Original Article

Central obesity is a burden even in normal weight adolescents of a non-metropolitan Indian City: A case for alarm and action for prevention and control

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Abstract

Introduction: Central obesity (CO) leads to increased cardiovascular and metabolic risks in children and adolescents. The evidence on prevalence of central obesity and its correlates are lacking among adolescents in India. **Objectives:** (1) To estimate the prevalence of central obesity in school-going adolescents, (2) To determine the association between central obesity and generalized obesity (GO) among adolescents, and (3) To determine the correlates of central obesity. **Methods:** Totally, 660 adolescents, selected using systematic random sampling, in four urban schools in Aligarh were interviewed using pre-designed questionnaire and Global Physical Activity Questionnaire. Height, weight, and waist circumference (WC) were measured. Body mass index (BMI) was calculated. CO was defined as >90th age-and-sex-specific percentile of WC and GO by BMI-for-age-and-sex percentiles given by WHO Growth Reference 2007. Chi-square test and logistic regression analysis were done using IBM SPSS version 20.0. **Results:** Overall prevalence of central obesity was found to be 28.5% [CI: 25.2-32.0], almost double of generalized obesity (14.6%, 95%CI: 12.1-17.6). The prevalence was significantly higher among girls (33.6%, 95%CI: 28.3-39.3) than in boys (24.7%, 95%CI: 20.7-29.3) and in the affluent group (38.8%, 95%CI: 33.7-44.1) than in non-affluent (18.2%, 95%CI: 14.4-22.7). More than 1/4th of normal weight adolescents [27.2% (99/364)] also had CO. Increased fast food intake (OR: 4.1; 95% CI = 2.1-8.1), low Physical Activity Level (OR: 2.4; 95% CI = 1.3-4.3) and more than 10 hours sedentary time spent per day (OR: 2.2; 95% CI = 1.1-4.8) were independent determinants of CO. **Conclusion:** Central obesity among school-going adolescents of a non-metropolitan Indian city is alarmingly high and a burden even in one-fourth of normal weight adolescents. Screening for CO among adolescents by primary physicians, pediatricians, and through School Health Programme is recommended. Behavior change communication regarding risk factors for CO is advocated.

Keywords: Adolescents, central obesity, generalized obesity

Introduction

Central obesity (CO) or abdominal obesity, a state of excessive accumulation of both central subcutaneous and visceral fat, has emerged as an important predictor for metabolic complications and adverse health effects.[1] It has been shown to be associated with insulin resistance, lipid profile alterations, and higher inflammatory states in overweight adolescents.[2]

Researchers have found central obesity to be higher among adolescents than generalized obesity.[3] There are studies indicating presence of central obesity in spite of normal body mass index (BMI), the most common marker used for generalized obesity among adults and adolescents. They highlight the importance of screening for central obesity even in adolescents with normal BMI, especially in Asian population. Waist circumference (WC) is simple, yet effective way of measuring

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CO and may be better predictor of cardiovascular disease risk than BMI in both adults[4] and children.[5]

It is noteworthy that overweight and obesity rates in children and adolescents in India are high not just among the higher socio-economic groups but also lower ones.[6] Some of the reasons implicated for increased overweight and obesity in the metro cities are westernization of culture, mushrooming of fast food joints, lack of open spaces for physical activity, and increasing sedentary pursuits during leisure.[7]

Generalized obesity among children and adolescents and its determinants has been studied aplenty in India[8] but data on CO among adolescents and its determinants are sparse. Is central obesity a burden among adolescents in non-metropolitan cities of India and is it a problem even in normal weight adolescents? Keeping these research questions in mind, a study was undertaken among the school-going adolescents of Aligarh, a small town located in North India, about 132 km from New Delhi, with the following objectives:

(1) To estimate the prevalence of central obesity among school-going adolescents.
(2) To determine association between central obesity and generalized obesity among adolescents.
(3) To determine the correlates of central obesity among the same.

