

Original Article

Skinfold thickness, body fat percentage and body mass index in obese and non-obese Indian boys

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Childhood obesity is presently increasing worldwide and has created enormous concern for researchers working in the field of obesity related diseases with special interest in child health and development. Selected anthropometric measurements including stature, body mass, and skinfolds are globally accepted sensitive indicators of growth patterns and health status of a child. The present study was therefore aimed not only at evaluating the body mass index (BMI), skinfolds, body fat percentage (%fat) in obese school going boys of West Bengal, India, but also aimed to compare these data with their non-obese counterparts. Ten to sixteen year old obese boys ($N = 158$) were separated from their non-obese counterparts using the age-wise international cut-off points of BMI. Skinfolds were measured using skinfold calipers, BMI and %fat were calculated from standard equations. Body mass, BMI, skinfolds and %fat were significantly ($P < 0.001$) higher for the sample of obese boys when compared to their non-obese counterparts. The obese group also showed progressive age-wise increments in all recorded anthropometric parameters. Stature (cm) showed no significant inter-group variation except in the 10 year age group ($P < 0.001$). All data for the non-obese group were comparable with other national and international studies, but those collected for the obese group could not feasibly be compared because the availability of data on obese children is limited. Current data and prediction equations will not only serve as a reference standard, but also be of vital clinical importance in order to identify or categorize obese boys, and to take preventative steps to minimise serious health problems that appear during the later part of life.

Key Words: obesity, skinfolds, BMI, %fat, boys, India

Introduction

The study of obesity in relation to disease and physical fitness is of major concern to those interested in child growth and development¹, as the prevalence of childhood obesity is increasing rapidly worldwide.² Obesity is associated with several risk factors for the development of heart diseases and other chronic problems including hyperlipidemia, hyperinsulinemia, hypertension and early atherosclerosis.³⁻⁵ Although a number of factors contributing to the development of obesity are well established, the etiology of obesity is not exactly clear.⁶ Giving evidence on the development of multiple risk factors at an early age, Gilliam *et al.*,⁷ proposed that diet modification and prescribed physical activity are possible means of CHD intervention for people having a family history of obesity. Later Watanabe *et al.*,⁸ suggested that obesity is to a large extent the result of physical inactivity with the maintenance of an abundant and frequently high fat diet.

Selected body measurements like stature, mass, mid upper arm circumference, various skinfold thicknesses and other body dimensional measurements have globally been accepted as sensitive indicators of growth progress and nutritional status of children and the growing population.^{9,10}

In recent times, in order to develop an internationally acceptable definition of obesity, Cole *et al.*,² scientifically specified cut-off points of BMI, a ratio of body mass and stature which are the two most easily measurable parameters, for categorizing children as obese in an age-wise pattern. Because of their public health importance, the trend in childhood obesity should be carefully and closely monitored. Data for BMI, skinfolds and %fat in Indian children are available,^{1,9-11} whereas despite concerns about childhood obesity which is an important and potentially modifiable risk for a range of concurrent and later morbidities, the corresponding standard data of physical parameters, skinfolds, BMI and %fat are lacking in case of Indian obese children. The present study was therefore designed to evaluate the BMI, skinfold measurements and %fat in school going obese boys of West Bengal, India, and also to compare these data with their non-obese counterparts.

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Methods

This cross sectional investigation was undertaken on 692 normal healthy school going boys (Obese, $N = 158$, Non-obese, $N = 534$) between the ages 10 and 16 years. The participants were randomly sampled from different schools of West Bengal and the obese boys were separated from the non-obese according to the international cut-off points of BMI as proposed by Cole *et al.*,² and were further confirmed by the %fat value as proposed by Watanabe *et al.*⁸ All the subjects belonged to the same socio-economic grouping. The age of each subject was calculated from the date of birth as recorded in their school register. The body mass and stature for each subject were measured by using a weighing scale (Avery India Ltd., Model No. 3306 ABV) fitted with stature measuring stand. BMI was calculated from the following equation: $BMI (Kg/m^2) = (Body\ weight\ in\ Kg) / (Body\ height\ in\ meter)^2$ (Meltzer *et al.*¹³, Cole *et al.*²). The skinfold measurements included the triceps, sub-scapular, chest, abdomen, mid-thigh and calf taken on the right side of the body with the subject standing in the proper upright posture according to methods proposed by Johnson and Nelson¹⁴ using a calibrated skinfold caliper (Holtain Ltd., UK) with constant tension. The following equations were used to compute the %fat as these were also used during previous studies on a similar population.^{1,10}

