Association of neck circumference and obesity with blood pressure in children aged 6-12 years

Madhulika C[1], ***A Thumjaa**[2], **N S Raghupathy**[2]

Sri Lanka Journal of Child Health, 2022; **51**(3): 418-422
DOI: http://dx.doi.org/10.4038/sljch.v51i3.10242

Abstract

***Background**:* Overweight / obesity is a major risk factor for non-communicable disease (NCD). Neck circumference (NC), a measure of upper body fat, can be used to predict obesity and its related disorders.

***Objectives**:* To find the association of NC and obesity with blood pressure (BP) in children aged 6-12 years.

***Method**:* A cross-sectional observational study was carried out over a period of 5 months; 800 children aged 6 to 12 years were included in the study and their body mass index (BMI), NC and BP were recorded with standard techniques. Children with malnutrition, neck abnormalities and metabolic disorders were excluded from the study. All variables were analysed using SPSS version 21. Receiver Operating Characteristic (ROC) curve was used to determine the best cut-off value of NC to predict obesity and hypertension.

Results: Of 800 children, 463 (57.9%) were boys and 337 (42.1%) were girls; 46 (9.9%) boys and 16 (4.7%) girls were obese and 55 (11.9%) boys and 46 (13.6%) girls were hypertensive. NC had a significant correlation with BMI in both boys and girls ($p < 0.001$). Median NC in boys was 28 (26-29) and 27 (26-29) in girls. The best cut-off value of NC by ROC curve to identify obese boys was 24.5-25.5cm with a sensitivity of 93.5% and a specificity of 9.6%. The best cut-off value of NC by ROC curve to identify obese girls was 24.5-25.5cm with a sensitivity of 93.8% and a specificity 12.8%. The best cut-off value of NC by ROC curve to identify hypertensive boys, was 28.5-29.5cm with a sensitivity of 87.3% and a specificity 20.3%. The best cut-off value of NC by ROC curve to identify hypertensive girls, was 25.5-26.5cm with a sensitivity of 82.6% and a specificity 22.3%.

Conclusions: In our study there was a strong association of elevation in BP with high NC and overweight/obesity. The NC measurement was a simple, non-invasive test to detect obesity and hypertension in children.

(Key words: Body mass index, Obesity, Neck circumference, Hypertension)

Introduction

Globally, there is a rapid increase in prevalence of overweight / obesity in childhood and adolescence[1]. Overweight / obesity is a major risk factor for non-communicable disease (NCD)[2]. Regional fat deposition, especially upper body fat, is associated with increased free levels of fatty acids[3,4]. Though dual x-ray absorptiometry, bio-impedance and hydro-densitometry more accurately measure body fat content and distribution, they are neither practical nor inexpensive[5]. Neck circumference (NC) has been used to measure upper body fat which strengthens the relevance of measuring NC to detect overweight / obesity and hypertension in children[6,7]. Early identification will help in reducing the incidence of NCDs in the future.

Objectives

To find the association of NC and obesity with blood pressure (BP) in children aged 6-12 years.

Method

A cross-sectional observational study was carried out in the paediatric outpatient department of Aarupadai Veedu Medical College and Hospital over a period of 5 months (April–August 2021). A total of 800 children aged 6-12 years was included in the study. Children with malnutrition, neck abnormalities and metabolic disorders were excluded from the study.

Anthropometric measurements such as weight (in kg) with digital scale, height (in cm) with stadiometer and body mass index (BMI) were calculated. BMI was plotted on the revised Indian Association of Paediatrics (IAP) 2015 growth charts

[1]*Post-Graduate,* [2]*Professor, Department of Paediatrics, Aarupadai Veedu Medical College and Hospital, Puducherry, India*
**Correspondence:* thumjaa@gmail.com
https//orcid.org/0000-0002-0474-3122

(Received on 03 January 2022: Accepted after revision on 18 February 2022)
The authors declare that there are no conflicts of interest
Personal funding was used for the project.

and the children were categorised as normal (5th to 84th centile), overweight (85th to 94th centile) and obese (above 95th centile)[8].

NC was measured with a flexible tape with child standing, head erect, eyes facing forward; tape was placed just below the laryngeal prominence and positioned perpendicular to the long axis of the neck at the level of the thyroid cartilage. NC was measured to the closest 0.1 cm and plotted; it was categorised as normal (≤90th centile) or high (>90th centile)[9].

BP was recorded thrice at 15-minute intervals and the average of the measurements was taken and plotted; it was categorised as normal [systolic BP (SBP) and diastolic BP (DBP) <90th centile), pre-hypertension (average SBP or DBP between >90th centile and <95th centile) and hypertension (average SBP or DBP >95th centile)[10,11].

