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Original Article

BIOELECTRICAL IMPEDANCE TECHNOLOGY FOR EVALUATING HUMAN BODY COMPOSITION PARAMETERS: "AN ADVANCED DIAGNOSTIC TECHNOLOGY FOR BODY COMPOSITION AND PHYSICAL FITNESS ANALYSIS"

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ABSTRACT

Enormous use of sophisticated technology in daily living has resulted in lifestyle disorders in form of obesity, hypertension, cardiac disorders and musculoskeletal problems in a community as a whole. This significant rise in physically unfit community prompted us to find a most cost-effective, simple, and reliable mode of physical fitness evaluation in form of Bioelectrical Impedance technology. An observational randomized experimental study was conducted at Multispecialty Department of Physiotherapy, Bombay Hospital-Indore-India. Tanita BC-418 working on the principle of Bioelectrical Impedance Technology was used for Body composition Analysis of 100 male and females with age group 40-50 years.

Conclusion: BIA has proved to be an advanced diagnostic technology for evaluating human body fitness in today's fast and rapidly advancing life style. The Body Composition Parameters important in evaluating physical fitness such as Body fat%, Fat Free Mass, Total Body Water%, BMR, segmental fat distribution can be easily assessed with this technique. Multi-frequency segmental Bioelectrical Impedance analysis identifies the Differences in segmental body fat% distribution and these differences signify the presence of regional pain, having musculoskeletal origin.

KEYWORDS: Bioelectrical Impedance Technology, Human Body Composition parameters, Body Fat (BF) %, Fat Free Mass (FFM), Total Body Water (TBW) %, BMI, Basal Metabolic rate (BMR) and segmental Fat % Distribution.

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INTRODUCTION

Enormous use of sophisticated technology in daily living has resulted in lifestyle disorders in form of obesity, hypertension, cardiac disorders and musculoskeletal problems in a community as a whole. This significant rise in physically unfit community prompted us to find a most cost-effective, simple, and reliable mode of physical fitness evaluation in form of Bioelectrical Impedance technology. It evaluates the human body composition parameters and brings fitness awareness among physically unfit individuals.

Bioelectrical Impedance Technology: Bioelectrical impedance has become increasingly popular and an appealing tool in recent years for the assessment of body composition and body fluid status, mainly because of its rapid processing of information, noninvasiveness, production of information with a portable instrument of easy handling, relatively inexpensive and requires minimal subject

compliance.[1-2] The principles underlying the use of Bioelectrical Impedance for assessing body composition is the relationship of body composition to the water content of the body.[3] It is based on the passage of a low-amplitude and high-frequency current measuring resistance , reactance, impe-dance, and the phase angle. [4]

Analysis of body composition by Bioelectrical Impedance technology produces estimates of total body water [5-7], fat-free mass (FFM) [8-11], and fat mass [12-13] by measuring the resistance of the body as a conductor to a very small alternating electrical current [14-16]. This is an accurate and time efficient method of ascertaining lean tissue and fat mass percentage along with individualized basal metabolic rate intracellular and extra cellular water distribution, parameters of overall health [17-19]

Body Composition Analysis: Body composition assessment is being increasingly recognized as an important tool in the evaluation of nutritional status in a variety of clinical conditions [20-22]and for fitness assessment in both research and clinical settings[23], because of the important role of body components in human health, especially regarding the influence of excess of body fat.[24] It is said that BODY FAT, NOT BODY WEIGHT is the best measure of health and fitness, thus body composition assessment should be an integral part of each individuals physical fitness profile regardless of body weight.[25]

The evaluation of body composition parameters help in quantification of the major structural component of the body, muscle, bone, and fat.[26] The body is composed of fat, water, bone, muscles, soft tissue and protein content of the body. [27-29] As muscular tissue takes up less space in our body than fat tissue, our body composition, as well as our weight, determines leanness[30] therefore primary goal of assessing body composition is to determine the proportion of fat mass relative to lean body mass. [31]

Thus the main objectives of our study are to establish the importance of Bioelectrical Impedance technology for evaluating Body Composition Parameters and creating awareness among general population regarding Body composition parameters like Body Fat (BF) %, Fat Free Mass (FFM), Total Body Water (TBW) %, BMI, Basal Metabolic rate (BMR) and segmental Fat % Distribution and Bioelectrical impedance Technology as an ideal fitness evaluator.

