ANALYSIS OF BIOELECTRICAL TISSUE CONDUCTIVITY IN MALAYSIAN ADULTS

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ABSTRACT

This paper presents the bioelectrical tissue conductivity (BETC) analysis of Malaysian adults using bioelectrical impedance. A total of 142 subjects (91(64.1%) female and 51(35.9%) male) with no past medical history were studied. The BETC was measured using phase angle (α), resistance (R), reactance (Xc) and body capacitance (BC). There is a significant difference (P<0.001) in the BETC mean values of the subjects. The mean phase angles measured were 7.4±0.8° and 6.3±0.6° with corresponding mean body capacitances of 818±158pF and 557±101pF for male and female, respectively. The results show that α and BC mean values are higher in the male than the female. However, the female R (635±71.5Ω) and Xc (69.9 ± 8.4Ω) were higher than the male R (504 ± 63.4Ω), and Xc (64.6 ± 6.8Ω), respectively. These results show that the BETC values in Malaysian adults are in agreement with the normal healthy subjects at large.

Index Terms—Bioelectrical, tissue conductivity, Bioelectrical impedance, Malaysian

1. INTRODUCTION

Measurement of body composition is important to assess the nutritional status in both normal individuals and hospital patients. Many techniques are currently available for estimating body composition, but all are indirect [1]. Recently, a new and non-invasive technique known as bioelectrical impedance analysis (BIA) has been used to estimate body composition in adult human [2-4] and also to assess changes in electrical tissue conductivity that indicates altered body composition. However, most of these studies have been carried out in the developed countries [4-6]. To date, no known literature describes the body composition and bioelectrical tissue conductivity (BETC) in Asian population including Malaysia. In this study, we focused on the BETC measurements (reactance (Xc), resistance (R), phase angle (α), and body capacitance (BC)) in BIA for the adult's Malaysian population. Hence, this paper will be the first attempt to describe the BETC reference values for the Malaysian adults, hence, which may also be useful as a guideline or reference for the general Asian population.

2. BIOELECTRICAL IMPEDANCE ANALYSIS

Bioelectrical impedance analysis (BIA) is a technique to estimate body composition and measures the impedance or opposition to the flow of an electrical current through the body fluids [7-9]. The impedance of biological tissue comprises two components, the resistance (R) and the reactance (Xc). In the body, highly conductive lean tissue contains large amounts of water and conducting electrolytes, and represents a low resistance electrical pathway. Fat and bone, on the other hand, are poor conductors or high resistance electrical pathway with low amounts of fluid and conducting electrolytes. Reactance (Xc) is also known as capacitive reactance when describing biological tissues is the opposition to the instantaneous flow of electric current caused by capacitance [8-10].

Hence, the human body is a circuit of resistors and capacitors. Although the electrical circuit, which represents the body, is very complex, it can be reduced to the following model as shown in Fig. 1.

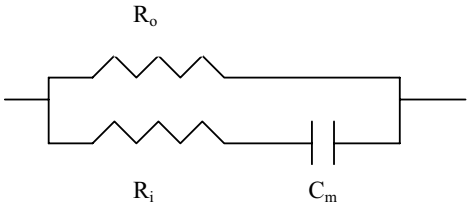

Fig. 1: Equivalent Electrical circuit model of the human body.

where,

Ro = Fluid component of the body which is outside (extra cellular) the cells.

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R_i = Fluid component of the body which is inside (intracellular) the cells.
C_m = Lipid bilayer cell is an electrical dielectric that acts like a capacitor.

BIA technique is based on the passing of a low amplitude electrical current less than 1mA (500 to 800μA) with frequency (50kHz), and it measures the whole body's resistance (R), reactance (Xc), impedance (Z) and phase angle [11,12]. In clinical practice, and for most of the numerous experiments published in the literature, the current (about 1mA at 50kHz) is injected through the distal electrodes on the hand and foot and the voltage drop between electrodes provides a measure of impedance [13].

To date, most studies on bioelectrical impedance have used machines operating at a single frequency, commonly 50kHz, which is the characteristic frequency for skeletal muscle tissue. It is assumed that the total conductive volume of the body is equivalent to that of total body water, most of which is contained in muscle tissue [14,15].

3. SUBJECTS AND METHODS

Subjects: A total of one hundred and forty two volunteers with no past medical history were recruited and studied. Subjects were on-randomly volunteers, recruited through advertisement in the University Malaya's monthly news bulletin 'BERITA UM', internal posters circulation, and internal University of Malaya's email (uminfo@list.um.edu.my). Some of the volunteers were from general public during the University Malaya convocation exposition 2002 and the University Malaya Second College Creative Week Open day in 2002.

