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Body Composition of Young Females (20-25 years) by Bioelectrical Impedance: Relationship with Body Mass Index

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ABSTRACT

The study deals with the assessment of anthropometric measurements & body composition of young college going females (n=100), with mean age ranged between 23.10±1.42 to 24.00±1.79 years. Anthropometric indices were measured using standard procedures & equipments. Body composition was analyzed using bioelectrical impedance method. Subjects were classified on the basis of body mass index (BMI) [underweight (UW), n=25; normal (N), n=25; overweight (OW), n=25 & obese (O), n=25]. Body fat (BF), fat free mass (FFM) & total body water (TBW) increased with increase in the BMI. In contrast, impedance reduced with increment in the BMI. BF & FFM reflected positive correlations with body weight & waist hip ratio (WHR). BMI reflected positive relationship with basal metabolic rate (BMR), BF & FFM. From the results, it can be said that effect of BMI can be seen in relationship with anthropometric & body composition parameters. With increase in body weight, there found changes in body composition variables.

Keywords: *BMI, body composition, BMR, body fat, fat free mass.*

INTRODUCTION:

Body composition is the term used to describe the different components that, when taken together, make up a person's body weight. The human body is composed of a variety of different tissue types including lean tissues (muscle, bone, and organs) that are metabolically active, and fat (adipose) tissue that is not. Human body is made up of fat mass and fat-free mass. Fat-free mass includes lean muscle, bones, organs, tissue and water.

The analysis of body composition by bioelectrical impedance produces estimates of total body water (TBW), fat-free mass (FFM), and fat mass by measuring the resistance of the body as a conductor to a very small alternating electrical current. Bio Impedance Analysis (BIA) is a method of assessing body composition, the measurement of body fat in relation to lean body mass. It is an integral part of a health and nutrition assessment. Research has shown that body composition is directly related to health. A normal balance of body fat is associated with good health and longevity. Excess fat in relation to lean body mass, altered body composition, can greatly increase risks for cardiovascular disease diabetes, and more. BIA allows for early detection of an improper balance in body composition, which fosters earlier intervention and prevention. BIA also provides a measurement of fluid and body mass that can be a critical

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assessment tool for current state of health (http://www.dh.org/Bio-ElectricalImpedanceAnalysisBIA-BodyMass Analysis).

Accurate assessment of body composition is necessary in order to monitor obesity class, nutritional status, training outcomes, and general health. Measurements of body composition are important because a measure of weight alone cannot differentiate between the amount of fat-mass and fat-free mass present in the human body (Heitmann, B. L. & Garby, L., 2002). Measurements of body weight and body dimensions (anthropometry) are used to reflect body fat in large epidemiological studies or in clinics settings as such measurements provide rapid and cheap way to estimate body fatness and fat distribution. Body mass index (BMI) has traditionally been used to identify individuals who are most likely to be overweight and obese. BMI can be considered to provide the most useful, albeit crude, population level measure of obesity (Bray, G. A. et al., 2005). The degree of obesity is simply defined in most epidemiological studies by means of the BMI. BMI has now progressively replaced the concept of 'ideal body weight' since the latter had the drawback of being dependent upon reference standards of body weight and height from populations, which slowly changed from decade to decade and also varied according to which reference standard was used. The number of publications using the BMI as an index of obesity is large and it has been described in a wide variety of populations (Kuczmarski, R. J. et al., 1997 & Ferraro, K. F. & Both, T. L., 1999).

One can gain or lose body fat, fat-free mass, cellular mass components as a result of disease, overeating, sports, or under nutrition or as a result of nutritional intervention programs. These changes can only be detected by using valid body composition measurement techniques. In addition, the world-wide epidemic of obesity and its association with chronic disease has also contributed to the need to study body composition and the distribution of body components. One of the important aspects of health of individuals is their nutritional status which is defined as the result of the interaction of body composition, energy balance and body functionality. Body composition is the best long-term indicator of nutritional status.

