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Metabolic Age and Phase Angle in Iranian Population: How Is Their Health Status?

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Abstract

Background: Non-communicable diseases are the main causes of mortality and morbidity. Metabolic age (MA) explains overall fitness, and if it is higher than chronological age (CA), it is necessary to improve general health. The phase angle (PA) is a direct measurement of the cell membranes and is a remarkable window to describe how the body responds to changes in health status.

Objectives: The aim of this study is to estimate the health status of the sample population.

Methods: A total of 445 healthy individuals participated, who were selected through convenience sampling from a health promotion clinic in a general hospital in Tehran. A body composition analyzer was applied using bioelectrical impedance analysis (BIA). We used SPSS version 25 to describe statistics. The bivariate Pearson Correlation, R, measured linear relationships between pairs of age, MA, and PA. A linear regression method for predicting MA and PA was related to the dependent variables, age and MA, respectively. A P-value less than 0.05 was considered statistically significant.

Results: 59.3% of participants were female, and 40.7% were male. There was no significant difference between the mean age and MA of men and women ($P > 0.05$). There was a significant difference between PA in men and women ($P < 0.05$). There was a strong correlation between increasing age and MA in Iranians, indicating their unhealthy lifestyle.

Conclusions: The PA is a prognostic marker in several health conditions. Based on the new technology, clinicians can look for changes in health status with healthy lifestyle interventions, prevention, and health promotion in public and private clinical settings.

Keywords: Metabolic Age, Phase Angle, Iranian Population, Body Composition Analyzer, Health Promotion, Risk Perception

1. Background

Non-communicable diseases are the main causes of mortality and morbidity in Iran, as well as globally (1). An unhealthy lifestyle leads to cardiovascular disease, cancer, chronic respiratory disease, and diabetes (2). Factors such as malnutrition, obesity, low physical activity, and stress contribute to a reduced health status. A healthy lifestyle consists of regular exercise, healthy eating, stress management, and adequate hydration (3).

Metabolic age (MA) is an intriguing concept used in health to explain overall fitness and metabolic activity. Chronological age (CA) refers to a person's age in calendar years. The MA is calculated by comparing an individual's basal metabolic rate (BMR) to the average BMR of their CA group and fat-free mass. If the MA is higher than the actual age, it is necessary to improve general health. The MA is very useful for increasing risk perception, encouraging individuals to be more active, lose weight, burn fat, and consume more vegetables and fruits (4).

The MA is a comparison between an individual's BMR and the average BMR for their age group. Therefore, if people have the same metabolism as someone younger, they would be in a better position. Free fat mass is the most predictive value for MA. The MA depends on free fat mass, visceral fat, weight, muscle mass, and age. A healthy lifestyle reduces MA (5, 6).

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Phase angle (PA) is a direct measurement of the cell membranes, which separate the internal environment of cells from the external environment. The PA serves as a remarkable indicator of how the body responds to changes in health status. Factors such as older age, immune deficiency, cancer, malnutrition, and illness can decrease PA. Low PA is due to the cell's inability to store energy, while high PA is associated with large quantities of intact cells (7).

The MA and PA reflect the general health status and fitness of the population. Disease prevention is a crucial component of primary health care. It is essential for individuals to engage in health-promoting activities and participate in health-promoting hospitals and centers. Health promotion services include screening (history and physical examination), medical counseling, intervention, and lifestyle changes (8). We aim to reduce people's risk factors through lifestyle interventions (9).

According to Pender's theory, health promotion behaviors encompass any activities performed to enhance and maintain an individual's health and self-actualization (10).

2. Objectives

The aim of this study was to evaluate the health status of an Iranian sample population admitted to a prevention clinic. This health promotion clinic was established in a general hospital to empower individuals to gain greater control over their health and reduce their risk factors. This research is novel in its area and holds significant utility.

The PA describes cell membrane integrity and represents the body's ability to suppress infections, such as the coronavirus. It serves as a very useful and rapid test for screening individuals who are predisposed to COVID-19 infection. Additionally, this method enhances risk perception and health literacy among people.

3. Methods

This was a cross-sectional study with ethics approval (IR.AJAUMS.REC.1398.081) conducted in the preventive clinic of a general hospital in Tehran, Iran. Iran is situated in the Middle East and Asia, and the population of this city has been continuously growing over the last decades. The study size comprised 445 individuals, selected using the convenience sampling method. We had no missing data, and all information was collected.

