National (3)

(10)

Ind. J. Nutr. Dietet., 2012, 49, 1

BODY COMPOSITION OF OVERWEIGHT AND OBESE ADOLESCENT GIRLS (15 – 19 YEARS)

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(Received 11th November, 2011)

Introduction

Adolescence is the period of transition between childhood and adulthood that involves biological, cognitive and socio – emotional changes. WHO defines "adolescents" as individuals in the 10 to 19 years age group. The most important predictor of adult obesity appears to be adolescent weight and changes of Body Mass Index (BMI) during this time[1]. Growth and development in children and adolescents are associated with changes in body composition that affect body fatness and leanness. Body composition, used as one of the measures of growth is commonly defined as the proportions of fat, muscle, bone and other tissues in the body[2]. Studies on body composition using Bioelectrical Impedance Analysis (BIA) method are scarce in India; hence, this study was an effort to provide data on the body composition of normal, overweight and obese adolescent girls aged 15 to19 years.

The specific objectives of the present study were to assess the incidence of overweight and obesity among adolescents of 15 to 19 years of age, assess the body composition parameters of the selected adolescents and to find associations between body composition, anthropometry and energy balance.

Materials and Methods

Nutritional assessment of subjects

A total of 530 adolescent girls in the age group of 15 to 19 years were screened for overweight and obesity using height, weight and BMI for age as parameters.

The height was determined using a stadiometer and body weight was determined using a lever actuated scale with an accuracy of 0.1 kg. After calculating the BMI, the value obtained was plotted on the Centre for Disease Control (CDC) BMI for age growth chart for girls of age 2 to 20 years to obtain a percentile ranking. Among the three groups of normal, overweight and obese adolescents, 15 girls were selected from each group for further study. Further nutritional assessment of the 45 adolescents was made through biochemical estimation, clinical examination and diet survey. Blood haemoglobin, fasting blood glucose and lipid profile of the adolescents were estimated using standard procedures. Clinical examination was done with the help of a medical practitioner.

Assessment of body composition

The body composition of selected adolescents was assessed using 'Bio Space, In Body 720 – the precision body composition analyzer'. It works on the principle of BIA. The measurement is made by Direct Segmental Multifrequency Bioelectrical Impedance Analysis method (DSM – BIA method). It records the 30 impedance (Z) measurements by using six different frequencies (1 kHz, 5 kHz, 50 kHz, 250 kHz, 500 kHz, 1000 kHz) at each of five segments (right arm, left arm, trunk, right leg, left leg) of the human body. Adolescents with an implantable electrical device such as pacemaker, defibrillator, nerve stimulator or those within the first twelve weeks of pregnancy were not included for the study. It was ensured that the subjects were properly hydrated and had not carried out any physical exercise in the previous four to six hours. Further, it was ascertained that they had not consumed alcohol, caffeine or diuretics in the past 24 hours besides they were not suffering from fever and electrolyte imbalance. The adolescents were asked to come for the study on an empty stomach and bladder. Ornaments and other metallic items in their position were removed and their palms and soles were wiped with electrolyte tissue (provided by Biospace) before analysis. The details such as individual's name, age, height (in cm) and sex were entered in the instrument and after completion of analysis, the result sheet was obtained.

Determination of energy balance

Energy balance of the adolescents was obtained after computing their energy intake and Total Energy Expenditure (TEE). Twenty four hour recall method was used to obtain details regarding the food intake of adolescents. The nutrient intake was calculated for individuals using the 'Nutritive Value of Indian Foods' (ICMR). TEE was estimated through factorial calculations that combined the time allocated to habitual activities as obtained from the individual's time motion record and the energy cost of those activities. The energy cost of activities was calculated as a multiple of BMR per minute, also referred to as the Physical Activity Rc (PAR), and the 24-hour energy requiremen was expressed as a multiple of BMR per 24 hours by using the Physical Activity Level (PAL) value.

