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BODY COMPOSITION MEASURES OF OVERWEIGHT AND OBESE ADULT FEMALES OF 20 – 24 YEARS AGE

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ABSTRACT

In urban areas of India, Obesity is becoming an important public health problem. The rising prevalence of obesity and overweight is also related to the associated disorders like dyslipdemia, hypertension, type II diabetes mellitus and cardiovascular diseases. Not many studies are available on the association between body composition measures and anthropometry among overweight and obese young adult females. Hence was the need for the present study. The study aimed at assessing the incidence of overweight and obesity among young adult females (20 – 24 years), determining the body composition and finding the association between body composition measures, anthropometry and energy balance. Around 400 young adults (20-24 years) from Coimbatore district were screened for overweight; obesity and underweight based on body mass index and forty five subjects, fifteen from each BMI category were chosen for the study. Their background information and life style pattern was recorded by an interview schedule and nutritional status was assessed using the biochemical profile (blood profile, glucose, and lipid profile), clinical examination and diet survey. Body composition measures were done using Biospace Inbody – 720 - body composition analyzer using BIA principle. Results showed that all the body composition

parameters were found to be higher in obese subjects when compared to that of normal and overweight individuals. Visceral fat area was above normal in obese and fat free mass, total body water and protein were deficit in normal subjects. The study showed association between body composition, biochemical parameters, energy balance and anthropometry.

Keywords: body composition, visceral fat area, fat free mass, total body water

INTRODUCTION

Adults are individuals who have completed their growth and are ready to assume their status and responsibilities in society. Psychologists generally consider early adulthood to begin around age 20 and last until about age 40 to 45, and middle adulthood to last from about age 40 to 45 to around 65 (Bhatt, 2007). Adults include a broader age range and all those in 20 to 64 yr (WHO, 1998). Individuals in the age group of 20 - 24 year are also referred to as young adults (Jekielek and Brown, 2002). As per WHO, Obesity leads to changes in physical, psychological and social implications and thereby cause a risk in morbid mortality rates and exposing individuals to chronic life style related disorders.

The prevalence of obesity in India is 16.0 percent in women and 12.1 percent in men (NFHS, 2006). In Tamil Nadu, the prevalence of obesity among the age group 20- 29 years is 19.4 percent in women and 9.5 percent in men (NFHS, 2007). The major determinants of epidemiology responsible for obesity are dietary fat intake, exercise and energy expenditure, smoking and alcoholism. The measurement of BMI based on height does not differentiate fat and lean body mass. Further the distribution of fat in the body is not assessed. Whereas in the determination of body composition, the total body weight contributed by bone, muscle, fat and other tissues are considered. The recent methods introduced are dual X-ray Absorptiometry (DEX A), Magnetic Resonance Imaging (MRI) or Computed Tomography (CT), Bio Electrical Impedance (BIA) distinguish fat depots from nonfat body mass (Visser, 2009). Body composition is a key element in determining energy expenditure (Insel *et al.*, 2003). Body composition gains importance in term of correlating the adipocity with degenerative disorders. In India, data on body composition measures among different age groups of population are not available. Hence, there is an urgent need to collect data on measures of body composition of different age groups of Indians. Towards achieving this goal, the present study was an effort to measure body composition among adults especially to compare the body

composition of normal, overweight and obese adult females (20 – 24 years). The specific objectives of the study were to:

- Assess the incidence of overweight and obesity among adults aged 20 – 24 years
- Assess the nutritional status of the selected adults
- Assess the body composition measures of the selected adults
- Find the association between anthropometric measures, energy balance and body composition

MATERIALS AND METHODS

1. Selection of the Study Area and Subjects

The area chosen for the study was Coimbatore district. For the conduct of the study, 400 female subjects in the age group of 20-24 years were selected from different taluks of Coimbatore. Based on their willingness to participate in the study, informed consent was obtained from the subjects before the conduct of the in-depth body composition studies.

2. Formulation of Interview Schedule for Data Collection

The interview method of collecting data involves presentation of oral – verbal stimuli and reply in terms of oral – verbal responses (Kothari, 2011). A specially designed interview schedule was used by the investigator to collect information on socio – economic background, health history, life style pattern and dietary pattern of selected individuals.

3. Assessment of Nutritional Status of Selected Subjects

Nutritional assessment involves interpretation of data from the nutritional screen and incorporates additional information. The nutrition assessment organizes and evaluates the information gathered to make a professional judgment about nutritional status (ASPEN, 2002). In the present study, the nutritional status of the subjects was from anthropometric measurements, biochemical estimation, dietary recall method, and body composition measures.

3. a. Anthropometric Measurements

To evaluate the nutritional status of children and adults, it is important to determine the measurements of anthropometry. Anthropometric measurements have become an indispensable approach for the evaluation of nutritional status of children and adults. It is a simple, inexpensive and safe method. Height, Weight and Body Mass Index of all the 400 subjects was determined.

