

Body composition along with morphometric characters are useful measure of nutritional status of a population. Typically the composition of human body is assessed to determine percentage of body fat (PBF). However, it is now clear that in addition to the amount of fat in the body, its topography particularly the abdominal fat deposition is considered to be the most atherogenic, diabetogenic and hypertensiogenic fat deposition of the human body.^[6] The three most commonly used measures of abdominal or central adiposity are waist circumference (WC), waist-to-hip ratio (WHR), and BMI. These parameters have been utilized in recent investigations to study abdominal or central adiposity.^[7,8] Recent studies have also reported that central as well as subcutaneous adiposity is associated with body composition measures like PBF and fat mass (FM).^[9,10]

Nutritional problems, especially obesity in women can result in reduced productivity, slow recovery from illnesses, increased susceptibility to infections, and a heightened risk of adverse pregnancy outcomes. A woman's nutritional status has important implications for her health as well as the health of her children. A woman with poor nutritional status, as indicated by a low BMI, short stature, or other micronutrient deficiencies, has also a greater risk of obstructed labour, having adverse pregnancy outcomes, producing lower quality breast milk, death due to postpartum haemorrhage. Malnutrition among women has long been recognized as a serious problem in India; but national-level data on levels and causes of malnutrition have been scarce,^[11] especially, information regarding the obesity pattern among the undergraduate female students. Thus, the present investigation has been carried out to screen the obesity pattern in the female undergraduates of Kolkata.

As cohort studies, ideal for nutritional conditioning monitoring, suffer, in third world countries, from the logistic difficulties usually associated with population studies of large magnitude, less expensive cross-sectional studies can provide relevant element for understanding the connection between health status and physical condition of life,^[12] the present investigation was designed as a small-scale cross-sectional study to investigate the relationship of various physical efficiency and anthropometric measures with body composition variables among college students of Kolkata, India.

Subjects and Methods

Participants

In this cross-sectional cohort study (carried out during July, 2011-March, 2012) female ($n = 100$) subjects between 18 years and 22 years of age were randomly selected to participate in the present study (SPSS v.15.0 and MS-Excel v.2013). Subjects are undergraduate students of different colleges of Kolkata. The entire experimental protocol was explained to them to allay their apprehension. Consent from each participant was taken for conducting the study and the experiments were carried out following Institutional ethical permission. Subjects were instructed to take their last meal at least 2 h before conducting

the test in order to avoid the specific dynamic action of food. All the experiments were carried out and measurements were taken in temperature of 20-25°C and relative humidity of about 45-50% in winter season in India, to avoid seasonal influence on fitness pattern. To minimize the experimenter bias each measurement was taken for 3 times and the mean was represented as final result. Subjects with any type of disease, specially cardiac and respiratory ailments were not taken for experiments, only healthy subjects are considered for each experiment. Each subject was given sufficient rest before each experiment to get accurate result.

Measurement of physical parameters

The BMI of Quetelet is the statistical measure, which compares a person's weight and height by the following formula: $BMI = \text{mass (kg)}/\text{height in (m}^2\text{)}$.^[13] The WHO regard a BMI of less than 18.5 as underweight and may indicate malnutrition, an eating disorder, or other health problems, while a BMI greater than 25 is considered overweight and above 30 is considered obese.^[14]

Body fat can be estimated from the BMI. There is a linear relationship between densitometrically-determined PBF and BMI, taking age and gender into account. Based on which following prediction formulas have been derived, which showed a valid estimate of the body fat at all ages, in males and females. However, in obese subjects the prediction formulas are slightly overestimated. The prediction error is comparable with other methods of estimating body fat percentage, such as skinfold thickness measurements or bioelectrical impedance.^[15,16] The following formula to predict body fat percentage is based on current BMI, age, and gender: $PBF = (1.20 \times BMI) + (0.23 \times \text{Age}) - 5.4$ [for females].