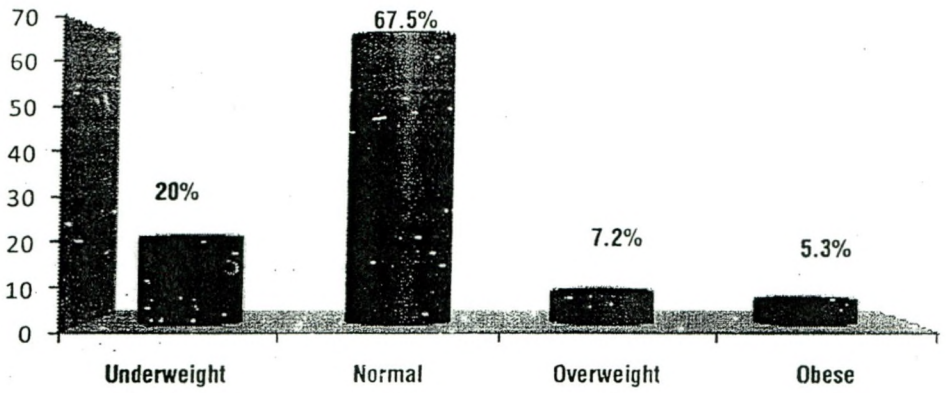
Statistical analysis and interpretation of data

The mean and standard deviation were computed. The data was statistically appraised using the software SPSS version 16.0. Comparisons were made between various parameters of three groups using Student's t-test. Correlations among anthropometric measurements, body composition parameters and biochemical parameters were derived using Karl Pearson's coefficient of correlation. Probability at both 0.05 and 0.01 levels of significance wc considered to draw conclusions.

Results and Discussion

Incidence of overweight and obesity

The incidence of overweight and obesity in adolescent girls were 7.2 and 5.3 per cent respectively. Incidence of underweight was observed to an extent of



Incidence of Overweight and Obesity among Adolescent Girls

Figure 1

20 per cent among the adolescent girls. The remaining 67.5 per cent belonged to normal weight category. The incidence of overweight and obesity among the adolescent girls of 15 to 19 years age is presented in Figure I.

Anthropometric measurements of the adolescents

The mean anthropometric measurements namely height, weight, BMI, Waist Hip Ratio (WHR), Arm Circumference (AC) and Arm Muscle Circumference (AMC) of the selected adolescents are presented in Table I.

The mean differences in the height of normal, overweight and obese subjects were 3.44, 1.58 and 0.89 cm respectively. The mean weight of the normal subjects was close to the standard. As the body weight increased, the mean BMI also increased with a significant difference in obese and overweight subjects.

TABLE I

Anthropometric Measurements of the Adolescents

Parameters	Standard value	Normal (n = 15)	Overweight (n = 15)	Obese (n = 15)
Height (cm)	160.0*	156.56 ± 6.33	158.42 ± 5.53	159.11 ± 6.39
Weight (kg)	52.0*	50.49 ± 5.43	69.37 ± 6.24	84.20 ± 15.39
BMI (kg/m²)	20.25*	20.57 ± 1.58	27.61 ± 1.02	33.05 ± 3.84
WHR	0.70 – 0.80*	0.79 ± 0.02	0.85 ± 0.02	0.89 ± 0.04
AC (cm)	22.10$	26.71 ± 1.39	32.25 ± 1.09	36.28 ± 4.06
AMC (cm)	18.65$	20.72 ± 0.77	23.64 ± 0.83	25.37 ± 1.50

* ICMR (2010)[3] $ NNMB (2002)[4]

TABLE II

Biochemical Parameters of the Adolescents

Biochemical parameters	Standard value	Normal (n = 15)	Overweight (n = 15)	Obese (n = 15)
Haemoglobin	> 12 g/dL	11.73 ± 1.71	13.19 ± 1.38	12.55 ± 1.41
Fasting glucose	70 – 105 mg/dL	81.96 ± 10.29	89.25 ± 10.20	89.38 ± 9.60
Total cholesterol	< 200 mg/dL	165.10 ± 9.90	159.67 ± 12.50	172.07 ± 11.60
Triglycerides	< 150 mg/dL	77.33 ± 20.37	82.4 ± 19.48	83.47 ± 18.04
HDL-C	> 50 mg/dL	47.33 ± 9.11	42.73 ± 8.96	42.8 ± 11.02
LDL-C	< 100 mg/dL	102.30 ± 13.13	100.5 ± 16.11	112.6 ± 15.42
VLDL-C	< 40 mg/dL	15.4 ± 4.14	16.4 ± 3.89	16.67 ± 3.50

The waist-to-hip circumference ratio is positively related to a more centralized pattern of body fat distribution[5]. In the present study, the waist hip ratio increased proportionately with weight, indicating the presence of android obesity in obese and overweight subjects. Greater variation was seen in mean arm circumference among three groups but there existed only a lesser difference in mean arm muscle circumference.