This research is an attempt to estimate body composition of young college going females using bio-electrical impedance technique.

METHODOLOGY:

Selection of Sample & Sample Size:

In the preliminary survey, height & weight of females (20-25 years) from various educational institutes of Nagpur city (Maharashtra) were recorded. BMI was calculated using the formula: Weight (kg) ÷ Height (meter)^2(WHO, 2000). Only those females who were normal weight, underweight, overweight & obese were chosen. Under each category, sample size was fixed to 25. Total 100 females from age group 20-25 years were purposively selected based on their body mass index (BMI) (WHO, 2000).

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Anthropometric Measurements:

Besides height & weight, body circumferences like mid upper arm circumference (MUAC), waist circumference (WC), hip circumference (HC) & wrist circumference (WrC) were measured using non stretchable plastic tape & standard procedures. Based on waist & hip circumference, waist to hip ratio (WHR) of subjects was calculated using the formula: Waist Circumference ÷ Hip Circumference. Based on height & wrist circumference, body frame size (BFS) of subjects was calculated using the formula: Height (cm) ÷ Wrist Circumference (cm) (Anderson, L. et al., 1982).

Body Composition:

Body composition of subjects was analyzed using Bio-Electrical Impedance Technique using standard procedure. TANITA Body fat analyzer was used to assess body composition parameters.

Statistical Analysis:

Data was gathered, compiled & classified on the basis of BMI. Mean, standard deviation, range & percentage were calculated. Correlations were derived using Pearson's Product Moment Correlation of Coefficient. A level of significance at both 5% and 1% was tested.

RESULTS AND DISCUSSION:

No major variations were noted for age of subjects (Table 1).

Table 1: Data on Age of Subjects Classified on the Basis of BMI

BMI Class (kg/m^2)	No. of subjects (N=100)	Age (years)	
		Mean±SD	Range
Underweight (<17.5)	25	23.23±1.30	20-24
Normal (17.5-22.9)	25	23.10±1.42	21-25
Overweight (23-27.99)	25	23.45±2.42	22-25
Obese (>28)	25	24.00±1.79	24-25

Greater variations in the height of subjects were noted (Table 2). With increase in the class of BMI of subjects, body weight was also found to be increased. In comparison with ideal body weight for height, underweight subjects showed percent deficit of 41.86. In contrast, overweight & obese subjects showed percent excess as compared to IBW (20.47% & 31.85%, respectively, Table 2).

Table 2: Data on Height and Weight of Subjects

Anthropometric Indices		BMI Class (kg/m^2)			
		Underweight (n=25)	Normal (n=25)	Overweight (n=25)	Obese (n=25)
Height (cm)	Mean±SD	156.08±6.50	154.82±6.82	156.73±6.29	154.83±3.87
	Range	149-167	140-170	143-165	148-159
Weight	Mean±SD	39.53±3.63	54.49±5.77	62.77±6.75	72.27±7.62

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(kg)	Range	35.10-46.00	47.80-62.50	60.10-74.50	65.50-84.50
	IBW (kg)	56.08	54.82	56.73	54.83
	% Deficit/ Excess	- 41.86	--	20.47	31.85

Table 3: Data on Body Circumferences, Waist Hip Ratio and Body Frame Index of Subjects

