

## Neck circumference as a useful marker of obesity: A comparison with body mass index and waist circumference

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### Abstract

**Objective:** To evaluate the usefulness of neck circumference as an index of excess weight and obesity in young adults while identifying its appropriate cutoff points.

**Methods:** The study comprised 41 male and 109 female students, aged 18-20 years. Anthropometric markers of obesity were measured, including body mass index, waist circumference, hip circumference, waist-to-hip ratio, and compared with neck circumference of the same subjects. Overweight and obesity levels were defined by BMI  $\geq 23.0$  and  $\geq 25.0$  respectively.

**Results:** Overall 29.2% males and 25.6% females were found overweight/obese. The mean body mass index was 21.7 kg/m<sup>2</sup> in males and 21.0 kg/m<sup>2</sup> in females. The mean waist and neck circumferences were higher in males (80.6 cm, and 35.5 cm) than females (78.1 cm, and 31.5 cm). Neck circumference had a strong positive correlation ( $p < 0.001$ ) with other relevant indicators in all subjects, except the waist-to-hip ratio which was applicable on males only. At BMI of 23.0 and 25.0, males had neck circumference 35.7cm and 37.5cm, while females had it at of 32.2cm and 33.5cm respectively.

**Conclusion:** Neck circumference is a potentially useful initial screening tool for overweight/obesity. A neck circumference  $\geq 35.5$  cm in men and  $\geq 32$  cm in women should be considered the cutoff point for overweight/obesity.

**Keywords:** Overweight, Obesity, Neck circumference, BMI, Waist circumference, Anthropometry (JPMA 62: 36; 2012).

### Introduction

Overweight and obesity are terms used for people who weigh more than the limits recommended for their age and gender. This leads to a number of diseases that contribute to increased morbidity and mortality. The presence of obesity worldwide has led to the usage of the term 'globesity' to describe the epidemic trend towards increased body weight.<sup>1</sup>

According to International Obesity Taskforce (IOTF) analysis (2010),<sup>2</sup> the numbers of overweight and obese adults are approximately 1.0 billion and 475 million respectively. Using

Asian cut-off values, the number of obese people rises to 600 million. A similar trend is seen in children of school-going age with an estimated 200 million classified as either overweight or obese.<sup>2</sup> The National Health and Nutrition Examination Survey (NHANES) has observed that the proportion of American adults who are obese has doubled from 15% in 1971-74 to 34% in 2003-6.<sup>3</sup> Countries having the lowest rates of obesity, such as Japan and Korea, are also experiencing a similar trend.<sup>4</sup> The prevalence of overweight and obesity in Pakistan, using Asian cut-off values for BMI, is 25% which means one out of every four person is either overweight or obese.<sup>5</sup>

Practical and easily performed methods for measuring obesity include various anthropometric measures such as body mass index (BMI), waist circumference (WC), waist-to-hip ratio (WHR), as well as the not-so-easy method of measuring the thickness of subcutaneous fat layer at specific sites for estimating body fat percentage. BMI has been adopted by most health professionals for obesity surveys, as it is easy to perform on a large scale. However, it does not depict the true body composition. Furthermore, visceral obesity, which closely relates to cholesterol levels in the body and its associated coronary artery disease, is better defined by measuring the waist circumference.<sup>6</sup>

Measurement of neck circumference (NC) has recently been used to identify overweight and obesity and is observed to have good correlation with age, weight, waist and hip circumferences, waist-to-hip ratio, and BMI for both genders.<sup>7</sup> Besides, NC is considered an index of upper body obesity and correlates positively with changes in systolic and diastolic blood pressure and other components of the metabolic syndrome.<sup>8</sup>

The purpose of the study was two-fold: one, to determine the reliability of NC as a measure of obesity as compared to BMI or WC; and, two, to identify the cutoff points for overweight and obesity for young adults using NC.

## Subjects and Methods

The cross-sectional study was conducted by the Physiology Department of Fatima Jinnah Dental College, Karachi, during 2011, involving 155 first year dental students aged 18 to 20 years. Written informed consent was obtained from them prior to the study which was approved by the Research and Ethics Committee of the college. All the subjects were examined for enlargement of thyroid gland and, if found positive, were excluded from the study.

