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ASSESSMENT OF NECK CIRCUMFERENCE IN A SAMPLE OF PRIMARY SCHOOL CHILDREN

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ABSTRACT

Background: Neck circumference (NC) is one of the proposed assessments for child obesity, but limited information is available for Malaysian children. This study assessed NC and its relationship with anthropometric indices in a sample of primary school children.

Materials and Methods: This cross-sectional study recruited 758 children aged 7-10 years old from a selected primary school in Serdang, Selangor. Anthropometric indices included assessments of height, weight, waist circumference (WC) and NC. Body mass index (BMI) was calculated which was then used to determine BMI-for-age Z-score based on the WHO Child Growth Standard.

Results: Their mean age of the children were 8.2±1.1 years old, mainly boys (54.6%) and Malays/Bumiputera (91.0%). The prevalence of overweight and obesity were 8.3% and 3.8% respectively, lower than the thinness (16.6%). The mean NC was 27.8±2.5cm with no differences between boys and girls. There was a significant difference between BMI and NC in which thinness (25.7±1.3cm) and normal weight (27.6±1.9cm) children had significantly lower NC as compared to overweight (31.6±1.8cm) and obese (32.5±2.5cm) children (p< 0. 001). However, no different in NC between overweight and obese children. NC was also significantly higher in children with WC of more than 90th percentiles as compared to those less (31.5±2.2 vs 27.2±1.8 cm) (p< 0. 001). NC was positively correlated with BMI-for-age (r = 0.781), BMI-for-age Z-score (r= 0.762), WC (r= 0.755), body weight (r= 0.752), height (r= 0.430) and age (r= 0.117) (p< 0. 001). There were a significant relationship of BMI and WC with NC (Adjusted R2 = 0.625, F (2, 753) = 630.9 p < 0.000).

Conclusion: NC was significantly related to excess weight and adiposity. The results suggest that NC assessments can potentially be used to assess child obesity.

Keywords: Childhood Obesity, Neck Circumference, Body Mass Index

1.0 Introduction

Childhood obesity is public health issues around the world. Malaysia has not spared from this health issue. About 34.5% of urban primary school-aged children were either overweight or obese (Poh et al., 2013), a data that was comparable to other developed countries (Manyanga et al. 2014; Mohd Nasir et al. 2012). The health consequences of childhood obesity are well reported and similar to the obese adults. There are at a high risk of developing metabolic syndrome, type 2 diabetes and obstructive sleep apnea (Wells, 2012; Nafiu et al. 2010), suggesting an urgent needs to identify method of assessments that can predict obesity-related consequences (Nafiu et al. 2010; Ben-noun & Laor, 2003; Ben-noun, Sohar, & Laor, 2001)

Various methods are used to assess overweight and obesity in children. Body mass index (BMI; ratio of weight by the square of height) is the most common tool used to identify child obesity based on WHO Child Growth Standard using BMI-for-age Z-scores (Ogden et al., 2009). BMI is simple and universally used in a clinic or a community setting (Adamu et al. 2013; Chan & Woo, 2010). Nevertheless, it is not the best tool to assess fat deposition mainly in the central area which is known as a primary predictor of obesity-related consequences (Chan & Woo, 2010). Although waist circumference (WC) is considered as an alternative indicator measuring central obesity, the limitation is explicit. Clothing is one major factor affecting the measurements of WC. Besides, WC is easily affected by abdominal distention following eating (Nafiu et al. 2010). In some population, measuring WC is not culturally accepted as they are required to expose some part of the body in getting a precise measure (Taheri et al., 2016).

Neck circumference (NC) may be used as a simple assessment tool to identify child obesity mainly focusing on visceral obesity (Nafiu et al. 2010). NC is a surrogate marker for upper body subcutaneous fat (Taheri et al., 2016) which was associated with cardiovascular risk factors in children and adolescents (Yang et al., 2010). Limited information, however, is available for primary school-aged children in Malaysia. Therefore, this study aimed to assess NC and its correlation with anthropometric indices in a sample of primary school-aged children.

