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Original Research Article

TO ESTIMATE THE PREVALENCE OF OBESITY AND HYPERTENSION IN PAEDIATRIC POPULATION AMONG 10 TO 14 YEARS AND TO KNOW THE CORRELATION BETWEEN WRIST CIRCUMFERENCE IN COMPARISON WITH OTHER ANTHROPOMETRIC INDICES LIKE BMI, NECK AND WRIST CIRCUMFERENCE AMONG OBESE, OVERWEIGHT AND HYPERTENSIVE CHILDREN

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Abstract

Background: Paediatric obesity is a growing global health concern because of factors like socioeconomic status, lifestyle changes, reduced physical activity, increased consumption of high calorie and low nutrient foods and increased screen time. Early screening and life style modification can bring out greater impact in reducing major complications especially in nutrient obesity. The wrist circumference is closely associated with insulin resistance, a key feature of metabolic syndrome. The objective is to estimate the prevalence of obesity and hypertension in paediatric population among 10 to 14 years. To know the correlation between wrist circumference in comparison with other anthropometric indices like BMI, neck and wrist circumference among obese, overweight and hypertensive children. **Materials and Methods:** The study was conducted among school-going children aged 10 to 14 years from both rural and urban areas of Thanjavur. The sample included both boys and girls. The measurements recorded included were height, weight, Body Mass Index (BMI), wrist circumference, neck circumference and blood pressure. Using IAP charts they were classified as normal, overweight, obese and underweight. The wrist circumference for obese and overweight children were analysed and it's correlation with other anthropometric parameters was established. **Result:** This study shows the prevalence of obesity and overweight among school children (ages 10-14 years) conduced in a sample size of 764. Obesity prevalence: 4.8% Overweight prevalence: 6.4%. The urban population shows a higher prevalence of obesity and overweight compared to the rural population. Girls have a higher prevalence of both obesity and overweight compared to boys. Wrist circumference shows a positive correlation with other parameters, such as BMI (Body Mass Index) and neck circumference, particularly in overweight and obese individual. **Conclusion:** Wrist circumference is an useful anthropometric measure that correlate with various other anthropometric measures like BMI, waist and neck circumference. Establishing cut off values for wrist circumference can help in assessing body fat in different age groups.