The study compared BMI and WC, with NC as an index of obesity. The subjects were categorised according to their BMI, and at each level their WC and NC were determined. Normal weight was considered as BMI 18.50 to 22.99 kg/m<sup>2</sup>. Subjects with BMI <18.50 kg/m<sup>2</sup> were considered as

underweight. The cutoff values for overweight and obesity were  $\geq 23.00$  to  $24.99$  kg/m<sup>2</sup> and  $\geq 25.00$  kg/m<sup>2</sup>, respectively, as specified for the Asia-Pacific population by the Western Pacific Regional Office (WPRO) of the World Health Organisation (WHO).<sup>9</sup>

Anthropometric measurements were conducted using standard techniques<sup>10</sup> as under:

Weight was measured while wearing light clothing and without shoes, after emptying of bladder, using a digital scale to the nearest 100 g. Height was measured without shoes, with stadiometer to the nearest 0.5 cm. BMI was calculated by dividing weight (kg) with the square of height (m). Waist circumference (cm) was taken horizontally to within 1 mm, using plastic tape measure at midpoint between the costal margin and iliac crest in the mid-axillary line, with the subject standing and at the end of a gentle expiration. Hip circumference (HC) was measured in centimetres, at the level of greater trochanters, with the legs close together. WC was then divided by HC to get the waist-to-hip ratio (WHR).

The neck circumference (cm) was taken to the nearest 1 mm, using plastic tape measure. It was taken in a plane as horizontal as possible, at a point just below the larynx (thyroid cartilage) and perpendicular to the long axis of the neck (the tape line in front of the neck at the same height as the tape line in the back of the neck). While taking this reading the subject was asked to look straight ahead, with shoulders down, but not hunched. Care was taken not to involve the shoulder/neck muscles (trapezius) in the measurement.

Statistical analyses were performed using Microsoft Excel 2007. All results were expressed as mean standard deviation (SD) or n (%) or range where appropriate. Pearson's correlation coefficient was used to determine the relation between various anthropometric indices. A p value <0.05 was considered to be significant.

## Results

Of the 150 students that participated in the study, 41 (34.5%) were male and 109 (65.5%) females (Table-1). The

**Table-1: General characteristics of the study subjects.**

	Male (n = 41)		Female (n = 109)	
	Mean $\pm$ SD (Range)	Correlation (r) of NC with	Mean $\pm$ SD (Range)	Correlation (r) of NC with
Age (years)	18.86 $\pm$ 1.09 (17 - 21)	-	18.78 $\pm$ 0.52 (17 - 20)	-
Weight (kg)	65.51 $\pm$ 17.44 (37.0 - 127.0)	0.885***	53.01 $\pm$ 10.27 (34.0 - 85.0)	0.764***
Height (cm)	173.26 $\pm$ 7.46 (156.0 - 189.5)	0.429**	157.31 $\pm$ 16.31 (145.0 - 181.0)	0.230*
BMI (kg/m <sup>2</sup> )	21.69 $\pm$ 4.93 (14.45 - 40.77)	0.861***	21.04 $\pm$ 3.82 (14.34 - 33.46)	0.703***
WC (cm)	80.67 $\pm$ 12.94 (60.0 - 126.2)	0.858***	78.17 $\pm$ 9.12 (63.5 - 110.0)	0.623***
HC (cm)	95.31 $\pm$ 10.03 (77.0 - 131.0)	0.828***	96.15 $\pm$ 9.14 (70.5 - 129.0)	0.588***
Waist:hip ratio	0.84 $\pm$ 0.057 (0.71 - 0.96)	0.691***	0.75 $\pm$ 0.055 (0.68 - 0.98)	0.228*
NC (cm)	35.56 $\pm$ 2.77 (29.2 - 44.2)	-	31.52 $\pm$ 1.96 (27.0 - 37.5)	-

BMI, Body Mass Index; WC, Waist Circumference; HC, Hip Circumference; SD, Standard deviation; r, Pearson's correlation coefficient between NC and other anthropometric indices of male and female subjects; \*p<0.05, significant; \*\*p<0.01, very significant; \*\*\*p<0.001, extremely significant.

