Sensitivity and Specificity of Waist to Height Ratio (WHTR) as a Screening Tool for Assessment of Abdominal Obesity among Rural and Urban School Girls in Chennai, Tamil Nadu: A Comparative Cross-Sectional Study

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Abstract

The most recommended obesity measurement is using the Body Mass Index (BMI) method as a gold standard in predicting obesity and the risk of illness. Another alternative method which can also be used is Waist-to-Height Ratio (WHtR). Somehow, lack of sensitivity and specificity data comparison between WHtR and BMI is still remaining unknown. Therefore, the purpose of this study was to determine the sensitivity (Se) and specificity (SP) of WHtR against that standard BMI -for-Age based testing and prevalence of overweight and obesity. The design of this study was comparative cross-sectional. The subjects of the study were from both urban and rural government schools in and around Chennai District,Tamilnadu which amounted to 2180 middle aged school children with age range 8-12 years. The sampling technique used was Stratified random sampling. Anthropometric measurements (weight, height and waist circumference) were measured, and WHtR were calculated and then divided into percentiles derived by using Least Median Square (LMS).The data obtained then tested normality with Kolmogorov-Smirnov test which then continued with sensitivity test and specificity by using Receiver Operator Characteristic Curve (ROC). The study outcomes showed that among the tested sample population of 2180, there is greater significance could be explored with regards to urban population compared with rural sample population as they exhibited greater BMI ranges (between 16.7±2.8- 18.2±3.2 among the rural population; between 17.1±1.9 - 18.5±2.8 in urban population) within the age group of 8-12 years old. The observed WHtR represented the WHtR cut-offs by age and location showed sensitivity (89.6-91.8% and 88.4–95% in Rural and Urban respectively) among obese category, whilst overweight category showed an overall specificity (90.4% and 91.7% in Rural and Urban respectively), indicated urban population with higher correlated based on WHO criteria for obesity and overweight population. Based on assessment from BMI-for Age wise distribution under 85^{th} and 95^{th} percentile showed a growth in prevalence on overweight population with increase in age group of population (Overweight prevalence for 8 years- 7.21% Versus 12 years-13.28), however the obese category fluctuated within 3.6%-4.8% among the observed sample population compared with WHtR assessment at 85^{th} and 95^{th} percentile, exhibiting better prevalence concerned with overweight and obesity categories. From the observed investigation so far concluded that WHtR could possibly serve as a suitable and reliable anthropometric measurement technique compared with standardized BMI measurement for predicting metabolic risk factors in children.

Keywords: Obesity, Overweight, WHtR, BMI, Urban, Rural, Children

Introduction

Metabolic disorders like obesity and overweight have emerged as a serious health burden globally. These disorders contribute to an extensive metabolic reorganization those results in excessive nutrient intake by animals [1]. The exponential increase in obesity prevalence is on par with obese condition, as both conditions are interlinked as weight gain followed by lifestyle and economic changes, poor dietary habits collectively attributed for this alarming rate [2, 3].

The prevalence governing with disorders oriented with obesity has skyrocketed to alarming levels in recent decades, as they act as independent risk factor that attributes for several other non-communicable diseases like diabetes, cancer and cardiovascular related diseases [4, 5]. This associated disorder could be witnessed vastly among the children and adolescent population as they are much more prone to acquire obesity compared to the adult population [6]. According to WHO (2020), the underlying risk associated with non-communicable diseases tend to increase with elevated Body Mass Index levels. Also it further emphasize that there is a greater likelihood of association with regard to childhood obesity to pose irreversible health effects/ morbidity like obesity, disability and premature death while reaching their adulthood [7].

Pathogenesis in the case of childhood obesity is multifaceted, as it could result from hereditary, socio-demographic, environmental and most importantly due to metabolic factors. Under the Indian context, the prevalence in overweight/ obesity in Indian children rose to about 9.8% from 2006 to more than 11.7% by 2009 [8]. From the computational prediction reported by Lobstein and Jackson-Leach et al., (2016) displayed there will be an overall estimation of 17 million Indian children are most likely to acquire childhood obesity by the year 2025 [9]. This worsening condition prevails as an indistinguishable phenomenon across both urban and rural communities in India.

