Research Article

Neck Circumference, a Novel Predictor of Overweight/ Obesity in School Children in Pokhara

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ABSTRACT

Background: Calculating BMI in an individual is a standard anthropometric procedure to estimate overweight/obesity. But it has been observed to be a bad predictor of central obesity. On the other hand, waist circumference, in many studies, has been found to be a good predictor of central obesity but not so frequently used because of tendency to vary throughout the day. In the recent years, NC has been found to have a good correlation with both BMI and WC. The aim of this study was to find out whether neck circumference is a good predictor of Overweight/Obesity or not.

Methods: This was a cross sectional study carried out among the school children, aged 12 to 15 years, in Pokhara city, Nepal. In total, 408 students, 238 males and 170 females were screened. Anthropometric markers of obesity measured: included body mass index (BMI), waist circumference (WC), and compared with neck circumference (NC) of the same subjects. Pearson's correlation test was used to see the correlation between NC with BMI and WC, and receiver operating characteristic curve analysis was used to determine the best cut off value of neck circumference in predicting high BMI.

Results: Among 408 students, 238 (58.3%) were male and 170 (41.7%) were female. Among them 37 (9.1%) were overweight and 32 (7.8%) were obese. All the anthropometric parameters were significantly higher in cases, except height in male, than in controls. NC was significantly correlated with age, BMI, and waist circumference in both boys and girls. The best cut-off value of neck circumference by ROC to identify boys with a high BMI was 29.5 with sensitivity of (76%), specificity (54%), and for girls was 28.5 with sensitivity of (97%), specificity (48%).

Conclusion: Statistically significant positive correlation was found between NC with BMI and WC. The value of NC as a screening tool

has been found comparably lower in compare to WC.

Keywords: BMI, Neck circumference, Obesity, Overweight, Waist circumference.

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INTRODUCTION

Is humanity eating itself into an early grave an opinion piece in a newspaper was so intriguing.[1] Overweight and Obesity is becoming very common. Now, it is common not only in developed nations, from where it has started, but also in developing nations. Mirroring the experience already established in the developed nations, the obesity rate in developing nations too, first started to increase in adults, then in children and adolescents.[2]

Worldwide obesity has nearly tripled since 1975. In 2016, nearly 40% of world's population above 18 years were overweight and among them almost 30% were obese. Overweight and obesity rates are increasing in children and adolescents too, which was only 4% in 1975, it now stands at 18 percent.[3]

One of the frequently used tools for categorizing individuals as obese or not is, Body Mass Index (BMI) which is defined as an individual's weight in kilograms divided by the square of their height in meters (BMI=kg/m2).[4] Another frequently used anthropometric tool is Waist Circumference (WC), which is believed to be a good predictor, in compare to BMI, of central obesity, which closely relates to the cholesterol level in the body and which is also very common among South Asians.[5] Either singly or together with BMI, WC may be stronger predictor of some health outcomes like hypertension, heart diseases etc. than BMI alone. Yet not so frequently used as primary screening tool because of its tendency to vary throughout the day and also not so easy to perform.

Henceforth, Neck Circumference (NC) a novel parameter has increasingly been recognized as a good tool for estimating overweight and obesity as well as regional adiposity, which in turn is a better predictor of some obesity related complications, such as hypertension, diabetes and heart disease. Its usefulness as an additional screening tool to BMI, if used in combination, may have stronger health outcome prediction than BMI alone.

The objectives of this study are to examine the correlation between NC, BMI and WC in children, to find out ability of neck circumference to identify correctly children with high BMI, and to determine the best NC cut point for identifying children and adolescents as overweight/obese.

METHODS AND METHODOLOGY

This was a cross sectional study carried out among the school children, aged 12 to 15 years, in Pokhara city, Nepal from August 2019 to October 2019. For the calculation of the sample size, prevalence of overweight at 12.2% was taken from the study carried out in Lalitpur metropolitan city[6] and calculated using the formula $4pq/d^2$.[7,8,9] It is calculated that sample size of 169 students will provide an estimate of prevalence with 5% error within 95% confidence limits.

