

Original Research Article

Body mass index and body fat percentage in determining overweight and obesity among school going adolescents of urban Mysuru, Karnataka: a cross-sectional study

Dhanya Sathiarajan^{1*}, M. R. Narayana Murthy², Arun Gopi²,
Amoghashree², Krishnaveni Y. S.²

¹Department of Community Medicine, MS Ramaiah Medical College, Bengaluru, Karnataka, India

²Department of Community Medicine, JSS Medical College, Mysuru, Karnataka, India

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*Correspondence:

Dr. Dhanya Sathiarajan,

E-mail: dhanya9227@gmail.com

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ABSTRACT

Background: Overweight and obesity among adolescents is an important global health issue. BMI is the commonly used screening tool but there can be under or over estimation. Body fat percentage estimation using bioelectrical impedance analysis is easy and non-invasive technique and along with BMI can provide a better predictive capacity. Considering importance of early detection of overweight and obesity in adolescents, present study was done among school going adolescents of urban Mysore. Objectives were to determine the prevalence of overweight and obesity using BMI and body fat percentage among school going adolescents and to determine the relationship between BMI and body fat percentage.

Methods: A cross sectional study was conducted among 706 school students in urban Mysuru aged 13-16 years and semi-structured proforma was used to collect data. Anthropometric measurements taken and Omron HBF 701 Karada scan complete digital body composition monitor used to measure body fat percentage. BMI-for-age (5-19 years) WHO 2007 and McCarthy's body fat reference used to classify participants. Statistical tests like Pearson's correlation used.

Results: According to BMI, 9.8% and 5% were overweight and obesity prevalence respectively and according to body fat percentage 19.4% were over fat and 17.1% were obese. Among adolescents with normal BMI, 18.4% and 11.9% were classified as overfat and obese respectively according to body fat percentage. The correlation between BMI and body fat percentage was statistically significant.

Conclusions: Higher prevalence of obesity seen according to body fat percentage cut-offs than according to BMI.

Keywords: Adolescents, BMI, Body fat percentage, Obesity, Overweight

INTRODUCTION

Obesity or overweight is the excessive fat accumulation that pose risk to health. Since 1975, global obesity has tripled.¹ It can lead to endocrine complications like type 2 diabetes and also mental health complications, cardiovascular complications, obstructive sleep apnoea, asthma, exercise intolerance, gastrointestinal, renal and dermatological complications. Long term complications like carotid artery atherosclerosis, stroke, IHD and even

premature death can occur.² Complex interplay of genetic and environmental factors seen in the causation of obesity.³ Prevention, early detection and management of non-communicable diseases in adolescents is necessary for a better adulthood life.⁴

BMI (Body mass index) is a common method used to measure obesity. Waist circumference, neck circumference, waist-to-hip ratio, skinfold thicknesses, and bioelectrical impedance etc are the ones that can be

applied clinical setting as well as in community and large epidemiological studies.^{5,6} Magnetic resonance imaging or dual energy x-ray absorptiometry are among the reference measurements.⁵ BMI is a function of height and mass. It originates from Quetelet's goal of identifying statistical laws governing the many dimensions of the average man, their manifestations in the population. BMI is convenient clinical and epidemiological metric for identifying and monitoring obesity prevalence.⁷ As per World Health Organization (WHO), for children aged 5-19 years, BMI-for-age greater than one standard deviation is considered as overweight, and a BMI-for-age greater than two standard deviations above the WHO growth reference median is taken as obese. The formula $BMI = \text{weight in kg} / (\text{height in metres})^2$ gives body mass index.⁵ BMI alone won't be enough to determine adiposity related health problems as it doesn't distinguish between increased mass in the form of fat, lean tissue or bone.⁸ Systematic reviews of a high-quality and consistent evidence pointed out that BMI as a tool to detect obesity is highly specific, but have low to moderate sensitivity. Pathology associated with obesity is excess fat mass hence monitoring excess fat mass is ideal monitoring tool to assess adiposity.⁹ Excess body fat was found to be significantly associated with an atherogenic lipid profile.¹⁰ Bioelectrical analysis (BIA) measures body fat percentage by indirectly measuring adiposity of body. When a very small electric current is passed through the body lean tissue mass acts as a conductor and fat mass acts as an insulator. Measuring impedance to the changes in voltage helps to distinguish lean mass and fat mass.⁵ It is simple, fast, non-invasive and provide reliable measurements of body composition with less intra- and inter-observer variability.¹¹ Results are reproducible with <1% error on repeated measurements.¹² BIA seem to be acceptable and reproducible to determine body composition adolescents who are obese.¹³ BIA instrument is portable, safe, relatively low cost with minimal participant burden and gives quick and relatively inexpensive estimates of Fat-free mass and TBW (total body water). Hand-to-foot method of BIA was found to have high correlation ($r = 0.96$) with hydro densitometry.¹⁴ Only very few studies have used combination of BMI and body fat percentage to detect obesity among adolescents. Considering importance of early detection of overweight and obesity in adolescents, present study was done among school going adolescents of urban Mysore.