While considering the gender-based prevalence in obesity/ overview among children were found to showcase no significance in terms of gender, however there are instances where boys reported greater prevalence compared with girls. From a report by NCDRC showed that gender disparity has greatly narrowed across the globe by 2016[10]. From the observed data, the BMI achieved among both sexes, especially in East as well as South Asia showed a rise in the overall BMI ranges among both the genders. Besides, the narrowing prevalence, the physical health consequences faced by girls are different from that of male and there is a greater concern whilst considering the sedentary lifestyle of female childhood as well as during their adult life could be much more evident in resultant obesity related disorders. For instance, there are reports suggestive of females exhibiting a greater likelihood for developing asthma [11] [12], early onset of puberty as well as menarche, which could in turn link with breast cancer or other related cancers in their reproductive areas, greater risk for spontaneous abortion and menstrual problems, in particular due to polycystic ovary syndrome which possibly result in infertility in their later stage of life [13, 14, 15].

As a result of creeping growth in the prevalence of paediatric obesity alongside with other associated co-morbidities, clearly indicates the necessitation for performing simple anthropometric surveys that can be utilized for assessment and identification of children who are susceptible to risk of obesity and also the measurement tool subsequently facilitate for devising a suitable and appropriate intervention approach. However the significance governing with public health in contemporary times followed by the rapid childhood obesity requires closer monitoring for a healthier society in the future. The trends appear to be quite complicated to quantify and compare further since there exists a wide array of definitions pertaining to childhood obesity which are in existence and there exists no standardized approach for determining the overall prevalence in a survey. For instance BMI centile curves, [16] followed by other forms of approaches namely: waist circumference centiles, [17] and the presently and much more effective method involving waist to height ratio [18] are regarded as some of the accepted and standardized measures for determination of obesity in children. From a recent study that conducted a workshop by the International Obesity Task Force suggested that body mass centiles applied for adult cut off points seemingly could be applied for child cut off points as well. [19] BMI centile curves were commonly developed approach that has been used for surveying paediatric population for performing clinical and even epidemiological purposes in certain cases. [16] Despite their standardized application, BMI tend to be less as a sensitive indicator in determining childhood obesity, as it provides no indication on distribution of bodily fat. During the growth stages in childhood, the body fat is deposited in both subcutaneously as well as intra abdominally, thus it is imperative for acquiring information on waist circumference of children which could further strengthen alongside with BMI findings for categorizing children as overweight and obese conditions [17]. Also waist circumference could serve as a measure for obesity and overweight status, but it has a major disadvantage of not considering the major criteria pertaining to body height and weight. A WHtR could pose as a suitable indicator on obesity. This approach has been reported to serve as effective predictor in identifying the metabolic risks that are in relation with the investigations, which tend to provide a much more suitable measurement over relative fat distribution between the subjects under varied degree of age distribution as well as with individuals' statures followed with the possible independent effect over height that could ascertain with the metabolic risks asides their independent effect over coronary-related disease itself. Aside these advantages, WHtR ratio**(OR)**Waist-to-Stature Ratiowas reported to exhibit a closer value and relation between gender based physiological difference, which is much more keenly determined compared with BMI or with measuring the waist circumference alone; thus the same boundary value might be apply for both boys and girls. The index governing with Waist-to-Height ratio of 0.5 appeared to be simple and quite effective index as it not only identifies and categorises either as overweight or obese among children, but also aids in identifying children who are falling within the normal weight range.[19] Even so, for devising the perfect relation governing with this factor on obesity/ overweight status require furthermore standardization followed with much more detailed investigations and efforts in this particular aspect as it is showcased that individuals reported with scores greater than 0.5 are more likely falling in the category of either overweight/ obese, irrespective of their age [20]. Also WHtR cut-offs tend to differ from one country to another. This is primarily as a result of genetic and also due to environmental factors. As each country have shown to define their own reference values for identifying abdominal obesity within the country and also facilitates furthermore on comparison with world-wide curves that are derived from other adolescent populations. The objective of the present study aimed **(a)** To Develop Age Specific Percentile Charts for Waist –to –Height Ratio with determination of its Validity in comparison to International Criteria of 0.5 as Cut-off Value. **(b)** To Compare Specificity and Sensitivity of WHtR with BMI-for-Age in diagnosing Overweight and obesity in Chennai school aged children

Material & Method

Participant Selection:A Comparative Cross-Sectional study was conducted among middle-aged school students in the 8–12-year-old children from both urban and rural government schools in and around Chennai District, divided into four sectors (North, East, South and West). Ethical clearance was obtained from Independent ethical review board (Ref No.AHC/GEN/028/2018-19) of Universal Ethics Committee, Chennai (CDSCO Reg No.ECR/125/Indt/TN/2013, OHRP Reg No.IORG0007234) and consent was obtained from the Chief Educational Officer (Chennai Corporation).