After the approval from institutional research board, total of 408 students from three different school, two private and one

public, were enrolled in the study. Informed consent from School administrations and students, who were willing to participate in the study voluntarily was obtained priorly. All the students were subjected to history taking, general clinical examination, blood pressure assessment, and the anthropometric measurements. Pre-designed questionnaire was use as a tool for collecting all the relevant information. All the measurements, including height, weight, waist circumference and neck circumference were taken by the trained individuals.

A digital weighing machine was used to measure the weight to nearest 0.1 kg and non- stretchable measuring tape was used to measure height to nearest 0.1cm. The students were asked to remove their shoes and stand with heels joined together. A flat wooden plank was placed on the top of the head so that it was perpendicular to the measuring tape. Waist circumference was measured nearest to 0.1cm, using non-stretchable measuring tape, at the end of expiration, midpoint between the lowest rib and the upper point of iliac crest. For the neck circumference, measurement was taken using a tape, children in standing position, at the level of thyroid cartilage.

BMI was calculated for every student, each with BMI >85th percentile was categorized as overweight/obese (adolescents with BMI >85th percentile as overweight and with >97th percentile was as obese) and the individuals with BMI <85th percentile as normal weight in accordance to the WHO 2007 growth standards.[10]

For the statistical analysis, Statistical Package for the Social Sciences (SPSS) version 17 was used. Data were expressed in terms of mean and standard deviation. Pearson correlation coefficient was applied to test correlation between the NC and other continuous variables like Age, BMI, and WC. Receiver operating characteristic (ROC) analyses was used to find out the ability of NC to identify correctly children with high BMI, and to determine the best NC cut-off point for identifying children of various ages as overweight/obese.

RESULTS

The estimates are expressed in terms of means and standard deviation. Total 408 students were included in this study, with 238 (58.3%) being male. Among them 37 (9.1%) were overweight and 32 (7.8%) were obese. Among the 69, either overweight or obese students, 37 (53.6%) were males and 32 (46.4%) were females. Anthropometric parameters of the study population are given in Table 1.

Table 1: Anthropometric Parameters of the Study Population

Specifications	Male (238)	Female (170)	Total (408)
Age (years)	13.4±1.1	13.3±1.1	13.4±1.10
Height (cm)	146.6±11.5	144.2±8.9	5.7±10.58
Weight(kg)	40.8±10.8	41.1±10.7	41.0±10.7
BMI (kg/m	18.7±3.07	19.5±3.4	19.03±3.2
WC (cm)	68.2±12.69	67.9±9.39	8.15±11.4
NC (cm)	29.9±3.5	29.3±5.0	29.6±4.2

The variations in height, weight, BMI, WC and NC with age, in both male and female students, were found to be statistically significant. Furthermore, in the post-hoc test the variations in height, weight, BMI, WC and NC between the age groups, in both male and female students, were statistically significant except for the height between 14 and 15 years girls, weight between 13 and 14 years girl, BMI between 13 and 14 years girls, 12 and 14 years boys. The statistical association was also insignificant for WC and NC in boys between

12 and 13 year age groups. Whereas in girls it was in 13 and 14 years age groups.

The mean and standard deviation of the anthropometric characteristics of the students by age and gender is given in Table 2.