Objectives

To determine the prevalence of overweight and obesity using body mass index and body fat percentage among school going adolescents. To determine the relationship between body mass index and body fat percentage.

METHODS

It was a cross-sectional community-based study conducted at JSS high schools urban Mysuru district, Karnataka from January 2020 to December 2021. The

study included adolescents of 13-16-year-old school going students.

Inclusion criteria

High school students under JSS Mahavidyapeetha in Urban Mysore who were willing to participate in the study.

Exclusion criteria

Any student in a state of dehydration at the time of conducting the study was excluded.

Sample size and sampling method

The prevalence of obesity/overweight taken as 20.9% according to study done by Saikia et al.¹⁵ For a confidence level of 95% with a 3 percent margin of error, sample size was calculated as 706 using the formula $n = (Z/M)^2 \times p \times (1-p)$. Schools under JSS Mahavidyapeetha were selected by simple random sampling and sample size achieved by collecting data from students who were willing to participate in the study considering COVID-19 pandemic.

Method of data collection

Ethical clearance was obtained from Institutional Ethics Committee of JSS Medical College and informed consent taken from Headmasters of schools, parents of students. Assent of students taken before data collection. A pre-tested, semi-structured questionnaire was used to collect data by interview method and anthropometric measurements were obtained using standard protocol. BMI-for-age (5-19 years) WHO 2007 reference and McCarthy's body fat reference used and Omron HBF 701 Karada scan complete digital body composition monitor used to estimate body fat percentage.

Statistical analysis

Collected data was coded and transferred to Microsoft Excel worksheet 2016 and analysis of the data done using SPSS version 22 (licensed to JSS AHER). Descriptive statistics like percentages and inferential statistics including t test used to determine the difference in means. To analyse the correlation between the anthropometric measurement variables Pearson's correlation coefficient was calculated. Association between qualitative variables was established using analytical tests like Chi-square test. Differences and associations were interpreted as statistically significant p value <0.05.

RESULTS

Among 706 school going adolescents aged 13-16-year-old, 346 (49%) were boys and 360 (51%) were girls. With regard to age distribution, 231 study participants (32.7%) belonged to 13-year-old age group, 274 (38.8%) in 14-

year-old age group, 127 belonged to 15-year age group and 74 study participants belonged to 16-year age group. Mean BMI among study participants was found to be 18.75 ± 4.02 and mean body fat percentage was found to be 22.98 ± 8.34 . According to 2007 WHO reference BMI for age and gender classification, 9.8% of the students were overweight and 5% were obese and according to McCarthy, body fat percentage cut offs 19.4% were over fat and 17.1% were obese (Table 1 and 2).

Table 1: Classification of study participants according to BMI.

BMI classification	Boys	Girls	Total
Severe thinness	10.4% (36)	4.4% (16)	7.4% (52)
Thinness	17.6% (61)	11.9% (43)	14.7% (104)
Normal	57.5% (199)	68.6% (247)	63.2% (446)
Overweight	8.7% (30)	10.8% (39)	9.8% (69)
Obese	5.8% (20)	4.2% (15)	5% (35)
Total	346	360	706

Among the participants who were classified as normal by the body mass index, 18.4% were classified as overfat

and 11.9% were classified as obese according to their body fat percentage. 19.2% and 13.5% who were categorized as severe thinness and thinness respectively by BMI were classified as overfat and obese based on body fat percentage. While 22.9 percent who were obese according to BMI was categorized as overfat by body fat percentage. Among the participants who were normal according to body fat percentage, 4.2% were overweight according to body mass index. Among 54.1% who were classified as normal based on body fat percentage, 4.21% (16) was classified as overweight according to BMI and 17.11% (65) were classified as thinness and 6.84% (26) were classified as severe thinness as per BMI.