Material and Methods

Study area, sample size and recruitment of study subjects

This study was part of a cross-sectional study done for the assessment of overweight and obesity among school-going adolescents and was conducted in the urban areas of Aligarh. Two schools catering to the affluent section of society (tuition fees more than Rs 10,000 per annum) and two for the non-affluent section (tuition fees less than Rs 10,000 per annum) were selected purposively, for studying socio-economic status differentials. Taking estimated prevalence of overweight as 3.23%,[9] 5% alpha error, 2% absolute allowable error and 10% non-response rate, sample size was calculated as 321, rounded off to 330. Systematic random sampling of 330 adolescents from each group of schools was done, making total sample size 660.

Apparently healthy adolescents of Vth to Xth standard, aged 10-16 years (as per school records) were interviewed, after taking assent. Those having chronic illness, severe malnutrition, endocrinal problems, physical and mental defects, those with apparent obesity induced or associated with any syndrome, those found to be smokers (defined as any amount of smoking or tobacco chewing at any time during past 6 month) and those not cooperating for anthropometric measurements, were excluded. The study was conducted from August 2009 to July 2010. The Institutional Ethical Committee approved the study design. Informed consent was taken from the school authorities and the parents. Children in need of medical attention were appropriately referred.

Study tools and study variables

Interviews were conducted in a non-judgmental and confidential manner. A pre-designed questionnaire was used to collect data for socio-demographic and behavioral factors. Total calorie intakes per day were assessed by individual 24 h recall method and categorized as deficient, adequate, and excess as per age-and-sex-wise calorie requirements of adolescents recommended by Indian Council of Medical Research.[10] Frequency of fruit and fast food intake during the past one month were assessed by food frequency questionnaire.

Duration of watching TV in hours per day, during the past month, was enquired and categorized. Total physical activity level (PAL) of the adolescents and the total sedentary time per day were assessed using Global Physical Activity Questionnaire [GPAQ].[11] PAL was categorized into low, moderate, and high based on metabolic equivalents cut-offs suggested in GPAQ.

Anthropometric measurements were done in a separate examining room. Waist circumference was measured to the nearest 0.1 cm horizontally at the midpoint point between inferior margin of the last rib and iliac crest using a non-stretchable tape, as advocated by World health Organization (WHO).[12] Central obesity was defined as ≥ 90th percentile of WC-for-age-and-sex[13] using WC percentile charts given by McCarthy *et al.*[14] Weight was measured in light clothing without shoes in the upright position to the nearest 0.1 kg using calibrated Salter weighing balance. The weighing scale was regularly checked with known standard weights. Height was measured without shoes to the nearest 0.1 cm using calibrated stadiometer. Body mass index (BMI) was calculated as weight (in kg)/height^2 (in meter^2). Generalized overweight and obesity was defined using BMI-for-age-and-sex percentiles given by WHO Growth Reference 2007.[15]

Statistical analysis

Descriptive statistics were shown in percentages for categorical data. Chi Square test and Fischer's Exact test were applied to study association between categorical variables. Kalmogorov-Smirnov test was applied to test for normality of continuous variables. Association between WC and BMI groups was studied by Kruskal-Wallis Test. The strength of association of determinants of central obesity was studied by unadjusted odds ratio [95% confidence interval]. Based on univariate analysis results, variables having significant association were subjected to stepwise multiple logistic regression model to determine the significant independent risk factors. P <0.05 was considered as statistically significant. All analyses were performed using the IBM Statistical Package for Social Sciences (SPSS) (version 20, Armonk, NY, USA).

Results

Socio-demographic profile and nutritional status of adolescents

Out of total adolescents, 57.6% (380/660) were males. Socio-demographic profile and nutritional status (by BMI group) of study subjects stratified by sex has been shown in Table 1.