10 – 12 Years: Body density (BD) = $1.108 - (0.027 \times \log A) - (0.0388 \times \log B)$

13 – 16 Years: Body density (BD) = $1.130 - (0.055 \times \log A) - (0.026 \times \log B)$

Where A = triceps skinfold thickness in mm and B = sub-scapular skinfold thickness in mm, %fat = $\{(4.95/BD) - 4.5\} \times 100$

Statistical analysis

Unpaired one tail t-Test was performed to compute the level of significance of difference between the mean values obtained in obese and non-obese groups. Pearson's product-moment correlation and regression analysis were also adopted to test the relationship between different variables. (The entire work was carried out after getting permission from the ethical committee.)

Results

The physical parameters including BMI of obese and non-obese boys are presented in Table 1, which depicts progressive age wise increments in body mass and stature for both the groups. BMI also shows similar age wise

progressive increments for obese boys, but in the non-obese group BMI was depicted through fluctuating alterations between 10 to 13 years of age. Values for skinfold measurements along with their sum are tabulated in Table 2. In all cases the obese group possesses significantly higher ($P < 0.001$) values when compared to their non-obese counterparts. Obese boys also exhibited much higher values ($P < 0.001$) for body fat percentage parameter in all age categories (Fig. 1).

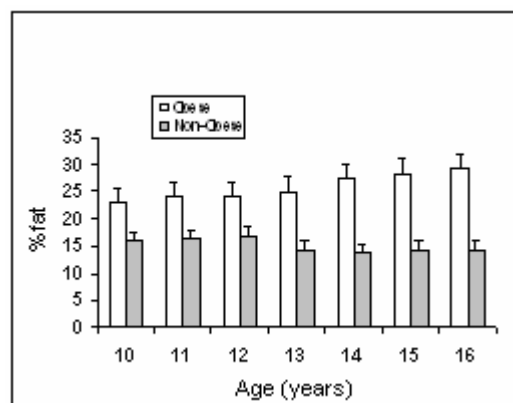


Figure 1. Percentage of body fat (% fat) in obese and non-obese boys.

Correlation statistics revealed significant ($P < 0.001$) positive relationship of both %fat and BMI with all individual skinfold and sum of skinfolds not only in obese and non-obese boys but also when all the boys were considered as a whole in a group (Table 3). Prediction equations for %fat from BMI in both of these groups and as a whole of the sample are represented in Figure 2.

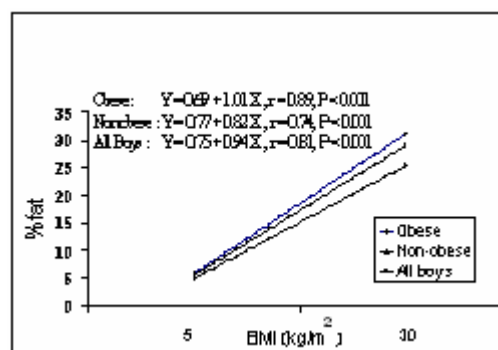


Figure 2. Regression line for prediction of % fat from BMI in Bengalee Indian boys.