The only inclusion criterion was a healthy status in individuals with no obvious disease. We defined 'healthy status' as the absence of chronic or acute diseases based on a clinical interview and physical examination during the routine visit. Participants with known cardiovascular, metabolic, infectious, autoimmune, or other systemic illnesses were excluded. General health status was very important because we evaluated a healthy sample population without confounders.

The body composition analyzer is applicable for individuals aged between 5 and 99 years. Subjects included all individuals admitted to the health promotion clinic in 2020. This hospital is located in the center of Tehran, and the subjects admitted to this clinic were representative of the entire population. Body composition analysis is a method that differentiates between fat, protein, body water, and bone mass, providing a snapshot of health (including MA and PA). This technique involves simply standing on a scale.

All participants underwent body composition analysis in the morning after an overnight fast and were instructed to avoid strenuous activity for 24 hours prior to testing to minimize hydration and physical activity-related variation in bioelectrical impedance analysis (BIA) results. Collected variables included free fat mass, bone mass, body water, muscle mass, MA, PA, BMR, etc. The main outcomes were MA and PA, as they reflect total body health.

In descriptive statistics, we analyzed the percentage of women and men, as well as the mean and standard deviation of quantitative variables (age, MA, PA). We then used correlation analysis to provide information about the strength and direction of the linear relationship between two quantitative variables. A simple linear regression was used to estimate parameters in a linear equation to predict the values of one variable based on the other.

In analytical statistics, we used the bivariate Pearson Correlation, denoted as r, to measure the strength and direction of linear relationships between pairs of continuous variables (age, MA, and PA). A normality test (Kolmogorov-Smirnov) was performed for the main continuous variables. Since the data were approximately normally distributed, parametric tests, including the *t*-test and Pearson correlation, were applied.

We applied linear regression analyses to predict independent variables (MA and PA) in relation to the dependent variables and to explore the forms of these relationships. A P-value less than 0.05 (typically ≤ 0.05) was considered statistically significant. The potential confounders included having an illness or clinically apparent disease under treatment that influenced general health status. We excluded these patients from the study before conducting the body composition analysis.

All data were collected using G-mon software version 4.3.5, then coded, entered, and analyzed using SPSS version 25. We identified no potential sources of bias or conflicts of interest in this study.

4. Results

4.1. Participants, Outcomes, Main Results, and Other Analysis

All healthy participants were included in the analyses (n = 445) with no missing data, and body composition analyses were performed for all individuals.

4.2. Descriptive Analyses

The participants were representative of the socio-demographic status of the community (data collected by history). Of the participants, 59.3% were female and 40.7% were male (Table 1). The mean and standard deviation of numerical variables were calculated. The mean age in males was 39.8 ± 11.3 years, and in females, it was 40.52 ± 12.01 years. The mean MA was 39 ± 12.9 in males and 39.2 ± 13.67 in females. The mean PA was 6.78 ± 0.69 in males and 6.18 ± 1.27 in females (Table 2).

The differences between the means of age, MA, and PA (male and female) were analyzed at two levels of sex using an independent sample *t*-test. There was no significant difference between the mean age and MA of men and women (P > 0.05). The range of PA in Iranian healthy subjects was 6.78 ± 0.69 in men and 6.18 ± 1.27 in women (Table 2). There was a significant difference between PA in men and women (P < 0.05) (Table 3).

4.3. Analytical Statistics

The Pearson correlation between age and MA was 0.652, indicating a very good linear and positive association (P < 0.05) (Table 4). The correlation between age and (PA was not significant (-0.014) (P > 0.05) (Table 5). The correlation between MA and PA was negative and weak (-0.103) (P < 0.05) (Table 6).

4.3.1. Linear Regression Between Age and Metabolic Age

The scatter plot indicated a strong positive linear relationship between age and MA, supported by the correlation coefficient (R = 0.652, P < 0.05). Checking the assumptions using a residual plot did not indicate any problems with the data. The linear equation for predicting MA from CA was MA = 9.375 + 0.738 (age). The y-intercept indicated that for a person whose age was zero, their MA is predicted to be 9.375. The CA significantly predicts MA, such that for every 1-point increase in age, individuals are predicted to increase by 0.738 in MA (t = 18.1, P = 0.000). Regression analysis was used for predicting the MA of participants from their age (Tables 7 and 8).