Parameters (cm)		**BMI Class (kg/m^2)**			
		Underweight (n=25)	**Normal (n=25)**	**Overweight (n=25)**	**Obese (n=25)**
MUAC	Mean±SD	23.55±1.39	26.69±1.52	30.71±2.43	32.18±1.63
	Range	20.32-30.48	20.32-35.56	20.32-40.64	25.40-35.56
Waist circumference	Mean±SD	73.28±1.63	76.61±1.87	82.19±1.96	86.36±3.35
	Range	68.58-81.28	66.04-86.36	71.12-91.44	76.20-96.52
Hip circumference	Mean±SD	95.94±4.11	100.89±4.33	108.08±2.34	109.65±3.60
	Range	81.28-119.38	78.74-121.92	96.52-116.84	96.52-121.92
WHR	Mean±SD	0.76±0.07	0.76±0.06	0.76±0.03	0.79±0.05
	Range	0.64-0.88	0.63-0.88	0.73-0.82	0.71-0.86
Wrist circumference	Mean±SD	14.26±2.33	16.81±2.75	20.09±3.30	21.80±3.89
	Range	11.43-20.32	12.70-22.86	15.24-25.40	16.5125.40
Body Frame Index	Mean±SD	11.18±1.69	9.44±1.54	7.98±1.24	7.31±1.42
	Range	7.53-14.00	6.56-12.44	6.50-10.37	6.14-9.27

According to Collins et al. (2000), MUAC from 16.0 to 18.5 cm indicates moderate degree of malnutrition in adults. For the present study, none of the underweight subjects had MUAC in the range of 16.0-18.5 cm. With increase in the BMI class, there found increment in the values of MUAC of subjects. A difference of 1.24, 1.58 & 2.16 cm was noticed for MUAC values of subjects from underweight, overweight & obese categories when compared with MUAC of subjects from normal BMI class. MUAC showed positive correlation with BMI for subjects from all groups (r = 0.2014 to 0.5077, Table 5).

Waist circumference (WC) is the best indicator of visceral fat. For this study, waist & hip circumference values of subject from all BMI class showed increasing trends with the increase in the BMI class. BMI showed positive correlation with waist & hip circumference for subjects from all groups (r = 0.2318 to 0.7397, Table 5). A difference of 5.58 & 9.75 cm was noted between waist circumference of normal weight & overweight & obese subjects, respectively. As per the waist girth norms given by American College of Sports Medicine (ACSM) (https://www.acsm.org/.../measuring-and-evaluating-body-composition), underweight subjects had mean waist circumference ≤73.66 cm (i.e. excellent category) whereas normal weight subjects were found "good" as their mean waist circumference was found to be in the range of 76.20 to 81.28 cm. However, overweight & obese subjects showed mean waist circumference values above 81.28 cm & hence, were found to be in the zone of "risk". Waist circumference gives a better prediction of visceral & total fat. Waist circumference above 80 cm is considered to be dangerous (WHO, 2000).

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Over the past 10 years it has been accepted that a high WHR (> 0.85 in women) indicates abdominal fat accumulation. The high WHR has been associated with an increased risk of cardio vascular diseases and non insulin dependent diabetes mellitus. For this study, WHR of subjects from all BMI categories was found to be less than 0.80. WHR showed negative correlation with BMI for all groups of subjects (r = - 0.0607 to - 0.4660, Table 5).

Frame size is a description of the supportive structure of the skeleton that is used to adjust for skeletal mass and size in measures of body composition and weight (Chumlea, W.C. et al., 2002). An attempt was made to measure wrist circumference of subjects and to calculate body frame size (BFS) using wrist circumference and height of subjects. It was noted that lower the value of body frame index (BFI) higher is the body frame size (BFS). Obese subjects showed broader BFS as compared to subjects from underweight, normal & overweight categories. Underweight subjects had smallest BFS with BFI calculated as 11.18±1.69 followed by normal subjects (9.44±1.54). BFI showed negative correlation with BMI for all groups of subjects (r = -0.0583 to -0.5394, Table 5). Similar observations were noticed for relationship between BMI & wrist circumference. Table 4 shows data on basal metabolic rate and body composition of subjects.

Basal metabolic rate (BMR) was found to be increased with the increase in the value of BMI. BMR reflected positive correlation with BMI for subjects from all categories of BMI (r = 0.3489 to 0.8341, Table 5). Lowest value of analyzed BMI was 4881.00 kcal (for underweight) and highest value of BMR was analyzed as 6861.00 kcal (for obese) (Table 4). With increase in the BMR, there found decrease in the impedance. Obese subjects showed lower mean impedance than overweight, normal & below normal subjects. Lowest impedance value was recorded as 400 Ω & that of highest recorded as 848 Ω.

