Measurement of Body Fat of Bangladeshi Adults by Bioelectric Impedance Analyzer

Md. Rezaul Karim[1], *M. Abu Khaled*[2], *Md. Abdul Malek*[3], *Md. Belial Hussain*[4], *Md. Nizamul Hoque Bhuiyan*[5] **Lutfun Nahar**[6] **and** *Khaleda Islam*[7]

1, 3, 4, 5, 6, 7 Institute of Nutrition of Food Science, University of Dhaka, Bangladesh.
2, University of Alabama, U.S.A.

Introduction

Body composition measurements are necessary for the understanding of the nutritional status in the human population. Reliable, non invasive, rapid and accurate methods for determinig body compositions are, therefore, highly desirable. In underdeveloped countries like Bangladesh, common means for assessing body copositions are usually the anthropometric methods of Gomez[13] and Waterlow[14,15,16] that involve weight for age, weight for height and height for age. Other anthropometric methods such as skin fold thickness and circumference measurements, although easy to make are not always utilized because of the lack of expertise in remote village areas in Bangladesh.

Several sophisticated and modern methods [6](Khaled, 1987) are under development in the developed countries like USA. One such method is the Bioelectrical Impedance analysis (BIA), which is currently under extensive investigations in many developed countries [19](Nyboer, 1959; Hoffer et al.[3] 1969, Chumlea et al.[18] 1988; Houtkooper at al.[4] 1989; LUKASKI AND BOLONCHUK[12] 1988; SiriWE[21] 1961; Likaski et al. 1987; Vanloan and Mayelin,[22] 1987).

One particular attractive feature of this method is its portability which could be extremely useful for field studies (nutritional survey in Bangladesh). One such portable unit, model BIA-101, form RJL System Inc., Detroit, Michigan, USA, was made available to the Institute of Nutrition and Food Sciences (INFS) of Dhaka University (Bangladesh). The method was employed initially in a group of normal adult subjects and the results are reported here. Serious concerns for its applicability in a field setting in countries like Bangladesh have been raised by our investigations.

Meterials and Methods

The Bangladesh standard electric voltage is 220 volts, and BIA instrument was modified accordingly by the manufacturer (RJL) for the purpose of recharging the batteries in the machine. The instrument is a tetrapolar system that utilizes 800 UA current at 50 KHz. Measurements were made on subjects lying on a stretcher with the limbs abducted from the body. Current was induced through electrodes which were placed below the meta-carpophalangeal joint in the middle of the dorsal side of the right hand, and below the transverese

Bangladesh Journal of Nutrition Vol. 7, Nos. 1 & 2, June 1994. Printed in Bangladesh. Institute of Nutrition and Food Science, University of Dhaka, Bangladesh.

(metatarsal) arch in the superior side of the right foot over metatarsophalangeal joint. The voltage detector electrodes were placed on the posterior side of the right wrist, midline, with the prominent pisiform on the posterior side of the right wrist, midline, with the prominent pisiform bone on the medial side and ventrally across the medial ankle bone of the right ankle. Resistance (R) was measured on a 0 to 1000 Ohms scale while reactance (Xc) was measured on a 200 Ohms scale. A total of 43 normal adult subjects were recruited from the staff and students of the Institute of Nutrition and Food Science and other departments of University of Dhaka, Bangladesh for this preliminary study. Their physical characteristics are shown in Table 1. Various body compartment measurements from the BIA paramenters were derived by utilizing the following published regression, equations : such as lean body mass (LBM) Total Body Water (TBW) and Fat Mass (FM).

i) RJL copmputer program (disc) supplied by the manufacturer.

ii) Lukski et al. (1968) $FFm=0.838H^2/R+4.179$

iii) Kushner and Schoeller (1986) $TBW=0.556\ H^2/R+0.095/W+1.73$

iv) Khaled et al. (1986)% $Fat=41.532\ WZH^2-30.027$

v) Segal et al. (1988)