4.3.2. Linear Regression Between Phase Angle and Metabolic Age

The scatterplot indicated a weakly negative linear relationship between PA and MA, supported by the correlation coefficient (R = -0.103, P < 0.05). A check of the assumptions using the residual plot did not show any problems with the data. The linear equation for predicting PA from MA was: The PA = 6.771 + (-0.009) MA. The y-intercept indicates that for a person whose MA is zero, their PA is predicted to be 6.771. The MA significantly predicts PA, such that for every 1-point increase in MA, individuals are predicted to decrease by 0.009 in PA (t = -2.167, P = 0.031). Regression analysis was used for predicting the PA of participants from their MA (Tables 9 and 10).

5. Discussion

This study utilized convenience sampling from a central preventive clinic in Tehran. While this population represents a range of individuals concerned with their health, the sampling method may limit generalizability and introduce potential selection bias. This cross-sectional study is the first to describe and predict MA and (PA in a healthy sample population. The study showed that women paid more attention to their health status and visited prevention clinics more frequently. Gender was not a confounding factor in our results.

The MA reflects the health of body composition and physical fitness. In our participants, MA was not lower than their CA, indicating that their bodies were not healthier or fresher compared to their age. Due to the cross-sectional nature of this study, we cannot infer causation from the observed associations.

Jeddi et al. evaluated the body composition of healthy Iranian children and adolescents in southern Iran, focusing on adiposity and total body fat assessment. They found that Iranian children had lower total body fat in all age groups compared to Western children (11). They used a body composition analyzer in healthy individuals similar to our study, but with different objectives.

Abedini et al. described visceral obesity in patients with psoriasis using bioimpedance analysis. They measured PA as an indicator of cell membrane condition, suggesting that body mass analysis can aid physicians in managing comorbidities associated with

Table 1. Frequency and Percentage of Statistical Populations' Sex

Variables	No. (%)	Valid Percent	Cumulative Percent
Valid			
Male	181 (40.7)	40.7	40.7
Female	264 (59.3)	59.3	100.0
Total	445 (100.0)	100.0	-

Table 2. Descriptive Data Analyze Age, Metabolic Age, and Phase Angle

Group Statistics	N	Mean ± SD	Std. Error Mean
Age			
Male	181	39.8177 ± 11.33504	0.84253
Female	264	40.5265 ± 12.01580	0.73952
MA			
Male	181	39.0000 ± 12.99231	0.96571
Female	263	39.2205 ± 13.36727	0.82426
PA			
Male	181	6.789 ± 0.6942	0.0516
Female	264	6.181 ± 1.2768	0.0786

Abbreviations: MA, metabolic age; PA, phase angle.

Table 3. Independent Sample *t*-Test (Age, Metabolic Age, and Phase Angle) at Two Levels of the Sex (Male and Female)

Independent Samples Test	Levene's Test for Equality of Variances		*t*-Test for Equality of Means						
	F	Sig.	*t*	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Age	0.408	0.524							
Equal variances assumed			-0.625	443	0.532	-0.70884	1.13332	-2.93619	1.51852
Equal variances not assumed			-0.632	401.209	0.528	-0.70884	1.12105	-2.91269	1.49502
MA	0.065	0.799							
Equal variances assumed			-0.173	442	0.863	-0.22053	1.27635	-2.72900	2.28794
Equal variances not assumed			-0.174	394.098	0.862	-0.22053	1.26965	-2.71666	2.27560
PA	7.912	0.005							
Equal variances assumed			5.836	443	0.000	0.6075	0.1041	0.4029	0.8121
Equal variances not assumed			6.463	423.620	0.000	0.6075	0.0940	0.4227	0.7923

Abbreviations: MA, metabolic age; PA, phase angle.

psoriasis (12). Their method and conclusions regarding PA measurement were similar to our study.

Segal et al. described the body analyzer as utilizing the differing electrical properties of muscle tissue and fat, highlighting its convenience, rapidity, and safety. We employed this method as well (13). Mohammadi and Saberi evaluated the relationship between body composition and physical fitness in female university students, suggesting that more attention should be paid to sports programs to enhance physical fitness and general health in Iranian universities. Our study demonstrated that more attention is needed for health

Table 4. The Pearson Correlation Between Age and Metabolic Age

Variables	Age	MA
Age		
Pearson correlation	1	0.652 [a]
Sig. (2-tailed)	-	0.000
N	445	444
MA		
Pearson correlation	0.652 [a]	1
Sig. (2-tailed)	0.000	-
N	444	444

Abbreviation: MA, metabolic age.
[a] P-value < 0.01 (2-tailed).