Body surface area (BSA) is the measured or calculated surface of a body. Various calculations have been published to arrive at the BSA without direct measurement. Dubois and Dubois formula was used for estimating body surface BSA.^[17]

Anthropometry

A total of 24 metric measurements were taken for each subject including direct and derived anthropometric and physiological variables. The anthropometric measurements taken for each subject were: Height, weight, eye height standing, elbow rest height standing, abdominal extension, sitting height, knee height, buttock-to-knee length, five circumferences i.e., MUAC, thigh, calf, waist, and hip (BC). However, in the present communication, thirteen directly measured variables and eleven derived variables: BSA, BMI, body adiposity index (BAI), FM, fat mass index (FMI), fat free mass (FFM), fat free mass index, waist-to-height ratio, WHR, MUAC-to-height ratio and conicity index (C-index) were included. All anthropometric measurements were made by using standard anthropometric techniques as proposed by Lohman *et al.*^[18] All the derived variables were computed using standard equations.^[19]

Resting on heart rate (HR) and blood pressure (BP)

Baseline HR was obtained after 5 min rest in the sitting position. The resting heart beat was measured at the carotid pulse. When two successive HR scores become equal then it was considered as resting HR.^[20] Arterial pressures are most commonly measured by a sphygmomanometer, which historically used the height of a column of mercury to reflect the circulating pressure.^[21] BP values were obtained after 5 min rest in the sitting position.^[22]

Physical fitness index (PFI)

PFI was calculated by measuring HR after performing Harvard's step test (HST) developed by Brouha *et al.*^[23] in the Harvard Fatigue Laboratories using long form PFI equation. However, following modified HST under Indian condition, using a stool of 51 cm high stepping up and down, with a rate of 30 cycles/min, for 3 min or up to exhaustion. Exhaustion is defined as when the subject cannot maintain the stepping rate for 15 s.^[24] The recovery pulse was counted at 1-1.5, 2-2.5 and 3-3.5 min of recovery. Long Form Equation-Fitness index = $[100 \times \text{test duration in seconds}] / [2 \times \text{recovery HRs (1-1.5 min + 2-2.5 min + 3-3.5 min)}]$. The cut-off values of PFI are: Very poor (<50), poor (50-60), fair (60-70), and good (70-80) and excellent (>80).^[23]

Anerobic power test by margaria double step method

It is a short-term anaerobic test or power test in which the subject taking two steps at a time; the heights of the stairs are measured by measuring tape. To calculate the anaerobic power; the height of ascend, the body weight, and the duration (s) is noted by the stopwatch.^[25] At first the work done is calculated by the following formulae: Work done = body weight \times height of ascend \times 0.002342. From the calculated work done, the anaerobic power is obtained by the formulae: Anaerobic power = $[\text{work done (kg/m)}/\text{duration (s)}]$.

Determination of aerobic capacity (VO_{2max})

Nomogram of Astrand was used to determinate the VO_{2max} .^[26] Participants maximum (peak) HR, as obtained from HST, was used to determine the aerobic capacity.

Statistical analysis

To carry out the analysis of the data statistically SPSS v.15.0 and MS-Excel v.2013 were used. Results were expressed as mean (standard deviation). If differences between groups were established, the values of the treated groups were compared with those of the control group by a modified *t*-test. A value of $P < 0.05$ was interpreted as statistically significant.^[27]

Results

The direct and derived anthropometric parameters that indicate the prevalence of obesity of the studied population based on PBF, WC and WHR are presented in Table 1. It also represents comparative aspects of physical variables (BSA

and BMI). The results though indicate moderate body weight with respect to their height in female students (according to WHO weight-to-height tables), but, the fat distribution is quite higher in females than of the cut-off values. The cut-off points of obesity were adopted as recommended by Dudeja *et al.*^[28] of PBF ($\geq 30.0\%$), Dasgupta and Hazra^[29] for WC (≥ 72.0 cm), and Rahim *et al.*^[30] for WHR (≥ 0.85). PBF (though $< 30.0\%$), FM, FMI and BAI are higher in female students, which indicate increased inclination towards obesity.

The frequency of overweight and underweight students is presented in Table 2. The overall prevalence of obesity (BMI > 30.00) was almost absent in the studied sample, only 3.84% of the studied population showed obesity. However, the frequency of overweight (BMI 25.0-29.9) was higher in undergraduate females of Kolkata (total of 21.95%). However, most of the student populations are found to have normal range of body weight, as found on the basis of BMI. Among 100 students, 67.95% of students showed normal BMI. Here, it should be mentioned that all these estimations are based on an indirect technique, i.e., anthropometry and International Classification of BMI cut-off points.^[14]

Table 3 represents some common physical fitness variables of female students. They showed poor physical fitness (i.e., between the cut-off value 50 and 60). But, in all other parameters they fit in normal range.