INTRODUCTION

Childhood obesity is turning into a serious pandemic in developing nations like India. From only 8% in 1990 to 20% in 2022, the prevalence of overweight and obesity in children and adolescents aged 5 to 18 has increased. This trend shows minimal gender difference with 21% of boys and 19% of girls are classified overweight according to WHO standards as per March 2024. Furthermore, an anticipated 37 million children under the age of five were overweight in 2022, bringing attention to a serious public health issue. In Asia almost 50% of children are overweight or living with obesity in 2022 which has raised the prevalence to 23% since 2000.[1] The highest rates of childhood obesity are found in the United States with around 19% of children being obese from 2 to 19yrs of age. As per Indian data from childhood obesity atlas , 5 to 9 years in 2016 boys who were obese were 3.7 % and girls 2.6 % and among 10 to 19 yrs boys were 1.8% and girls 1.1%,[2] According to NHFS 5 analysis, between 2016 and 2021, the percentage of overweight children under five years old increased from 2.1% to 3.4%.[3] The global prevalence of hypertension as per American academy of paediatric guideline in 2017 was in range between 2 to 4%.They found that prevalence at age of 5 was 1.07 times more than other guidelines.[4] 1 to 7 years :0.78 per 1000 people 8 to 12 years : 2.24 per 1000 people 13 to 17 years : 5.95 per 1000 people. According to Indian Paediatrics, the prevalence is increased from 1% [2015 – 2016] to 3 % in 2021. Obesity is characterized by chronic mild inflammation because of cytokines secreted by white adipose tissue (WAT) as fat mass rises. Acanthosis nigrans is a manifestation of such inflammation associated with obesity. Insulin normally signals for energy expenditure, but in the stage of insulin resistance, glucose utilization and energy expenditure decrease, leading to increased fat storage. The release of FFA after it has been deposited as triacylglycerols in white adipose tissue controls the primary buffering of energy expenditure and consumption. This process helps to maintain energy balance. Obesity is characterized as the expansion of adipose tissue primarily white adipose tissue (WAT). It acts as the primary location for the synthesis of critical hormones involved in energy balance, including as leptin. The brain uses leptin to control appetite and energy expenditure. The uptake of sugar Into white adipocytes involves several proteins, including GLUT4, which is insulin-sensitive. WAT functions as a major secretory organ, releasing fatty acids during fasting.[5] It also secretes lipids like cholesterol, steroid hormones, and prostaglandins. Steroid hormones are converted in white adipocytes, and enzyme lipoprotein lipase is released to break down circulating triglycerides (TGL) into FA, which are then stored within adipocytes. Adiponectin,[6] a complement-related factor, is thought to directly signal in energy balance. Adipocytes also secrete TNF-α, which is increased in obesity and has an crucial role in insulin resistance by stimulating lipolysis and apoptosis. Leptin, a hormonal signal from adipocytes, regulates intake and energy balance through interactions with hypothalamic pathways, including orexigenic (appetite-stimulating) and anorexigenic (appetite- suppressing) pathways. Adipose tissue secretes the hormone RESISTIN,[5] which reduces the body's sensitivity to insulin and is a contributing factor to type 2 diabetes and insulin resistance. It has association with higher LDL cholesterol and more metabolic risks in upper body fat distribution compared to lower body fat distribution. THRIFTY GENE HYPOTHESIS: The thrifty gene hypothesis states that individuals who were able to store energy as fat during periods of scarcity had a survival advantage.[7] Those with efficient fat storage mechanisms survived periods of famine, whereas those unable to store fat succumbed to malnutrition.

Barkers Hypothesis: Barker's hypothesis, also known as the "foetal origins of adult disease" hypothesis, suggests that intrauterine growth restriction (IUGR) followed by postnatal overfeeding, leading to a rapid increase in growth curve percentiles, significantly increases the early-onset diseases in adulthood.[7] WHO suggests a three-pronged strategy to address this issue: Reducing the consumption of HFSS foods, Promoting physical activity, Encouraging healthier dietary patterns. Wrist circumference as an indicator of obesity and hypertension: Wrist circumference is a distinctive marker of fat distribution and skeletal frame size.[8,9] According to a study conducted by Mandolin et al., in overweight and obese people, wrist circumference has been demonstrated to independently correlate with both the metabolic syndrome and the visceral adiposity index. It is a simple way to gauge the size of the bony frame and can be a useful proxy for determining how well bone metabolism is correlated with hyperinsulinemia.[10] This is especially important because insulin-like growth factor 1 (IGF-1) is involved in a lot of these activities. Evidence was shown by Capizzi et al. showing a correlation between fasting plasma insulin levels and insulin resistance in overweight and obese children and adolescents and the transversal wrist bone tissue area as determined by nuclear magnetic resonance.[11] This suggests that in this paediatric cohort, the relationship between wrist circumference and insulin resistance is mostly due to the wrist bone area rather than wrist fat. Since children and adolescents have rapidly growing skeletons, the anabolic effects of insulin in bone development are substantial. Insulin stimulates osteoblastic proliferation enhancing bone growth and development and inhibiting osteoclastic proliferation—the skeleton's endocrine role involves increasing insulin production, improving glucose tolerance, enhancing adiponectin expression, and reducing visceral fat. Wrist circumference is a useful anthropometric parameter,[12] for evaluating the cross-sectional area of long bones without significant confounding from other tissues. It is a straightforward and reliable measure compared to waist and hip circumferences, which can be complicated by clothing. Additionally, wrist circumference reflects how bone within the wrist grows in response to insulin levels.

