

Original Research Article

A study on correlation of waist indices with body mass index among school children in North Kerala

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Received: 24 November 2020

Accepted: 05 December 2020

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ABSTRACT

Background: Childhood obesity is a serious problem worldwide. Body mass index (BMI) has been the widely used tool to detect obesity. Central adiposity detected by waist indices is a better predictor of obesity related complications like metabolic syndrome. Objective of this study was to analyze the correlation of waist indices with BMI as indicators of overweight (OW)/obesity in school going children.

Methods: This study was done in 880 adolescents from two schools in Kerala. Anthropometric measurements including waist circumference (WC) were taken according to guidelines and BMI, waist hip ratio (WHR), waist height ratio (WHtR) calculated. We categorized children as normal, OW/obese according to BMI charts by centers for disease control and prevention (CDC). A cutoff 70th centile in WC charts by Khadilkar et al, WHR of more than 0.85 in girls and 0.9 in boys, WHtR >0.5 were taken as central obesity.

Results: The prevalence of overweight/obesity (BMI >85th centile) was estimated to be 26.3%. Prevalence of central obesity was 12.3% when measured by WC, 22.8% measured by WHR, 14.8% measured by WHtR. All three waist indices showed statistically significant correlation with OW/obesity and BMI ($p < 0.001$). Multivariate regression showed association of OW/obesity with urban school, acanthosis nigricans, hypertension, WHtR ($p < 0.001$) and with WC ($p = 0.004$).

Conclusions: The prevalence of overweight and obesity is alarmingly high in adolescent children. Waist height ratio was best correlated with Body mass index and overweight/obesity, followed by Waist circumference. We recommend waist height ratio as a screening tool to predict obesity in school going children.

Keywords: Obesity, Body mass index, Waist circumference, Waist hip ratio, Waist height ratio

INTRODUCTION

Childhood obesity is a serious problem worldwide in all age groups. The international association for the study of obesity (IASO) and international obesity task force (IOTF) estimated that 200 million school children worldwide are either overweight or obese.¹ Urbanization, change in lifestyle and diet are the major causes for the increase in incidence over the last few decades. Developing countries like India has the double burden of

undernutrition and obesity to deal with. In children it can lead to increased morbidity and mortality. The consequences of childhood obesity include physical and psychological issues.

World health organization (WHO) refers obesity as “abnormal or excessive fat accumulation that may impair health”.² Obesity can be detected by various anthropometric measurements and body fat estimation by dual-energy X-ray absorptiometry. Measurements include BMI, waist indices, conicity index, skin fold thickness,

neck and wrist circumference. BMI has been the widely used tool to detect obesity. Disadvantage is it doesn't give an idea about fat distribution. It is proved that compared to generalized obesity, central obesity has more adverse effects later in life.³ The prevalence of central obesity in Indian children is high compared to other ethnic groups.⁴

Waist indices include waist circumference, waist hip ratio and waist height ratio. According to WHO the waist to hip ratio (WHR) has been suggested superior to the BMI in predicting the cardiovascular disease risk in adults and adolescents.⁵ There is no consensus on utility of these indices in children. Several studies indicate that waist circumference remains the simplest clinical measure of central obesity in children.^{6,7} Whereas many studies found that ratios like WHR, WHtR are better predictors of obesity.^{8,9} Studies done in India suggest a lower cut off value for waist indices compared to the widely accepted value.^{3,10,11}

Obesity can cause hypertension, diabetes mellitus, dyslipidemia, cerebrovascular accidents and various other disorders. Early identification of children at risk may help in preventing these complications. Screening with BMI is difficult especially in busy outpatient clinics, as it requires calculation and reference charts to interpret. A simple screening tool like waist hip/height ratio is a good alternative to BMI, which has the added advantage of detecting central obesity also. These ratios with a single cut off value can be used by non-professionals like health workers/teachers and thereby detect many undiagnosed obese children. This study aims at correlation of waist indices with body mass index as indicators of overweight/obesity in school going children.