Body fat% (BF%) for subjects from underweight category was found to be less than the BF % norm given by ACSM (https://www.acsm.org/.../measuring-and-evaluating-body-composition). Minimum BF% was found to be 2.89 for underweight subject. According to ACSM norms, BF% from 21.1 to 24.00 indicates overweight & that from 24.1 to 28.00 indicates obesity. For this study, BF% of overweight subjects was recorded as 28.92±3.07 & that for obese subjects as 35.05±2.52. These values are far above the reference norms & hence, indicate higher risk. Highest BF% value was found to be 37.80 for an obese subject.

Table 4: Data on Basal Metabolic Rate and Body Composition of Subjects

Parameters		BMI Class (kg/m^2)			
		Underweight (n=25)	Normal (n=25)	Overweight (n=25)	Obese (n=25)
BMR (kcal)	Mean±SD	5078.00±180.28	5414.12±288.39	6010.27±341.36	6380.17±345.81
	Range	4881 -5400	4935-6117	5412-6561	5828-6861
Impedance (Ω)	Mean±SD	708.00±68.88	651.02±53.42	530.64±76.41	493.00±48.85
	Range	588.00-848.00	544.00-788.00	429.00-673.00	400.00-538.00
Body Fat %	Mean±SD	6.87±5.58	20.19±4.90	28.92±3.07	35.05±2.52
	Range	2.89-10.88	8.50-28.10	23.10-34.00	31.10-37.80

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Body Fat (kg)	Mean±SD	6.07±10.88	10.13±4.08	18.38±3.74	29.15±11.98
	Range	1.00-41.00	0.80-23.10	14.20-25.30	19.10-52.10
Fat Free Mass (kg)	Mean±SD	36.64±1.51	38.57±2.78	44.19±3.70	46.82±3.39
	Range	34.40-39.40	28.80-46.4	37.90-49.20	42.40-52.60
Total Body Water (kg)	Mean±SD	36.64±1.51	38.57±2.78	44.19±3.70	46.82±3.39
	Range	34.40-39.40	28.80-46.40	37.90-49.20	42.40-52.60

BF content of subjects showed positive correlation with BMI (r = 0.0640 to 0.6353, Table 5). Mean BF (kg) was found to be ranged between 6.07±10.88 to 29.15±52.10 kg. Obese subjects showed lowest quantity of fat free mass as compared to subjects from underweight, normal and overweight categories. Greater variations were noticed for the range of fat free mass for subjects.

Mean total body water (TBW) content was found to be increased with the increased level of BMI. A difference of 10.18 kg was noticed between TBW of underweight and obese subjects. Subjects from normal, overweight & obese groups showed positive correlation of BMI with TBW. Underweight group showed negative correlation between BMI & TBW.

Table 5: Correlates of BMI

Correlation Coefficient Between:	BMI Class (kg/m^2)			
	Underweight (n=25)	Normal (n=25)	Overweight (n=25)	Obese (n=25)
BMI & BMR	0.3489	0.4925	0.4834	0.8341
BMI & Body Fat	0.0640	0.5970	0.6353	0.0940
BMI & TBW	-0.6015	0.3174	0.4975	0.9120
BMI & MUAC	0.5077	0.4748	0.2682	0.2014
BMI & BFI	-0.5394	-0.3246	-0.2460	-0.0583
BMI & WrC	-0.9391	-0.9538	-0.9597	-0.9824
BMI & WC	0.6353	0.3498	0.2795	0.2592
BMI & HC	0.5900	0.2318	0.2625	0.7397
BMI & WHR	-0.3342	-0.0612	-0.0607	-0.4660

From the results of the present study, it is said that effect of BMI can be seen in relationship with anthropometric & body composition parameters. With increase in body weight, there found changes in body composition variables.

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