Aims and Objectives

1. To know the prevalence of obesity and hypertension in paediatric population among 10 to 14 yrs.
2. To know the correlation between wrist circumference in comparison with other anthropometric indices like BMI, neck circumference, waist circumference among obese, overweight and hypertensive children.

Review Of Literature

NA Kajale et al and AV Khadilkar conducted a study in 2013 revealed that about 5% of people were

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overweight or obese with hypertension being significantly associated. All anthropometric indices correlated with obesity and hypertension, showing that the likelihood of obesity was twice as high and the likelihood of hypertension was seven times higher. All five indices had similar area under the ROC curves, with higher values seen in the older age groups, suggesting similar sensitivity and specificity for these assessments. Vidhya ahilan et al,[13] have done a study in 2018 on In a study with 118 participants, the usefulness of wrist circumference in identifying metabolic syndrome in overweight and obese South Indian children was evaluated. The findings showed that metabolic syndrome affected thirty children. There is a moderately favourable link between wrist circumference z- scores and BMI scores; the metabolism z-scores for wrist circumference in individuals with and without metabolic syndrome were 2.7 and 2.1, respectively. A wrist circumference at the 97th percentile was identified as an effective cut-off tool for identifying metabolic syndrome in this population. Young Fang Li et al.'s study, "The Association of Wrist Circumference with Hypertension in North-eastern Chinese Residents: A Comparison with Other Anthropometric Measures".[14] A study that involved 2331 participants found that there was a strong positive link between BMI and wrist circumference, as well as between waist circumference, neck circumference, waist to hip ratio, and waist to height ratio. Turkey's 6–17-year-old Turkish children and adolescents in Kayseri were studied in 2015 by Ahmet Ozturk et al.[15] Both genders wrist circumferences (WRCs) rose linearly with age, with boys WRCs ranging from 13 to 16.8 cm and girls WRCs from 12.5 to 15.5 cm. Between the ages of 6 and 17, boys frame sizes increased by 1.25 cm and girls by 0.85 cm. The gender gap in WRC in boys expanded by 1 to 2 cm between the ages of 12 and 18. Notably, this increase in wrist circumference reflected changes in frame size rather than a direct relation to obesity.

MATERIALS AND METHODS

Study title: Wrist circumference as an indicator of hypertension and obesity and Correlation with other anthropometric measures among school going Children. Study design was cross-sectional. Study setting was Rural and Urban educational institutions. Study period was from August 2023– July 2024. Study population: School going children from 10 to 14yrs of age Sample size: We have included 764 subjects in our study by cluster sampling. Samples were recruited by systemic sampling. The minimum sample required for our study by standard calculation was 384. Due to cluster sampling the Sample size reached was 764. Inclusion criteria: Children between the ages of 10 and 14. Exclusion criteria: Children with pre existing illness like renal disease, liver disease, endocrine obesity, seizure disorder.

Methodology

After receiving approval from the headmasters of the relevant schools and implied consent, children between the ages of 10 and 14 who appeared healthy were included in the study. The exclusion criteria in children with pre existing illness. With the help of stadiometer , weighing machine ,inch tape and BP apparatus (mercury). Weight, height, wrist, waist, neck circumferences and blood pressures were measured. From those values BMI was calculated , and based on IAP charts the children were classified as underweight, normal, overweight and obese.[16] And then BP was recorded and categorized as per standard guidelines. A mercury gravity manometer was used to measure and appropriate cuff size was used. Between the olecranon and acromion, the width of the bladder inside the fabric should encircle 40% of the patient's arm circumference. 80–100% of the arm's circumference should be covered by the bladder's length in the cuff. The child should have the device at heart level and be in a relaxed, comfortable position—preferably sitting. An appropriate per centile chart should be used to illustrate the findings of the auscultatory method used to record the systolic and diastolic blood pressure. Using a stretch-resistant inch tape stretched horizontally immediately above the right ileum's uppermost lateral border—the narrowest region between the lower rib cage and the upper iliac crest—waist circumference was measured. WC more than 90th percentile were considered adipose. The middle or index finger at the base of the left hand was used to measure the wrist circumference at the most noticeable part of the radial styloid. Applying firm pressure, the measurement was close to 0.1 cm.Using a non-stretchable tape, the circumference of the neck was measured to the nearest 0.1 cm, was measured in a horizontal plane at the level of the thyroid cartilage, which is the most conspicuous position, between the mid cervical spine and the mid anterior neck using a flexible tape while the child was standing with their head up. Next, every parameter was examined for children in both rural and urban locations, including gender, normal, overweight, and obese children, then wrist circumference was compared with cut-offs of other parameters for normal, obese and overweight children.