METHODS

This cross-sectional study was conducted in two schools from the field practice area of Kannur medical college from April to June 2019. One was a government rural school and the other one was a private urban school. Institutional ethical committee approved study and consent was obtained from all the study participant's attendants. 880 adolescents aged 12-15 years were included under the study. Purposive sampling technique was used. Baseline characteristics and relevant history related to socio-economic status, diet and physical activity were recorded in a pretested proforma. Consumption of junk food or sweetened beverages more than twice a week was taken as risk as per American Academy of Pediatrics guidelines. Relevant clinical findings like acanthosis nigricans, blood pressure (BP) were noted. Blood pressure was measured using mercury sphygmomanometer according to recommendations by American heart association. A value of >95th centile for age and gender was taken as high. High values were confirmed by remeasurements on another day to exclude hypertension induced by anxiety.

Height and weight were recorded using stadiometer and digital scale respectively according to standard guidelines. BMI was calculated using the formulae weight in kg/height in m². CDC charts were used to categories children as normal/overweight/obese. BMI <85th centile-normal, 85-95th centile-overweight, >95th centile-obese. Waist circumference was measured using non stretchable tape in standing posture with arms at the sides and feet positioned close together, at the midpoint between the lower margin of the last palpable rib and the top of the iliac crest at the end of normal expiration. Measurements were taken with the tape held snugly, but not constricting, and at a level parallel to the floor. Centile charts on waist circumference by Khadilkar et al were used as reference.³ A cut off value of 70th centile was taken as an indicator of central obesity. Hip circumference (HC) was measured around the widest portion of the buttocks with the tape parallel to the floor. Waist hip (WHR) and waist height ratios (WHtR) were calculated from the above-mentioned measurements. A WHR ratio of >0.85 in girls and >0.9 in boys was taken as obesity. A WHtR of >0.5 was taken as obesity.

For categorical variables, number/percentage and for continuous variables, mean/standard deviation were used. Pearson correlation was used to find the correlation of WC, HC, WHR and WHtR with BMI. One-way ANOVA with post hoc Bonferroni correction was used to compare the WC, HC and WHR by BMI centiles. Chi-square test was used to compare the categorical risk factors with weight status. Forward conditional multiple binary logistic regression analysis was used to predict the risk factors of weight status and to estimate the odds ratio (OR) with 95% confidence interval (CI). Statistical analysis was conducted using SPSS version 20.0 for Windows (IBM Corporation ARMONK, NY, USA).

RESULTS

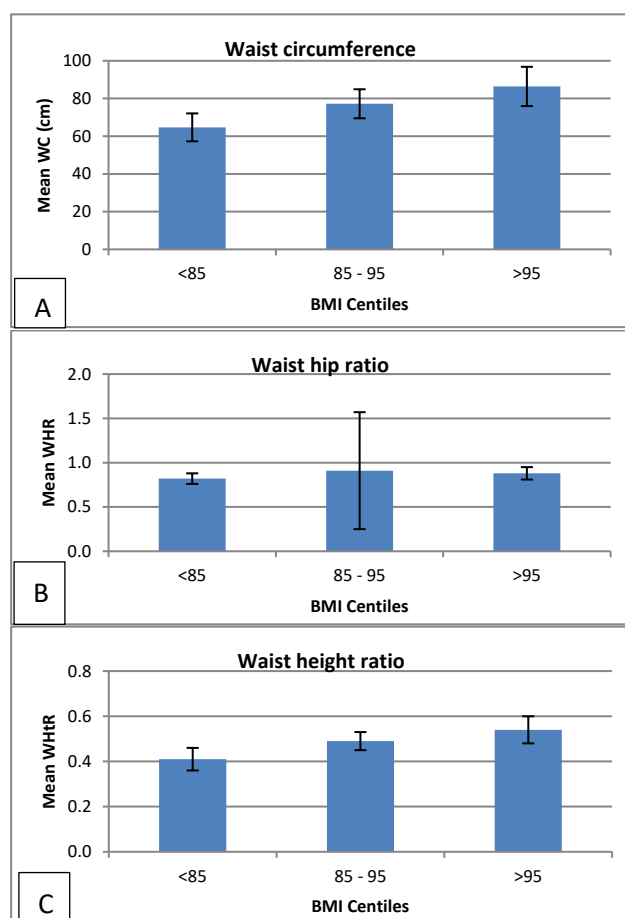
A sample of 880 adolescents were studied from two schools. Out of that 566 students were from urban school and 52% were boys. Mean age of students from rural school was 13.8 years and urban school was 14.1 years. Children aged 12-13 years constituted 29.7% and 13-14 years constituted 70.3% of sample respectively.

