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Evaluation of the obesity in the adolescents by assessing the body mass index and body fat percentage: A cross sectional study

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Abstract
Background: Adolescent obesity is one of the most serious public health challenges of the 21st century having high prevalence rate in low- and middle-income countries, including in Asia. The relationship between BMI and body fat percentage (BF %) has been studied in various ethnic groups to estimate the ability of BMI to predict adiposity. Accuracy of obesity screening by commonly used BMI criteria is unclear in young south Indian population.
Materials and method: A total of 2212 participant (1320 males and 892 females) mean age was 11.5±1.6 years. BMI and BF% were recorded, the latter was determined by bioelectrical impedance analysis (BIA). Height and weight were measured and BMI was calculated (kg/m^2)). A comparison between study population and previously available nationally representative (1989) data was performed for each age-sex group. WHO cut-off values were used and their respective status was assigned. The prevalence of overweight and obesity was expressed in percentages
Results: The prevalence of overweight and obesity was found to be 21.6% and 10.4%, respectively as per BMI category, while according to BF%, it was 17.0% and 10.9% respectively and the mean differences were found to be statistically significant (P=0.001. The fat percentages in girls were higher than in boys. BMI noted to increase with age in young in both boys and girls. This curvilinear effect was more significant in females (R2 = 0.27, R2 change = 0.058, SEE 11.5%) (p = <0.000) compared to males (R2 = 0.89, R2 change = 0.009, SEE 13.7%) (p = ≥0.05). Though females had a higher mean BMI values than males it was statistically insignificant (p ≥0.05). There was a positive linear correlation between BMI-BF% in both sex (males r =0.47, females r =0.64; p < 0.001).
Conclusion: The finding from our studies firstly provides the baseline value of the BMI and BF% in school going children in Kerala and BMI can also be used to evaluate the body fat percentage of the participants.

Keywords: Adolescent obesity, BMI, overweight, body fat percentage (BF %), BIA

1. Introduction
Obesity and overweight are defined as abnormal or excessive fat deposition in the body that may impair health [1]. Childhood obesity has assumed a global epidemic proportions in the recent past [2]. According to The World Health Organization (WHO), the majority of children who have overweight and obesity children live in developing countries, where these conditions are increasing faster than in developed countries [3]. The proportion of overweight and obesity was 24.5% in Eastern Asia countries and 11.9% in the Western Asia regions [4]. A comparative study across developing countries reported that prevalence rates of obesity in adolescents in Asia are highest [4]. Moreover, there are wide variations both within and between countries across Asia: 3.5% in rural Bangladesh to over 65% in the Maldives [5], 30% in Iran and Saudi Arabia and approximately 12.5% for Chinese children [5]. Meta-analysis on studies related to obesity in adolescents in India showed that the pooled estimates of overweight and obesity ranged from 2%–6% in low prevalence group, 11%–18% in intermediate to 23%–36% in high prevalence group [6]. Pediatric obesity is multifactorial in origin and can be due to a vast array of genetic, behavioral and environmental factors [7]. Appropriate early clinical and behavioural interventions can be undertaken to reduce obesity associated complications such as elevated blood cholesterol, type 2 diabetes mellitus, and hypertension [8]. These aspects emphasize the need for reliable

measures which can better identify the affected individuals. X-ray imaging techniques have been considered generally as the most accurate measures of adiposity, and are often used in research as gold standard for fat mass assessment [9]. Unfortunately, this technique is expensive, lengthy to carry out and lacks applicability for routine clinical measurements in epidemiological studies.