Table 1. Physical parameters and BMI in 10 to 16 years of obese and non-obese boys

| Age (Yrs) | 10 ($N_1 = 84$, $N_2 = 20$) | 11 ($N_1 = 80$, $N_2 = 25$) | 12 ($N_1 = 60$, $N_2 = 18$) | 13 ($N_1 = 90$, $N_2 = 28$) | 14 ($N_1 = 100$, $N_2 = 16$) | 15 ($N_1 = 60$, $N_2 = 29$) | 16 ($N_1 = 60$, $N_2 = 22$) |
|--------------------------|---|--|---|--|--|--|---|
| Body Mass (Kg) | 27.38±2.32 (44.75±3.61) [#] | 28.44±3.96 (48.50±4.91) [#] | 31.24±5.05 (53.30±4.65) [#] | 33.16±5.80 (59.15±6.20) [#] | 39.32±5.74 (67.40±6.17) [#] | 42.44±5.57 (71.68±6.81) [#] | 46.72±6.57 (78.11±7.25) [#] |
| Stature (cm) | 129.43±4.55 (135.43±5.59) [#] | 135.41±9.03 (138.9±10.07) ^{NS} | 141.30±9.03 (143.02±10.13) ^{NS} | 143.40±8.90 (147.92±10.0) ^{NS} | 154.08±7.70 (155.91±6.91) ^{NS} | 158.03±8.27 (158.60±20.5) ^{NS} | 163.0±5.54 (164.41±9.65) ^{NS} |
| BMI (Kg/m ²) | 16.46±1.40 (24.41±1.85) [#] | 15.67±1.70 (25.12±2.39) [#] | 15.58±1.05 (26.06±1.86) [#] | 16.24±2.64 (27.03±2.54) [#] | 16.47±1.61 (27.72±2.21) [#] | 16.96±2.15 (28.50±2.27) [#] | 17.24±1.60 (28.90±1.85) [#] |

Values within parentheses indicate the values for the obese group, $N_1 =$ No. of Non-obese boys, $N_2 =$ No. of Obese boys, Values are mean ± SD, # $P < 0.001$, NS = Not significant.

Table 2. Different skinfold measurements and their sum in 10 to 16 years of Obese and Non-obese boys

| Age (Yrs) | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---------------|---|---|---|---|---|---|---|
| Skinfold (mm) | ($N_1 = 84,$ $N_2 = 20$) | ($N_1 = 80,$ $N_2 = 25$) | ($N_1 = 60,$ $N_2 = 18$) | ($N_1 = 90,$ $N_2 = 28$) | ($N_1 = 100,$ $N_2 = 16$) | ($N_1 = 60,$ $N_2 = 29$) | ($N_1 = 60,$ $N_2 = 22$) |
| Triceps | 5.84 ±1.70 (8.71 ±2.61) [#] | 6.62 ±2.62 (9.34 ±4.29) [#] | 5.83 ±1.36 (9.16 ±2.06) [#] | 6.00 ±1.73 (10.10 ±2.61) [#] | 6.00 ±2.44 (12.00 ±4.60) [#] | 6.32 ±2.49 (12.91 ±3.69) [#] | 6.09 ±2.08 (13.06 ±4.20) [#] |
| Sub-scapular | 5.55 ±1.10 (8.24 ±2.61) [#] | 5.82 ±1.76 (9.26 ±3.15) [#] | 5.54 ±0.88 (9.70 ±2.61) [#] | 6.23 ±1.53 (10.02 ±3.10) [#] | 6.37 ±1.21 (11.90 ±2.41) [#] | 7.06 ±2.50 (12.48 ±3.10) [#] | 7.37 ±1.64 (14.65 ±3.61) [#] |
| Chest | 4.58 ±1.09 (8.26 ±2.01) [#] | 4.70 ±1.90 (9.24 ±3.16) [#] | 4.38 ±0.85 (10.54 ±1.26) [#] | 4.94 ±1.14 (11.26 ±3.15) [#] | 5.04 ±1.70 (12.01 ±2.74) [#] | 5.36 ±1.93 (13.59 ±3.10) [#] | 5.45 ±1.60 (13.96 ±3.51) [#] |
| Abdominal | 5.30 ±1.41 (9.40 ±3.14) [#] | 6.05 ±2.24 (10.10 ±3.60) [#] | 5.31 ±2.20 (10.69 ±4.21) [#] | 6.16 ±2.30 (11.26 ±3.69) [#] | 6.45 ±3.00 (12.10 ±4.61) [#] | 6.47 ±2.49 (12.69 ±4.15) [#] | 5.89 ±1.72 (14.64 ±2.69) [#] |
| Mid-thigh | 9.74 ±2.88 (12.00 ±4.26) [#] | 9.78 ±2.64 (13.61 ±2.95) [#] | 9.76 ±2.24 (14.26 ±3.61) [#] | 10.62 ±2.92 (16.01 ±3.45) [#] | 9.14 ±2.70 (16.79 ±4.10) [#] | 9.45 ±2.88 (18.42 ±4.21) [#] | 9.42 ±2.73 (18.16 ±4.60) [#] |
| Calf | 9.98 ±2.80 (12.16 ±4.70) [#] | 10.15 ±2.28 (12.70 ±4.16) [#] | 10.83 ±2.40 (14.69 ±4.60) [#] | 11.90 ±3.02 (15.10 ±4.01) [#] | 9.15 ±2.68 (15.92 ±4.10) [#] | 9.76 ±3.05 (16.81 ±2.0) [#] | 9.53 ±2.60 (17.20 ±2.90) [#] |
| Sum | 46.56 ±4.32 (58.21 ±6.24) [#] | 48.25 ±6.34 (64.05 ±6.71) [#] | 45.92 ±5.46 (68.96 ±7.20) [#] | 49.41 ±7.54 (63.86 ±5.90) [#] | 48.42 ±6.92 (70.70 ±6.82) [#] | 49.27 ±7.60 (86.90 ±8.51) [#] | 48.84 ±7.85 (91.70 ±8.69) [#] |