2.0 Materials and Methods

2.1 Study Design and Samples

This study employed a cross-sectional design and recruited a total of 758 children aged 7-10 years old who attended a selected primary school in Serdang, Selangor. This study was part of the screening database for a subsequent community-based intervention to improve child obesity (Nurul Ain, 2018). Students with a chronic disease, history of chronic medication consumption and those who were on a specific diet were not enrolled in this study. Permission to carry out data collection was obtained from the Ministry of Education and the authority of the selected school. The Ethics Committee of Research Involving Human in Universiti Putra Malaysia approved the study. Written informed consent was obtained from the parents or guardians of all the children, and verbal permission was obtained from each child before data collection.

2.2 Measurements

A team of trained researcher performed the measurements under standard protocols by using calibrated instruments. Measurements include the height, body weight, waist circumference and neck circumference. The participants wore light clothing and without shoes.

Weight was measured using a digital weighing machine (SECA Model 803, Vogel and Halke GmbH & Co., Germany) to the nearest 0.1 kg on a scale placed on flat ground. Height was assessed using a stadiometer to the nearest 0.1 cm (SECA Model 213, Vogel and Halke GmbH & Co., Germany). BMI was calculated as weight in kg/height in m^2. Anthropometric status of the children was classified by referring to the WHO growth reference for 5 to 19 years (WHO, 2007). Z-scores for BMI-for-age for children aged > 5 years were identified by using the WHO AnthroPlus version 1.0.4 (WHO, Geneva, Switzerland) software (WHO, 2009). WC was measured using a non-elastic tape at a point midway between the lower border of the rib cage and the iliac crest at the end of normal expiration to the nearest 0.1 cm. Classification of the 90th percentiles of waist circumference was based on Poh et al. (2011). NC was measured in a horizontal plane at the level of the inferior border of the thyroid cartilage and perpendicular to the vertical axis of the neck by using a non-elastic tape. While taking the NC reading, the subject was needed to look straight ahead, with shoulders down, but not hunched (Adamu et al. 2013). The cut-off points for wasting, stunting and thinness were -2SD, while cut-off points for overweight and obesity were 1SD and 2SD respectively (WHO, 2007; WHO, 2006).

2.3 Statistical Analyses

Data were analysed using SPSS version 22.0 (Chicago, IL, USA) and a statistical level of $p < 0.05$ was considered significant. Frequencies (n; %) were used to describe the sample distribution in the distribution of body weight status. Descriptive statistics including means and standard deviations (SD) used to report subjects' characteristics and body weight status. The mean differences in WC or NC according to body weight status were determined using ANOVA. The correlation of selected variables including age and anthropometric indices and NC was determined using the Pearson correlation, and the magnitude of correlation was reported (Cohen, 1993).

3.0 Results

All subjects (n= 758) completed all measures and were included in the analyses. Slightly more than half of the children were males (54.6%). They are predominantly Malay / Bumiputera ethnicity (91.0%) with their mean age were 8.2 ± 1.1 years (Table 1).

The mean body weight and height were 26.6 ± 8.8 kg and 127.3 ± 8.9 cm, respectively (Table 1). Using the WHO 2007 BMI-for-age, 16.6% of the subjects were in the thinness/severe category, 71.2% of them classified as having normal weight status, and 12.1% were either overweight (8.3%) or obese (3.8%). Boys and girls showed similar distributions ($p > 0.05$). NC and WC was 59.3 ± 9.4 cm and 27.8 ± 2.5 cm, respectively. About 15.5% had WC > 90th percentiles indicate having abdominal obesity (Table 1).

Table 2 shows the mean differences in NC and WC according to BMI and WC cut-off points. Children with BMI classified as overweight and obese had significantly wider NC than those with a normal weight, thinness and severe thinness (p< 0.001). NC was also significantly wider in children with WC of > 90th percentiles (31.5 ± 2.2 cm) than those with WC of < 90th percentiles (27.2 ± 1.8 cm) (p< 0. 001).