Sample Size: The sample size was determined using the prevalence study formula:

$$n = \frac{z^2 (pq)}{d2}$$

where z is the value for confidence interval set at 95%, d is the margin of error set at 3%, and (p) is the estimated prevalence of childhood obesity, taken as 54% (from the base article [21]). Using the above formula, the sample size was calculated to be 2180, with an equal distribution of 1090 subjects from both rural and urban areas of Chennai District

Sampling Technique:

The study participants were recruited using stratified random sampling technique. The schools were stratified into all-rural', all-urban'. Then one school was randomly selected from each stratum. A total of twenty government schools were studied (Tenrural and Ten urban schools). Participants were proportionately selected from each school according to the school's population by multiplying the school's population with the sampling fraction (sample size/total population of selected schools). In each school, the proportional allocation wasalso applied to obtain the sample size for each grade to meet the target sample size. An arm was chosen from each grade by simple random sampling method. Otherwise, thestudents were randomly selected using the class register assampling frame. The ratios of 1:1 were allocated for both rural: urban sector (depending on the distribution of schools) .Only those children who were present at school on the day of the study were approached to participate. Children who had major physical abnormality or dysmorphic features (syndromes) were not included.

Method of Data Collection: The written consent was attained from the principal of the selected schools and written consent was attained from the parents of the students prior to the measurements of anthropometric. Non-elastic flexible tape was used to ascertain the height in a standing position without wearing anything on the feet and recorded within a range of 0.1 cm. A portable weighing scale was used to determine the body mass within a range of 0.1kg.The waist circumference was measured to the nearest of 0.1 cm at the midpoint between lower margin of the last palpable rib and the top of iliac crest bystretch - resistant tape.BMI was determined for each participant by physical aid and weight gain (body mass (kg)/height $(m)^2$).WHtR was determined using the formula :waist circumference (cm) divided by height (cm) (WC÷ Ht).Depending upon the age-specific BMI percentile (WHO Growth Chart, 2000), the students were divided into four categories: obese (>/95th percentile), overweight (85th->95th percentile), normal weight

(5th -<85th percentile) and underweight (<5th percentile). To measure the central obesity ratio, WHtR was used with the discriminatory values of ≥ 0.500 as obesity [22].

Statistical Methods

Smoothed WHtR centile curves were constructed by the LMS method, using the LMS Chartmaker Pro (version 2.3). To verify the normality of WHtR values, the Kolmogorov-Smirnov test ($p<0.05$) and the coefficients of skewness and kurtosis were used. They all showed a significant departure from normality and, therefore, a non-parametric statistical analysis was performed. A descriptive analysis of the study variables was carried out, and Mann-Whitney test was used for comparing WHtR between the two groups and the Kruskal-Wallis test for comparing percentiles (three or more groups). Additionally, an analysis was performed using the receiver operating characteristic (ROC) curve for WHtR to assess sensitivity and specificity of cut-offs according to BMI classification based on WHO criteria. All analyses were performed using Statistical Analysis System (SAS) package [29] at 5% significance level.

Results and Discussion

The study included 2180 participants comprising of girls within the age group of 8-12. Table1 shows the age-wise distribution of study subjects. Table 1 shows the age-based prevalence governing with mean BMI ranges from both rural and urban settings.

Table 1

Distribution of Studied Children according to BMI –for Age Wise in Rural and Urban Sector (N=2180)

LOCATION	**AGE[a] (Years)**	**Frequency (n=2180)**	**MEAN±SD**	**p value**
Rural **(N=1090)**	8	218	17.3±2.3	P<0.05*
	9	218	17.2±2.1	
	10	218	16.8±1.8	
	11	218	16.7±2.8	
	12	218	18.2±3.2	
Urban **(N=1090)**	8	218	17.1±1.9	P<0.05*
	9	218	17.4±2.2	
	10	218	17.8±2.6	
	11	218	18.1±3.4	
	12	218	18.5±2.8	

Foot Notes: - t-statistics parentheses *p <0.05;[a]Indicates whole-age group,e.g.8.00-8.99 years ,SD=Standard Deviation

From the inferred data, there is greater significance could be explored with regards to urban population compared with rural sample population as they exhibited greater BMI ranges that could be most possibly orient the sample population to be affected with overweight and obesity related complications.