Statistical Analysis

The data were analyzed with SPSS version 16 after being entered into an MS Office Excel sheet. The mean and standard deviation were used to express continuous data having a normal distribution. The frequency with percent was used to express categorical data. The frequency differences between the groups were compared using Fisher's exact test. The means of the two groups were compared using the unpaired "t" test. ANOVA one-way using Bonferroni to compare the variance between more than two groups, the post hoc test was employed. Using Pearson's correlation, the degree and direction of wrist circumference's relationship to other parameters were ascertained. ROC curve was constructed for wrist circumference in diagnosing the cut off value for obesity. Cut off values derived from the ROC and diagnostic indices were calculated. Statistics were deemed significant when P <0.05.

RESULTS

The prevalence of overweight in this study 6.4 % and obesity is 4.8%. There was no hypertension or prehypertension in this study population in overweight or obese children. In rural boys and girls, the prevalence of obesity is 1.1% and 4.1%, respectively. In rural boys and girls, the prevalence of overweight is 3.8% and 5.7% respectively. In urban boys and girls, the prevalence of obesity is 3.9% and 5.1%, respectively. In urban boys and girls, the prevalence of overweight is 7% and 8.8%, respectively. In comparing wrist, neck and waist Circumferences in girls and boys of age 10 to 14 years all AUC values were statistically significant in determining overweight and obese children. The sensitivity and specificity and p values for girls for wrist circumference as per table are 83 %, 27% and 0.009. The sensitivity and specificity and p values for boys for wrist circumference as per table are 81.3% ,54% and p value 0.0001. The sensitivity, specificity and p values for girls for neck circumference as per table are 98%,28 and 0.0001. Similarly for boys there are 93%, 62, 0.0001. The sensitivity, specificity and p values for girls for Waist Circumference as per table are 87%, 48 and 0.0001 Similarly for boys as per table is 84.4%, 62, 0.0001. There is statistical significance for neck and wrist circumference and slightly higher significance for neck circumference in relation to obesity than with wrist circumference.

Table 1: Comparison of the study's observed weight category and wrist circumference (in centimetres).

S.NO	wrist circumference (cm)	n	Mean	SD	df1, df2	F value	p value
1	Underweight	216	14.9	1.21	3 , 760	63.1	<0.0001*
2	Normal	462	16.1	1.46			
3	Over weight	49	16.8	1.57			
4	Obese	37	17.5	1.21			

Bonferroni post hoc test comparison

S. No	Group Vs Group	Absolute mean difference	Adjusted p value
1	Underweight Vs Normal	1.17	<0.0001*
2	Underweight Vs Overweight	1.98	<0.0001*
3	Underweight Vs Obese	2.57	<0.0001*
4	Normal Vs Overweight	0.81	<0.0001*
5	Normal Vs Obese	1.39	<0.0001*
6	Overweight Vs Obese	0.58	0.326(NS)

The data are presented as mean + SD. The means throughout the groups were compared using a one-way ANOVA and the Bonferroni post hoc test. * Denotes statistical significance, with p<0.05. NS stands for not significant