3.a.i. Height: The subject was allowed to stand in stadiometer with his/her back and heel against the height scale, the head being in horizontal plane and person stand erect in position.

3.a.ii. Weight: Body weight is the most widely used and the simplest reproducible anthropometric measurement used to assess the nutritional status. This actually is one of the indicators of one's individual's health. A digital platform weighing scale was used for the measurement of the weight. The balance was adjusted to zero and the reading noted when the subject was standing barefoot and erect on the machine to the nearest 0.1 kg. The balance was checked for accuracy against standard weights.

3.a.iii. Body Mass Index (BMI): Body Mass Index (BMI) also called Quetlet Index. The body composition may be estimated by measuring one's weight to height to lean body mass that correlates an individual's weight and height to lean body mass obtained by dividing weight in kilograms by height in meters squared.

$$\text{BMI} = \frac{\text{Weight (kg)}}{\text{Height in m}^2}$$

Forty five girls were selected for the conduct of the study based on their body mass indices. They were selected in such a way that one group consisted of fifteen girls with BMI normal (BMI – 18.5 – 23.0, according to WHO standard for Asian – Pacific Population), second group of fifteen girls whose BMI was overweight (BMI – 23.1 – 26.9, according to WHO standard for Asian – Pacific Population) and the last group of fifteen girls whose BMI was obese (BMI - $\geq$ 27, according to WHO standard for Asian – Pacific Population).

3.b. Biochemical Tests

Biochemical tests are the most objective and sensitive measures of nutritional status. The hematological parameters namely hemoglobin (Cyanmethemoglobin

method), blood glucose (GOD – PAP method), total cholesterol (CHOD – PAP enzymatic colorimetric method), serum triglycerides (GPO – PAP method) and HDL cholesterol (Direct enzymatic colorimetric method) were analyzed. The VLDL cholesterol and LDL cholesterol were calculated using the desired formulae. Using ICMR (1989) clinical assessment proforma, clinical examination was done with the help of a medical practitioner.

3.c. Clinical Assessment

Careful observations of physical signs of nutritional status provide an important added dimension to the overall assessment of the individuals (Robert and Williams, 2000). Using ICMR (1989) clinical assessment proforma, clinical examination was done with the help of a medical practitioner and the deficiency signs and symptoms of the selected adolescents were recorded.

3.d. Food and Nutrient Intake

24 hour recall method was used to obtain details regarding the food intake of the selected individuals. The nutrient intake was calculated for individuals using the 'Nutritive Value of Indian Foods' (ICMR) and compared with Recommended Dietary Allowances (ICMR, 2010).

3.e. Body Composition Measures

Nutritional assessment using anthropometry is now increasingly augmented through additional measurement of BIA. The technique of BIA is based on properties of electrical conductivity using sensors to predict body composition (Shils *et al.*, 2006). In terms of health risk, body composition is more important than body weight (Insel, 2003). Body composition was determined using Bioelectrical Impedance Analysis (BIA) with Inbody – 720 (USA), a four compartment model.

BIA is based on the concept that electrical f low is facilitated through hydrated fat free body tissues and extracellular water compared to fat tissue because of the greater electrolyte content (and, thus, lower electrical resistance) of the fat – free component. Once the resistance exists, the current f low is measured which is directly related to the amount of fat in the body. (Mcardle *et al.*, 2007). BIA is recorded at five segments namely left arm, right arm., trunk, right leg and left leg and measured at six different frequencies namely *1 kHz,115 kHz, 50 kHz, 250*

kHz, 500 kHz, 1000 kHz. It was ensured that the subjects were well hydrated and had not carried out any physical exercise in the previous four to six hours. The subjects were asked to present themselves early daylight without food and water consumption for measuring their body composition. The subject was then asked to stand on the analyzer by adjusting her foot in such a way that they are placed correctly on the two electrodes provided near the feet and the weight was recorded. The subjects name, age, height and gender were entered by the user. Two electrodes were provided for the left and the right arm. The subject was asked to hold the electrodes by placing the thumb and the four fingers in the space provided and the subject was asked to stand motionless till the test is done. The four main body components measured in the analyser are total body water, protein, fat and mineral mass. Other parameters measured include skeletal muscle mass, percent body fat, waist hip ratio, lean balance, visceral fat area, arm circumference, arm muscle circumference, Degree of obesity, mineral content in bone, body cell mass, basal metabolic rate ratio to ECF to TBF.

4.a. Computation of Energy Balance

A balance exists between nutrient intake which regulates body weight and in the energy balance maintenance, the intake of nutrients and energy expenditure are regulated and related in the formula:

$\Delta E = Ein - Eout$ (Eastwood, 2003)

4.b. Total Energy Expenditure (TEE)

For arriving at the factorial calculations to estimate total energy expenditure, the time line of activities followed by an individual in a day should be recorded. A BMR multiple is used to calculate the energy cost of activities followed by the individual in a day. BMR multiple per minute is also referred to 24 hour energy requirements using physical activity level:

PAR = Energy cost of an individual activity per minute

= Energy cost of BMR per minute

PAL (for the day) = Total PAR hours / Total time

TEE (24 hr) = Predicted BMR × PAL

The PAL values proposed by ICMR expert group (2010) was used for

calculation of PAL of individuals, sedentary or light activity lifestyle - 1.53, active or moderately active lifestyle - 1.8, vigorous or vigorously active lifestyle - 2.3.