Ethical issues: The study was approved by the Institutional Human Ethical Committee of Aarupadai Veedu Medical College and Hospital, Pondicherry, India (No: AV/IEC/2021/004). Written informed consent/assent was obtained from parents / participants.

Statistical analysis: This was done using SPSS version 21. Continuous variables presented as median (interquartile range) and categorical variables as frequency and percentage. Spearman rank correlation was used to find the association between the variables. To obtain gender-specific cut-offs for overweight/obesity and hypertension, Receiver Operating Characteristic (ROC) curve analysis was used.

Results

Of the 800 children included in the study, 463 (57.9%) were boys and 337 (42.1%) were girls; 78% boys and 78.3% girls were of normal weight, 12.1% boys and 16.9% girls were overweight, and 9.9% boys and 4.7% girls were obese. Table 1 shows the gender-wise comparison of different variables in the study population. The results were not statistically significant (p>0.05).

Table 1: ***Gender-wise comparison of different variables in study population***

Variable	Total *(n=800)*	Boys *(n=463)*	Girls *(n=337)*	p-value
Age (years) - Median (IQR)	9 (7-11)	9 (7-11)	9 (8-11)	0.177[1]
Weight (kg) - Median (IQR)	26 (21-32)	25 (21-32)	26 (22-32)	0.239[1]
Height (cm) - Median (IQR)	130 (122-138)	129 (121-137)	130 (123-139)	0.416[1]
Body mass index (kg/m^2) - Median (IQR)	15.5 (13.8-17.5)	15.3 (13.8-17.3)	15.7 (14.1-17.7)	0.069[1]
Neck circumference (cm) - Median (IQR)	27 (26-29)	28 (26-29)	27 (26-29)	0.130[1]
Average SBP (mmHg) - Median (IQR)	100 (93.33-103.33)	100 (95-103.33)	100 (93.33-103.33)	0.518[1]
Average DBP (mmHg) - Median (IQR)	66.67 (60-70)	63.33 (60-70)	66.67 (60-70)	0.175[1]

1: Wilcoxon-Mann-Whitney U test; IQR: inter-quartile range, SBP: systolic blood pressure, DBP: diastolic blood pressure

Prevalence rates of overweight, obesity and hypertension in boys and girls are shown in Table 2.

Table 3 shows the Spearman correlation coefficient between NC and other anthropometric parameters for boys and girls. NC showed a positive correlation with age, weight, height, BMI and SBP in both boys and girls and was statistically significant (p<0.05).

The accuracy of NC in identifying overweight, obesity and hypertension amongst gender specific group is shown in Table 4.

Table 2: ***Gender-wise prevalence rates of overweight, obesity and hypertension***

Variable	Total	Males	Females
Overweight	14.1%	12.1%	16.9%
Obesity	7.8%	9.9%	4.7%
Hypertension	12.6%	11.9%	13.6%

Table 3: ***Spearman correlation coefficient between neck circumference (NC) and other parameters gender-wise***

Parameter	Correlation of NC (rho) in boys	p-value	Correlation of NC (rho) in girls	p-value
Age***	0.17	< 0.001[1]	0.23	<0.001
Weight***	0.38	< 0.001[1]	0.43	<0.001[1]
Height***	0.22	< 0.001[1]	0.3	<0.001[1]
BMI kg/mm^2***	0.39	< 0.001[1]	0.39	<0.001[1]
SBP mmHg***	0.09	0.047	0.15	0.007
DBP mmHg	0.01	0.767	0.03	0.644

****Significant at p<0.05, 1: Spearman correlation, BMI: Body mass index, SBP: systolic blood pressure, DBP: diastolic blood pressure,*

Table 4: ***Area under curve (AUC) including the optimal neck circumference cut-offs***

Neck circumference		Cut-off (cm)	AUC	Sensitivity (%)	Specificity (%)	LR (+)	LR (-)
Boys	Overweight	26.5-27.5	0.644	87.5	37.4	1.40	0.33
	Obesity	24.5-25.5	0.663	93.5	9.6	1.76	0.66
	Hypertension	28.5-29.5	0.532	87.3	20.3	1.17	0.68
Girls	Overweight	28.5-29.5	0.546	84.2	15.5	1.40	0.90
	Obesity	24.5-25.5	0.601	93.8	12.8	5.23	0.67
	Hypertension	25.5-26.5	0.507	82.6	22.3	1.65	0.94

LR: Likelihood ratio

In boys, the best cut-off value of NC by ROC to identify overweight was 26.5-27.5cm (AUC-0.644) with sensitivity of 87.5% and specificity 37.4% positive likelihood ratio (LR) 1.40 and negative LR 0.33; the best cut-off value of NC by ROC to identify obesity was 24.5-25.5cm (AUC- 0.663) with sensitivity of 93.5% and specificity 9.6% with positive LR 1.76 and negative LR 0.66; the best cut-off value of NC by ROC to identify hypertension was 28.5-9.5 cm (AUC-0.532) with sensitivity of 87.3% and specificity 20.3% with positive LR 1.17 and negative LR 0.68.