Table 1: Socio-demographic profile and nutritional status of the study population [*n*=660]

Variable	Categories	Male [*n*=380]		Female [*n*=280]	
		n	[%]	*n*	[%]
Age Group	11-13 years	168	44.2	156	55.7
	>13-16 years	212	55.8	124	44.3
Religion	Hindu	151	39.7	110	39.3
	Muslim	227	59.7	169	60.4
	Others	2	0.5	1	0.4
Size of family	≤ 4	65	17.1	46	16.4
	≥ 5	315	82.9	234	83.6
Type of school	Affluent	189	49.7	141	50.4
	Non-affluent	191	50.3	139	49.6
Father's education	Up to high school	91	23.9	51	18.2
	Inter	71	18.7	47	16.8
	≥ graduate	218	57.4	182	65.0
Mother's Education	Up to high school	151	39.7	103	36.8
	Inter	82	21.6	44	15.7
	≥ graduate	147	38.7	133	47.5
Father's occupation	Service	87	22.9	75	26.8
	Professional	54	14.2	45	16.1
	Business	189	49.7	132	47.1
	Others	50	13.2	28	10
Mother's occupation	Housework	358	94.2	257	91.8
	Working	22	5.8	23	8.2
Family history of obesity	Absent	274	72.1	192	68.6
	In Either Parent	92	24.2	77	27.5
	In Both the parents	14	3.7	11	3.9
Nutrirtional Status by Body Mass Index [BMI] Groups*	Underweight	106	27.9	93	33.2
	Normal weight	210	55.3	54	55.0
	Overweight	43	11.3	22	7.9
	Obese	21	5.5	11	3.9

*BMI groups were categorized according to WHO Growth Reference 2007

Majority of adolescents were Muslim, belonged to large family, 60% adolescents had fathers who were graduate and above and 42.4% adolescents had mothers who were graduate and above. Totally, 9.8% were overweight and 4.8% were obese.

Behavioral factors among adolescents

Majority of adolescents were non-vegetarian (65.5%), used refined oil/mustard oil as cooking medium (73.6%), and took outside meal less than once a week (83.5%) but were deficient in total calorie intake (74.8%). About 37.7% reported consuming fruits more than 5 times a week whereas fast-food consumption 3-4 times a week was reported by 21.7% adolescents. More than one-fourth adolescents (28%) had low PAL. Majority of adolescents reported watching TV up to 2 h per day (65%) and spending 6-10 sedentary hours/day (58.6%). Significantly higher proportion of girls were found to have low physical activity level (51% vs 11.1%), watch TV more than 2 h/day (17.1% vs 9.7%) and spend more than 10 h/day as sedentary time (10% vs 4.5%) as compared to boys [Table 2]. Various dietary behaviors were not found to have statistically significant differences between boys and girls.

Prevalence of central obesity

The prevalence of CO among the adolescents was 28.5% (CI: 25.2-32.0), whereas that of generalized obesity (both overweight and obesity) was 14.7% (95% CI: 12.1 -17.6) (97/660). Prevalence of CO among females was 33.6% (CI: 28.3-39.3) whereas among males 24.7% (CI: 20.7-29.3), difference being statistically significant (χ^2-6.177, df = 1, $P < 0.05$). Adolescents of affluent group showed significantly higher prevalence of central obesity than those of non-affluent group [38.8% (CI: 33.7-44.1) vs 18.2% (CI: 14.4-22.7), χ^2-34.392, df = 1, $P < 0.05$]. The elevated WHtR was found in 16.6% (63/380) males and 16.8% (47/280) females.

Central obesity and its association with BMI groups and generalized obesity

Figure 1 shows the association between CO and general overweight and obesity. A significantly higher proportion of overweight [84.6% (55/65)] and obese adolescents [90.6% (29/32)] had CO as compared to other BMI groups (χ^2 = 227.38, df = 3, $P < 0.000$). More than 1/4th of normal weight adolescents [27.2% (99/364)] also had CO. Median WC was found to increase in higher BMI group, as shown in Figure 2. There was statistically significant difference in median WC between groups as determined by Kruskal-Wallis Test [Chi Square (3) =232.220, $P = 0.000$].