Among the 137 participants who were classified as overfat by body fat percentage, 7.3% (10) were classified as severe thinness, 8% (11) were classified as thinness and 59.9% (82) were classified as normal and 5.84% (8) were classified as obese according to BMI. Among the 121 study participants classified as obese by body fat percentage, 5.8% (7) were classified as severe thinness, 5.8% (7) were classified as thinness and 43.8% (53) were classified as normal and 22.31% (27) were classified as overfat according to BMI (Table 3).

Table 2: Classification of study participants based on body fat percentage.

Classification of study participants based on body fat percentage	Boys	Girls	Total
Under fat	13.9% (48)	5% (18)	9.3% (66)
Normal	42.8% (148)	65% (234)	54.1% (382)
Overfat	23.7% (82)	15.3% (55)	19.4% (137)
Obese	19.7% (68)	14.7% (53)	17.1% (121)
Total	346	360	706

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

Classification according to BMI	Classification according to body fat percentage				Total
	Under fat	Normal	Overfat	Obese	
Severe Thinness	17.3% (9)	50% (26)	19.2% (10)	13.5% (7)	52
Thinness	20.2% (21)	62.5% (65)	10.6% (11)	6.7% (7)	104
Normal	8.1% (36)	61.7% (275)	18.4% (82)	11.9% (53)	446
Overweight	0	23.2% (16)	37.7% (26)	39.1% (27)	69
Obese	0	0	22.9% (8)	77.1% (27)	35
Total	9.3% (66)	54.1% (380)	19.4% (137)	17.1% (121)	706

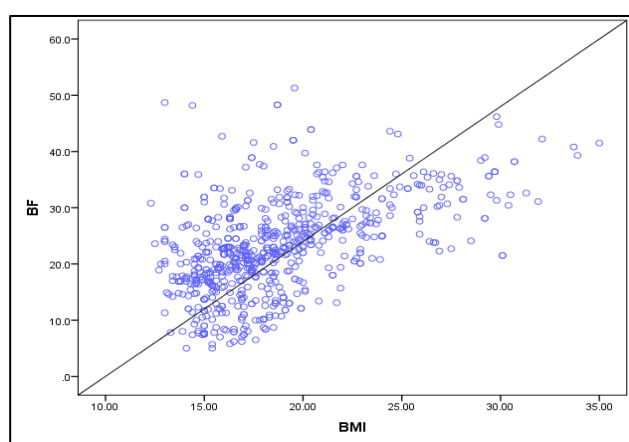
Table 4: Distribution of male study participants according to body mass index and body fat percentage.

Classification according to BMI	Classification according to body fat percentage (boys)				Total
	Under fat	Normal	Overweight	Obese	
Severe Thinness	13.9% (5)	38.9% (14)	27.8% (10)	19.4% (7)	36
Thinness	23% (14)	57.4% (35)	9.8% (6)	9.8% (6)	61
Normal	14.6% (29)	46.73% (93)	23.62% (47)	15.1% (30)	199
Overweight	0	20% (6)	46.7% (14)	33.3% (10)	30
Obese	0	0	25% (5)	75% (15)	20
Total	13.9% (48)	42.8% (148)	23.70% (82)	19.7% (68)	346

Table 5: Distribution of female study participants according to body mass index and body fat percentage.

Classification according to BMI	Classification according to Body fat percentage (girls)				Total
	Under fat	Normal	Overfat	Obese	
Severe Thinness	25% (4)	75% (12)	0	0	16
Thinness	16.3% (7)	69.8% (30)	11.6% (5)	2.3% (1)	43
Normal	2.8% (7)	73.7% (182)	14.2% (35)	9.3% (23)	245
Overweight	0	25.6% (10)	30.8% (12)	43.6% (17)	39
Obese	0	0	20% (3)	80% (12)	15
Total	5% (18)	65% (232)	15.3% (55)	14.7% (53)	358

The correlation between BMI and BF% was statistically significant with $r=0.527$. Figure 1 presents the comparison of BMI with BF%.