Body density (d)= 1.1554-0.0841. WR/H2 for male.

d = 1.1113-0.556 WR/H2-0.027 for female.

vi) Hughes et al. (1987)

$FFM=0.775H^2/R+0.146\ W+0.185\ Xc-15.26$

vii) Van Loan et al. (1987)

$FFM= 0.000985\ H^2+0.3736\ W-0.0238\ R-4.2921\ sex-0.1531\ age$

viii) % FM=(495/d)-450. Siri equations (Siri. 1961)

% FM=(W-FFm)* 100/W

% FM=(W-TBW/0.732) * 100/W

d- density was derived from skin fold thickness by Siri 1961.

In the above equations, W is Weight in Kg. H is height in CM. FFM is the fat free mass in Kg. TBW is total body water in litres, R and Xc are resistance and reactance, respectively, in Ohms. The weight and length was measured in Wt/height machine made by detecto scale incorporation, Brooklyn, New York, U.S.A. used in INFS. Resistance and Reactance was recorded by BIA applying normal method, i.e. R/R, L/L. Data analysis was done according to descriptive analysis (mean, standard devitation etc.)"

Results and Discussion

As mentioned in the introduction, the purpose of this study was to establish the potential applicability of the BIA method for measurement of body component of Bangladeshi adult. Data collected on a section of normal adult subjects are average and listed in Table 1. Percentage of Fat Mass (FM) as derived by using various published equations for the BIA method, are also given in Table II. It can be seen that the percentage of fat, as given by each equation for the same population, varied considerably. For the male subjecs. percentage of fat varies from 17 to 31% while for the famale subjects is ranges from 27 to 42%.

Table 1. Physical characteristics of subjects :

	Male	Female
	Male=28 mean±SD	*Female=15 mean±SD*
Age (Year)	24.±3.1	27.2±1.3
Height (Cm)	164.97±3.66	154.65±5.54
Weight (Kg)	57.01±7.51	48.77±7.94
Body Mass Index (BMI) (Kg/m2)	20.93±2.52	20.43±3.33

Table 2. Percentage of body fat as derived from BIA measurement using diffrernt equations :

		Male	Female
		Male=28 mean±SD	*Female=15 mean±SD*
i)	RJL	26.96±4.96	30.70±5.66
ii)	Lukaski et al. (1986)	29.6±6.37	34.67±7.78
iii)	Kushner & Schoeller (1986)	25.85±6.09	31.16±7.18
iv)	Khaled at al. (1988)	22.38±4.55	28.20±6.62
v))	Segat et al. (1988)	20.20±4.91	27.13±4.89
vi)	Hughes et al . (1987)	31.45±7.20	42.59±5.97
vii)	Van Loan et al. (1987)	17.57±5.03	31.33±4.43

Although the (BMI) does not give an accurate measurement of the body copmosition, it does however delineate between the overweight and underweight groups. An average BMI of 23 is commonly used for this purpose 2(Forbes, 1987); BMI values above this are considered to indicate overweight, while lower values are indicative of underweight. The BMI values for the Bangladeshi male and female subjects investigated in this study are all below

average around 20 (see table II) whcih characterised them to be underweight. The % values obtained by utilizing the published equation, on the other hand, indicate that all the subjets tend to be overweight (see Table II). This disagreement posses a serious concern for the use of any published equations and the body composition program supplied by the manufacturer of BIA method. Recently Lohman[9] (1989), has suggested that various laboratories should develop their own equations for the BIA method against any standard methods. This may be quite feasible for a developed countries but may be very difficult for those country who do not have any other methods of body compositions that are considered so-called "Gold Standard", e.g. hydrostic densitometry, isotopic dilution, etc. Moreover, validation made by using certain populations may not be useful on other populations as clearly demonstrated by the presently available published results. For example if the BIA method is validated in a laboratory setting in an urban area like Dhaka, the capital of Bangladesh, and utilizing its populations who are more affluent, the same may not give accurate results when applied on the populations of rural areas who usually suffer from malnutrition.