Table 2

Distribution of Studied Children according to Waist to Height Ratio in Rural and Urban Sector (N=2180)

LOCATION	AGE[a] (Years)	Frequency (n=2180)	MEAN	MIN	MAX	STD	
Rural (N=1090)	8	218	0.4607	0.2764	3.9644	0.2476	P<0.05*
	9	218	0.4161	0.0416	0.5	0.0437	
	10	218	0.3715	0.1	0.6	0.0666	
	11	218	0.3669	0.2	0.6	0.0658	
	12	218	0.4327	0.1986	0.6043	0.0565	
Urban (N=1090)	8	218	0.4439	0.21	2.6	0.1535	P<0.05*
	9	218	0.4336	0.32	0.62	0.0487	
	10	218	0.6067	0.31	41	2.7487	
	11	218	0.6482	0.34	43	2.8820	
	12	218	0.4474	0.35	0.63	0.0510	

Foot Notes: - t-statistics parentheses *p <0.05;[a]Indicates whole-age group,e.g.8.00-8.99 years ,SD=Standard Deviation

Table 2 outline the distribution of studied children (N=2180) according to waist to height ratio in rural and urban sector are aged between 8 years to 12 years. From descriptive statistics, the mean and standard deviation for 8 years was carryout for rural as 0.4607±0.2476 and for urban 0.4439±0.1535. For 9 years rural as 0.4161±0.0437 and for urban 0.4336±0.04876, For 10 years rural as 0.3715±0.0666 and urban as 0.6067±2.7487, For 11 Years rural as 0.3669±0.0658, For 12 years rural as 0.4327±0.0565 for urban as 0.4474±0.0510. The overall Mean Waist-Height Ratio Values by location and age was observed to have increased for urban sample population among 8-12 years old. From the assessment based on locality, there exists a significant statistical difference in by rural and urban area based on Mean waist-height ratio, as there is a gain in weight could be reflected with growing age among the urban population compared with rural population.

Table 3:

Smoothed Aged-Specific Waist to Height Ratio Percentiles for Rural Middle Aged School Children (N=1090)

WAIST-HEIGHT RATIO PERCENTILES CHART FOR RURAL AREA										
AGE (Year)	**3rd**	**10th**	**15th**	**25th**	**50th**	**75th**	**85th**	**90th**	**95th**	**97th**
8**(n=218)**	0.31	0.35	0.37	0.39	0.44	0.49	0.51	0.53	0.56	0.57
9**(n=218)**	0.34	0.36	0.38	0.39	0.42	0.44	0.45	0.46	0.48	0.48
10**(n=218)**	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.5	0.5
11**(n=218)**	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.5	0.5
12**(n=218)**	0.34	0.36	0.37	0.39	0.42	0.47	0.49	0.50	0.52	0.54

Table 4:

Smoothed Aged-Specific Waist to Height Ratio Percentiles for Urban Middle Aged School Children (N=1090)

WAIST-HEIGHT RATIO PERCENTILES CHART FOR URBAN AREA										
AGE (Year)	**3rd**	**10th**	**15th**	**25th**	**50th**	**75th**	**85th**	**90th**	**95th**	**97th**
8 **(n=218)**	0.37	0.39	0.39	0.4	0.43	0.47	0.48	0.49	0.51	0.51
9**(n=218)**	0.36	0.37	0.38	0.4	0.42	0.46	0.48	0.5	0.52	0.54
10**(n=218)**	0.35	0.37	0.38	0.4	0.42	0.44	0.46	0.46	0.48	0.52

11**(n=218)**	0.36	0.38	0.41	0.42	0.45	0.48	0.5	0.51	0.54	0.56
12**(n=218)**	0.37	0.38	0.4	0.41	0.44	0.48	0.49	0.52	0.55	0.55

The above Table 3 and 4 shows smoothed aged-specific waist-height ratio percentiles charts forboth rural and urban middle aged school going Childrenand 3rd, 5th, 10th, 15th,25th, 50th, 75th, 85th, 90th, 95th and 97th percentile values forWHtR by age and gender in 8-12 years old were presented in Table 4.