Review of Literature:

Monica Popa, Dana Sîrbu, Daniela Curseu, Alina Ionutas, Iuliu Hatieganu studied The measurement of body composition by Bioelectrical Impedance and found bioelectrical impedance analysis (BIA) an inexpensive, reliable, simple, safe, and noninvasive Technique for clinical and non clinical purposes the ability of BIA to accurately assess body composition is dependent upon a Number of technical and biological assumptions. This paper provides an overview of the strengths and weaknesses of the BIA Method with specific reference to assessment of body composition**.**

Richard Ricciardi & Laura A. Talbot studied on Use of Bioelectrical Impedance Analysis in the evaluation, treatment, and prevention of overweight and obesity. The purpose of this study was to present an overview of bioelectrical impedance analysis (BIA) and To familiarize nurse practitioners (NPs) with the potential benefits of using BIA in Prevention, monitoring, and long-term follow-up of healthy individuals and Those with chronic conditions (e.g., obesity). Data sources: original research articles and comprehensive review articles Identified through Medline, CINAHL, OVID, and electrical engineering databases. Conclusions: obtaining serial measurements of percent body fat using BIA can identify patients at greatest health risk and gives NPs an additional tool to assess Treatment response in patients seeking to lose or maintain body weight and/or Increase muscle mass.

Carolina H.Y. Ling, Anton J.M. De Craen, Pieternella E, Slagboom , Dave A. Gunn E, Marcel P.M. Stokkel, Rudi G.J. Westendorp, Andrea B, Maier worked on Accuracy of direct segmental multi-frequency bioimpedance analysis in the assessment of total body and segmental body composition in middle-aged adult population A total of 484 middle-aged participants from the Leiden longevity study were recruited. Agreements between DSM-BIA and DEXA for total and segmental body composi-

tion quantification were assessed using intraclass correlation coefficients and blandealtman plots. Dsm-bia is a valid tool for the assessments of total body and segmental body composition in the general middle-aged population, particularly for the quantification of body lean mass.

Mirele Savegnago M, Fernanda Rodrigues De O, Estela Iraci R, Alceu Afonso Jordão J, Paula Garcia CH studied Determination of body composition by segmental Bioeletrical impedance analysis: considerations and practical applications. The study was conducted on female subjects divided into two groups: group I (n = 8) consisted of healthy women and group II (n=25) of obese wo-men with polycystic ovary syndrome (PCOS). All subjects were submitted to examination by total and segmental bioelectrical impedance. Results and discussion: anthropometric parameters (weight, BMI, total lean mass and total fat mass) showed significant differences between groups. There was a significant difference between groups I and II for all body segments evaluated, except for lean mass of the leg. Conclusion: procedures of segmental bioelectrical impedance will be increasingly useful in the nutritional assessment of tissue masses, enabling more sensitive assessment and monitoring of nutritional care.

Mirele Svegnago Mialichl, Juliana Maria Faccioli Sicchieri, Alceu Afonso Jordao Junior studied the analysis of body composition: a critical review of the use of bioelectrical impedance analysis**.** The objective of the present report is to review the main concepts involved in the BIA a technique, to describe the types of BIA available, their limitations and applications to clinical practice, especially the monitoring of chronic diseases. After this review, we conclude that BIA is an important instrument for health professionals and that its use can provide safe data about body composition, in addition to complementary data about the clinical course of patients followed up on a medium- and long-term basis.

Birgit A. Shanholtzer, Stephen M. Patterson researched on "Use of bioelectrical impedance in hydration status assessment: Reliability of a new tool in psychophysiology research**".** The goal of this study was to determine the reliability of bioelectrical impedance assessment (BIA) in assessing total body water (TBW), extracellular water (ECW) and intracellular water (ICW) and to assess whether individuals can be reliably classified as being hypo hydrated or hyper hydrated using lower and upper quartiles, respectively. The findings suggests that hydration Status, as indexed by bioelectrical impedance technique, is reliable across time and is also reliable within individuals Who are chronically hyper hydrated or hypo hydrated.

Robert Ross, Luc Leger, Paul Martin, and Roch Roy studied Sensitivity of bioelectrical impedance to detect changes in human body composition Body mass (LBM) and percent body fat (%BF), as predicted by Bioelectrical impedance (BIA) and sum of skinfolds (SF), with those derived by hydrostatic weighing (HW) obtained before and after a lo-wk diet and exercise regimen. The findings of this study Suggest that the BIA method, by use of either the Lukaski or Segal prediction equations, is a valid means of predicting Changes in human body composition as measured by the Siri Transformation of body density.

A. S. Jackson, Michael L. Pollock, James E. Graves, and M. T. Mahar study was designed to examine the reliability and validity of the bioelectrical impedance method BIA) of measuring body composition and compare its accuracy with the results obtained by standard anthropometric methods. Results obtained were comparable to the BMI Method, with height and weight accounting for most of the Variance in the BIA equation.