Determinants of central obesity

As shown in Table 3, adolescents having fast foods 1-2 times a week were 2.1 times (OR: 2.1; 95% CI = 1.1-4.0) more at risk of CO. The risk increased to 4 times (OR: 4.1; 95% CI = 2.1-8.1) when fast food intake increased to 3-4 times a week and ≥5 times a week. The risk of CO was found to be 2 times more (OR: 2.0; 95% CI = 1.1-3.4) in adolescents having moderate PAL whereas it increased to 2.4 times (OR: 2.4; 95% CI = 1.3-4.3) in those with low PAL. Sedentary level (>10 h/day) increased the risk of CO by 2.2 times (OR: 2.2; 95% CI = 1.1-4.8). Mustard or refined oil used as cooking medium decreased the odds of CO by half (OR: 0.5; 95% CI = 0.3-0.8)

Discussion

Our study reports the prevalence and behavioral determinants of central obesity among school going adolescents of a non-metropolitan city in north India. With almost three adolescents out of ten having central obesity, we have found the prevalence to be high. The adolescents who belong to affluent section of society and the female adolescents appear to be more at risk. This finding of high prevalence (28.5%) is similar to that reported by Kuriyan *et al.*[16] in South Indian children (30%). Whereas Misra *et al.*[17] have reported much lower prevalence of CO (4.5%), which may be so because their study subjects belonged to a broader age range of 8-18 years including both children and adolescents.

Alarmingly, this prevalence is also comparable to that in some other developed countries like Italy (29%),[18] and higher than that of Spanish adolescents (9.6%).[19] In a study of Brazil, prevalence of CO was 32.7% (girls = 36.3%, boys = 28.4%).[20] It harbingers

Table 2: Distribution of behavioural factors among school going adolescents by sex. [*n*=660]

Behavioural factors	Male [*n*=380] *n* [%]	Female [*n*=280] *n* [%]	Test of significance
Cooking medium used			
Refined oil/Mustard oil	273 [71.8]	213 [76.1]	χ^2=2.293, df=2, *P*>0.05
Ghee/Vanaspati	42 [11.1]	31 [11.1]	
>One type of oil	65 [17.1]	36 [12.9]	
Type of diet			
Vegetarian	122 [32.1]	106[37.9]	χ^2=2.359, df=1, *P*>0.05
Non-vegetarian	258 [67.9]	174 [62.1]	
Calorie intake per day			
Adequate	40[10.5]	30[10.7]	χ^2=0.149, df=2, *P*>0.05
Deficient	283 [74.5]	211[75.4]	
Excess	57 [15.0]	39 [13.9]	
Taking meals outside home			
<Once a week	317[83.4]	234 [83.6]	χ^2=0.109, df=2, *P*>0.05
Once a week	35 [9.2]	27 [9.6]	
>Once a week	28 [7.4]	19 [6.8]	
Fast food intake			
<Once A Week	63 [16.6]	49[17.5]	χ^2=4.803, df=3, *P*>0.05
1-2 Times a Week	157[41.3]	135[48.2]	
3-4 Times a Week	92[24.2]	51[18.2]	
5+Times a Week	68[17.9]	45[16.1]	
Fruit intake			
<Once A Week	86[22.6]	56 [20.0]	χ^2=1.344, df=3, *P*>0.05
1-2 Times a Week	94[24.7]	65[23.2]	
3-4 Times a Week	63[16.6]	47[16.8]	
5+Times a Week	137 [36.1]	112 [40.0]	
PAL**			
Low	42 [11.1]	143 [51.0]	χ^2=147.139, df=2, *P*<0.05*
Moderate	226 [59.5]	121 [43.2]	
High	112[29.5]	16 [5.7]	
Tv watching time			
Do Not Watch	86 [22.6]	60 [21.4]	χ^2=7.926, df=2, *P*<0.05*
Up to 2 hours/day	257 [67.6]	172 [61.4]	
More than 2 hours/day	37 [9.7]	48 [17.1]	
Total sedentary time			
Up to 6 Hours	143 [37.6]	85 [30.4]	χ^2=9.775, df=2, *P*<0.05*
6-10 Hours	220 [57.9]	167 [59.6]	
>10 Hours	17 [4.5]	28 [10]	

* Statistically significant. **Physical activity level [PAL] was categorized according to metabolic equivalents/day as per Global Physical Activity Questionnaire

