Yamada G, Jones-Smith JC, Castillo-Salgado C, Moulton LH. Differences in magnitude and rates of change in BMI distributions by socioeconomic and geographic factors in Mexico, Colombia, and Peru, 2005-2010. *Eur J Clin Nutr.* (2020) 74:472–80. doi: 10.1038/s41430-019-0479-9
- Instituto Brasileiro de Geografia e Estatística. Projeções da População. Portal IBGE. (2018). Available online at: https://www.ibge.gov.br/estatisticas/sociais/ populacao/9109-projecao-da-populacao.html?=&t=resultados (accessed April 26, 2022).
- 29. IBGE. Pesquisa Nacional de Saúde. Rio de Janeiro: IBGE (2019). p. 113.
- Borghi E, de Onis M, Garza C, Van den Broeck J, Frongillo EA, Grummer-Strawn L, et al. Construction of the World Health Organization child growth standards: selection of methods for attained growth curves. *Stat Med.* (2006) 25:247–65. doi: 10.1002/sim.2227

**Conflict of Interest:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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