5. Statistical Analysis and Interpretation of Data

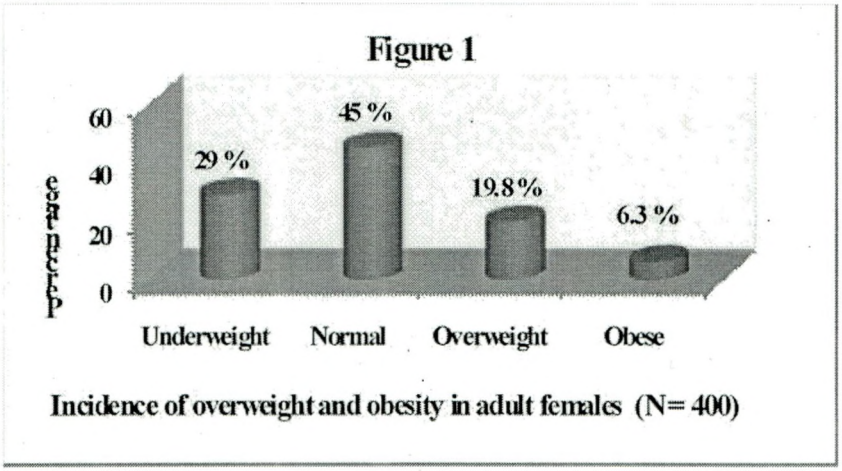
The data was consolidated and tabulated in which mean, standard deviation and percentage were computed. The data was analyzed using the software SPSS version 16.0. Comparisons were made between various parameters of three groups using Student's t-test. Correlation between anthropometric measurements, body composition parameters, and biochemical parameters were derived using Karl Pearson's co–efficient of correlation. Probability at both 0.05 and 0.01 levels of significance was considered to draw conclusions.

RESULTS

1. Incidence of Overweight and Obesity

A total of 400 girls in the age group of 20 to 24 years were screened for the prevalence of overweight and obesity using anthropometric measures like height, weight and BMI as parameters. The results are presented Figure 1.

Figure 1
INCIDENCE OF OVERWEIGHT AND OBESITY IN ADULT FEMALES
(N=400)



2. Health History of the Subjects

Table I provides the health history of the selected adults.

Table I
HEALTH HISTORY OF THE SELECTED ADULTS

(N=45)

Details	Normal (n = 15)	Overweight (n = 15)	Obese (n = 15)	Total (n = 45)
	No.	No.	No.	No.
Recent Illness*				
Diarrhoea	2	0	1	3
Fever	4	2	4	10
Dysentery	1	0	1	2
Jaundice	1	0	0	1
Common Cold	12	7	9	28
Typhoid	2	0	0	2
Food Poisoning	1	0	2	3
No Recent Illness	4	2	3	9
Age Of Menarche				
12 Years	5	2	9	16
13 Years	4	11	3	18
14 Years	1	1	2	4
15 Years	5	1	1	7
Problems In Menstrual Cycle*				
Excessive Bleeding	3	1	2	6
Irregularities Physical	6	3	7	16
Discomfort Other	6	3	3	12
Problem	0	1	4	5

*Multiple responses

Common cold was more common among overweight (46.7 percent) and obese (60 percent) subjects, whereas fever was seen in all the three groups.

Among the forty five selected adult females, a majority of them were in the age of 13 years at the start of their menstrual cycle. The onset of puberty for nine of the obese subjects was at the age of 12 years. Three of forty five girls said they had excessive bleeding. Sixteen subjects from all the three groups complained about irregularities in menstruation. Twelve subjects said that they had physical discomfort during menstrual cycle. Problems like poly cystic ovarian syndrome (PCOS), thyroid hormone level changes were seen among 26.7 percent of obese subjects'.

3. Lifestyle Pattern of the Selected Subjects

Data on lifestyle pattern adopted by the selected subjects is shown in Table II.