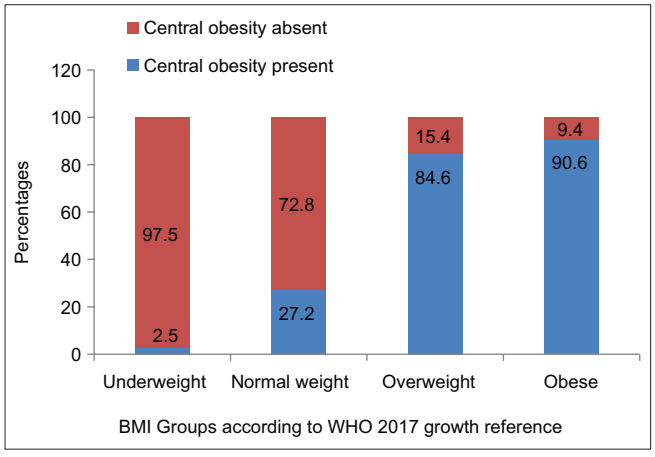

Figure 1: Central obesity in adolescents according to BMI Groups (*n*=660)

a worrying trend as obesity is not only confined to larger metro cities but has even percolated into non-metropolitan cities.[21]

It is notable that prevalence of CO was found to be higher than generalized obesity in our study (28.5% vs 14.6%) and more than 1/4th of normal weight adolescents in our study had CO. El-Kassas *et al.*[3] have also reported higher CO (41.8%) as compared to generalized obesity rates (32.2%) in their study among Lebanese adolescents. Given the fact that childhood obesity tracks into adulthood,[22] this trend merits grave concern as normal-weight central obesity has been shown to be associated with higher mortality than BMI-defined obesity, particularly in the absence of central fat distribution in adults.[4] These findings are also alarming because central obesity (but not overall obesity) has been reported to be a significant predictor of depressive symptoms in the children and adolescents[23] and is a predictor

Table 3: Behavioural factors as determinants of central obesity among school going adolescents by Logistic regression analysis. [*n*=660]

Behavioural factors	*n* [%]	Unadjusted OR [95% CI]	*P*	Adjusted OR [95% CI]	*P*
Type of diet					
Vegetarian	228 [34.5]	1.3 [0.8-1.8]	0.201	-	-
Non-vegetarian	432 [65.5]	1.0	-	-	-
Cooking medium					
Refined/mustard oil	486 [73.6]	0.4 [0.3-0.7]	0.000	0.5 [0.3-0.8]	0.003
Ghee/vanaspati	73 [11.1]	1.3 [0.7-2.3]	0.432	1.3 [0.7-2.5]	0.428
Others	101 [15.3]	1.0	-	-	-
Total calorie intake					
Adequate	70 [10.6]	1.0	-	-	-
Deficient	494 [74.8]	1.2 [0.7-2.1]	0.599	-	-
Excess	96 [14.5]	1.2 [0.6-2.4]	0.624	-	-
Taking meals outside home					
< Once a week	551 [83.5]	1.0	-	-	-
Once a week	62 [9.4]	2.0 [1.2-3.5]	0.009	1.7 [0.9-3.0]	0.079
> Once a week	47 [7.1]	0.7 [0.3-1.5]	0.365	0.5 [0.2-1.1]	0.094
Fast food intake					
< Once a week	112 [17.0]	1.0	-	-	-
1-2 Times a week	292 [44.2]	2.1 [1.2-3.9]	0.015	2.1 [1.1-3.9]	0.027
3-4 Times a week	143 [21.7]	3.9 [2.1-7.4]	0.000	4.1 [2.1-8.1]	0.000
≥5 Times a week	113 [17.1]	4.6 [2.4-8.9]	0.000	4.0 [2.0-8.0]	0.000
Fruit intake					
< Once a week	142 [21.5]	1.0		-	-
1-2 Times a week	159 [24.1]	1.5 [0.9-2.5]	0.128	1.4 [0.8-2.4]	0.283
3-4 Times a week	110 [16.7]	1.2 [0.6-2.1]	0.612	0.9 [0.5-1.7]	0.755
≥5 Times a week	249 [37.7]	1.8 [1.1-2.9]	0.017	1.3 [0.8-2.2]	0.316
Physical activity level					
Low	185 [28.0]	2.6 [1.5-4.5]	0.001	2.4 [1.3-4.3]	0.005
Moderate	347 [52.6]	2.0 [1.2-3.3]	0.009	2.0 [1.1-3.4]	0.016
High	128 [19.4]	1.0	-	-	-
Tv viewing					
Do not watch	146 [22.1]	1.0	-	-	-
Up to 2 hours/day	429 [65.0]	1.5 [0.9-2.3]	0.081	1.2 [0.7-1.9]	0.466
More than 2 hours/day	85 [12.9]	2.5 [1.4-4.5]	0.003	1.4 [0.7-2.7]	0.296
Total sedentary time					
Up to 6 hours/day	228 [34.5]	1.0	-	-	
6-10 hours/day	387 [58.6]	1.7 [1.2-2.6]	0.004	1.2 [0.8-1.9]	0.337
>10 hours/day	45 [6.8]	3.1 [1.6-6.0]	0.001	2.2 [1.1-4.8]	0.038