Table 2. Mean and standard deviation of the anthropometric characteristics of the students by age and gender

Age (yrs.)	No. of students	Height (cm)	Weight (kg)	BMI	WC (cm)	NC (cm)
BOYS						
12	64	135.4±5.44	31.96±6.09	17.4±2.8	62.4±6.9	28.2±3.19
13	61	141.9±8.08	36.5±8.09	17.99±2.9	65.65±7.27	28.7±3.72
14	64	153.7±8.6	45.56±8.54	19.20±2.9	69.22±6.38	30.7±2.7
15	49	158.11±5.9	51.88±5.9	20.67±2.6	73.88±9.98	32.6±2.5
Total	238	146.6±11.5	40.88±10.8	18.7±3.0	67.4±8.6	29.9± 3.5
F (P)		124.2 (.000)	72.32 (.000)	14.36(.000)	10.78 (.000)	12.31 (.000)
GIRLS						
12	52	135.9±7.6	31.9±5.7	17.22±2.3	60.5±9.8	27.0±3.37
13	48	145.2±8.0	42.6±11.9	19.9±3.8	69.5±7.9	30.69±7.9
14	35	149.2±5.9	44.5±7.9	19.9±3.1	70.5±5.5	29.9±2.23
15	35	150.5±4.0	49.3±6.6	21.7±2.6	74.6±5.9	30.2±1.5
Total	170	144.2± 8.9	41.1± 10.7	19.4±3.4	68.0±9.4	29.3±4.9
F (P)		154.8 (.000)	129.4 (.000)	16.4 (.000)	25.8 (.000)	76.7 (.000)

Table 3, compares the mean and SD of normal weight children (<85th percentile) with overweight/obese children (>85th percentile). All the characteristics, except for the age and height in boys, were found to be statistically significant.

Table 3: Comparison of anthropometric characteristics by gender between normal weight and overweight children

Characteristics/ Boys	Children with BMI <85	Children with BMI >85	Leven's test F (P-value)	t-value (P-value)
Age in years	13.3±1.1	13.4±1.07	0.22 (0.647)	-0.451 (0.652)
Height in cm	146.2±11.6	148.7±10.6	1.41 (0.235)	-1.176 (0.241)
Weight in kg	39.01±9.4	51.04±12.6	2.43 (0.120)	-6.744 (0.000)
BMI	17.9±2.4	22.6±3.2	2.28 (0.132)	-10.27(0.000)
WC in cm	66.2±7.1	73.8±12.5	15.5 (0.000)	-3.568(0.000)
NC in cm	29.5±3.3	32.22±3.4	0.413 (0.521)	-4.468(0.000)
Characteristics/Girls				
Age in years	13.2±1.1	13.6±0.9	2.04 (0.154)	-1.954(0.052)
Height in cm	143.3±9.02	148.2±7.8	4.14 (0.043)	-3.027(0.004)
Weight in kg	38.2±8.2	53.5±11.3	0.46 (0.496)	-8.737(0.000)
BMI	18.4±2.5	24.09±3.2	0.035 (0.853)	-6.271(0.000)
WC in cm	66.08±8.5	76.5±8.1	0.27 (0.870)	-6.271(0.000)
NC in cm	28.7±5.2	31.6±2.6	0.174 (0.677)	-2.986(0.003)

Table 4, presents the Pearson correlation between the NC and the anthropometric parameters (height, weight, BMI and WC) for boys and girls. NC showed strong positive correlation with all the above mentioned anthropometric parameters.

Table 4: Pearson correlation between Neck Circumference and other Anthropometric Variables

Variables	Neck circumference			
	Boys		Girls	
	r	p - value	r	p - value
Age	0.467	0.000	0.222	0.004
Height	0.527	0.000	0.285	0.000
Weight	0.717	0.000	0.346	0.000
BMI	0.662	0.000	0.313	0.000
Waist circumference	0.586	0.000	0.368	0.000

Table 5 and 6, demonstrate the ROC and AUC curve, likelihood ratios and Youden's Index for the NC and WC respectively.