Method: The BIA safety measurements procedure and other safety precautions were made known to the subjects and informed consent was obtained from each subject prior to the BIA measurement. All patients were asked to abstain from eating and drinking for 4 hours prior to the BIA measurement.
For each patient anthropometrics measurements (height and weight) were taken and demographics data were recorded by the investigator using standardized questionnaire data collection forms designed for the study.

BIA Measurement: Subjects were asked to lie supine on their bed and two electrodes were placed on the right hand, one at the base of knuckles and another slightly above the wrist joint. Another two electrodes were placed on the right foot, one near the base of the toes and the other slightly above the ankle joint. A constant current less than 1mA at a single frequency of 50kHz [16] was injected to the base of the knuckles and base of the toes and the signal was pick-up by the other two sensor electrodes (slightly above the ankle and wrist joint). Each measurement took approximately 3 minutes. Bioelectrical impedance measurement was performed with a biodynamic Model 450 bioimpedance analyser, from Biodynamic Corporation USA. The subject's profile such as age, sex, height and weight were entered to the BIA 450 analyzer. The analyser directly measures resistance (R), reactance (X_c), body capacitance (BC), and phase angle, and uses regression analysis to compute the mass distribution and water compartments.

4. STATISTICAL ANALYSIS

The statistical analysis was performed using SPSS statistical package version 10.01 for Window 1998. Data were expressed as mean and standard deviation. Student's *T* Test was applied for comparison between two means for both genders. A probability level of $p < 0.001$ was taken as significant.

5. RESULTS

The BIA measurements have been conducted to a total of one hundred and forty two healthy Malaysian subjects 91(64.1%) female and 51(35.9%) male. All of the subjects have no past medical history. The ages of the subjects vary between 14 and 60 years old with mean age of 28 years. The subjects race distribution were 94 (66.2%) Malay, 36 (25.4%) Chinese, 3 (2.1%) Indians and 9 (6.3%) other races. Most of the subjects are from Wilayah Persekutuan Kuala Lumpur and Selangor population. The detail anthropometrics descriptive for the healthy subjects is in Table 1. The mean and significant differences of the BETC parameters between male and female subjects are shown in Table 2.

From Table 2, it was found that BC and α were significantly less in the female subjects compared to their male counterparts ($p<0.001$). However, R and Xc were significantly more in female than in male ($p<0.001$). These results obtained in Table 2 are in agreeament with the normal healthy subjects from the large white population [3,4]. However, it was observed that the Malaysian adults experienced low mean values of α and BC, while, high in R and Xc in comparison with the white population [3,4].

6. DISCUSSION

Due to large degree of heterogeneity in body composition of different populations, the use any single frequency may provide a significant limitation to use of this technology. Differences in body fluid distributions across body fluid compartments,

variability in tissue hydration both within and among individuals, and differences in age, degree of physical fitness and adiposity can affect bioimpedance measures. Consequently, subsequent manipulation of baseline data to derive specific body composition information may be spurious. Multifrequency bioelectrical impedance has been reported to be effective in quantifying body fluid [17].

However, in recent study conducted by Paton et al, comparing single versus multi-frequency testing, proved that the differences in estimating water content by the two methods were found to be insignificant [18].

One of the major limitations of this study was that the subjects were selected from the Wilayah Persekutuan Kuala Lumpur and Selangor urban population, which do not represent the general, population in this country. Results of this study also showed that bioimpedance assay is an easy, noninvasive method and can be applied to measure the BETC in healthy adults. This information can be used for the Malaysian as a benchmark to compare the variations brought about by diseases.

Table 1. The anthropometrics measurements for the healthy subjects.

Anthropometrics	Male Means ± SD	Female Means ± SD
Age	29.4±10.8	27.2±9.1
Height (cm)	169.5±7.9	155.5±6.2
Weight (kg)	65.3±10.1	51.9±7.6

Table 2. The BETC parameters of male and female healthy subjects.

(BETC)	Male Means ± SD	Female Means ± SD	P values
α (°)	7.4±0.8	6.3±0.6	0.000
BC (pF)	818±158	557±101.2	0.000
R (Ω)	504±63.4	635±71.5	0.000
Xc (Ω)	64.6±6.8	69.9±8.4	0.000

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