METHODOLOGY

Bioelectrical Impedance method is based on the assumption that the body is a cylindrical-shaped ionic conductor in which extracellular and intracellular non-adipose tissue compartment acts as resistors and capacitors respectively.[32] Bioelectrical Analyzer uses an alternating current that enters the body at very low and safe amperage. The conductor is the water content of the body and the Bioelectrical Analyzer measures the impedance of this fluid conductor.[33]

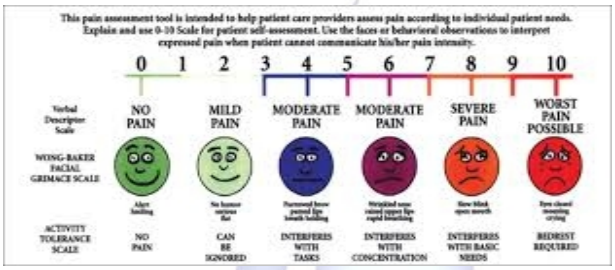
Study design and setting: An observational randomized experimental study conducted at

Multispecialty Department of Physiotherapy, Bombay Hospital-Indore.

MATERIALS

Tanita BC 418 Body Composition Analyzer, Height Chart, and Visual analog pain scale

Fig. 1: Visual analog pain scale.



Sampling:

Population: Total 100 subjects of age group 40-50 years were taken for study.

Sample Size and Sampling Criteria: Divided into Two Group (Group A Males and Group B Females) and each group consists of (50 subjects).

Inclusion Criteria for the study has 100 subjects of Age Group- 40-50 years, free from any major illness were included in the study.

Exclusion Criteria for the study has Subjects of above 50 years and below 40 years of age, with any illness or disease and Other methods of body composition analysis were excluded.

Procedure: Body composition parameters of subjects were measured using segmental Multi-frequency Bioelectrical Impedance Technology by "Tanita" machine.

Subjects should be with empty bladder and normally hydrated i.e. proper time gap should be there between measurement/analysis and meal or competition/practice.

Verbal questionnaire was utilized to evaluate the presence of any musculoskeletal pain. Severity of pain was measured using VAS scale.

Outcome measures: Height, Weight, Body fat%, Fat mass, Fat free mass/ Lean Body Mass, Body Mass Index, Basal Metabolic Rate, Right and left leg fat mass, Right and left arm fat mass, Trunk fat mass and Pain.

Variables: Independent Variables, Such as Room ergonomics, Patient psychology and emotional status, Religious, Economical status and Body composition analysis.

Dependent Variables: Such as Weight, Height, Fat mass, Fat free mass, BMR, Segmental fat mass.

RESULTS

Body composition parameters evaluated from bioelectrical impedance technique among individuals with Age=44.66 ± 3.34 (SD) yr & 45.92 ± 3.41 (SD) yr and Height=169.36 ± 5.77 (SD) cm & 154.68 ± 7.24 (SD) cm for males and females respectively were as under:

1.**Body Fat** %=26.68 ± 5.18% in males and 42.8 ± 8.17% in females

2.**TBW**%=42.04 ± 4.24% in females and 48.9 ± 4.37% in males

3.**FFM**=55.26 ± 7.20kg in males and 40.46 ± 5.77kg in females

4. **BMI**=30.34 ± 6.28 in females and 27.11± 4.81 in males

5. **BMR** =1256.64 ± 175.41kcal in females and 1573.94 ± 219.05 kcal in males.

Table 1: Mean and Standard deviation of Body composition parameters for males and females.

Body Composition Parameters	Males	Females
Age	44.66 ± 3.34	45.92 ± 3.41
Weight (kg)	77.472 ± 13.9	72.47 ± 14.5
Height (cm)	169.36 ± 5.77	154.68 ± 7.24
BF %	26.68± 5.18	42.8± 8.17
FFM(kg)	55.26± 7.20	40.46± 5.77
TBW%	48.9 ± 4.37	42.04± 4.24
BMI	27.11± 4.81	30.34± 6.28
BMR (kcal)	1573.94± 219.05	1256.64± 175.41

BF= Body Fat, FFM= Fat Free Mass,
TBW= Total Body Water, BMR= Basal Metabolic rate,
BMI= Body Mass Index.

Fig. 2: Mean Distribution of various Body Composition Parameters for Males and Females.