Table 5: Receiver Analysis cure and Area under the Cure Analysis for Neck Circumference

Characters	AUC	P value	95%CI	Cutoff	Sensitivity	1-specificity	LR+	LR-	Youden's Index (J)
Boys	0.735	0.000	0.64-0.82	29.5	0.76	0.46	1.65	0.44	0.3
Girls	0.802	0.000	0.72-0.87	28.5	0.97	0.52	1.86	0.06	0.45

Table 6: Receiver Analysis cure and Area under the Cure Analysis for Waist Circumference

Characters	AUC	P value	95%CI	Cutoff	Sensitivity	1-specificity	LR+	LR-	Youden's Index (J)
Boys	0.739	0.000	0.63-0.85	68.75	0.76	0.34	2.23	0.38	0.42
Girls	0.849	0.000	0.77-0.92	69.5	0.90	0.36	2.66	0.16	0.54

The AUC curve for NC, for boys and girls, is 0.735 and 0.802 respectively. For WC, it is 0.739 and 0.849 respectively. Which is slightly higher in compare to the Neck Circumference. Nevertheless, AUC value above 0.7 is considered to be a fairly good test (reference). In addition to this, the sensitivity (true positive) and 1- specificity (false positive) at a given cut-offs, for both boys and girls, for NC and WC, is given in table 5 and 6 respectively. Which showed NC to be a satisfactory test on predicting overweight and obesity in school children. Furthermore, Youden's J statistics for NC and WC, in both boys and girls, are also been satisfactory with WC performing slightly better than NC.

DISCUSSION

In the age of abundance where people don't have to think about 'how to grow food' easy availability of highly processed food with increasing dependency on fast food coupled with high consumption of sugary drinks is slowly but steadily becoming a norm in modern human's life.[11] The rise in the rate of overweight/obesity as a result of our food habit

and our life style is having a negative effect on our health.[12,13] Cardiovascular ailments, kidney diseases, hypertension, diabetes, to name a few, have seen increase in rates over the past several decades.

Children are no exception, the increase in rate of overweight/obesity over the past few decades among the children is astounding. There is at least increase in rate by 300% in the last 40 years.[3] The need for the development of a tool which is easy to perform and can also give accurate result is imminent. Neck circumference, an anthropometric parameter (tool), which in many studies has found to have a strong correlation not only with BMI but also with Waist Circumference, which in many studies is found to be a good predictor of central adiposity, in adolescents and in children as well.[7-8, 14-15.]

In the present study, strong positive (Pearson's) correlation was found between NC with BMI and WC. Which showed NC to be a good predictor for BMI and WC as well. Furthermore, NC has also been found to be good test on predicting overweight/obesity, with AUC more than 0.7, in both boys and girls. Which is quite consistent with the findings from studies carried out in similar age gropus.[7-8]

Another important statistical analysis, Youden's J statistic, which looks at a performance of dichotomous test.[16] Its value ranges from 0 through 1. Test being considered useless if it is 0 and there is gradual increase in its usefulness as it moves towards 1, with the test considered to be perfect if it is 1. In this study the index is found to be above zero for the NC and WC as well.

There are several studies which evaluated the best cutoffs of NC for children and adolescents of different age groups, in different countries at different sensitivity and specificity level is displayed.[17-19] Comparison of the results of these studies with the result of this study resembled some similarities. The best cutoffs observed in this study were, in boys 29.5 cm with 76% sensitivity and 54% specificity, and in girls 28.5 cm with 97% sensitivity and 48% specificity.

Therefore, based on the finding of this study NC could be a useful screening tool which could expand the ability of BMI not only on predicting overweight/obesity but also will be helpful on finding the possibility of some health outcomes as hypertension, diabetes, heart condition etc.

Nevertheless, as being a cross sectional study chance of selection bias cannot be ruled out. The small sample size further limits our capability of estimating the various obesity related estimates to different age groups. The paucity of similar types of study in the Nepali children and adolescents allowed the present study to fill in the gap to some extent.

CONCLUSION

The study has found positive correlation of NC with BMI and WC. The study has further demonstrated the potential of NC to be a quite reliable screening test. It is a very simple and easy measure to perform, thus reliable and results can be easily reproducible. Additional studies are needed to evaluate the usefulness of NC as an index of adiposity in children and adolescents.

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