Table 1: Subjects' characteristic and body weight status (N= 758)

	Total (n= 758)	**Boys (n = 414)**	**Girls (n= 344)**	**p-value**
		Mean ± SD		
Age (years)	8.2 ± 1.1	8.2 ± 1.1	8.1 ± 1.1	0.315
Body weight (kg)	26.6 ± 8.8	26.8 ± 8.6	26.3 ± 9.0	0.415
Height (cm)	127.3 ± 8.9	127.4 ± 8.5	127.2 ± 9.4	0.748
Body Mass Index (kg/m^{-2})	16.1 ± 3.8	16.3 ± 3.8	16.0 ± 3.8	0.316
BMI-for-age Z-score	-0.4 ± 1.9	- 0.3 ± 1.9	-0.4 ± 1.7	0.356
Waist Circumference (cm)	59.3 ± 9.4	59.6 ± 9.5	58.9 ± 9.4	0.368
Neck circumference (cm)	27.8 ± 2.5	27.9 ± 2.4	27.6 ± 2.5	0.052
		n (%)		
Ethnicity (%)				
• Malay/ Bumiputra	690 (91.0)	379 (91.6)	311 (90.4)	0.391
• Indian	48 (6.3)	29 (7.0)	19 (5.5)	
• Chinese	1 (0.1)	0 (0.0)	1 (0.3)	
• Others	19 (0.7)	6 (1.5)	13 (3.8)	
BMI classifications				
• Severe thinness	42 (5.5)	22 (5.3)	20 (5.8)	0.196
• Thinness	84 (11.1)	43 (10.4)	41 (11.9)	
• Normal weight	540 (71.2)	291 (70.3)	249 (72.4)	
• Overweight	63 (8.3)	36 (8.7)	27 (7.8)	
• Obesity	29 (3.8)	22 (5.3)	7 (2.0)	
Waist circumference classification				
• < 90th percentiles	639 (84.5)	344 (83.5)	295 (85.8)	0.420
• > 90th percentiles	117 (15.5)	68 (16.5)	49 (14.2)	

Table 2. Mean differences in neck and waist circumference according to BMI classifications (N= 758)

	Neck circumference (cm)	Waist circumference (cm)
BMI classifications		
• Severe thinness (n= 42)	25.4 ± 1.4[a,c,d,e]	51.7 ± 3.5[a,c,d,e]
• Thinness (n= 84)	25.9 ± 1.2[b,c,d,e]	51.8 ± 2.8[b,c,d,e]
• Normal weight (n = 539)	27.6 ± 1.9[a,b,c,d,e]	58.1 ± 6.7[a,b,c,d,e]
• Overweight (n= 62)	31.6 ± 1.8[a,b,c,d]	75.2 ± 7.7[a,b,c,d,e]
• Obese (n= 29)	32.5 ± 2.7[a,b,c,e]	80.2 ± 8.0[a,b,c,d,e]
F- statistic	162.28	218.94
p-value	0.001	0.001
Waist circumference classifications		
• < 90th percentiles (cm)	27.2 ± 1.8	56.1 ± 5.5
• > 90th percentiles (cm)	31.5 ± 2.2	76.9 ± 6.9
T- statistic	20.20	30.72
p-value	0.001	0.001

BMI = Body Mass Index; Underweight = $\leq$ 18.9 kgm^{-2}, Normal BMI = 19.0 – 24.9 kgm^{-2}; overweight = 25.0 – 29.9 kgm^{-2}; obese = $\geq$ 30.0 kgm^{-2} (WHO Expert Consultation, 2004)

In a univariate analysis (Table 3), there was a significant positive correlation of age (r= 0.117, p= 0.001), height (r=0.408, p= 0.001), body weight (r= 0.752, p= 0.001), WC (r= 0.755, p= 0.001), BMI-for-age Z-score (r= 0.762, p= 0.001) and BMI (r= 0.781, p= 0.001) with NC. The multiple linear regression model showed a significant relationship of BMI, and WC with NC (Adjusted R^2 = 0.625, F (2, 753) = 630.9 p < 0.000). Children with a higher BMI and WC were more likely to have a wider NC. These variables explained 62.5% the variability of NC (Table 3).