Table 5

Sensitivity and Specificity of Waist-Height Ratio Cut-Offs by Location and Age According to the ROC Curve Analysis for Obesity Based on the World Health Organization (WHO)Criteria (N=2180)

LOCATION	**AGE (Year)**	**Frequency (n=2180)**	**AREA***	**SENSITIVITY**	**SPECIFICITY**	**WHtR**
Rural**(n=1090)**	8	218	0.891	91.3	86.5	>0.04
	9	218	0.882	89.7	84.8	>0.24
	10	218	0.921	88.9	90.6	>0.41
	11	218	0.932	89.6	91.6	>0.49
	12	218	0.943	91.8	89.4	>0.54
Urban **(n=1090)**	8	218	0.933	92.6	94.5	>0.47
	9	218	0.925	88.4	88.4	>0.3
	10	218	0.911	95	89.5	>0.23
	11	218	0.889	94.7	92.4	>0.28

	12	218	0.911	92.4	90.9	>0.1

Foot Notes: -*Area under the ROC curve; WHtR=Waist -to-Height Ratio

The Table 5 shows the sensitivity and specificity of Waist-to -Height Ratio cut-offs by location and age. According to the ROC curve analysis for obesity based on the WHO criteria, WHtR cut-offs by age and location showed sensitivity (89.6-91.8% and 88.4–95% in Rural and Urban respectively) and high specificity (84.8-91.6% and 88.4-92.4% in Rural and Urban respectively) based on WHO criteria for obesity.

Table 6

Optimal Waist to Height Ratio Cut-off for Identifying Overweight and their Related Sensitivity and Specificity (N=2180)

LOCATION	AGE (Completed Years)	AREA*	SENSITIVITY	SPECIFICITY	WHtR
Rural **(n=1090)**	8 to 12	0.83	86.3	79.4	>0.45
Urban **(n=1090)**	8 to 12	0.89	88.1	81.5	>0.43

Foot Notes: -*Area under the ROC curve; WHtR=Waist -to-Height Ratio

Optimal waist to height ratio cut-off for identifying overweight and their related sensitivity and specificity. Where for sensitivity 86.3% for rural and 88.1% for urban. Whereas urban plays high sensitivity when compared to rural area. For specificity 79.4-81.5% in Rural and Urban respectively) and high specificity was shows in urban area based on WHO criteria for overweight.

Table 7

Optimal Waist to Height Ratio Cut-off for Identifying Obesity and their Related Sensitivity and Specificity (N=2180)

LOCATION	AGE (Completed Years)	AREA*	SENSITIVITY	SPECIFICITY	WHtR
Rural **(n=1090)**	8 to 12	0.89	91.3	90.4	>0.48
Urban **(n=1090)**	8 to 12	0.93	91.7	91.1	>0.52

Foot Notes: -*Area under the ROC curve; WHtR=Waist -to-Height Ratio

Optimal waist to height ratio cut-off for identifying obesity and their related sensitivity and specificity was calculated. For sensitivity91.3% for rural and 91.7% for Urban and high was carried out in urban area. Specificity (90.4% and 91.7% in Rural and Urban respectively), whereas urban shows high correlated based on WHO criteria for obesity.

Table 8

Prevalence Overweight and Obese Category Based on BMI-for Age wise Percentile for both Rural and Urban Sector (N=2180)

Age (Years)	N	Mean BMI (SD)	BMI PERCENTILE		OVER WEIGHT N (%)	OBESE N (%)
			85^{th}	95^{th}		
8	436	17.3 (3.02)	19.62	21.52	7.21	4.8
9	436	17.4 (2.85)	19.85	22.64	8.56	4.2
10	436	17.2(3.34)	20.35	22.95	9.52	3.6

11	436	18.15 (3.32)	21.74	24.42	12.56	4.2
12	436	18.35 (3.15)	20.82	21.52	13.28	4.6