Characteristics like consumption of high calorie food, physical activity, clinical findings like acanthosis nigricans, hypertension, BMI, waist indices are given in Table 1. The prevalence of overweight/obesity (BMI >85th centile) in the sample population was 26.3%. Among that, overweight (BMI 85-95th centile) was observed in 16.7% and obesity (BMI >95th centile) was observed in 9.6% of children. Prevalence of central obesity was 12.3% when measured by WC, 22.8% measured by WHR, 14.8% by WHtR. A WC >90th centile was observed in 4.2% of students. Acanthosis nigricans was noted in 5.2% and asymptomatic hypertension in 9.6% of children.

Table 1. Prevalence of risk factors and obesity according to BMI, WC, WHR, WHtR.

Characteristics	Urban school (n=566)	Rural school (n=314)	Total (n=880) N (%)
High calorie diet	150	27	177 (20.1)
Sedentary lifestyle	217	159	376 (42.8)
Acanthosis nigricans	14	32	46 (5.2)
Hypertension	53	31	84 (9.5)
BMI >85 th centile	189	43	232 (26.3)
WC >70 th centile	94	14	108 (12.3)
WHR >0.85 in girls >0.9 in boys	148	53	201 (22.8)
WHtR >0.5	108	23	131 (14.8)

All the three waist indices were significantly high ($p<0.001$) in children with overweight/obese group compared to normal children (Figure 1). Mean waist circumference and waist height ratio were high in obese group followed by overweight and normal children. Statistical correlation using Pearson co-efficient (2 tailed significance at 0.01 level) showed maximum correlation between BMI (co-efficient-1) and WC (0.788), followed by WHtR (0.764) and WHR (0.089).

**Figure 1: Correlation between (A)WC, (B) WHR, (C) WHtR with BMI (normal, overweight, obese).**

All three parameters had statistically significant correlation ($p<0.001$).

Univariate analysis of risk factors and waist indices with BMI is shown in Table 2. Statistically significant difference in risk was noted between two schools with a p value of <0.001 (urban-33.4%, rural-13.7%). Seventy-one percentage (71%) of children with acanthosis nigricans and 64% of children with hypertension were found to be overweight/obese. Significant correlation was not found with gender, physical activity and high calorie diet. All three waist indices were statistically correlated with BMI ($p<0.001$). Overweight/obesity was observed in 86.1% of children with WC >70th centile, 82.4% with increased WHtR, 46.8% with increased WHR.

Table 2: Association of risk factors and waist indices with BMI categories (normal and OW/obese).

Category	BMI (kg/m ²)		P value
	<85 th centile N (%)	>85 th centile N (%)	
Group			
Urban school	377 (66.6)	189 (33.4)	<0.001
Rural school	271 (86.3)	43 (13.7)	
Age group (year)			
12	24 (54.5)	20 (45.5)	0.033
13	161 (74.2)	56 (25.8)	
14	309 (75.0)	103 (25.0)	
15	154 (74.4)	53 (25.6)	
Acanthosis			
No	635 (76.1)	199 (23.9)	<0.001
Yes	13 (28.3)	33 (71.7)	
BP			
Normal	618 (77.6)	178 (22.4)	<0.001
High	30 (35.7)	54 (64.3)	
WC			
Normal	633 (82.0)	139 (18.0)	<0.001
>70 th centile	15 (13.9)	93 (86.1)	
WHR			
Normal	541 (79.7)	138 (20.3)	<0.001
>0.85 for girls	107 (53.2)	94 (46.8)	
>0.9 for boys			
WHtR			
Normal	625 (83.4)	124 (16.6)	<0.001
>0.5	23 (17.6)	108 (82.4)	

Among parameters in univariate analysis, parameters with p value of <0.2 were considered for multiple regression analysis. Result is shown in Table 3. Statistically significant correlation for overweight/obesity was found with urban school, children with acanthosis nigricans, hypertension, increased waist height ratio ($p<0.001$) and increased WC with a p value of <0.004 .