Table II
LIFESTYLE PATTERN ADOPTED BY THE SELECTED SUBJECTS
(N = 45)

Details	Normal (n = 15)	Overweight (n = 15)	Obese (n = 15)	Total (n = 45)
	No.	No.	No.	No.
Mode of Travel				
By Walk	13	10	3	26
By Bus	0	0	5	5
Others	2	5	7	14
Hours of Sleep Per Day				
< 6 Hours	2	1	2	5
6 – 8 Hours	11	13	13	37
>8 Hours	2	1	0	3
Habit of Snacking				
Yes	14	12	12	38
No	1	3	3	7
Television Viewing, Hours/ Day				
1 Hour	8	10	8	26
2 Hours	3	2	0	5
>2 Hours	4	3	7	14
Regular Exercise				
Yes	2	2	5	9
No	13	13	10	36

From the above Table, it is seen that 26 of them travelled to college / work by walk, 5 of them by bus and 14 of them by other means of travel. Around five subjects slept less than six hours a day, 37 subjects slept for 6-8 hours a day and three of them slept for more than eight hours a day. Thirty eight of the selected individuals had the habit of snacking. This included junk foods, carbonated beverages and healthy foods.

Fourteen subjects watch television more than two hours, five subjects for two hours a day and twenty six subjects for one hour a day. The results showed physical activities did influence change in BMI. It is seen that among the obese subjects only 10 subjects exercise regularly whereas the rest five subjects do not exercise at all.

4. Dietary Pattern of the Selected Subjects

Table III provides the dietary pattern data of the selected adult females.

Table III
DIETARY PATTERN OF ADULT FEMALES

(N=45)

Details	Normal (n = 15)	Overweight (n = 15)	Obese (n = 15)	Total (n = 45)
	No.	No.	No.	No.
Vegetarian	2	1	6	9
Non-vegetarian	12	14	7	33
Ova-vegetarian	1	0	2	3

From the above table, it is seen that 33 subjects were non – vegetarians, 9 subjects were vegetarians and 3 subjects were ova vegetarians.

5. Assessment of Anthropometric Parameters

Data on mean and standard deviation of body measurements of subjects based on their BMI categories is shown in Table IV.

Table IV
ANTHROPOMETRIC PARAMETERS OF THE SELECTED NORMAL, OVERWEIGHT AND OBESE SUBJECTS

Parameters	Standard*	Normal (18.5 – 22.9) (n=15)	Overweight (23 – 26.9) (n=15)	Obese (≥ 27) (n=15)
Height (cm)	160.7	158.35 ± 2.77	157.65 ± 7.05	157.78 ± 6.66
Weight (kg)	56.7	53.05 ± 3.86	64.63 ± 6.12	78.69 ± 7.96
BMI (kg/m^2)	21.2	21.12 ± 1.09	25.93 ± 1.19	31.64 ± 3.15
Waist Hip Ratio	0.70 – 0.80	0.80 ± 0.01	0.85 ± 0.02	0.88 ± 0.04
AC (cm)	22.6	27.08 ± 1.01	31.05 ± 0.91	34.85 ± 2.32
AMC (cm)	18.8	20.93 ± 0.65	22.89 ± 0.82	25.03 ± 1.07

*NNMB Standards, 2002

The standard height for the age group 18 – 24 years was found to be 160.7 cm. The mean height of normal (158.4cm), overweight (157.7 cm) and obese (157.8 cm) was found to be lesser than that of the standard. Mean weight of

the normal was found to be 53.05kg, that of overweight was 64.63kg and that of obese was 78.69kg.

The BMI is an indicator of overweight and obesity. The BMI of overweight and obese subjects was greater than the standard BMI whereas the normal subjects lie within the normal value. Arm circumference and arm muscle circumference were also seen to be higher with obese when compared to normal or overweight.

6. Assessment of Biochemical Parameters

The various biochemical profiles of the subjects are shown in Table V.

Table V
BIOCHEMICAL PARAMETERS OF THE SELECTED NORMAL, OVERWEIGHT AND OBESE SUBJECTS

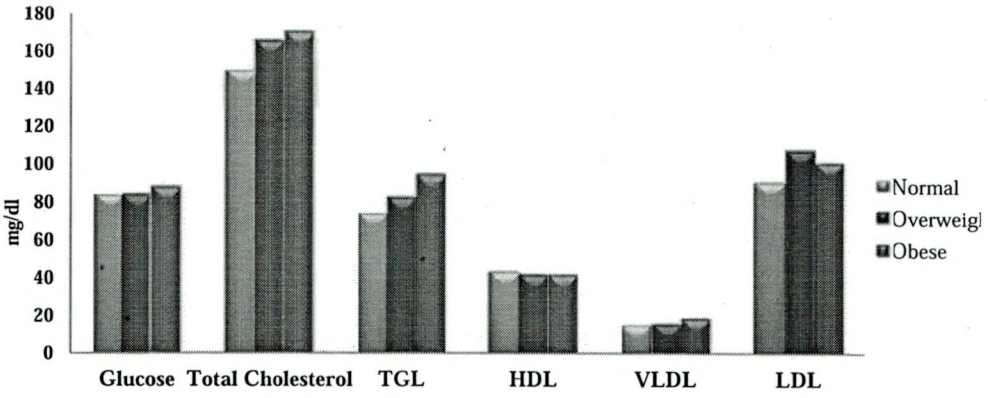
(N=45)