Values within parentheses indicate the values for the obese group, N_1 = no. of Non-obese boys, N_2 = no. of Obese boys, values are mean ± SD, # $P < 0.001$.

Table 3. Values of correlation coefficient of %fat and BMI with different skinfolds and sum of all the skinfolds

| | Triceps | Sub-scapular | chest | Abdominal | Midthigh | Calf | Sum of Skinfolds |
|------|----------------|----------------|----------------|----------------|----------------|----------------|------------------|
| %Fat | 0.76 (0.82) | 0.72 (0.86) | 0.62 (0.68) | 0.76 (0.87) | 0.70 (0.72) | 0.58 (0.62) | 0.84 (0.91) |
| BMI | 0.79 (0.70) | 0.80 (0.74) | 0.65 (0.80) | 0.81 (0.79) | 0.71 (0.69) | 0.60 (0.67) | 0.88 (0.81) |
| | 0.62 (0.66) | 0.63 (0.69) | 0.65 (0.73) | 0.67 (0.73) | 0.63 (0.66) | 0.51 (0.60) | 0.76 (0.79) |

Values within parentheses indicate the values of correlation coefficient for the obese group and bold digits indicate the values of correlation coefficient of the whole sample.

Discussion

The stature recordings do not show any inter-group variation, except in the age-group of 10 years where obese boys have significantly ($P < 0.001$) higher values when compared to the non-obese boys which concurs with the findings of reports in numerous studies.^{8,15,16}

These researchers all reported significantly higher values for body mass in obese group as also observed in the present study in all age groups and this is accredited to the excess accumulation of fat mass among obese individuals.¹⁷ Mean stature and body mass data for non-obese boys corroborate with the previous study in rural boys of West Bengal¹⁰ but present findings show lower values that those obtained for middle class school boys of Kolkata.¹⁸ Percentage fat values obtained among non-obese boys in the present study is probably due to fall of the ratio between subcutaneous fat and total body fat after reaching adulthood.¹⁹ However, non-obese participants are within the "normal" range of stature and mass for the socioeconomic group-I according to the Indian Council of Medical Research.²⁰

BMI is significantly ($P < 0.001$) higher among obese participants because of the significantly ($P < 0.001$) higher

body mass when compared to their non-obese counterparts. Mean BMI values for all ages further establish the relevance of proper categorization of participants into obese and non-obese groups² with respect to the primary aim of the current study.