of cardiovascular complications in overweight children and adolescents also.[24] This highlights the importance of screening for central obesity even in adolescents with normal BMI.

In this study, WC was found to increase with higher BMI group and CO was significantly higher in overweight and obese adolescents. Das *et al.*[25] have reported similarly in their study in 6-16 years old school children of Bhubaneshwar, Odisha. The prevalence of central obesity was 13.6% in children who were overweight and 68.4% in children who were obese in their study.

Prevalence of CO among adolescent girls was found to be higher as compared to boys. Other researchers from India[17] and different parts of world[26] have reported similarly. This may be attributed low physical activity level among girls due to lesser opportunities for outdoor physical activities and inclination for more sedentary pursuits. This differential behavior has been found in our study also with significantly higher proportion of girls having low PAL, higher screen time, and higher sedentary time than boys. On the other hand, El-Kassas *et al.*[3] have reported CO to be higher among males (50.7%) as compared to females (34.1%) among Lebanese adolescents, and some other researchers have not found any significant difference between gender.[27,28]

Among various dietary factors, we found fast food intake to be a significant determinant of central obesity. Moraes *et al.*[20] have also reported in their study in Brazil that excessive consumption of soda was positively associated with CO among girls, but negatively associated with CO in boys.

Low physical activity levels and higher sedentary times spent per day were found to increase risk for CO in our study, which

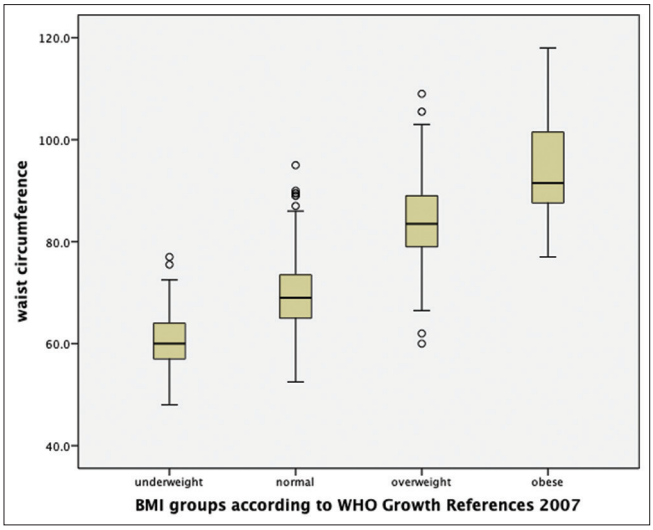

Figure 2: Distribution of WC [median and IQR] between BMI groups

has been reported by other researchers also.[3] In a study of Brazil, Castro *et al.*[26] also found that adolescents who watched television daily for two or more hours (OR = 2.11, 95%CI 1.08 to 4.13) had a higher chance of having CO. Nasreddine *et al.*[29] have also found sedentary time to significantly increase the odds of CO (OR = 1.10; 95% CI: 1.01–1.22).