Table 8 shows that the mean BMI of the study population was 17.68 with a standard deviation of 3.136 and the mean BMI increases from 17.2 at 10 years to 18.35 at 12 years of age. Among the study population 222 (10.18%) were overweight, 93.304 (4.28%) were obese and overall the prevalence of overweight/ obesity was found to be 13.28%. From the inferred data, it could be determined that the prevalence appears to be common in terms of the obesity and overweight category among the girls within the age group of 8-12 years ago. Obesity among young children has become an established risk factor for diseases such as coronary heart diseases, diabetes mellitus, etc. in adulthood [5]. Similar to the prevalence observed, previous study done in Chennai, Tamil Nadu among urban school children revealed a similar prevalence of overweight (8.0-10.81%) and obesity (5.26-9.52%) [25]. The NCDR study pooled data for 2416 population-based studies. This included data of 31.5 million children and adolescents aged 5–19 years. The mean BMI in 1975 was 17.2 and 16.8 kg/m2 for girls and boys, respectively. A study done in the urban areas of Udupi in South India, found prevalence of overweight and obesity in school children to be 10.8 and 6.2%, respectively [10]. Another study from Central India found 3.1% (95% CI 2.5–3.8) of children between 10 and 17 years to be overweight and 1.2% (95% CI 0.8–1.8) to be obese and overall 4.3% were overweight/obese [26]. From Surat, in Western India, Gamit et al. reported the prevalence of overweight and obesity to be 10.2 and 6%, respectively [27]. In Kanpur, the prevalence of overweight and obesity were 4 and 2%, respectively. The authors attributed this low prevalence, when compared to other studies from North India, to local dietary habits [28]. A systematic review conducted by Gupta et al., reported that prevalence of overweight, among 5–19 years children, ranged between 6.1 and 25.2%, while that of obesity ranged between 3.6 and 11.7% [29] Khadilkar et al., in 2010, estimated the combined prevalence of overweight and obesity to be 19.6% as per IOTF classification, while this was 27% according to WHO definitions [30].

From the observed investigation, it could be witnessed that the cut off value achieved for WHtR of 0.5 appeared to be in good agreement with age and gender specific (i.e.) Indian girls, similar to the study performed among German adolescents. [31] stated, with gender and ethnicity-specific ratios on cut-off value seems to have improved the overall specificity and sensitivity towards identifying the greater metabolic risks associated with childhood obesity. Likewise, a study conducted in Korean children who were falling within the age distribution of 6-18 years showed 85^{th} percentile of WHtRcutoffs value, exhibiting sensitive to determine metabolic risk factors pertaining to screening of insulin resistance (demonstrating Homeostatic Model of Assessment involving Insulin Resistance>2.5) [32] followed with cardiometabolic susceptibilities (LDL-cholesterol ranges ≥ 100 mg/dL, HDL-cholesterol- 90th percentile) in case of 6-10-years Brazilian children [33], wherein the WHtRcutoff ranging to 0.59 thus suggested as a efficacious predictor in determining metabolic-related complications (risk factors among WC≥90th percentile, glucose≥110 mg/dL, HDL-cholesterol). Thus from our investigation and comparison with various literature sources emphasising that there is need for developing/ devising different criteria as well as study approaches that might effectively increase the overall variance for determining optimal cutoffs between the studies, followed by exercising caution while implementing and implementing newer strategies for achieving the study outcomes that reflect the best plausible anthropometric survey for child obesity.

BMI percentiles are taken as widely utilized approach for classifying children as obese or overweight for identifying the greater likelihood of higher health-oriented risks involved. The utility governing with this percentiles are found to be essential in identification of greater levels of risks, which is seemingly less studied. The following investigation provides a greater insights pertaining to the determination of obese and overweight category among Indian population and further ascertains for deriving an optimal BMI percentile that differentiates those with higher levels of cardiometabolic risks involved due to the existing obesity condition among paediatric sample. As denoted by Harrington et al [33], BMI ranges at 95th percentile would seem to satisfactorily identify and are much suitable for children and adolescents who are exhibiting signs of associated health risk as a result of overweight and obesity due to higher levels of adiposity, thereby minimizing under and over-diagnosis. From WHO recommendations concerning with measuring the BMI cut off value in the case of US and UK under 85th percentile from the observed BMI charts, especially in the case of seven years in boys and nine years for girls. Wherein boys under 75th percentile from the showed mean BMI of 24.2 and girls had a mean BMI of 24 at 18 years, this value is just under the adult cut-off (25) for overweight.[34] In our study however exhibited moderate range of overweight and obese condition as the study under 85^{th} and 95^{th} percentile from the observed data, compared to WHtR report on 85^{th} and 95^{th} percentile in assessing obese and overweight population. WHO, however, recommends that for adult Asian Indians the BMI cut off value for overweight should be 23 and for obesity 28 [35].