Table 2: The study found a correlation between the wrist circumference of boys and other anthropometric variables

S. No	Correlation of wrist circumference with	Pearson's r	P value	Inference
1	Height (cm)	0.589	<0.0001*	a strong and moderately favorable association
2	Weight (Kg)	0.721	<0.0001*	Strong strength significant with a positive association
3	BMI (Kg/m2)	0.583	<0.0001*	a strong and moderately favorable association
4	Waist circumference (cm)	0.588	<0.0001*	strong positive association of moderate strength
5	Neck circumference(cm)	0.607	<0.0001*	Strong strength with a significant positive association

N total is 346. Pearson's correlation test was used to perform the correlation. The "r" value was used to indicate the association's degree and direction. * Denotes statistical significance, with p<0.05. NS stands for not significant

Table 3: Correlation of various anthropometric measures with respect to wrist circumference observed in the study (in girls)

S. No	Correlation of wrist circumference with	Pearson's r	P value	Inference
1	Height (cm)	0.461	<0.0001*	a strong and moderately favourable association
2	Weight (Kg)	0.677	<0.0001*	Strong strength significant association with a positive
3	BMI (Kg/m2)	0.612	<0.0001*	A significant association with strength positive strong
4	Waist circumference (cm)	0.681	<0.0001*	Strong strength significant with a positive association
5	Neck circumference (cm)	0.522	<0.0001*	a strong and moderately favorable association

N total is 418. Pearson's correlation test was used to perform the correlation. The "r" value was used to indicate the association's degree and direction. * Denotes statistical significance, with p<0.05. NS stands for not significant

Table 4: Description of diagnostic parameters and ROC curve parameters in detecting overweight/obesity based on neck circumference observed in the study

S.No	Age	AUC	95% CI	P value	Cut off point (cm)	PV+	PV-	Sensitivity (%)	Specificity (%)
1	Boy 10	0.836	0.658 – 0.999	0.002*	≥25.5	23	93	88.9	33
2	Boy 11	0.989	0.967 – 0.999	<0.0001*	≥26.5	16.6	100	100	41
3	Boy 12	0.867	0.751 – 0.984	0.003*	≥28.5	41.1	100	100	65
4	Boy 13	0.919	0.811 – 0.999	0.002*	≥28.5	57.1	98	80	95
5	Boy 14	0.892	0.741 – 0.999	0.011*	≥28.5	23	97.6	75	81
6	Boy 10 – 14	0.887	0.813 – 0.962	<0.0001*	≥27.5	25.2	98.6	93.8	62
7	Girl 10	0.886	0.745 – 0.999	0.001*	≥25.5	36	100	100	23
8	Girl 11	0.919	0.838 – 0.999	<0.0001*	≥25.5	28.2	100	100	32
9	Girl 12	0.931	0.864 – 0.999	<0.0001*	≥27.5	46.4	100	100	66
10	Girl 13	0.921	0.854 – 0.989	<0.0001*	≥28.5	41.6	100	100	74
11	Girl 14	0.964	0.912 – 0.999	<0.0001*	≥28.5	35.4	100	100	71
12	Girl 10 – 14	0.898	0.855 – 0.941	<0.0001*	≥26.5	24.3	98.4	98.1	28

AUC = Area under the curve; PV = predictive value; CI =Confidence interval

Table 5: Description of diagnostic parameters and ROC curve parameters in detecting overweight/obesity based on wrist circumference observed in the study