The individual and sum of skinfolds were significantly ($P < 0.001$) higher for the obese group (Table 2) who also have excessively higher values of %fat in all age groups in comparison to non-obese boys (Fig. 1). Though there is neither a progressive nor regressive age wise change in %fat or skinfolds among non-obese boys but obese participants have exhibited progressive age related increases in both of these parameters. In normal healthy children the greatest proportion of body fat is formed by subcutaneous fat which tends to approach the adult value during growth and development in a fluctuating manner as also observed in the present study are lower than the Japanese, Czech and USA boys^{8,19,21,22} whereas values are comparable with the study conducted on rural boys of West Bengal (India), Zaragoza (Spain).^{10,23} Skinfolds, especially the triceps skinfold, have been excessively studied in Indian and international populations of children^{1,9,10,11,24-27} but corresponding data for the obese

population is minimal and thus restricts the corroborating discussion on the current skinfold data of obese population. However, the skinfolds of the non-obese boys in the present study were lower than the Nilgiri boys of West Bengal, more affluent Haydrabad boys of Karnataka, Calcutta middle class boys, rural boys of West Bengal and the young children of California and Michigan. Values appear to be higher, but comparable with Sodepur boys of west Bengal and socio-economically poor boys of Hyderabad, respectively.^{9-11,25,27-29} Significant ($P < 0.001$) correlation of individual skinfolds and sum of all the skinfolds with % fat and BMI indicates that they are good predictors of % fat either independently or together. The value of correlation coefficient is highest when sum of all the skinfolds were considered, but existence of comparatively higher values of correlation coefficient in cases of triceps, subscapular, chest and abdominal skinfolds (when considered individually) further justifies that they are better predictors of % fat than other skinfold thicknesses. But as the measurement of skinfolds needs highly expertise technical skill and probability of individual variation is excessively high, therefore from the present data regression lines have been computed for prediction of %fat from BMI in the studied population (Fig 2).

Conclusion

From the present study it can therefore be concluded that skinfolds, BMI and body mass are expectedly higher among obese boys because of their excessive body fat percentage. The present data will not only serve as a standard for BMI and skinfolds measures in obese boys of the studied population, but prediction equations for %fat from BMI will also be of vital clinical importance during the identification of the signs of obesity as well as assisting in the prevention of the serious health problems/consequences, generally in the later part of life.

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Original Article

Skinfold thickness, body fat percentage and body mass index in obese and non-obese Indian boys

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印度肥胖与非肥胖男孩皮褶厚度、体内脂肪百分率和体重指数

当今世界儿童肥胖日益增加，已经引起对儿童健康和发展有着特殊兴趣，在肥胖相关疾病领域工作的科研人员的极大关注。我们选择的人体分析指标身高、体重、皮褶厚度等是全世界公认儿童生长模式和健康状态灵敏的指标。因此本研究的目的不仅是为了评估印度西孟加拉肥胖学龄男孩的体重指数（BMI）、皮褶厚度和体内脂肪百分率，而且是为了与非肥胖男孩来比较分析这些相关数据。以不同年龄的国际 BMI 界点值为标准挑选出 10 到 16 岁的肥胖男孩（ $N = 158$ ）。采用皮脂夹测定皮褶厚度，以标准公式计算出 BMI 和脂肪百分率。肥胖男孩样本组的体重、BMI、皮褶厚度和脂肪百分率显著高于非肥胖男孩（ $P < 0.001$ ）。肥胖儿童组所有记录的人体分析指标也呈现出随年龄逐步增加的趋势。除了 10 岁的男孩组间身高有明显差异外（ $P < 0.001$ ），其它组间身高并没有表现出明显的不同。非肥胖儿童组测定得到所有数据与其它国内和国际研究得到的数据相当，但是因为所能利用的关于肥胖儿童资料有限，肥胖儿童组收集到的数据不能与其它研究数据相比。目前所得到的数据和预测的公式不仅仅能作为参考标准，而且对肥胖男孩进行判断或归类，进一步采取预防措施减小肥胖儿童在以后的生活中所出现的严重的健康问题带来的危害有着至关重要的临床意义。

关键词:肥胖，皮褶厚度，体重指数，脂肪百分含量，印度