Maximum association was found for children with acanthosis nigricans (OR-8.7). Among waist indices, waist height ratio had the best correlation with overweight/obesity (OR of 7.4, 95% CI 3.6- 15.2) (Figure 2).

Table 3: Correlation of risk factors and waist indices with overweight/obese using multivariate regression.

Risk factors	Odds ratio	P value
Urban school	4.0	<0.001
Acanthosis nigricans	8.7	<0.001
Hypertension	5.9	<0.001
WC centile >70	3.4	0.004
WHtR >0.5	7.4	<0.001

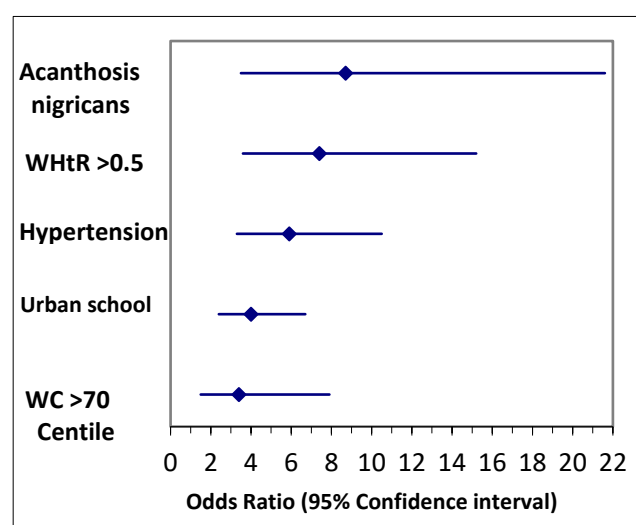


Figure 2: Forest plot of odds ratio with 95% CI of parameters analyzed by multiple regression.

Acanthosis nigricans, hypertension, urbanicity were found to be associated with overweight/obesity. Among waist indices WHtR was best correlated with BMI, followed by WC.

DISCUSSION

Childhood overweight/obesity is a forerunner of many disorders like metabolic syndrome, mental and respiratory problems, coronary artery disease. Various genetic, behavioural and environmental factors play a role in its pathogenesis. It happens primarily because of high calorie intake or sedentary lifestyle or both. This study was focused on risk factors of OW/obesity as well as its detection by anthropometric measurements like BMI, waist indices. Study was conducted in a sample of 12-15 years aged 880 students from two schools.

The prevalence of OW/obesity based on BMI in children aged 5-19 years is estimated to be 10% worldwide. Studies showed that there is marked regional variation in prevalence which ranges from 5.7 to 40%. A meta-analysis on Indian studies showed that the prevalence of

overweight varies 2.7-25.2% and obesity varies 0.1-11.7% in children >5 years.¹² In this study the prevalence of OW/obesity was 26.3% (OW-16.7%, obesity-9.6%), which is higher than many other studies done in Kerala.^{13,14} This can be attributed to consumption of high calorie food (20%) and sedentary lifestyle (42%) observed in the sample population.

Central obesity (measured by waist indices) is a better predictor of cardiovascular and other complications than generalized obesity. In a study on ethnicity and anthropometry, it was found that Indians have larger WHR, WC and WHtR at a specific BMI compared to the other populations.⁴ The prevalence of central obesity using WHtR was found to be 26.4% by Kilinc et al and 33.4% by Grigorakis et al.^{15,16} A study in India found that 36% of adolescents had central obesity measured by WC and 18.5% when measured by WHR.⁹ Our study showed an obesity prevalence of 12.3% when measured by WC, 22.8% measured by WHR, 14.8% measured by WHtR.