S. No	Age	AUC	95% CI	P value	Cut off point (cm)	PV+	PV-	Sensitivity (%)	Specificity (%)
1	Boy 10	0.904	0.787 – 0.999	<0.0001*	≥14.75	40	96.5	88.9	70
2	Boy 11	0.993	0.967 – 0.999	<0.0001*	≥16.5	41.1	100	100	84
3	Boy 12	0.658	0.411 – 0.905	0.201(NS)	---	---	----	----	----
4	Boy 13	0.885	0.721 – 0.999	0.005*	≥17.5	57.1	98	80	95
5	Boy 14	0.885	0.741 – 0.999	0.011*	≥17.75	15	97.2	75	68
6	Boy 10 – 14	0.803	0.717– 0.889	<0.0001*	≥16.75	19.5	95.4	81.3	54
7	Girl 10	0.852	0.694 – 0.999	0.003*	≥14.75	50	92.8	88.9	62
8	Girl 11	0.753	0.595 – 0.911	0.011*	≥15.5	37.5	92.8	81.8	63
9	Girl 12	0.552	0.352 – 0.751	0.575(NS)	---	----	---	----	---
10	Girl 13	0.517	0.274 – 0.759	0.868(NS)	---	----	---	----	---
11	Girl 14	0.662	0.489 – 0.835	0.086 (NS)	---	----	---	----	---
12	Girl 10 – 14	0.614	0.527 – 0.701	0.009*	≥15.5	21.2	87.3	83.3	27

AUC = Area under the curve; PV = predictive value; CI =Confidence inter

DISCUSSION

As per study conducted in south Indian obese children, there was fair positive correlation and sensitivity of wrist circumference was 86.7% and specificity 37.5% Similar to this study, IN Northen Crypus ezgi turkey, seyray kabran showed that 26, 9cm in girls (sensitivity 70.5 % specificity 65%)27 ,9 cm in boys (sensitivity 76.4% Specificity 79%. The Khalidar study's sensitivity and specificity were found to be equivalent, as evidenced by the area under the curves for all five indices being similar and larger in older age groups. Obesity and hypertension prevalence among school-age children between 10 – 14 years in this study has found more prevalence in urban population, also girls are more than boys. As a review, this study provides a comprehensive analysis between obese children and normal children and also for comparing neck, wrist and waist circumference and how far they are statistically significant in obese children. Initially these studies were conducted in Europe, Italy, China and Greece as there was high prevalence of obesity. But nowadays India is also in the situation of rising pandemic due to paediatric obesity. Similarly in Chinese adolescents, the study showed NC correlated positively with BMI and WC but BMI was more significant in obese children in contrast to our study. Another study in ozturk A et al Turkish children established frame size percentiles for wrist circumference and increment in frame size was 1.25 cm in boys and 0.85cm in girls and linearly increases with age were as in our study it varies with both obesity and age, the frame percentiles correlate with obesity in our study. Tatar et al. evaluated the relationship between neck circumference and wrist circumference and general and abdominal obesity by conducting a cross-sectional study with 136 participants. With r=0.405 and p<0.001.2, WrC and WC exhibited a somewhat positive and statistically significant connection. In our study wrist circumference correlation with neck is 0.547 (Pearson r) of moderate strength positive correlation and waist has strong correlation of Pearson r of 0.634 in obese children.

Limitations

The study could have been improvised if the children with risk of metabolic phenotype have been identified based on triglyceride levels and fasting glucose levels. Urban population was higher than rural population and the ratios could have been equal for better results and outcome. In the overweight and obese population in the study pre diabetic risk could have been identified by insulin and fasting glucose levels and insulin resistance could have been identified by IGF-1 levels and cardiovascular risk could have been identified by triglyceride levels because wrist circumference has better correlation for insulin resistance and hypertension in obese children. Tanners staging could have been added to assess pubertal changes in adolescent age group.

CONCLUSION

Wrist circumference is a useful anthropometric measure that can correlate with various other anthropometric measures like BMI, weight, waist height and neck circumference in children These correlations vary with age, puberty and demographic factors. Since wrist circumference tends to change with growth and development, it offer insights into overall body composition and adiposity when used alongside other measures. Establishing cut off values for wrist circumference can help in assessing body fat and growth patterns in different age groups and other demographics. This approach can help in identifying trends and making more accurate evaluations of body composition in children.

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