Biochemical parameters

As shown in Table II, the haemoglobin levels were low in normal subjects compared to WHO standard[6]. The fasting glucose levels and total cholesterol levels were within the normal ranges reported by Raghuram *et al*[7] and Ghafoorunissa and Krishnaswamy[8]. The HDL Levels in overweight (42.73 mg/dl) and obese individuals (42.8 mg/dl) were less than standard HDL-cholesterol levels reported by young[9]. Though VLDL levels of the subjects were less than 40 mg as stated by Bray and Bouchard[10], the LDL Levels were more than the standard value reported by them.

On comparing the biochemical parameters among normal, overweight and obese adolescents, statistically significant ($p<0.05$) difference was observed in t' haemoglobin level of normal vs. overweig.. subjects, glucose level of normal vs. obese and total cholesterol and LDL cholesterol of overweight vs. obese subjects. VLDL cholesterol was found to be within the normal value in all the three groups of subjects. Other biochemical parameters had no significant difference among the three groups.

Body composition measures of the adolescents

The body composition measures and comparison of body composition parameters of the normal, overweight and obese adolescents are presented in Tables III and IV respectively.

The body fat mass in overweight and obese individuals were 30.5 kg and 41.53 kg respectively. It is evident that a statistically significant difference existed in body fat mass and per cent body fat among the three groups – normal vs. overweight, normal vs. obese and overweight vs. obese. Fat free mass, total body water, protein, skeletal muscle mass, mineral, bone mineral content and body cell mass on comparison among normal vs. overweight, and normal

TABLE III
Body Composition Measures of the Adolescents

Parameters	Reference range**	Normal (n = 15)	Overweight (n =15)	Obese (n = 15)
Body Fat Mass (kg)	9.8 – 17.7	16.96 ± 3.86	30.59 ± 3.89	41.53 ± 9.87
Per cent Body Fat	17.4 – 27.4	33.37 ± 5.35	44.03 ± 3.47	49.04 ± 4.14
Fat Free Mass (kg)	35.9 – 43.6	33.54 ± 3.56	38.79 ± 3.96	42.65 ± 6.87
Total Body Water (l)	26.2 – 31.9	24.54 ± 2.59	28.36 ± 2.90	31.22 ± 5.03
Soft Lean Mass (kg)	33.8 – 41.1	31.49 ± 3.33	36.44 ± 3.72	40.11 ± 6.43
Intra Cellular Water (l)	16.2 – 19.8	15.18 ± 1.58	17.63 ±1.79	19.35 ± 3.10
Extra Cellular Water (l)	10.0 – 12.1	9.35 ± 1.03	10.73 ± 1.10	11.85 ± 1.92
Protein (kg)	7.2 – 8.7	6.56 ± 0.68	7.61 ± 0.79	8.36 ± 1.34
Skeletal Muscle Mass (kg)	2.5 – 3.01	17.79 ± 2.04	20.99 ± 2.38	23.26 ± 4.05
Mineral (kg)	19.8 – 24.1	2.46 ± 0.28	2.82 ± 0.31	3.06 ± 0.51
Bone Mineral Content (kg)	2.1 – 2.5	2.05 ± 0.23	2.36 ± 0.26	2.55 ± 0.43
Body Cell Mass (kg)	23.7 – 28.9	21.74 ± 2.24	25.23 ± 2.60	27.76 ± 4.44
Visceral Fat Area (cm^2)*	< 100	51.90 ±12.08	93.77± 11.79	148.34 ± 35.59
ECW/TBW	0.36 – 0.39	0.38 ± 0.003	0.38 ± 0.004	0.38 ± 0.004
ECF/TBF	0.31 – 0.34	0.33 ± 0.003	0.33 ± 0.004	0.33 ± 0.003

* Visceral fat area was analysed only for adolescents above 17 years of age.
**Reference range as per 'In body 720' body composition analyser data for normal subjects.

vs. obese subjects showed a significant difference, whereas the comparisons were not significant among overweight and obese subjects. Visceral fat area (VFA) was significantly different among three groups.

Correlations among body composition parameters

The coefficients of correlation among body composition parameters in normal, overweight and obese subjects are presented in Table V.