Anthropometric measures are therefore more frequently used in the clinical settings. Body mass index (BMI) is generally regarded as a good predictor of overall adiposity [10], which is having significant sensitivities in identifying overweight children [11]. Other measures, such as waist circumference, waist-to-height ratio and subscapular/triceps skinfolds, have also been shown to strongly correlate with dual energy X-ray absorptiometry (DXA) measurements. [11, 12] A number of studies have found positive and comparable associations between BMI, waist circumference and skinfolds in children from Western Europe [13], India [14] and Brazil [15]. The combinations of various anthropometric measures can give a better overall picture of a child's weight status than individual parameters alone in certain population [16]. However, these associations are not universal and differences do exist in the association between anthropometric measures in different populations [16]. Some measures, such as waist-hip ratio, have also been neglected in research, and there is a paucity of data for certain measures due to their reduced clinical use in different healthcare systems around the world [17]. These factors point towards a need for studies which can clarify the overall picture in anthropometric measure associations. Although there are many studies available, related to the determination of overweight and obesity in Indian adolescents using BMI and other anthropometric measures [18]. Our study attempts to fill up this knowledge gap by analysing the prevalence of overweight and obesity among the early adolescents studying the schools of south Kerala India by anthropometric measurements (BMI, waist-hip ratio, waist-to-height ratio).

2. Materials and Methods

2.1 Study settings

The study was designed as a cross-sectional (population) study. The participants were 10–14 years adolescents studying in the schools of Kannur town, Kerala. The study was done for 1 year from June 2016 to March 2017. Height, weight and body composition measurements were carried out by a group of medical graduates of Dept. of Community medicine, Kannur Medical College, Kannur. Informed written consent was taken from all participants and their parents. Confidentiality was maintained during the storage, retrieval and analysis of data. Ethical approval was taken from Ethics Review Committee of the institution.

2.2 Subject selection

Inclusion criteria

Students (10–14 years) studying in the classes of 5^{th}-10^{th} standard of the schools of Kannur town.

Exclusion criteria

1. The students who were unwilling to participate in the study were excluded. Any student having vomiting or diarrhoea, dehydration at the time of conducting the study was excluded.

2.3 Sampling Design

Stratified sampling technique was used to select the study participants. The schools of Kannur town were divided into two categories: Government School and Private School. Then, the sample size was equally allocated in each of the categories, i.e., 800 each. Altogether 1600 students from 16 schools (8 private and 8 government schools). The selection of these schools was done by simple random sampling. Then, we selected equal number of students (i.e., 20) from each of the classes - Class V–IX using simple random sampling technique.

2.4 Body Composition Measurements

2.4.1 Anthropometry

Measurements were taken using standardized equipment. Height of all participants were measured using a stadiometer (seca 206, Germany) in standing position without footwear to the nearest 0.1 cm. Weight was measured with minimum clothes using a calibrated electronic scale with digital readout (seca 808, Germany) to the nearest 0.1 kg. BMI was calculated by weight (kg) divided by height (m) squared (kg/m2) [19].

2.4.2 BIA derived per cent body fat

Total body fat percentage (BF %) was estimated by using a commercially available single-frequency, 8 electrode bio impedance analyser system (BC-418, Tanita Corp, Tokyo, Japan). The reliability and validity of this system in measuring BF% has been previously verified in multiple ethnicities [20]. All measurements were taken during morning hours (0830–1200) [20]. Finally BF% was calculated from the whole body impedance value and the pre-entered personal data (age, gender, height and weight) of the corresponding subject. BF% was estimated to the nearest 0.1%. Whole-body composition was estimated using standard equations provided by the bioelectrical impedance analysis (BIA) manufacturer.

2.4.3 Height and weight

Height was measured to the nearest 0.1 cm using stadiometer. Weight was measured to the nearest 0.1 kg using digital weighing machine. BMI was calculated using the equation BMI = weight (kg)/square of height (m2). To determine the weight status of the study, participants' age- and sex-specific WHO 2007 reference for BMI for 5–19-year-old children (z-score) were used. The students were categorized as severe thinness, thinness, normal, overweight, and obese.[21]

3. Statistical Analysis

Data collected in school were entered in Microsoft Excel-2007 (Microsoft Excel. Redmond, Washington, USA) and analysed using SPSS version 16.0 (SPSS Inc. USA) software for Windows. Basic descriptive statistics for subject data were expressed as means ± standard deviations. Differences between means were separated by one way ANOVA. Pearson's' correlation coefficients (r) were calculated to assess the link and the degree of relation between BMI and BF%, in relation to gender and age variables. BMI derived was categorized by using Z score tables of WHO-BMI for age standards for children and adolescents between 5 and 19 years. The differences were considered to be statistically significant at $P < 0.05$.