Limitations of the study include a purposive selection of schools and use of 24 h recall for assessment of dietary intake per day. Because most individuals' diets may vary greatly from day to day, data from a single 24 h recall might fail to characterize an individual's usual diet. As the findings of a school-based study like this cannot be generalized to the whole population, a larger study conducted in schools as well as the general adolescent population can provide more conclusive results about central obesity and the risk factors. Also, this paper reports the findings of a study conducted a decade ago in 2009-2010 and may not represent the burden of CO among adolescents prevalent currently, but all the same it provides insight into the alarming scenario of CO present even among normal weight adolescents and its determinants.

Conclusions

This study concludes that prevalence of central obesity is high among school going adolescents of a non-metropolitan city of India, more so among affluent section and girls. Central obesity is quite high among adolescents with generalized obesity and is present even in one fourth of normal weight adolescents. Low physical activity levels, watching TV more than 2 h per day and more than 10 h spent in sedentary activities are main drivers of central obesity among adolescents.

Consequentially, it becomes necessary to initiate timely and appropriate screening procedure for central obesity among adolescents. This can be done by incorporating WC measurements in the school health programme for screening of "at-risk" adolescents and prevent obesity through primary health care approach. Being a single measurement, it can be easily incorporated into practice by primary physicians and pediatricians also for screening of central obesity. Behavior change communication activities promoting physical activity, reducing sedentary time and limiting fast food intakes should be targeted towards adolescents.

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Conflicts of interest

There are no conflicts of interest.

References

1. Lukács A, Horváth E, Máté Z, Szabó A, Virág K, Papp M, *et al.* Abdominal obesity increases metabolic risk factors in non-obese adults: A Hungarian cross-sectional study. BMC Public Health 2019;19:1533.
2. Velásquez-Rodríguez CM, Velásquez-Villa M, Gómez-Ocampo L, Bermúdez-Cardona J. Abdominal obesity and low physical activity are associated with insulin resistance in overweight adolescents: A cross-sectional study. BMC Pediatr 2014;14:258.
3. El-Kassas G, Ziade F. Exploration of the risk factors of generalized and central obesity among adolescents in north lebanon. J Environ Public Health 2017;2017:2879075. doi: 10.1155/2017/2879075.
4. Sahakyan KR, Somers VK, Rodriguez –Escudero JP, Hodge DO, Carter RE, Sochor O, *et al.* Normal weight central obesity: Implications for total and cardiovascular mortality. Ann Intern Med 2015;163:827–35.
5. Tuan NT, Wang Y. Adiposity assessments: agreement between dual-energy X-ray absorptiometry and anthropometric measures in U.S. children. Obesity [Silver Spring] 2014;22:1495-504.
6. Ranjani H, Mehreen TS, Pradeepa R, Anjana RM, Garg R, Anand K, *et al.* Epidemiology of childhood overweight and obesity in India: A systematic review. Indian J Med Res 2016;143:160-74.
7. Kalra S, Unnikrishnan AG. Obesity in India: The weight of the nation. J Med Nutr Nutraceut 2012;1:37-41.
8. Jena Samanta L, Parida J, Badamali J, Pradhan A, Singh PK, Mishra BK, *et al.* The incidence, prevalence, and contributing factors of overweight and obesity among adolescent population of India: A scoping review protocol. PLoS One 2022;17:e0275172.
9. Raj M, Sundaram KR, Paul M, Deepa AS, Kumar RK. Obesity in Indian children: Time trends and relationship with hypertension. Natl Med J India 2007;20:288-93.
10. Indian Council of Medical Research. Nutrient Requirements and Recommended Dietary Allowances: A Report of the Expert Group of the ICMR. 1990.
11. Global Physical Activity Questionnaire [GPAQ]. Available from: www.who.int/chp/steps. [Last accessed on 2023 Aug 10].
12. WHO Expert Committee. Physical status – the use and interpretation of anthropometry. Recommended

measurement protocols and derivation of indices. WHO Tech Rep Series 1995;854:424-38.