In girls, the best cut-off value of NC by ROC to identify overweight was 28.5-29.5cm (AUC- 0.546) with sensitivity of 84.2% and specificity 15.5% positive LR 1.40 and negative LR 0.90; the best cut off value of NC by ROC to identify obesity was 24.5-25.5cm (AUC-0.601) with sensitivity of 93.8% and specificity 12.8% with positive LR 5.23 and negative LR 0.6); the best cut off value of NC by ROC to identify hypertension was 25.5-26.5cm (AUC-0.507) with sensitivity of 82.6% and specificity 22.3% with positive LR 1.65 and negative LR 0.94.

Table 5 is a comparison of cut-off values of NC of other studies

.

Table 5: ***Comparison of cut off values of neck circumference of other studies***

Study	Country (year)	Age	Number	Cut-off value (Boys)	Cut-off value (Girls)
Hatipoglu N, *et al*[14]	Turkey (2010)	6-18	976	28.0-38.0	27.0-34.5
Nafiu O, *et al*[15]	USA (2010)	6-18	1102	28.5-39.0	27.0-34.6
Taheri M, *et al*[16]	Iran (2013)	6-17	864	27.50-38.3	26.7-33.4
Atwa H, *et al*[17]	Egypt (2012)	12-15	2762	29.3-31.7	28.6-31.4

Discussion

Obesity in children is on the rise and is linked to cardiovascular and metabolic illnesses. As a result, early prevention and treatment of paediatric obesity is critical, and a precise diagnostic criterion is required. NC is a simple and practical anthropometric indicator that can be used to assess higher fat distribution, especially for screening. Since there is different body morphology, neck skin-fold was used to analyse upper body fat distribution which is linked to obesity and its complications as suggested first by Vague J[12]. NC has excellent inter- and intra-rater reliability, requiring no multiple measurements for precision and consistency[13].

The results of this study were similar to studies conducted in Turkey, USA, Iran and Egypt indicating that NC increases with the age of the child and that NC strongly correlates with BMI[14-17]. Our study is in agreement with observations made by Hatipoglu N, *et al*[14], Nafiu O, *et al*[15] and Taheri M, *et al*[16] in which similar age groups were included (Table 5).

The prevalence rates of overweight and obesity in our study were 14.1% and 7.8% respectively. In a study by Kuciene R, *et al*[10], prevalence rates of overweight and obesity were 12.6% and 3.2% respectively, which were low compared to our study, whereas in a study by Nafiu O, *et al*[15], prevalence rates of overweight and obesity were 19.0% and 18.7% which were higher when compared to our study. In our study, prevalence rate of hypertension was 12.6%, whereas in studies by Kuciene R, *et al*[10] and Nafiu O, *et al*[15] prevalence rates were 25.1% and 19.1% respectively which were higher compared to our study.

In our study NC showed a positive correlation with weight, height and BMI in both boys and girls which was similar to studies by Nimawat AK, *et al*[18] and Yashoda HT, *et al*[19]. NC also had a positive correlation with SBP in both boys and girls which was similar to studies by Kuciene R, *et al*[10] and Nafiu O, *et al*[15], whereas NC was not correlated with DBP in our study which was not similar to studies by Kuciene R, *et al*[10] and Nafiu O, *et al*[15].

The best cut-off values of NC by ROC to identify overweight were 26.5-27.5cm in boys and 28.5-29.5 cm in girls and the best cut-off value of NC by ROC to identify obesity was 24.5-25.5cm in both boys and girls. This was similar to studies by Hatipoglu N, *et al*[14], Nafiu O, *et al*[15], Taheri M, *et al*[16], and Atwa H, *et al*[17]. The best cut off values of NC by ROC to

identify hypertension were 28.5-29.5 cm in boys and 25.5-26.5cm in girls.

There were some limitations in the study. This was a cross-sectional observation study conducted in a single hospital set-up, the study's interpretation of validity of correlations was limited and the results cannot be generalised over the entire population. As a result, our findings must be confirmed and expanded in bigger research covering different areas with children of a wider age range.

Conclusions

In our study there was a strong association of elevation in BP with high NC and overweight and obesity. The NC measurement was a simple, non-invasive test to detect obesity and hypertension in children.