Another interesting observation was also made while the BIA data were collected which may create a serious problem for the application of this method in the field set-up. Generally, weather of Bangladesh is hot and humid except during the winter season which lasts only for 2 to 3 months. When the subjects reported for this study came from outside and the BIA measurements were made (before the subjects settled for sometime under a ceiling fan) the resistance and reactance values drifted noticeabley. Resistance and reactance values drifted by 20-30 ohms. The trends of the rift were random, i.e. in some cases from higher to lower and in other cases, the opposite.

Summary

Application of newer method for measurement of body composition by bioelectrical impedance analysis (BIA) was made on a selected Bangladeshi population. The attractive feature off the instrument is that it is portable and non-invasive. The serious problem is in the establishment of an appropriate mathematical formula suitable for the Bangladeshi since all of the published mathematical expression for the BIA method do not give accurate estimation of composition for this cohort of subjects. Another point of concern observed in this study is the inability of the method to give consistent readings of its parameters, resistance and reactance, at a field setting under hot and humid conditions.

Although the alterations of BIA values with temperature is known [12](Lukaski, 1986), the variations noted in this study may not only be attributed to this factor, but it may also be a combination of both-temperature and loss of body electrolyte due to the perspiration. This makes the use of the BIA method all the more difficult for the field studies in countries like Bangladesh where the availability of any means of dehumidification is virtully nonexistent, particulaly in the rural areas. But the system can be applied by estimation of total body water with D_2O (Deuterium oxide) dilution technique which will help to validate the application of BIA technique over Bangladeshi Population.

Referecnes

1. Chumlea WC. Baumgartner RN, AF, Specific Resistivity Used to Estimate Fat-Free Mass Form Segmental body Mesaures of Bioelectrical Impedance. Am JClin Nutr 48:715.1988.
2. Forbes GB. Human Body Composition. New York : Springer-Verlag, 21:10-11. 1987.
3. Hoffer EC. Meador CK. Simpson, DC, Correlation of Whole-Body Impedance with total Body Volume. J Appl Physiol 27:531-534-1969.
4. Houtkooper LB. Lohman TG. Going SB, Hall MC Validity of Bioelectrical Impedance for Body Composition Assessment in Children. J Appl Physiol 66:841-819. 1989.
5. Huges VA. Evans WJ. Assessment of Fat Free Mass in an older population Using Bioelectrical Impedance. Fed proc 46:1186. 1987.
6. Khaled MA, Modern Methods for Assessing Human Body Composition, Bengal. J. Nutr 1:66-80. 1987.
7. Khaled MA. McCutcheon MJ. Reddy S. Pearman PL, Hunder GR, Weinster RL. Eletrical Impedance in Assessing Human Body Composition : The BIA Method. Am J Clin Nutr 47:789-792. 1988.
8. Kushner Rf. Schoeller DA. Estimation of Total Body water by Bioelectrical Impedance Analysis. Am J Clin Nutr 44:417. 1986.
9. Loman TG. Bioelectric Impedance. 9th Ross Round table Report. page 22 22 - 25 1986.
10. Lukaski HC. use of the Tetrapolar Bioelectrical Impedance Method to Assess Human Body Composition. In: Human Body Composition and Fat Patterning Norgan, N, (ed). Wageningen, Holland : Euro-Nut 143-148 1986.
11. Lukaski HC, Bolonchuk WW. Estimation of Body Fluid Volumes using Terapolar Bioelecticl Impedance Measurements. Aviat Space Environ Med 59:1169. 1988.
12. Luksski HC. Bolonchuk WW. Hall Seders WA. Validation of Terapolar Bioelectrical Impedance Method to Assess human Body Composition J App physiol 60-1327-1332. 1986.
13. Guery M, Gurney J.M. and jutsum P. The Gomez classification. Time for change of Bulletin of World Health Organization 1980, 58(5) :773-77.
14. Waterlow JC. classification and definition of protein-Caloric malnutrition, Br. Med. J. 1972, 3:566.
15. Waterlow JC. Note on the assessment and classification of malnutrition of children. Br. Med. J 1974, 4:88-90.
16. Waterlow LC, Some aspects of childhood manutrition as a public health problem Br. Med. J. 1974, 4 : 88-90
17. Nutrition survey of Rural Bangladesh 1975-76. Institute of Nutrition and Food Science, University of Dhaka, Banladesh, 1977