Table 1: Mean body mass index, mean body fat percentage of the study participants (*n*=2212)

Variables	Mean±SD			P value
	Boys	Girls	Total	
BMI (kg/m2)	19.4±3.90	20.6±4.7	20±3.34	<0.034
BF% (%)	20.56±4.56	24.5±6.10	22.53±5.55	<0.013.

*t-test. SD: Standard deviation, BMI: Body mass index, BF%: Body fat percentage

Table 2: Prevalence of overweight and obesity of the study participants (*n*=2212)

Variables	Boys (n=1320) (59.6%)	Girls (n=892) (40.3%)	Total (%)
BMI category Overweight Obese	242 (18.5) 100 (7.7)	236 (26.5) 124 (14.0)	478 (21.6) 224 (10.4)
BF% category Overweight Obese	194 (14.6) 118 (9.0)	184 (20.6) 128 (14.3)	378 (17.0) 246 (10.9)

BMI: Body mass index, BF%: Body fat percentage

Table 3: Distribution of study participants according to body mass index and body fat percentage

BMI category	Category of BF%				Total (%)
	Under fat	Normal	Overweight	obese	
Severe thinness	32 (55.2)	22 (37.9)	0 (0.0)	0 (0.0)	54 (100.0)
Normal	88 (42.70)	116 (56.3)	0 (0.0)	2 (1.0)	206 (100.0)
Overweight	112 (9.0)	1014 (81.1)	112 (9.0)	12 (1.0)	1250 (100.0)
Obese	0 (0.0)	170 (35.5)	202(42.2)	106 (22.2)	478(100.0)
Total	0 (0.0)	34 (15.2)	64 (28.5)	126 (56.25)	224 (100.0)
	232 (10.5)	1356 (61.9)	378 (17.24)	246 (11.2)	2212 (100.0

BMI: Body mass index, BF%: Body fat percentage

4. Results

Baseline group characteristics

The study initially included equal number of participants from government (1150) and private schools (1150). However, completed questionnaires were obtained from 1120 (97.3%) participants from government schools and 1092 (94.95%) participants from private schools. Therefore, the total response rate of the study was 95.9 and analysis of the study was based on those 2212 participants. Of those 2212 participant, 59.67% were boys (1320). The mean age of the participants was 11.5±1.6 years. The mean BMI and BF% were found to be significantly higher among girls than among boys as shown in the Table-1.

Prevalence of overweight and obesity under BMI and BF% category

BMI category prevalence of overweight and obesity by was found to be 21.6% and 10.4%, respectively while according to BF% was 17.0% and 10.9% respectively as mentioned in the table-2. The mean differences of BMI and BF% were found to be statistically significant. Among the participants who were overweight according to their BMI, 35.5% fell under normal category of BF% while 22.2% were under normal category of BF%. Among the participants, who were obese according to their BMI, 15.2% fell under normal category of BF% while 28.5% were under overweight category of BF% as shown in table 3.

Independent relationship of age on BMI and BF%

BMI noted to increase with age in young age in both males and females. This curvilinear effect was more significant in females (R2 = 0.27, R2 change = 0.058, SEE 11.5%) (p = <0.000) compared to males (R2 = 0.89, R2 change = 0.009, SEE 13.7%) (p = ≥0.05). Though females had a higher mean BMI values than males it was statistically insignificant (p ≥0.05) (Table 1). There was a positive linear correlation between BMI-BF% in both sex (males r =0.47, females r =0.64; p < 0.001).