**Table-2: Relationship between Body Mass Index (BMI), Waist circumference (WC) and Neck circumference (NC).**

	Male (n = 41)				Female (n = 109)			
	UW (26.8%)	Normal (43.9%)	OW (9.7%)	Obese (19.5%)	UW (31.1%)	Normal (43.1%)	OW (12.8%)	Obese (12.8%)
BMI (kg/m <sup>2</sup> )	17.02±1.07	20.66±1.13	24.03±0.55	29.28±5.30	17.04±1.11	21.04±1.41	23.76±0.68	28.08±2.79
WC (cm)	68.93±5.09	77.38±4.22	87.12±1.49	100.97±11.73	71.35±4.91	77.72±6.04	81.33±5.44	93.05±9.99
NC (cm)	32.77±1.68	35.45±1.23	36.2±1.32	39.36±2.56	30.29±1.58	31.26±1.38	33.02±0.98	33.89±2.28

Values in Mean ± SD, Standard deviation; UW, Underweight = BMI < 18.5; Normal weight = BMI 18.5 to 22.9; OW, Overweight = BMI 23 to 24.9; Obese = BMI ≥ 25.

**Table-3: Cutoff point of Neck Circumference (NC) to define overweight and obese subjects.**

Study	Year	Overweight	Obese	NC of Male Overweight	NC of Female Obese
Ben-Noun <sup>5</sup>	2001	≥ 37 cm	≥ 39.5 cm	≥ 34 cm	≥ 36.5 cm
Yang <sup>10</sup>	2010	≥ 38 cm		≥ 35 cm	
Hatipoglu <sup>11</sup>	2010	Boys (6-18 years): 28-38 cm		Girls (6-18 years): 27-34.5 cm	
Nafiu <sup>13</sup>	2010	Boys (6-18 years): 28.5-39 cm		Girls (6-18 years): 27-34.6 cm	
This Study	2011	≥ 35.5 cm	≥ 37.5 cm	≥ 32 cm	≥ 33.5 cm

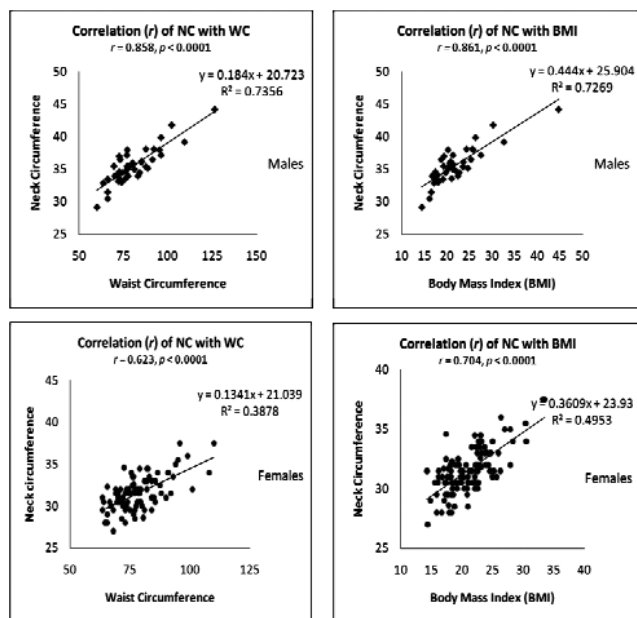


Figure: Scatter plot showing correlation (r) of neck circumference (NC; cm) with waist circumference (WC; cm) and body mass index (BMI; kilograms per meter square) in male and female subjects.

mean age was 18.5 ± 1.03 years. The mean BMI was 21.69 ± 4.93 kg/m<sup>2</sup> in males and 21.04 ± 3.82 kg/m<sup>2</sup> in females. There was no significant difference between genders for BMI, WC and HC. However, the mean WHR and NC were significantly higher (p < 0.001) in males (80.67 ± 12.94 cm, and 35.56 ± 2.77 cm) than females (78.17 ± 9.12 cm, and 31.52 ± 1.96 cm) respectively.

Pearson's correlation coefficients were generated between NC and other continuous variables, including body

weight, height, BMI, WC, HC and WHR (Table-1). Neck circumference was positively and significantly associated with BMI (r = 0.861, p < 0.0001 in males; r = 0.704, p < 0.0001 in females) and WC (r = 0.858, p < 0.0001 in males; r = 0.623, p < 0.0001 in females). Other variables also showed highly significant correlation with NC (p < 0.0001) for both males and females (Figure), except for height (p < 0.0046 in males; p < 0.0158 in females) and WHR in females (p < 0.0187).

The participants, both male and female, were divided into underweight, normal weight, overweight, and obese categories using BMI as the index. Mean WC and NC values in each category were also recorded (Table-2). Male and female subjects in these categories were as follows: Males 26.8%, 43.9%, 9.7%, and 19.5% respectively; females 31.1%, 43.1%, 12.8%, and 12.8% respectively. The overall percentages of male and female subjects that were overweight/obese was found to be 29.2% and 25.6%, respectively.