Parameters	Standard	Normal (n = 15)	Overweight (n = 15)	Obese (n = 15)
Blood Hemoglobin (g/dl)	12 – 13	13.33 ± 1.09	12.98 ± 0.58	12.31 ± 1.15
Glucose (mg/dl)	74 – 105	83.87 ± 15.65	84.66 ± 13.33	88.02 ± 5.58
Total Cholesterol (mg/dl)	<200	149.47 ±12.27	165.73 ± 21.04	170 ± 13.89
Triglycerides (mg/dl)	50 -150	74.4 ± 19.43	82.8 ± 16.96	94.53 ± 30.64
High – Density lipoprotein(mg/dl)	>45	42.6 ± 9.81	42.07 ±9.32	41.93 ± 11.43
Very Low – Density Lipoprotein	<40	14.87 ± 3.86-	16.07 ± 3.60	19 ± 6.25
Low – Density Lipoprotein (mg/dl)	<100	90.67 ± 14.52	107.6 ± 23.97	100.93 ± 18.98

The mean blood hemoglobin level was found to be higher in normal subjects and the least in obese girls. The normal hemoglobin level for adult female is 12 – 13 g/dl. Most of the girls had normal hemoglobin levels and were not anemic, the range being 12.24 – 14.42 g/dl. The overweight subjects were within the range of 12.4 – 13.56g/dl and obese subjects were within the range 11.16 -13.46 g/dl. Few girls were found to be mildly anemic among the obese group. The levels were high in obese subjects when compared to those of normal or overweight. All the forty five subjects including the obese fall under the normal range in both lipid profile and glucose level.

Figure 2
BIOCHEMICAL PARAMETERS OF THE SELECTED SUBJECTS

Figure 2



7. Clinical Assessment of the Selected Subjects

Table VI presents the data on clinical signs and symptoms of the selected individuals.

Table VI
CLINICAL SIGNS AND SYMPTOMS OF THE SELECTED SUBJECTS

(N=45)

Symptoms	Normal	Overweight	Obese
Healthy	6	5	5
Easily Plucked Hair	2	1	1
Rough and Dry Skin	0	1	2
Edema	0	0	2
Lethargy	0	0	3
Mild Anemia	4	2	7

Six girls from normal and five girls from both obese and overweight were free from all deficiency symptoms. Four girls from the forty five subjects had easily pluck - able hair. Three girls had rough and dry skin. Edema was not

seen among normal or overweight subjects but 2 obese subjects had edema. Similarly no normal or overweight showed signs of lethargy but three obese subjects showed lethargy. Thirteen subjects showed symptoms of mild anemia. No signs of dental carries were seen.

8. Dietary Pattern of the Selected Individuals

a. Mean Nutrient Intake of the Selected Subjects

Mean nutrient intake of the selected individuals are presented in Table VII.

Table VII
MEAN NUTRIENT INTAKE

(N = 45)

Nutrient	RDA*	Normal (n = 15)	Overweight (n = 15)	Obese (n = 15)
Protein	55	29.02 ± 8.62	39.65 ± 14.91	42.98 ± 10.96
Fat	20	22.42 ± 7.95	25.42 ± 9.18	31.82 ± 7.40
Energy	1900	1890 ± 67.42	2073± 111.59	2224 ± 98.79
Calcium	600	331.47 ± 76.91	382.32 ± 140.54	355.10 ± 150.25
Iron	21	7.11 ± 4.18	9.84 ± 5.66	7.17 ± 4.27

*RDA, ICMR, 2010

From the above table it is seen that the obese subjects consumed protein and fat at a higher level when compared to the normal or overweight subjects and therefore the mean energy intake by obese subjects was higher compared to the rest.

9. Body Composition Measures of the Selected Subjects

The mean of the various body composition measures are given in Table VIII.

Table VIII
BODY COMPOSITION PARAMETERS OF THE SELECTED NORMAL, OVERWEIGHT AND OBESE SUBJECTS

(N=45)

Parameters	Standard	Normal (n=15)	Overweight (n=15)	Obese (n=15)
Body Fat Mass (kg)	10.5 – 16.8	18.13 ± 2.87	26.89 ± 3.59	36.89 ± 6.02