18. Nutrition Survey of Rural Bangladesh 1980-81, Institution of Nutrition and food Science, University of Dhaka, Bangladesh, 1983.
19. Nyboer J. Electrical Impedance Plethysmography, Springield, IL. Charles C. Thomas, 113-115, 1959.
20. Segal KR, Van Loan M. Fitzgerald PI. Hodgdon JA, Van Itallie TB. Lean Bdy Mass Estimation by Bioelectrical Impedance; A Four-Site Cross-Validation Study. Am J Clin Nutr 47:7-14, 1988.
21. Siri WE. Body Composition from fluid Spaces and Density; Analysis of Methods. In : Techniques for Measuring Body composition, Brozek. J. And Henschel. A.d (Eds.). Washiington, D.C. nati. Acad. Press 223-244. 1961.
22. Van Loan M. Mayelin P. Bioelectrics Impedance Analysis, Is it a Reliable Estimator of Lean Body mass and Total Body water ? Hum Biol 59:299-306. 1987.

Information for Contributors

The Bangladesh Journal of Nutrition is published in June and December of the year by the Institute of Nutrition and Food Science, University of Dhaka, Dhaka-1000, Bangladesh.

The journal publishes original research articles, review articles, short communications dealing with the aspects of nutrition and letters to the editor.

Manuseripts

Articles written in English are accepted on the understanding that they are subject to editorial revision. Manuscripts should be submitted in quaduplicate, type written double spaced, on one side of good quality paper.

A covering letter from the author who will be responsible for correspondence is essential. Articles are accepted for publication only when they are submitted solely to this journal. The top page should include title with name and address of the contributor(s). Introduction, Materials and Methods, Results, Discussion, Summary, Acknowledgements and References should be started from second page.

Referenees

References should be indicated by consecutive numbers in superscripts in the text and listed sequentially in the bibliography. Examples of format of (1) a periodical and (2) a book follow:

(1) Albanese A A, Orto L A and Zavattare N. Biochemical significance of plasma ammonia nitrogen in man with comparison of other criteria of protein nitrogen, Metabolism 1958; 7: 256.
(2) Longenecker J.B. Newer Method of Nutritional Biochemistry (A.A. Albanese, editor), Academic Press Inc., New York 1963, p. 113.

Nomenclature and Abbreviations

1. Standard abbreviations such as mg, C, F, should be used.
2. Terms such as electrocardiogram, ultra-violet should be written in full first time followed by accepted abbreviation (ECG, UV).

Tables

Tables should be carefully constructed so that the data represented may understood easily. All tables must be referred to in the text by arabic numerals in consecutive order as Table 1, Table 2 etc. Every table and every column should be supplied with an appropriate heading. The table number and the title should be placed in a continuous heading above in the data presented.

Figures

All drawings should be made with China ink on white drawing paper. Figures should be referred to in the text in consecutive by arabic numerals as Fig. 1, Fig. 2 etc. Original drawings are preferable but photographic prints are also accepted if clear, well printed on glossy paper with strong contrasts.

Submission

All communications related to the journal sould be addressed to the Editor, Bangladesh Journal of Nutrition, Institute of Nutrition and Food Science, University of Dhaka, Bangladesh.

Subseription Rate

Bangladesh : Taka 50.00 including postage ; Other countries U.S. $ 10 including postage.