Table 3: Association between the selected variables and neck circumference (N= 758)

Variables	Neck Circumference	
	r	p-value
Age (years)	0.117	0.001
Height (cm)	0.430	0.001
Body weight (kg)	0.752	0.001
Waist Circumference (cm)	0.755	0.001
BMI-for-age Z-score	0.762	0.001
Body Mass Index (kg/m^{-2})	0.781	0.001

**. Correlation is significant at the 0.01 level (2-tailed)

4.0 Discussion

Our findings revealed a significant association between NC and other anthropometric measurements of obesity in a sample of school children. Various studies also supported the findings among school children in the United States, Turkey and Iran (Taheri et al., 2016; Hatipoglu & Mazioglu, 2010; Nafiu et al., 2010). We observed a strong correlation between BMI and NC (r = 0.781, p<0.01) which was consistent with a study conducted among ten years old children who had undergone elective non-cardiac surgery in the United State

(Mazicioglu et al., 2010). Similarly, other studies had also found a significant positive correlation between WC and NC (r = 0.755, p<0.01) as in our study (Taheri et al., 2016; Hatipoglu & Mazioglu, 2010). In another cross-sectional study among 5481 Turkish school subjects aged 5 to 18 years, NC was associated with BMI, age and WC with a strong association observed among the older children (Mazicioglu et al., 2010). The result suggests that NC can be used to diagnose overweight and obesity.

In this study, the optimal value of NC in boys and girls was 27.9 ± 2.4 cm and 27.6 ± 2.5 cm, respectively. The value observed close to other studies in the United States, Iran and Turkey (Taheri et al., 2016; Hatipoglu & Mazioglu, 2010; Nafiu et al., 2010). The optimal NC cut-offs ranged from 28.5 to 39.0 cm in boys and 27.0 to 34.6 cm in girls aged 6-18 years from the United States (Nafiu et al., 2010). The NC cut-offs among Turkish children aged 5-18 years old was 28 to 38 cm in boys and 27 to 35 cm in girls (Hatipoglu & Mazioglu, 2010). However, the NC cut-offs among Iranian children aged 6 to 17 years was 31.4 ± 3.9 cm in boys, and 29.6 ± 2.6 cm in girls (Taheri et al., 2016) was slightly higher than our study. The optimum NC cut-off was also higher among children aged 10 to 18 years from Turkey (boys = 36 cm; girls = 34 cm) (Kurtoglu et al., 2012).

The younger age group could explain the differences in optimal NC cut-off in our study than a broader age group including the pubertal age in other studies. Other factors include the ethnic's variation, smaller sample size and the sensitivity or specificity of the NC methods. Some study had a limited sample of children with a normal BMI as a control (Kurtoglu et al., 2012; Nafiu et al., 2010). Meanwhile, others included multi-ethnics with different physical fitness level and are usually practice different food habits. Both of these factors affect body composition and NC cut-off values (Adamu et al., 2013). Also, boys have shown a higher trend of NC than girls which could be related to fat distributions and metabolisms that were differed between them. The differences could also be related to sex hormones but future study warranted (Kurtoglu et al., 2012).

In this study, children with a higher BMI and WC were more likely to have a wider NC, and these variables explained 62.5% the variability of the NC. Beside anthropometric indices, other factors may influence the NC values such as blood parameters of the children. For example, high blood pressure was reported to be associated with high NC but not with BMI, WC and WHR (Fan et al., 2017) Therefore, it is recommended that NC can be used as a tool to assess the risk of hypertension among children which, however, did not determine in the current study.

NC reported being a reliable anthropometric measurement to assess upper body fat. Several studies reported that both the NC and WC had higher accuracy than BMI alone in predicting the risk of having cardiometabolic diseases among Iranian and Turkish children (Kurtoglu et al., 2012; Bizheh et al., 2011). It is suggested that NC could also be used to screen for other health complications and metabolic disorders including obstructive sleep apnea and diabetes in obese children (Nafiu et al., 2014; Adamu et al. 2013; Onat et al., 2009).

While results are intriguing, some limitations should be taken into consideration. The generalisation of the results is limited as it was only sampled from one school and mainly Malay children. Besides, the nature of the cross-sectional study limits the cause and effect explanation of the related factors to the NC.

5.0 Conclusions and Recommendations

In a sample of Malaysian school children aged 7 to 10 years, NC was significantly related to excess weight and adiposity. The finding suggests that NC measurements can be applied to assess child obesity. Future study should confirm the validity of the findings in a large population-based sample of children and identify the reference values of the NC in comparison to child obesity.

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Declaration

Authors of this article declare no conflict of interest.

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