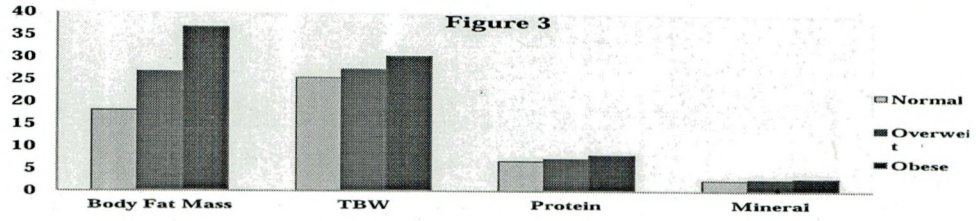
Percent Body Fat (%)	18 – 28	34.05 ± 8.78	41.69 ± 4.78	46.68 ± 4.08
Fat Free Mass (kg)	36.2 – 44.5	34.90 ± 2.24	37.73 ± 5.17	41.81 ± 4.01
Total Body Water (l)	26.5 – 32.7	25.51 ± 1.66	27.55 ± 3.76	30.59 ± 2.90
Intra Cellular Water	16.3 – 20.3	15.81 ± 1.02	17.09 ± 2.32	18.96 ± 1.78
Extra Cellular	10.2 – 12.4	9.7 ± 0.66	10.48 ± 1.44	11.63 ± 1.15
Protein (kg)	7.2 – 8.8	6.85 ± 0.43	7.4 ± 0.10	8.21 ± 0.77
SMM (kg)	19.9 – 24.3	18.64 ± 1.32	20.29 ± 3.03	22.71 ± 2.34
Mineral (kg)	2.5 – 3.0	2.55 ± 0.17	2.79 ± 0.42	3.02 ± 0.36
BMC (kg)	2.0 – 2.5	2.13 ± 0.14	2.34 ± 0.36	2.52 ± 0.31
Body Cell Mass (kg)	23.8 – 29.1	22.67 ± 1.45	24.48 ± 3.35	27.15 ± 2.55
Visceral Fat	<100	54.35 ± 9.32	87.87 ± 12.30	119.1 ± 22.56
ECF/TBF	0.36 – 0.39	0.333 ± 0.004	0.333 ± 0.003	0.334 ± 0.006
ECW/TBW	0.31 – 0.34	0.380 ± 0.004	0.380 ± 0.003	0.380 ± 0.006

*Reference range as per In Body composition analyzes data for normal subjects.

The normal range for total body fat content is said to be 10.5 to 16.8 kg for adult females. From the findings, it is seen that the body fat mass of normal (18.13 kg), overweight (26.89kg) and obese (36.89kg) vary largely. The normal subjects were close to the reference value, whereas the overweight and obese subjects had a fat content way beyond the reference value. Normal, overweight and obese subjects were found to have a total body water of 25.51, 27.55 and 30.59 respectively. The water content of normal subjects was found to be less than the normal range (26.5 – 32.7 l) whereas the obese and overweight subjects were within this range. The protein content of overweight and obese subjects were found to be within the normal range but the normal subjects had a mean protein level less than the normal range which directly reflected on the skeletal muscle mass which showed similar results. Minerals were found to be within the normal range in all the forty five adult females likewise the bone mineral content was also found to be within the normal range. The body cell mass was found to be below the normal range in normal subjects and was found to be normal in overweight and obese subject.

Figure 3 shows the body composition parameters such as body fat mass, total body water, protein, mineral of the selected individuals.

Figure 3
BODY COMPOSITION PARAMETERS OF THE SELECTED INDIVIDUALS



The association between anthropometric and body composition parameters of normal overweight and obese subjects are given in Table IX.

Table IX
CORRELATION BETWEEN ANTHROPOMETRIC AND BODY COMPOSITION PARAMETERS OF NORMAL OVERWEIGHT AND OBESE SUBJECTS

Parameters	BMI		
	18.5 – 23.0 Normal (n=15)	23.0 - 26.9 Overweight (n=15)	≥ 27.0 Obese (n=15)
Weight vs. BFM	0.816**	0.533*	0.871**
Weight vs. %BF	0.551*	-0.180^{NS}	0.468^{NS}
Weight vs. FFM	0.673**	0.811**	0.681**
Weight vs. TBW	0.674**	0.810**	0.683**
Weight vs. Protein	0.654**	0.799**	0.652**
Weight vs. SMM	0.654**	0.803**	0.656**
Weight vs. Mineral	0.717**	0.833**	0.686**
Weight vs. VFA	0.763**	0.536*	0.828**
Weight vs. BCM	0.658**	0.804**	0.654**
BMI vs. BFM	0.915**	0.799**	0.845**
BMI vs. %BF	0.767**	0.621*	0.821**
BMI vs. FFM	0.366**	0.088^{NS}	0.004 ^{NS}
BMI vs. TBW	0.365**	-0.086^{NS}	0.015 ^{NS}
BMI vs. VFA	0.909**	0.793**	0.893**
BMI vs. Protein	0.365**	-0.084^{NS}	0.006 ^{NS}
BMI vs. Mineral	0.415^{NS}	-0.103^{NS}	-0.067 ^{NS}
BMI vs. BCM	0.362^{NS}	-0.085^{NS}	0.006 ^{NS}