References

1. Weiss R, Caprio S. The metabolic consequences of childhood obesity. *Best Practice and Research: Clinical Endocrinology and Metabolism* 2005; **19**: 405-19. https://doi.org/10.1016/j.beem.2005.04.009 PMid: 16150383

2. Obesity and Overweight, Fact Sheet Updated; March, 2013.

3. Kissebach AH, Vydelinqum N, Murray R. Relation of body fat distribution to metabolic complications of obesity. *Journal of Clinical Endocrinology and Metabolism* 1982; **54**: 254-60. https://doi.org/10.1210/jcem-54-2-254 PMid: 7033275

4. Nielsen S, Guo Z, Johnson CM, Hensrud DD, Jensen MD. Splanchnic lipolysis in human obesity. *Journal of Clinical Investigation* 2004; **113**: 1582-8. https://doi.org/10.1172/JCI21047 PMid: 15173884 PMCid: PMC419492

5. Gillum RF. Distribution of waist-to-hip ratio, other indices of body fat distribution and obesity and associations with HDL cholesterol in children and young adults aged 4–19 years: the Third National Health and Nutrition Examination Survey. *International Journal of Obesity and Related Metabolic Disorders* 1999; **23**: 556–63. https://doi.org/10.1038/sj.ijo.0800866 PMid: 10411227

6. Jensen MD. Lipolysis: Contribution from regional fat. *Annual Review of Nutrition* 1997; **17**:127- 39. https://doi.org/10.1146/annurev.nutr.17.1.127 PMid: 9240922

7. Bassali RW, Waller JL, Gower B, Allison JD, Davis CL. Utility of waist circumference percentile for risk evaluation in obese children. *International Journal of Pediatric Obesity* 2009; **5**(1): 97–101. https://doi.org/10.3109/17477160903111722 PMid: 19606372 PMCid: PMC2851850

8. Kuczmarski RJ, Ogden CL, Guo S. 2000 CDC Growth Charts for the United States: Methods and Development. Vital Health Stat 11(246). Washington: National Center for Health Statistics; 2002

9. Mazicioglu MM, Kurtoglu S, Ozturk A, Hatipoglu N, Cicek B, Ustunbas HB. Percentiles and mean values for neck circumference in Turkish children aged 6–18 years. *Acta Paediatrica* 2010; **99**(12): 1847-53. https://doi.org/10.1111/j.16512227.2010.01949.x PMid: 20682008

10. Kuciene R, Dulskiene V, Medzioniene J. Association of neck circumference and high blood pressure in children and adolescents: A case-control study. *BMC Pediatrics* 2015; **15**: 127. https://doi.org/10.1186/s12887-015-0444-2 PMid: 26383844 PMCid: PMC4574610

11. The fourth report on the diagnosis, evaluation, and treatment of high blood pressure in children and adolescents. *Pediatrics* 2004; **114**(2 Suppl. 4th Report): 555-76. https://doi.org/10.1542/peds.114.2.S2.555

12. Vague J. The degree of masculine differentiation of obesities: a factor determining predisposition to diabetes, atherosclerosis, gout, and uric calculous disease. *American Journal of Clinical Nutrition* 1956; **4**(1): 20-34. https://doi.org/10.1093/ajcn/4.1.20 PMid: 13282851

13. LaBerge RC, Vaccani JP, Gow RM, Gaboury I, Hoey L, Katz SL. Inter- and intra-rater reliability of neck circumference measurements in children. *Pediatric Pulmonology* 2009; **44**(1): 64-9. https://doi.org/10.1002/ppul.20944 PMid: 19061227

14. Hatipoglu N, Mazicioglu MM, Kurtoglu S. Neck circumference: an additional tool of screening overweight and obesity in childhood. *European Journal of Pediatrics* 2010; **169**: 733-9. https://doi.org/10.1007/s00431-009-1104-z PMid: 19936785

15. Nafiu O, Burke C, Lee J. Neck circumference as a screening measure for identifying children with high body mass index. *Pediatrics* 2010; **126**(2): e306-10. https://doi.org/10.1542/peds.2010-0242 PMid: 20603254

16. Taheri M, Kajbaf TZ, Taheri MR, Aminzadeh M. Neck circumference as a useful marker for screening overweight and obesity in children and adolescents. *Oman Medical Journal* 2016; **31**(3): 170-5. https://doi.org/10.5001/omj.2016.34 PMid: 27162586 PMCid: PMC4852089

17. Atwa H, Fiala L, Fiala EM, Handoka NM. Neck circumference as an additional tool for detecting children with high body mass index. *Journal of American Science* 2012; **8**(10): 442-6.

18. Nimawat AK, Gupta VK, Natani BS, Verma CR. Neck circumference as a screening tool for overweight and obesity in children. *AJPR* 2020; **3**(2): 17-22 https://doi.org/10.9734/ajpr/2020/v3i230123

19. Yashoda HT, Swetha B, Goutham AS. Neck circumference measurement as a screening tool for obesity in children. *International Journal of Contemporary Pediatrics* 2017; **4**(2): 426-30. https://doi.org/10.18203/23493291.ijcp20170538