5. Discussion

This study was conducted to determine the predictive ability of BMI as a measure of BF% in adolescents, and to show any variation due to age and sex in this prediction. According to the WHO 2007 reference criteria of BMI for age and sex almost one-third of the study participants were found to be overweight and obese (30.1%) showing a higher estimation of overweight and obesity by BMI criteria than BF% criteria where it is found to be 27.3% [22]. The prevalence rate of overweight and obesity is quite high taking into account both the criteria. Some studies have reported the predictive effect of racial difference of BMI-BF% relationship[19].We analysed data of the group of school children from Kerala, who are categorized as South Asians (who are similar to Asian Indians), who have a different body composition compared to Caucasians, Blacks and even Asian Mongolians [23]. We hope that our study further add strength to the current pool of evidence regarding the relationship between BMI and BF% in adolescents obesity.

In a study by Antal *et al*. [24] in Hungarian school children aged about 7–14 years, reported that, on the basis of BMI, prevalence of overweight and obesity were 18.1 and 7.4% for boys and 19.6 and 6.3% for girls, respectively and on the basis of body fat percentage (%BF), prevalence of obesity was 17.9% for boys and 12.8% for girls. Boys (49%) and girls (28%) categorized as overweight by BMI were obese according to their % BF. In our study the prevalence on the basis of BMI, overweight and obesity were 21.6% and 10.4% for boys and girls19.6% and 6.3% for girls, respectively and on the basis of body fat percentage (%BF), prevalence of obesity was 17.9% for boys and 12.8% for girls. In our study participants who were categorized as overweight according to their BMI, 35.5% fell under normal category of BF% while 22.2% were under normal category of BF%. Among the participants who were obese according to their BMI, 15.2% fell under normal category of BF% while 28.5% were under overweight category of BF%.

In our study relationship of BMI with BF% was found to be strongly positive correlation (r = 0.70, P < 0.001) which was akin to as demonstrated in most of the former studies. An early study by P. Deurenberg [25] done in Caucasians,

BMI with BF% relation was significant. A Cross-sectional study by Rush *et al*. [23] shown that European, Maori, Pacific Island and Asian Indian adults and confirmed that Asian Indian men and women (BMI of 24 and 26 kg/m2, respectively) had the same BF% as Europeans with a BMI of 30 kg/m2 or Pacific men and women with BMI of 34 and 35 kg/m2, respectively and also confirmed the significant positive relationship in BMI-BF% in all these races. A recent study by S. Meeuwsen [9] on UK adults had shown that association is not significant, particularly so, when BMI is less than 25 kg/m2 [26]. BMI values of most of our participants were between 17–21 kg/m2, whereas the BMI range varied among other studies. The reasons for these discrepancies observed in these cross sectional studies is assumed to be due to, the use of different body composition methodology as well as biological differences in the characteristics of the study populations.[26]

6. Limitation of the Study

Limitation such as firstly, we were unable to control some of the BIA measurement prerequisites as we relied on information given by the participants (E.g. Measurements should be taken patient fasting for 3 hours/not having vigorous activity for past 12 hours). But the results of the study were comparable to other studies done in more controlled subject samples. Secondly the accuracy of bioelectrical impedance analysis (BIA) technique when compared with reference body composition measurement techniques (hydro densitometry, water dilution technique) or multicomponent models could not be ascertained. However, in epidemiological studies some degree of accuracy is sacrificed for simplicity, acceptability and rapid data acquisition.

7. Conclusions

Though use of BMI to determine the weight status of the adolescents remains a valuable tool body fat percentage (BF %) estimated by bioelectrical impedance analysis (BIA) which also can provide a good predictive capacity to determine excess body fat which is evident from our study and our findings provide the baseline values of the school going adolescents in Kerala.

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