13. International Diabetes Federation consensus definition of the metabolic syndrome in children and adolescents. International Diabetes Federation; 2007.
14. McCarthy HD, Jarrett KV, Crawley HF: The development of waist circumference percentiles in British children aged 5.0–16.9 y. Eur J Clin Nutr 2001;55:902-7.
15. WHO Growth Reference 2007. Available from: www.who.int/growthref/who2007_bmi_for_age/en/index.html. [Last accessed on 2019 Dec 05].
16. Kuriyan R, Thomas T, Lokesh DP, Sheth NR, Mahendra A, Joy R, *et al.* Waist circumference and waist for height percentiles in urban South Indian children aged 3-16 Years. Indian Pediatr 2011;48:765-71.
17. Misra A, Shah P, Goel K, Hazra DK, Gupta R, Seth P, *et al.* The high burden of obesity and abdominal obesity in urban Indian schoolchildren: A multicentric study of 38,296 children. Ann Nutr Metab 2011;58:203–11.
18. Papalia T, Greco R, Lofaro D, Mollica A, Roberti R, Bonofiglio R. Anthropometric measures can better predict high blood pressure in adolescents. J Nephrol 2013;26:899-905.
19. Schröder H, Ribas L, Koebnick C, Funtikova A, Gomez SF, Fíto M, *et al.* Prevalence of abdominal obesity in Spanish children and adolescents. Do we need waist circumference measurements in pediatric practice? PLoS One 2014;9:e87549.
20. Moraes AC, Falcão MC. Lifestyle factors and socioeconomic variables associated with abdominal obesity in Brazilian adolescents. Ann Hum Biol 2013;40:1-8.
21. Nawab T, Khan Z, Khan IM, Ansari MA. Is small town India falling into the nutritional trap of metro cities? A study in school-going adolescents. J Family Med Prim Care 2016;5:581-6.
22. Serdula MK, Ivery D, Coates RJ, Freedman DS, Williamson DF, Byers T. Do obese children become obese adults? A review of the literature. Prev Med 1993;22:167-77.
23. Esmaeilzadeh S, Farzizadeh R, Kalantari HA, Mahmoudi A, Bilehsavar OY, Mehranpour A. Central or overall obesity: Which one is a better predictor of depressive symptoms in children, adolescents, and youths? Eat Weight Disord 2018;23:117-23.
24. Trandafir LM, Russu G, Moscalu M, Miron I, Lupu VV, Leon Constantin MM, *et al.* Waist circumference a clinical criterion for prediction of cardio-vascular complications in children and adolescences with overweight and obesity. Medicine (Baltimore) 2020;99:e20923.
25. Das RR, Mangaraj M, Panigrahi SK, Satapathy AK, Mahapatro S, Ray PS. Metabolic Syndrome and insulin resistance in schoolchildren from a developing country. Front Nutr 2020;7:31.
26. Castro JA, Nunes HE, Silva DA. Prevalence of abdominal obesity in adolescents: association between socio-demographic factors and lifestyle. Rev Paul Pediatr 2016;34:343-51.
27. Fang HY, Liu D, Zhao LY, Yu DM, Zhang Q, Yu WT, *et al.* Epidemiological characteristics of waist circumference and abdominal obesity among Chinese children and adolescents aged 6-17 years. Zhonghua Liu Xing Bing Xue Za Zhi 2018;39:715-9.
28. Al-Hazzaa HM, Abahussain NA, Al-Sobayel HI, Qahwaji DM, Alsulaiman NA, Musaiger AO. Prevalence of overweight, obesity, and abdominal obesity among urban Saudi adolescents: gender and regional variations. J Health Popul Nutr 2014;32:634-45.
29. Nasreddine L, Naja F, Akl C, Chamieh MC, Karam S, Sibai AM, *et al.* Dietary, lifestyle and socio-economic correlates of overweight, obesity and central adiposity in Lebanese children and adolescents. Nutrients 2014;6:1038-62.