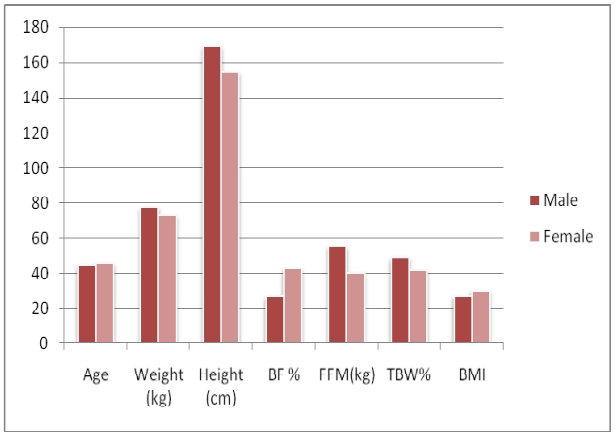
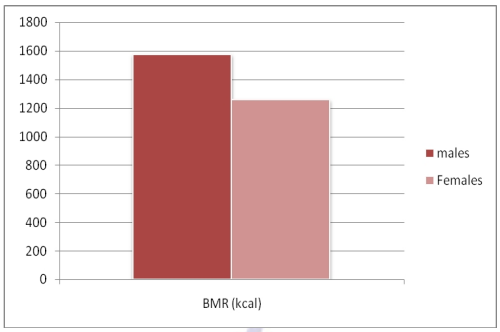


Fig. 3: Mean Distribution of BMR for Males and Females.



These results of statistical analysis showed that BF% was more and TBW% was less than the desired range among this age group suggesting that, majority of population was found to be unfit due to inappropriate body composition fitness parameters mainly Body Fat and Total Body Water. Significant results were established between musculoskeletal pain and difference in segmental Fat% distribution towards the same side, Indicating underlying musculoskeletal disorders.

DISCUSSION

The main objectives of our study were to establish the importance of Bioelectrical Impedance technology for evaluating Body Composition Parameters and creating awareness among general population regarding Body composition parameters like Body Fat (BF) %, Fat Free Mass (FFM), Total Body Water (TBW) %, BMI, Basal Metabolic rate (BMR) and segmental Fat % Distribution and Bioelectrical impedance Technology as an ideal fitness evaluator.

Enormous use of sophisticated technology in daily living has resulted in lifestyle disorders in form of obesity, hypertension, cardiac disorders and musculoskeletal problems in a community as a whole. This significant rise in physically unfit community prompted us to find a most cost-effective, simple, and reliable mode of physical fitness evaluation in form of Bioelectrical Impedance technology.

Bioelectrical Impedance Analyzer Tanita BC-418 was used for evaluation of Body Composition Parameters. The results of statistical analysis showed that BF% was more than the desired range (23-34% for females and 11-22% for males according to Tanita corporation) and TBW% was less than the desired range (55-65% of body weight according to Bern and Levy[34], Pierson et al [35]) among this age group suggesting that, majority of population was found to be unfit due to inappropriate body composition fitness parameters mainly Body Fat and Total Body Water. Bioelectrical impedance Technology proved to be an ideal fitness evaluator in our statistical result as established earlier by Mirele Savegnago M, et al [36].

Significant results were established between musculoskeletal pain and difference in segmental Fat% distribution towards the same side, Indicating underlying musculoskeletal disorders. Visual analog pain scale was applied on each Individual and it proved to be of immense significance in establishing the intensity of pain among males and females, presenting differences in unilateral or contra lateral peripheral segmental fat % distribution. These Results suggested establishment of significant relationship between musculo-skeletal pain and segmental fat % distribution among males and females as suggested earlier by many researches for further study and evidenced based analysis.

Finally our Discussion emphasizes that this study established relationship between differences in segmental body fat % distribution, which were seen among unfit individuals having musculoskeletal disorders and it was the main reason for musculoskeletal pain. Bioelectrical Impedance method helped in detecting these differences easily and thereby proved to be an important technology in analyzing Physical fitness. Musculoskeletal pain and difference in segmental Fat% distribution towards the same side, Indicated underlying musculoskeletal disorders and it was the main finding of our research and we suggest that due to void of similar studies further research should be carried out on different population with differences in age, region and nationality.

CONCLUSION

BIA has proved to be an advanced diagnostic technology for evaluating human body fitness in today's fast and rapidly advancing life style. The Body Composition parameters important in evaluating physical fitness such as Body fat%, Fat Free Mass, Total Body Water%, segmental

fat distribution can be easily evaluated with Bioelectrical Impedance technique. Differences in segmental body fat % distribution were seen among unfit individuals having musculoskeletal disorders, which caused pain. Bioelectrical Impedance method helped in detecting these differences easily. Thus, Bioelectrical Impedance method proved to be an accurate, safe and simple technology in assessing body composition parameters and thereby analyzing Physical fitness.

Conflicts of interest: None

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