Upon considering the sensitivity and specificity of WHtR approach, it could be inferred that from our study, it was found that there was greater level of specificity observed pertaining to the obese category showcasing an overall cut off range of Sensitivity- 91.3%; Specificity- 90.4% and Sensitivity- 91.7%; Specificity- 91.1%, among the overall urban and rural sample population respectively. From observed investigation from the literatures identified so far, from a study by Misra et al. [36] which exhibited WC cut-offs, of sensitivity: 68.7%, specificity: 71.8%. These study is indicative of WHtR approach could serve as a suitable and much more standardized approach for measuring the obesity levels among the juvenile population. Likewise from the observed overweight category among the observed population reported an overall sensitivity and specificity ranges with a cut off ranges of (sensitivity- 86.3%; Specificity- 88.1%) and Sensitivity- 79.4% and Specificity- 81.5%) among the rural and urban population. While considering the overall sensitivity and specificity observed in our study compared with Kamarkar et al., (2017) [37] which showed WC cut off of 78.8% and 80.4% for identifying overweight and a similar outcome showcased from a study by Misra et al, [32] which showed that, a WC cutoff of sensitivity 90.1%, specificity 83.6%.

From the investigation conducted by Panjikkaran&Kumaran [38] who raised concerns regarding the fact that there is minimal effort taken for precise determination of cut-off ratio concerning WHTR in Indian population. However this study unravelled the newer dimension concerning with the significance associated with utilization of WHtR as a suitable strategy for better determination of obesity and overweight prevalence in Indian population.

While considering BMI, WHtR, in its very nature tend to have greater correlation as there exists a greater concern regarding a suitable and yet simplistic anthropometric measure that is suitable and much more accurate to act as a suitable ‘early indicator of health risk’ [39][40]. From the observed investigation so far from the study, there is a much greater evidence concerning with utilization of WHtR which is further supported from several literatures across the world with regards to metabolic implications concerning with misclassifications that arises from measuring BMI alone as a standard procedure for anthropometric assessment. Similar to our investigation, a study conducted in Singapore reported WHtR ≥0.5 identified thus exhibiting a highest proportion especially pertaining to individuals who are susceptible to cardiometabolic risk factors among men and women, and is even more higher when applied in combination with BMI followed with WC [41]. From an investigation carried out in USA, among the children who are aged between 4 -18 years showed that over 10% of population were found to exhibit ‘healthy’ in accordance to the categorization of BMI, had WHtR>0.5, and that these children had raised cardiometabolic risk factors [42]. This further proves our necessitation to further investigation in the application of WHtR as a well-rounded and much more effective strategy for predicting the impending metabolic risk factors in children.

Conclusion

The study presents a high prevalence in terms of overweight as well as obesity category within the young girl students in the study population, thus depicting the effect of rapid urbanization of even rural areas as well, which could be attributed from lifestyle changes, in terms of changes in diet pattern followed by decreased physical activity. This emphasises the urgent requirement for screening of adolescents as well, both in the schools as well as in the community for the prevention of obesity and its consequences. Obesity among Indian school children is a cause of concern. To tackle this menace, a sustained multi-pronged approach is required, where all stake holders join hands. The strategy starts at the pre-conception time, continues during pregnancy, infancy and childhood. Apart from promoting healthy eating and an active lifestyle, it also includes active case finding among overweight and obese children and aggressive management of diabetes, hypertension and dyslipidaemia apart from weight loss. Ultimately, from the cross-sectional study employed for children revealed that WHtR is effective and even slightly better than WC and much more superior compared with BMI for prediction of obesity and overweight category, thereby subsequently acting as a sign for representing metabolic associated risks and co-morbidities. The study further stresses on developing large-scale prospective evaluation needed for confirming WHtR and its usefulness in children and adolescents on the basis of gender and ethnicity-specific investigations.

Strengths and Limitations

A main strength of this research was anthropometric measurements are performed using standardized protocols from a huge sample size, including both urban and rural residences with good representation from different age group. Also, WHtR provides extract and non-invasive measurements for both intra-abdominal as well as entire abdominal body fat.

First pubertal status of the students is not evaluated although sexual maturity is related to obesity or metabolic diseases in youth along with parental height/weight status. Next, the cut-off values obtained in this study cannot be applied to other ethnic groups. Also information on the dietary, socio-economic status, and lifestyle habits of Children was not considered, and non-schooling children were not considered.

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