WHR vs. BFM	0.607*	0.408NS	0.503 NS
WHR vs. %BF	0.523*	0.709**	0.680**
WHR vs. FFM	0.235NS	-0.639*	-0.328 NS
WHR vs. VFA	0.747**	0.464NS	0.625*
WHR vs. Protein	0.270NS	-0.633*	-0.298 NS
AC vs. Protein	0.449 NS	0.236NS	0.141 NS
AC vs. SMM	0.435 NS	0.237NS	0.136 NS
AC vs. FFM	0.423 NS	0.228NS	0.091 NS
AC vs. BFM	0.767**	0.670**	0.677**
AC vs. Mineral	0.412NS	0.217NS	-0.073 NS
AMC vs. Protein	0.792**	0.791**	0.477 NS
AMC vs. SMM	0.784**	0.790**	0.473 NS
AMC vs. FFM	0.774**	0.790**	0.437 NS
AMC vs. BFM	0.522*	0.329NS	0.573*
AMC vs. Mineral	0.704**	0.738**	0.242 NS

** Significant at 1 percent level * Significant at 5 percent level NS Not Significant

a) Weight and Body Composition Parameters

Weight when correlated with body composition parameters like FFM, TBW, protein, SMM, mineral and BCM showed a one percent significance an all the three groups. This shows that weight is directly proportional to FFM, TBW, protein, SMM, mineral and BCM. When correlated with BFM weight showed one percent significance in normal (r = 0.81) and obese (r =0.87) subjects and five percent significance in overweight (r = 0.53) subjects. Percent body fat and weight when correlated showed five percent significance in normal subjects and no significance was found in overweight and obese subjects. With VFA one percent significance is seen in normal (r = 0.76) and obese (r = 0.83) subjects, and a five percent significance is seen in overweight (r = 0.54) subjects.

b) BMI and Body Composition Parameters

BMI correlated with BFM and VFA was found to have one percent significance in all the three groups. The body fat mass and visceral fat area had a positive correlation with BMI. As the degree of obesity increases the body fat content is found to increase greatly. BMI with PBF was found to have one percent significance in normal (r = 0.77) and obese (r = 0.82) subjects and five percent significance in overweight (r = 0.62) subjects. FFM was not significant in overweight and obese subjects when correlated with BMI, but significance at one percent level was seen in normal subjects. Similar results were seen with

TBW and protein with BMI. BMI correlated with minerals was not found to be significant in all the three groups.

c) WHR and Body Composition Parameters

WHR correlated with BFM showed five percent significance in normal ($r = 0.61$) subjects and no significance was seen in overweight and obese subjects. With percent body fat, WHR ration showed a high positive correlation ($p<0.01$) in overweight and obese and five percent significant in normal subjects. FFM and protein when correlated with WHR was not found to be significant in normal and obese subjects but a negative correlation at five percent level is seen in overweight subjects. WHR with VFA correlation was not found to be significant in overweight subjects but had significant correlation with normal ($p<0.01$; $r = 0.75$) and obese ($p<0.05$; $r = 0.63$) subjects.

d) AC and Body Composition Parameters

AC when correlated with protein, SMM, FFM and mineral was not found to be significant in all the three groups. AC correlated with BFM showed a high positive significance ($p<0.01$) in normal ($r = 0.77$), overweight ($r = 0.67$) and obese ($r = 0.68$) subjects.

e) AMC and Body Composition Parameters

AMC when correlated with protein, SMM and FFM showed a high positive correlation in normal ($p<0.01$) and overweight ($p<0.01$) subjects and was not found to be significant in obese subjects. AMC and BFM was not found to be significant in overweight subjects where as one percent significance is seen in normal ($r = 0.52$) and obese ($r = 0.57$) subjects. AMC with minerals showed one percent significance in normal ($r = 0.70$) and overweight subjects ($r = 0.78$) and was not found to be significant in obese subjects.

Table X shows the data on correlation within body composition parameters in the selected subjects.

Table X
CORRELATION WITHIN BODY COMPOSITION PARAMETERS AMONG NORMAL, OVERWEIGHT AND OBESE SUBJECTS

Parameters	BMI Category		
	18.5 – 23.0 Normal (n=15)	23.0 - 26.9 Overweight (n=15)	≥ 27.0 Obese (n=15)
BFM vs. %BF	0.931**	0.734**	0.839**
BFM vs. FFM	0.122 NS	-0.063 NS	0.234 NS
BFM vs. TBW	0.123 NS	-0.064 NS	0.236 NS
BFM vs. Protein	0.103 NS	-0.082 NS	0.200 NS
BFM vs. Mineral	0.208NS	-0.040 NS	0.270 NS
BFM vs. VFA	0.908**	0.946**	0.976**
FFM vs. Protein	0.990**	0.998**	0.993**
FFM vs. TBW	1.000**	1.000**	1.000**
FFM vs. SMM	0.995**	0.999**	0.994**
FFM vs. Mineral	0.964**	0.985**	0.995**
TBW vs. ICW	0.995**	0.999**	0.994**
TBW vs. ECW	0.987**	0.998**	0.989**
Protein vs. SMM	0.998**	1.000**	1.000**
Mineral vs. BMC	0.999**	0.999**	0.999**

** Significant at 1 percent level NS Not Significant

Body fat mass was found to be highly correlated with percent body fat (r = 0.93 for normal; r = 0.73 for overweight and r = 0.84 for obese) in all the three groups. No significant correlation was seen between BFM and FFM, TBW, protein, mineral in all the three groups. The BFM when correlated with VFA showed a high positive significance ($p<0.01$). FFM was correlated with protein, TBW, SMM and mineral which showed a high positive significance ($p<0.01$) in normal, overweight and obese subjects. TBW when correlated with ICW and ECW showed one percent significance in all the three groups. Protein correlated with SMM and mineral correlated with BMC showed one percent significance in the three groups.