Figure 1 describes some common anthropometric measures of female college students; of these parameters also indicate the tendency towards obesity. Results show that female students

Table 1: Derived anthropometric variables of female (n=100) college students for screening body composition and obesity

Variables	Female students	
	Mean	SD
Age (years)	20.40	2.31
Physical parameters		
Height (cm)	153.30	4.26
Weight (kg)	54.60	5.13
BSA (m ²)	1.53	0.33
BMI (kg/m ²)	23.10	3.06
Adiposity measures		
PBF (%)	26.40	2.73
Fat mass (kg)	14.40	4.11
FMI (kg/m ²)	6.12	1.74
FFM (kg)	40.20	4.05
FFMI (kg/m ²)	17.22	1.62
BAI	34.12	5.43
Waist-to-hip ratio	0.87	0.03
Waist-to-height ratio	0.45	0.01
MUAC-for-height	0.14	0.01
C-Index	1.11	0.03

BSA: Body surface area, BMI: Body mass index, PBF: Body fat percentage, MUAC: Mid-upper arm circumference, BAI: Body adiposity index, FMI: Fat mass index, FFM: Fat free mass, FFMI: Fat free mass index

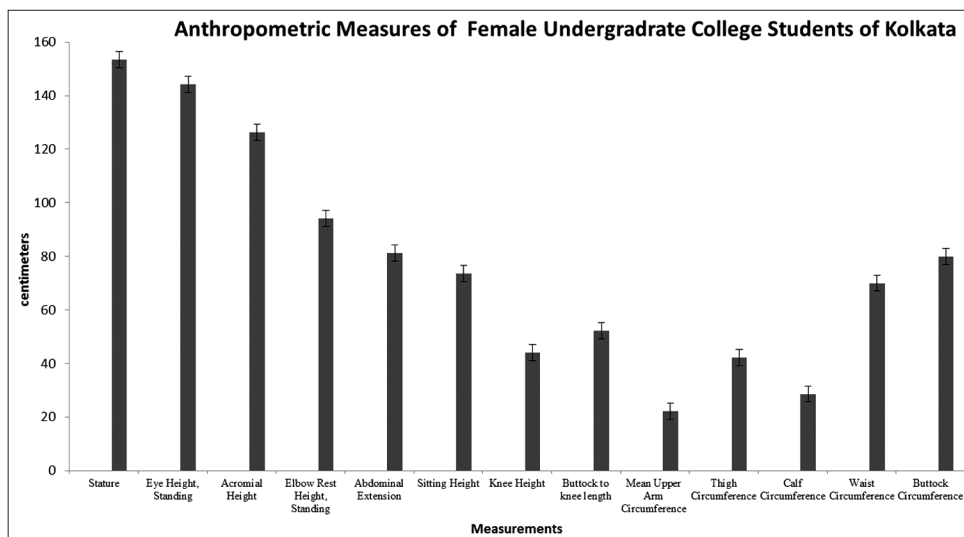


Figure 1: Direct anthropometric indices of female ($n = 100$) college students

Table 2: Prevalence of obesity based on body mass index: Undergraduate female college students of Kolkata ($n=100$)

Age (in years)	Sample size n (%)	Obese (BMI>30) n (%)	Overweight (BMI 24.9-29.9) n (%)	Normal (BMI 18.5-24.9) n (%)	Underweight (BMI<18.5) n (%)
18-20	48 (48.00)	0 (0.00)	10 (20.83)	32 (66.67)	6 (4.16)
20-22	52 (52.00)	2 (3.84)	12 (23.07)	36 (69.23)	2 (3.84)
Total	100	2 (3.84)	22 (21.95)	68 (67.95)	8 (4.00)

BMI: Body mass index

Table 3: Physiological parameters indicating physical fitness and endurance of female students

Parameters	Female students	
	Control	SD
Physiological variables		
Resting heart rate (beats/min)	78.60	7.14
Systolic blood pressure (mm Hg)	121.20	3.54
Diastolic blood pressure (mm Hg)	82.20	5.16
Physical fitness index	57.60	3.90
Anaerobic power (kg/m/s)	11.70	3.42
VO _{2max} (ml/kg/min)	31.00	2.33
Energy expenditure (K.Cal/min ²)	5.61	0.72

have lower stature, eye height, acromial height, elbow rest height, abdominal extension, and mean upper arm, thigh and WCs than the Indian standard values.^[31] Lower WC and abdominal extension reflects lower abdominal fat distribution in females, which has again reflected in WHR.