Table 5. The Pearson Correlation Between Age and Phase Angle

Variables	Age	PA
Age		
Pearson correlation	1	-0.014
Sig. (2-tailed)	-	0.763
N	445	445
PA		
Pearson correlation	-0.014	1
Sig. (2-tailed)	0.763	-
N	445	445

Abbreviation: PA, phase angle.

Table 6. The Pearson Correlation Between Phase Angle and Metabolic Age

Variables	PA	MA
PA		
Pearson correlation	1	-0.103 [a]
Sig. (2-tailed)	-	0.031
N	445	444
MA		
Pearson correlation	-0.103 [a]	1
Sig. (2-tailed)	0.031	-
N	444	444

Abbreviations: PA, phase angle; MA, metabolic age.
[a] P-value < 0.05.

promotion programs among all people, as sports programs and physical activity increase PA and overall health (14).

Solovev et al. explained that biological age prediction approaches can be based on data obtained using the most novel technologies, including bioinformatics innovations to predict biological age in humans. They expressed hope that the new technology would be useful for clinicians due to its translational purposes (15). We assert that MA and PA measurements are novel tools for increasing risk perception in people, similar to their findings.

The MA being less than CA reflects good body health. Iranians generally do not have a healthy lifestyle and do

Table 7. Linear Regression Model to Predict the Metabolic Age of Adults from Their Age

Variables	Sum of Squares	df	Mean Square	F	Sig.
ANOVA model					
Regression	32864.854	1	32864.854	327.614	0.000
Residual	44339.569	442	100.316	-	-
Total	77204.423	443	-	-	-

Table 8. Logistic Regression Analysis Predicting the Metabolic Age [a]

Variables	Unstandardized Coefficients		Standardized Coefficients (Beta)	*t*	Sig.	95.0% Confidence Interval for B	
	B	Std. Error				Lower Bound	Upper Bound
Coefficients model							
(Constant)	9.375	1.711	-	5.478	0.000	6.012	12.738
Age	0.738	0.041	0.652	18.100	0.000	0.658	0.818

[a] Metabolic age (MA) = 9.375 + 0.738 (age).

Table 9. Linear Regression Model to Predict the Phase Angle from Metabolic Age

Variables	Sum of Squares	df	Mean Square	F	Sig.
ANOVA model					
Regression	5.815	1	5.815	4.697	0.031
Residual	547.227	442	1.238	-	-
Total	553.042	443	-	-	-

not exercise enough, which is why their MA was close to their CA. If the MA is higher than the actual age, it indicates that individuals would benefit from more exercise and building healthy muscle, which will help increase their BMR. Engaging in resistance training, high-intensity interval training, getting plenty of sleep, consuming more protein-rich foods, fruits, and drinking green tea are necessary for Iranians to improve their lifestyle.

Although MA is not currently standardized for clinical decision-making, individuals with an MA higher than their CA may benefit from targeted lifestyle interventions aimed at improving metabolic health. In this study, there was a strong correlation between increasing age and MA, suggesting that people can influence the aging process. We found a negative correlation between PA and MA, indicating that as MA increases, PA decreases, and vice versa.

According to the research by Barbosa-Silva et al., estimated population averages of PA can be used as reference values. They found that the PA was significantly smaller in women and significantly larger in men (7.48 ± 1.10° and 6.53° ± 1.01°, respectively) (16). Iranian men had a higher PA than women, similar to their results, but Iranians had a lower PA compared to the reference value.

The CA significantly predicted MA, such that for every 1-point increase in age, individuals are predicted to increase by 0.738 in MA. The MA significantly predicted PA, such that for every 1-point increase in MA, individuals are predicted to decrease by 0.009 in PA.

Another study described that reference values can serve as a basis for PA evaluations in the clinical setting, demonstrating that PA is inversely related to inflammatory biomarkers (IL-6, TNF-α, and CRP) in older women. Phase angle is positively related to antioxidant enzymes and the total radical-trapping antioxidant parameter. The PA could be a useful tool to predict inflammatory and oxidative stress markers in older women (17).