A BMI of 18.5, lower limit of normal weight, corresponded to WC of 72.50 ± 0.70 cm and 72.84 ± 6.41 cm in males and females respectively. The corresponding NC values in males and females were 34.85 ± 2.33 cm and 30.36 ± 1.26 cm respectively. It was seen that overweight defined by BMI ≥ 23 corresponded to WC values of 84.25 ± 1.76 cm in males and 80.75 ± 4.71 cm in females. NC values at this level were 35.75 ± 0.49 cm in males and 32.21 ± 0.97 cm in females. Similarly, obesity defined by BMI ≥ 25 corresponded to WC values of 92.8 ± 2.11 cm in males and 85.86 ± 4.80 cm in females. The NC values at this level were 37.53 ± 0.89 cm in males and 33.51 ± 0.99 cm in females.

## Discussion

The study suggests the potential value of measuring NC

as an indicator of overweight and obesity. The method has been around for a while, but not utilised due to lack of proper research. The study tried to find out if NC was a valid parameter for the purpose by measuring the BMI and WC and estimating the corresponding optimal NC values in young adults.

BMI and WC are indices of general and central (visceral) obesity respectively, and are an important first step in determining the level and distribution of obesity.<sup>11</sup> The cutoff values of WC for overweight and obesity vary widely over different geographic regions of the world. Furthermore, for WC, 'underweight' and 'normal weight' has not been properly defined as there has been no mention in the literature of the lower limit of normal WC. Therefore, the study used BMI instead of WC as the primary reference point.

A BMI of 18.5 corresponded to WC of 72 cm in both male and female subjects. The WC cutoff values for overweight and obesity were lower in the study as compared to those proposed by the WHO for Asian population. These values are similar to those observed by Lee et al in Korean adults.<sup>12</sup>

The results show a strong positive correlation of NC with BMI and WC in both male and female subjects. Several studies have examined the association of conventional anthropometric measures of obesity with NC.<sup>13-16</sup> Onat et al reported that NC correlated strongly with BMI, WC ( $r \geq 0.6$ ), homeostatic model-assessed insulin resistance and blood pressure. The association between obstructive sleep apnoea and NC was even greater than WC in case of males.<sup>13</sup> In another study by Yang et al, NC was found to be positively related with BMI, WC, and metabolic syndrome in Chinese subjects having type 2 diabetes mellitus.<sup>14</sup>

The cutoff points of NC for overweight and obesity in the study were respectively, 35.5 cm and 37.5 cm for men and 32 cm and 33.5 cm for women, suggesting an action level lower than most other studies (Table-3). This may be due to the fact that the study used Asian cutoff values of BMI for comparison with NC, as opposed to the higher Caucasian cutoff points. Yang et al have also reported an NC of  $\geq 39$  cm for men and  $\geq 35$  cm for women as the cutoff point that best correlates with subjects having metabolic syndrome.<sup>14</sup> Ben-Noun et al, while comparing NC with BMI, found accuracy of NC measurement to determine overweight and obesity to be 91-95 % for men and 97-98% for women.<sup>7</sup> Hatipoglu et al determined NC measurements in children 6-18 years and have found a positive correlation between BMI-WC, BMI-NC, and WC-NC ( $p < 0.001$ ).<sup>15</sup> Mazicioglu et al determined the percentiles and mean values for NC in Turkish children aged 6-18 years and found a greater NC of boys as compared to girls, both before and after puberty, that fared well with other obesity parameters.<sup>17</sup>

The study has several limitations that need to be addressed in future research. First, the sample size was small

consisting of young healthy adults from a select population and, therefore, the results cannot be generalised over the whole population. Second, the cutoff points identified for NC should more properly be called as corresponding points relative to BMI. Furthermore, the cutoff points of BMI may not correspond with the actual cutoff points of WC or NC as these are indicators of fat accumulation at separate locations.<sup>11</sup> To determine the true cutoff points, one needs to expand the study, taking larger number of subjects from a wider age group, while especially including subjects with obesity-induced health problems.

Despite the limitations, the study has important implications for prevention of overweight and obesity in young adults as it points towards the practical usage of an easier alternative for obesity measurement. NC has been shown to independently contribute to the prediction of overweight and obesity and can be used as an initial screening tool for the purpose. It is a straightforward and inexpensive test that can be performed in any office with a tape measure. An NC  $\geq 35.5$  cm in men and  $\geq 32$  cm in women should be considered the cutoff point for overweight/obesity.

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