Discussion

BMI is considered as a better index for assessing obesity, because it does away with the need of height-weight tables and is independent of type of obesity frame and it can be used to estimate the prevalence of obesity within a population.^[32] Therefore, in the present study, the body composition of undergraduate college students was calculated according to critical limits of BMI as recommended by WHO.^[32] Table 1

shows various physical parameters and obesity indicators, among which female students have showed lower BSA due to their lower stature. They also showed higher PBF, FM, FMI and BAI, than the cut-off values, which are indicators of their overall higher fat distribution. Conversely, they showed significantly lower FFM and C-index, which showed lower abdominal fat and muscle mass distribution. These results indicate higher overall fat distribution in females, but, they have lower fat distribution in their abdominal regions.

Table 2 presents the distribution of all subjects according to BMI classification. Only 4% of the participants are reported to be underweight. Though, it was observed that most of the subjects have normal BMI (total of 67.95%), but, the results indicated higher propensity of being obese was observed in females. Among undergraduate female students, 21.95% were overweight (24.9-29.9). The results of female students also indicated an important aspect, that when they are getting aged, they are getting more weight than their young age, which has been reflected in age wise BMI distribution of students [Table 2]. In this present study it has been found that the females in the age group of 20-22 years have higher frequency of overweight students (69.23%) than those in the 18-20 years age group (66.67%). It has already been found in earlier studies that when the Bengali/Hindu females of Kolkata, getting aged, they gain more weight and becomes obese. They rank third in the prevalence of obesity in India, after Uttar Pradesh and Jammu and Kashmir.^[33] While comparing the present data with the other

populations of India, it is apparent that the prevalence rate of overweight/obesity in the present study is in line with other Indian studies which have also shown a high prevalence of overweight and obesity. Gopinath *et al.*^[34] studied urban women of Delhi and reported the prevalence rate of obesity as 33.4%. Visweswara Rao *et al.*^[35] studied females belonging to high socio-economic status of Hyderabad and reported the prevalence rate of obesity as 36.3%. The nutrition Foundation of India has just completed a study on the prevalence of obesity in urban Delhi, and has reported the prevalence rate of overweight (BMI 25+) and obesity (BMI > 30) as 50% and 14% respectively.^[36]

Overweight and obesity has been found to be associated with many disease particularly heart disease, type-2 diabetes and osteoarthritis.^[37] The prevention and control of this problem must, therefore, claim priority attention.

Cardiorespiratory fitness is a measure of how well a physiological system is capable of transport oxygen to muscles during prolonged exercise. Resting HR and aerobic capacity (VO_{2max}) has been extensively considered to be a reliable and valid measure of cardiopulmonary or aerobic fitness.^[38] Energy required by muscle for physical movement normally is originated through aerobic metabolism. Therefore, workload could be measured through calculation of VO_{2max} . Undergraduate students of Kolkata showed normal range of VO_{2max} . However, Bailey *et al.*^[39] have reported that lower VO_{2max} levels are associated with an increased probability of being overweight/obese. Strength exercise increases ventricular muscle mass,^[5] which results in increased force of contraction and hence cardiac output, but, in this study, a normal range of systolic BP was observed among female college students. While measuring physical fitness, their pulse rate recovered quite slowly; this is an indicator of poor fitness, and thus, reflected in PFI. They showed normal range of energy expenditure and anaerobic power [Table 3]. PFI scores are useful measures of fitness for strenuous exercises. Physical fitness has three main aspects: Static fitness (absence of disease), dynamic fitness (ability to perform strenuous work) and motor skills fitness. Of this three, dynamic fitness is very important and can be measured by HST.^[40]

Morphometric analysis of the body is virtually the investigation of the process of life which reflects the general health status of an individual.^[41] In this present study, lower stature, eye height, acromial height, elbow rest height, abdominal extension, and mean upper arm, thigh and WCs were found in female students than Indian standard values.^[31] MUAC, which is an estimate of energy store and protein mass of the body and an indirect estimate of strength,^[42] is found to be lower in female students. Lower WC and abdominal extension reflects lower abdominal fat distribution in females, which has again reflected in WHR. Among WC and WHR, WC is considered to be a better index for fat location than WHR for predicting lipid profile in adult women.^[40] However, it is a well-known fact that BMI also has a negative correlation with WHR, as reflected in our study,

which is very much important in case of women, because, this interrelation is a cue to the female physical attractiveness and beauty of women.^[43-46]

Conclusion

Overall findings of the present obesity screening report describes that almost one of four female students (24 out of 100 participants) are overweight/obese, and indicated higher body fat distribution and increased propensity of being obese with age. Therefore, appropriate precautionary measures to be taken to prevent further progression of the problem into the young population. Because if the present trends of overweight/obesity continues, the situation can get worse even single most important public health problem in adults.

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