Our study population showed lower average PAs compared to international reference values, such as

Table 10. Logistic Regression Analysis Predicting the Phase Angle [a]

Variables	Unstandardized Coefficients		Standardized Coefficients (Beta)	*t*	Sig.	95.0% Confidence Interval for B	
	B	Std. Error				Lower Bound	Upper Bound
Coefficients model							
(Constant)	6.771	0.165	-	40.950	0.000	6.446	7.096
MA	-0.009	0.004	-0.103	-2.167	0.031	-0.017	-0.001

Abbreviation: MA, metabolic age.

[a] Phase angle (PA) = 6.771 + (-0.009) [metabolic age (MA)].

those reported by Barbosa-Silva et al. This might reflect differences in baseline nutrition, physical activity, or genetic background. Our study concluded a similar result, indicating that PA increased with aging and is beneficial for health status screening and prognosis (16).

A healthy lifestyle includes a balanced diet with adequate intake of fibers, nuts, whole grains, healthy fats, and omega-3 fatty acids, while avoiding unhealthy foods such as red and processed meats, sugar, trans fats, and excessive salt. It also involves maintaining an adequate level of physical activity, with at least 30 minutes per day of moderate to vigorous activity, achieving a healthy weight, abstaining from smoking, and avoiding alcohol consumption.

The perceived risk factors increase when technology, such as the body composition analyzer, provides new information about the level of risk. A high PA is consistent with a large number of intact cell membranes. Jeong and Kim concluded that there is a positive relationship between health literacy and health behavior, noting that many Korean elders had low levels of health literacy, which was associated with poor health behavior (18).

Our findings indicated that increasing risk perception is necessary to enhance people's health behavior due to low health literacy and behavior. The BIA is influenced by factors such as hydration status, recent physical activity, and electrode placement. These limitations were addressed as far as feasible, but residual variability may still affect PA values.

In conclusion, our study demonstrated a highly progressive trend in the burden of unhealthy lifestyles in Iran, highlighting the urgent need for national and multi-sectoral interventions. This should draw the attention of governments, policymakers, and funders (19). Risk perceptions are central to many health behavior theories (20). The ongoing COVID-19 pandemic is challenging the foundations of public health governance worldwide (21).

A low PA remains an independent adverse prognostic marker of clinical progression and survival in HIV patients (22). The PA appears to be a good indicator of mortality in many clinical situations, such as COVID-19, and can be used to screen individuals prone to this outcome (23). The PA is a prognostic marker in several health conditions, including COVID-19, and correlates with mortality in diverse clinical situations.

With greater risk perception, we can develop new concepts for disease prevention and health promotion, encouraging people to engage in more physical activity, exercise more, and maintain a healthy diet. Based on the properties of new technology, clinicians can quantify a large number of body components and, through longitudinal evaluation, monitor changes in health status. This has implications for understanding the efficacy of healthy lifestyle interventions, prevention, and health promotion in both public and private clinical settings.

5.1. Suggestions

This study should be conducted in different areas and countries with larger sample sizes to evaluate the health status of diverse populations. Establishing a health promotion clinic in every health setting and utilizing technology can provide new insights to people, encouraging them to improve their health. When individuals become aware of their health status and recognize their non-optimal body conditions, they are more likely to adopt a healthy lifestyle to achieve positive results.

5.2. Strengths

This is the first novel study utilizing technology to estimate and predict PA and MA, making it a very useful and applicable approach for health promotion worldwide. The study's methodology can be replicated globally to enhance public health initiatives.

Footnotes

Authors' Contribution: M. D.: Conceptualization, formal analysis, investigation, and writing-original draft. A. N.: Methodology, resources, writing-review and editing, and supervision.

Conflict of Interests Statement: All the authors declare no conflict of interest.

Data Availability: The dataset presented in the study is available on request from the corresponding author during submission or after publication. The data are not publicly available due to patient privacy and confidentiality regulations, as it contains sensitive medical information that could potentially identify individuals.

Ethical Approval: This cross-sectional study, approved by the Ethics Committee (IR.AJAUMS.REC.1398.081), was conducted at a preventive clinic in a general hospital in Tehran, Iran.

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Informed Consent: Written informed consent was obtained from the participants.

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