Risk factors for obesity related to diet and lifestyle were also studied. Students from urban school (33.4 %) had high prevalence of OW/obesity compared to rural school (13.6%). This was statistically significant with a p value of <0.001. It may be because of the difference in socio-economic status (SES). Most of the children from urban school belonged to high SES and students from rural school belonged to low SES. Children from affluent family tend to be obese because of high consumption of junk food. Statistics showed that the intake of was junk/high calorie food was high in children from urban school (26.5%) compared to children from rural school (8.6%). Among age group, obesity risk was observed maximum in children aged 12 years. This may be because of the pubertal changes in BMI, which tend to reduce in mid adolescence.¹⁴ We did not find any gender difference in prevalence of OW/obesity. Study showed that the percentage of OW/obesity is high in children who consume high calorie diet (31%) and follow sedentary lifestyle (28%) compared to those who are physically active (25%) and follow healthy diet (25%). But it was not statistically significant. Clinical features like acanthosis nigricans and asymptomatic hypertension were strongly correlated with OW/obesity. Statistics showed a p value of <0.001 and an OR 8.7 with 95% CI 3.5-21.6 for acanthosis nigricans and an OR 5.9 with 95% CI 3.3-10.5 for hypertension.

The correlation between three waist indices with BMI (Normal, OW, obesity) was studied which showed significant correlation with all the three parameters (p value<0.001). Using multivariate regression correlation was found between OW/obesity with WC (p=0.004) and WHtR (p<0.001). This study showed that waist height ratio is the best indicator of adiposity compared to other waist indices. This is in consistent with many other studies. A study in 2339 adolescents in 2013 by Brambilla et al found that WHtR is a better predictor of adiposity compared to WC.¹⁷ Another study by Marroddan

et al also demonstrated that adiposity predictive power of WHtR is better than WC.¹⁸ A study on WC and waist hip ratio by Taylor et al found that compared to WHR, WC correctly identified a high proportion of truncal obesity in children and adolescents. Like many other studies waist hip ratio was not found to be very useful in this study.⁷ This may be because of the factors like age, shape of pelvis which influence the hip circumference.

There are studies which found that waist height ratio is not very useful in detecting central obesity. A study was conducted by Hubert et al in children comparing WC and WHtR.¹⁹ They concluded that WC is more sensitive and specific in diagnosing obesity, also concluded that WHtR was not very effective to classify childhood obesity. In another study in Venezuelan children and adolescents, the WHtR did not effectively identify fat distribution.²⁰

Many studies propose waist height ratio as a good screening tool to identify obesity in children.^{21,22} WHtR is easy to measure and simple to calculate. It doesn't need any costly instruments for measurement. It is age/ gender independent and cut off value for normalcy is single. Unlike BMI and WC, reference charts are not required. This makes interpretation also easy. In schools it can be used by teachers to identify OW/obese children and thereby refer to medical personnel. With early identification and life style modifications, the incidence of obesity associated complications can be reduced to an extent. Considering all these factors this study suggests waist height ratio as a screening tool to predict obesity in school going children. Whether WHtR can substitute BMI is questionable as it doesn't consider weight, the major determinant of obesity. Further multicentric studies in large population are required to conclude on that.

CONCLUSION

The prevalence of overweight and obesity is alarmingly high in adolescent children. The major risk factor found was urbanicity. Acanthosis nigricans and hypertension were found to be associated with adolescent obesity. All the three waist indices, were statistically correlated with BMI and overweight/obesity, the best correlation being with waist height ratio followed by waist circumference. We recommend waist height ratio as a screening tool to predict obesity in school going children.

Funding: No funding sources

Conflict of interest: None declared

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

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Cite this article as: Krishnan DK, Shyna KP, Urmila KV, Anand KV. A study on correlation of waist indices with body mass index among school children in North Kerala. *Int J Contemp Pediatr* 2021;8:20-5.