TABLE IV
Comparison of Body Composition Parameters among Normal, Overweight and Obese Subjects

Parameters	t- value		
	Normal vs overweight	Normal vs obese	Overweight vs obese
Body Fat Mass (BFM)	9.29**	8.67**	3.86**
Per cent Body Fat (PBF)	6.26**	8.67**	3.47**
Fat Free Mass (FFM)	3.69**	4.41**	1.82^{NS}
Total Body Water (TBW)	3.67**	4.42**	1.84 ^{NS}
Protein	3.77**	4.48**	1.81 ^{NS}
Skeletal Muscle Mass (SMM)	3.81**	4.51**	1.81 ^{NS}
Mineral	3.30**	3.88**	1.48 ^{NS}
Bone Mineral Content (BMC)	3.20**	3.76**	1.41 ^{NS}
Body Cell Mass (BCM)	3.80**	4.52**	1.84 ^{NS}
Visceral Fat Area	6.78**	7.26**	4.09**

* Significant at five per cent level ** Significant at one per cent level NS Not significant

TABLE V

Correlation among Body Composition Parameters in Normal, Overweight and Obese Subjects

Parameters	Normal (n=15)	Overweight (n=15)	Obese (n=15)
BFM vs. PBF	0.887**	0.732**	0.683**
BFM vs. FFM	0.073 NS	0.252 NS	0.680**
BFM vs. TBW	0.071 NS	0.246 NS	0.684**
BFM vs. Protein	0.038 NS	0.193NS	0.679**
BFM vs. Mineral	0.099NS	0.468*	0.656**
FFM vs. Protein	0.998**	0.997**	0.999**
FFM vs. TBW	1.000**	1.000**	1.000**
FFM vs. SMM	0.999**	0.997**	0.999**
FFM vs. Mineral	0.983**	0.942**	0.990**
TBW vs. ICW	0.999**	0.996**	0.999**
TBW vs. ECW	0.997**	0.993**	0.998**
Protein vs. SMM	0.999**	1.000**	1.000**
Mineral vs. BMC	0.999**	0.998**	1.000**

* Significant at five per cent level ** Significant at one per cent level NS Not significant

Body fat mass and per cent body fat had a high degree of positive correlation in the three groups. The correlation was found to be significant between body fat mass among fat free mass, total body water and protein in normal and overweight subjects, but significant correlation was found in obese subjects. The body fat mass and mineral content of the body had a significant correlation in overweight and obese subjects. As fat free mass primarily comprises of protein, total body water and mineral, there existed a high degree of positive correlation between fat free mass and the components such as protein, total body water and mineral. It is evident that the total body water had a significant positive correlation with ICW and ECW in all the three groups. The skeletal muscle mass of an individual is directly related to body's protein content, hence a hig degree of positive correlation was observe in all the three groups, similarly the bor mineral content and mineral content of th body were correlated significantly.

Correlation between WHR and body composition parameters

Table VI shows the correlation betwe WHR and body composition parameters in t normal, overweight and obese ad cer

WHR and body fat mass had positi correlation in normal weight and obe subjects. The relationship between WHR c per cent body fat was statistically signific in normal weight and obese subjec whereas it was insignificant in overwei subjects. Positive correlation between W and protein was observed in obese subje

TABLE VI

Correlation Between WHR and Body Composition Variables

Parameters	Normal (n=15)	Overweight (n=15)	Obese (n=15)
WHR vs. BFM	0.592*	- 0.116 NS	0.861**
WHR vs. PBF	0.693**	0.139 NS	0.729**
WHR vs. FFM	- 0.391 NS	- 0.324 NS	0.445*
WHR vs. Protein	- 0.397 NS	- 0.304 NS	0.455*

*Correlation is significant at five per cent level ** Correlation is significant at one per cent level
NS Not significant

Correlation between weight and body composition parameters

Table VII shows the correlation between body weight and body composition parameters in the selected adolescents.

There existed a significant correlation between weight and body fat mass in all the three groups. The relationship between per cent body fat and weight was not statistically significant. A high degree of positive correlation was found between weight and fat free mass in all the three groups. The individual components of fat free mass such as protein, total body water and mineral had significant positive correlation in all the three groups of subjects. Skeletal muscle mass and body cell mass were positive correlates with weight in normal, overweight and obese subjects. The findings of the study carried out by Nande et al[11], explains that an increase in body fat and/or fat free mass add to body weight and thereby to BMI.

Correlation between BMI and body composition parameters

Table VIII shows the correlation between BMI and body composition parameters in normal, overweight and obese subjects.