10. Energy Balance of the Selected Adults

From the data collected, BMR was calculated using the prediction equation and the mean BMR for normal, overweight and obese was found to be 1214, 1376 and 1573 respectively. The total energy expenditure was calculated using their physical activity expenditure and BMR.

Table XI presents the energy balance data of the selected individuals.

Table XI
MEAN ENERGY BALANCE OF THE SELECTED INDIVIDUALS

(N=45)

BMI Category	Energy Intake (kcal)	Energy expenditure	Energy balance (Kcal)
Normal	1867 ± 59	1809 ± 38	57 ± 68
Overweight	2038 ± 70	1830 ± 60	209 ± 90
Obese	2214 ± 69	1691 ± 68	523 ± 109

Positive energy balance was seen among the overweight and the obese subjects which indicate that their energy intake is greater than their energy expenditure.

DISCUSSIONS

The results were similar to a study conducted by Chhabra *et al.* (2007) in New Delhi which showed the prevalence to be 24.8 percent among underweight, 19.4 percent among overweight, and 6.1 percent among obese. The remaining 45 percent were normal. The incidence of overweight and obesity was found to be more among 400 subjects.

The onset of puberty for 60 percent of the obese subjects was at the age of 12 years. Girls who reach sexual maturation early are more likely to become overweight or obese than girls who do not mature until later. Age and stage of sexual maturation are associated with body fat and overall weight (Staci, 2009). In the present study, body weight was found to be directly proportional to BMI. Also, greater variations in body weight were noticed in subjects with normal BMI and the other two groups. There is significant difference between the overweight and obesity. Similar findings were shown in a study conducted by Nande *et al.* (2009) in adult women.

The normal range for total body fat content is said to be 10.5 to 16.8 kg for adult females. From the findings, it is seen that the body fat mass of normal (18.13 kg), overweight (26.89kg) and obese (36.89kg) vary largely. The normal subjects were close to the reference value, whereas the overweight and obese subjects had a fat content way beyond the reference value. This indicates that a major portion of weight for the obese subjects was their fat content. The body fat mass, percent body fat, visceral fat area was found to increase with increase

in the degree of obesity. Similar result was given by Nande *et al.* (2009) with a study on body composition of adult women. These results indicated that each group differed significantly from each other for BF content.

From the foregoing results and discussion, it is evident that the incidence of overweight and obesity among the selected adult female subjects were 19.7 percent and 6.3 percent respectively. The anthropometric measurements and body composition measures showed significantly higher values among the overweight and obese adult female subjects when compared to their normal counterparts. Though the normal subjects had a normal BMI, their body composition measures especially percentage body fat and WHR were above the standard. Similarly the biochemical values though within normal levels in all the three groups, the values were higher in overweight and obese groups. Thus there existed an association between energy balance, body composition and anthropometry.

SUMMARY AND CONCLUSION

The study shows that the incidence of obesity to be around 6 percent. With regard to anthropometric measurements the obese subjects had a greater WHR, arm circumference and arm muscle circumference (25.03 cm) than the overweight and normal subjects. On comparing all the 45 subjects, mild anemia was found to be observed among the obese subjects. Oedema was found to be in few of the obese subjects. The mean nutrient intake of the obese subjects showed that they had a deficit intake of protein, calcium and iron, but excess intake of fat and energy was noted. All the body composition parameters were found to be higher in obese subjects when compared to that of the normal and overweight. The VFA was found to be normal in both overweight and normal subjects, but was found to go beyond the normal value in obese subjects. Fat free mass, TBW, protein and mineral content were found to be deficit in normal subjects but considerably normal in overweight subjects and normal in obese subjects. Weight showed a positive and significant difference with FFM, TBW, Protein, SMM, Mineral, VFA, and BCM in all the three subjects. BMI showed a high significance with all the measures in normal subjects but a less significant data with overweight and obese. All the biochemical parameters when correlated with the body composition measures was not found to be significant. The energy intake of three group of subjects showed significant difference. A high positive and significant difference ($p<0.01$) was seen among all the three groups for energy intake,

energy expenditure and energy balance. The highest difference was seen between the normal and obese (t = 14.317) energy intake, expenditure (t = 5.726) and energy balance (t = 13.465). The study showed that there was a positive energy balance in overweight and obese subjects and there existed a significant difference in the energy balance among the three groups. Further studies on larger sample size are recommended.

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