**Figure 1: Correlation between BMI and body fat percent.**

Among boys belonging to normal BMI, 23.6% (47) were found to be overfat according to classification based on body fat percentage while 15.1% of normal BMI study participants were found to be categorized as obese according to body fat percentage (Table 4). Among female study participants categorized as normal by BMI, 2.8% (7) are underfat, 14.2% (35) are overfat and 9.3% (23) are obese according to body fat percentage (Table 5).

DISCUSSION

According to WHO report that percentage of adolescent overweight across different regions ranges from 10 to over 30% and our findings of the prevalence of overweight and obesity among the sample population of school going adolescents as 9.8% and 5% comes with in this range.¹⁶ Prevalence of obesity and overweight observed in our study was consistent with the prevalence of overweight and obesity stated by the study done by Gautam et al where the prevalence of overweight and obesity among school students in Udupi, India was found to be 10.8% and 6.2%, respectively.¹⁷

Saikia et al in a study conducted among adolescents in Dibrugarh, Assam found a higher prevalence of

adolescent overweight and obesity than our study, they found the prevalence of overweight and obesity to be 20.9% and 10.2% respectively.¹⁵ Singh et al in a study done among school going children in Hyderabad reported prevalence of overweight and obesity to be 9.9% and 14.0%, respectively which was similar to our findings.¹⁸ Compared to our study, higher obesity prevalence (17%) was observed in a study done by Premanath et al among 5-16 year old school children in Mysore.¹⁹

Our findings (19.4% over fat, 17.1% obese) were similar to the study done by Saikia et al, where the prevalence of overweight and obesity among adolescents were found to be 16.4% and 10.9% respectively.¹³ Overweight and obesity prevalence might vary across the regions. And due to urbanisation and life style changes, there is an increase in prevalence of overweight and obesity among adolescents. There was a steep increase in unemployment and economic loss due COVID-19 pandemic and since our study was done during the pandemic, our results might be affected due to it.

Among the participants who were classified as normal by the body mass index, 18.4% were classified as overfat and 11.9% were classified as obese according to their body fat percentage. In contrast to our findings, Saikia et al in his study among adolescents of Dibrugarh Assam found that among 625 participants having normal BMI, 9.0% were overweight and 1% were obese respectively based on body fat percentage.¹³ Among the participants who were normal according to body fat percentage, 4.2% were overweight, 17.11% and 6.84% were classified as thinness and severe thinness respectively as per BMI.

Among the 137 participants who were classified as overfat by Body fat percentage, 7.3% (10) were classified as severe thinness, 8% were classified as thinness and 59.9% were classified as normal and 5.84% were classified as obese according to BMI. Among the 121 study participants classified as obese by body fat percentage, 5.8% were classified as severe thinness, 5.8% were classified as thinness and 43.8% were classified as normal and 22.31% were classified as overfat according to BMI.

Saikia et al reported that among the participants, who were overweight according to their BMI, 39.3% fell

under normal category of BF% while 23.1% were under obese category of BF% while 15.2% of obese participants, fell under normal category of BF% and 33.0% were found to be overweight according to BF%. Similar to our study, correlation between BMI and BF% was statistically significant.¹⁵ Chiplonkar et al also reported a significant correlation between BMI with body fat percentage in the study conducted among the 5-17-year-old school children from across five major cities.²⁰

Correlation between BMI and BF% was statistically significant in the study done by Saikia et al as was as the study conducted by Jelena et al among adolescents of Serbian Republic.^{15,21} This disparity in classification of participants can be due to the fact that BMI consider only height and weight parameters compared to body fat percentage classification. Increase in muscle mass can also lead to misclassification as overweight or obese as well as lean person with optimal height and weight parameters might be having high levels of body fat and low levels of skeletal mass and this can go unnoticed if BMI alone is used for detection of overweight and obesity.

CONCLUSION

While misclassifications can occur using BMI which completely relies on height and weight and does not distinguish between increased mass in the form of fat, lean tissue or bone, misclassifications can also occur with body fat percentage too as increased hydration, dehydration and other factors can give inaccurate values. A combination of both might reduce the underreported cases of overweight and obesity.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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