TABLE VII

Correlation Between Weight and Body Composition Variables

Parameters	Normal (n=15)	Overweight (n=15)	Obese (n=15)
Weight vs. BFM	0.756**	0.787**	0.945**
Weight vs. PBF	0.372 NS	0.158 NS	0.410 NS
Weight vs. FFM	0.708**	0.795**	0.883**
Weight vs. TBW	0.707**	0.791**	0.885**
Weight vs. Protein	0.683**	0.756**	0.881**
Weight vs. SMM	0.697**	0.757**	0.878**
Weight vs. Mineral	0.716**	0.893**	0.863**
Weight vs. BCM	0.692**	0.758**	0.879**

** Significant at one per cent level NS Not significant

TABLE VIII

Correlation Between BMI and Body Composition Variables

Parameters	Normal (n=15)	Overweight (n=15)	Obese (n=15)
BMI vs. BFM	0.829**	0.597**	0.969**
BMI vs. PBF	0.689**	0.273 NS	0.647**
BMI vs. FFM	0.114 NS	0.418 NS	0.674**
BMI vs. TBW	0.116 NS	0.425 NS	0.678**
BMI vs. Mineral	0.063 NS	0.410 NS	0.637**
BMI vs. Protein	0.098 NS	0.397 NS	0.673**

** Significant at one per cent level; NS Not significant

BMI was positively correlated with body fat mass in all the three groups. This indicated that the body fat mass increased proportionately with BMI. On evaluating the body composition using BIA in Japanese children, Kubo *et al* [12] revealed that BMI was strongly correlated with per cent body fat in both sexes. Similar results are obtained in the present study. Per cent body fat and BMI had high degree of positive correlation in normal weight and obese subjects. BMI and fat free mass had a significant correlation in obese subjects where it was not statistically significar in normal weight and overweight subjects. Total body water, mineral and protein had positive correlation with BMI in obese subjects.

Correlation between arm circumference (AC), arm muscle circumference (AMC) and body composition parameters

Table IX shows the correlation between AC, AMC and body composition parameters in the normal, overweight and obese adolescents.

TABLE IX

Correlation Between AC, AMC and Body Composition Variables

Parameters	Normal (n=15)	Overweight (n=15)	Obese (n=15)
AC vs. Protein	0.163 NS	0.462*	0.769**
AC vs. SMM	0.174 NS	0.466*	0.762**
AC vs. FFM	0.180 NS	0.454*	0.760**
AC vs. BFM	0.861**	0.353 NS	0.934**
AC vs. Mineral	0.130 NS	0.313 NS	0.721**
AMC vs. Protein	0.569*	0.787**	0.860**
AMC vs. SMM	0.576*	0.795**	0.859**
AMC vs. FFM	0.580*	0.783**	0.854**
AMC vs. BFM	0.646**	0.080 NS	0.845**
AMC vs. Mineral	0.500*	0.568*	0.795**

* Significant at five per cent level ** Significant at one per cent level NS Not significant

TABLE X

Energy Balance of the Adolescents

Parameters	Normal (n = 15)	Overweight (n = 15)	Obese (n = 15)
Intake (kcal)	2296 ± 33.46	2390 ± 23.65	2627 ± 50.22
Expenditure (kcal)	2236 ± 59.24	2186 ± 102.84	2110 ± 125.58
Balance (kcal)	60 ± 74.60	204 ± 106.10	517 ± 123.50
t- value	Energy intake	Energy expenditure	Energy balance
Normal vs. Overweight	8.64**	1.57NS	4.16**
Normal vs. Obese	20.55**	3.36**	11.83**
Overweight vs. Obese	15.96**	1.73 NS	7.17**

** Significant at one per cent level NS Not significant

Relationship between AC and protein, skeletal muscle mass and fat free mass revealed that there was a positive association in overweight and obese subjects, whereas the relation was not statistically significant in normal weight subjects. AC and mineral content had a high degree of positive correlation in obese subjects. There prevailed a significant correlation between AC and body fat mass in normal weight and obese subjects.

A significant correlation was found between AMC among fat free mass, skeletal muscle mass, protein and mineral in all the three groups. The relationship between AMC and body fat mass was significant in normal weight and obese subjects.

Energy balance of the adolescents

The energy balance of the selected adolescents and the statistical interpretation on the comparison of energy intake, energy expenditure and energy balance among the three groups of subjects is given in Table X.

There existed a statistically significant difference between the energy intakes of the three groups of subjects. A significant difference in energy expenditure of normal and obese subjects was noted, which indicated the sedentary life pattern in obese subjects in comparison with normal weight subjects. The study revealed that a positive energy balance was maintained in obese (517 Kcal) and overweight (204 Kcal) subjects which was a smaller amount in normal weight (60 Kcal) subjects. There existed a significant difference in the energy balance among the three groups.

Summary and Conclusion

The results of the study indicated that the incidence of overweight and obesity among the selected adolescent girls were 7.2 and 5.3 per cent respectively. The anthropometric measurements and body composition measures showed significantly higher values among the overweight and obese adolescent girls when compared to their normal weight counterparts. Though the

normal subjects had a normal BMI, their body composition measures especially per cent 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 body composition and anthropometry.

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