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Neck Circumference as a Useful Marker of Obesity: A Study among the Marwari Population of Kolkata, West Bengal, India

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A B S T R A C T

Overweight and obesity are still major public health problems and an important criterion for predicting chronic diseases. Neck circumference (NC) is an important anthropometric measurement and an indicator of upper body subcutaneous adipose tissue distribution. The present study proposes NC as a useful screening measure of overweight and obesity as compared to the conventional anthropometric variables used among the Indian adults. In this cross-sectional study 144 Marwari adult population (Males-72, Females-72) were selected from Saltlake, Kolkata, India through purposive random sampling. Measurements like height, weight, Mid Upper-Arm Circumference (MUAC) and neck circumference (NC) were collected by standard procedures. The body mass index (BMI) was calculated and prevalence of overweight and obesity was assessed using standard cut-offs. The various statistical tests like t-test, Pearson's correlation and ANOVA were performed. The mean values of MUAC, BMI and NHtR were observed to be significantly higher in females than in males. The prevalence of obesity using BMI was 20.8% in males and 75.0% in females and this was found to be statistically significant. The prevalence of obesity using NC and NHtR was observed to be significantly higher in females than in males. For both males and females, a strong positive statistically significant correlation is observed between weight, MUAC, BMI, NHtR and NC. The association of anthropometric variables with age groups (ANOVA)was found to be statistically significant in females with respect to NC, NHtR and weight, MUAC and BMI. Thus, NC seems to be a simple, accessible anthropometric measurement and a good predictor of excessive adiposity. that can be used independently as a screening measure for the assessment of obesity.

Key Words: *Neck Circumference, Obesity, Overweight, Body Mass Index, Mid Upper Arm Circumference*

Introduction

Obesity is still a major problem of public health around the world. Overweight and obesity are terms used for people who weigh more than the limits recommended for their age and gender. According to WHO[1], obesity is increasing alarmingly worldwide including India. This might be due to more sedentary life style and more intake of energy rich diet, and it is associated with various chronic diseases thus posing a major public problem. The rising prevalence of overweight and obesity in India has a direct correlation with the increasing prevalence of obesity related co morbidities - hypertension, the metabolic syndrome, dyslipidaemia, type 2 diabetes mellitus (T2DM), and cardiovascular disease (CVD)[2].

Different anthropometric measurements are commonly used worldwide in order to determine obesity or central obesity. These are the body mass index (BMI), waist circumference (WC) and waist-to-hip ratio (WHR). BMI is a useful measurement of overall obesity, but not the perfect scale to assess central obesity. Therefore alternative scale indicators such as waist circumference (WC) and waist-to-hip ratio (WHR) have been introduced, but each has its limitations. The measurement of WC, which demonstrates the existence of abdominal visceral fat more accurately, may be time consuming and problematic in terms of cultural and environmental issues. Some people may not allow the measurement with light clothes due to socio-cultural reasons[3]. Overweight and obesity may be associated with fat deposition in the neck, resulting in higher neck circumference[4].

Neck circumference (NC) is a relatively new method of differentiating between normal and abnormal fat distribution. It is an important index reflecting the deposition of

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subcutaneous fat in the neck or fat surrounding the respiratory tract, and can help determine the degree of obesity, particularly upper body subcutaneous adipose tissue distribution and a reliable index of obesity.NC is the girth of the neck measured at a point just below the laryngeal prominence. It is easy to measure with excellent repeatability and minimal variance[2,5,6].

Thus, neck circumference (NC), could be potentially used as an easier and faster anthropometric measurement, to assess overweight and obesity and differentiate between the obese and the non-obese individuals. The present study is an attempt to establish the incidence of overweight and obesity using NC as a useful marker of obesity among the Marwari population of West Bengal, India.

Materials and Methods

India is a vast country with varied geographical conditions where different anthropometric measurements vary with age, sex, race and geographical locations. The present community based cross-sectional study was carried out among the adult Marwari population (males: 72; females: 72) of Saltlake, Kolkata. A total of 144 adult Marwari individuals in the age group of 18 to 65 years were apparently selected to participate in the study using a purposive random sampling method. All the participants were essentially healthy and were not suffering from any disease during the time of data collection. The individuals with any abnormality such as thyroid disorders, Cushing's disease, pregnant and lactating women were excluded from the present study.

The age of the participants was recorded from the voter identity cards or any other official documents issued by the Government. The data was recorded from the concerned household of the subjects. From each participant, an informed consent was obtained. The study was conducted during the period from March 2017 to May 2017.

All anthropometric measurements (weight, height, MUAC and NC) were recorded following the standard procedures of Hall et al[7]. Weight and height were measured using scales with an accuracy of 0.1 kg and 0.1 cm respectively, using Matrin's anthropometer and the standard weighting machine. Weight was measured with light clothing and without shoes. Height was measured with the subject standing in erect position on a flat surface and the head oriented in the Frankfort horizontal plane. The mid-upper arm circumference (MUAC) and NC was measured using a non-stretchable measuring tape to the nearest 0.1 cm. MUAC was measured on left arm, while the arm was bent at a 90^{o} angle at the midpoint of the interface between acromion processes and olecranon. Neck circumference (NC) was measured in the local situation immediately below the larynx (thyroid cartilage) and perpendicular to the longitudinal axis of the neck (so that the measuring tape in front and back of the neck was at the same height), and the minimal circumference was recorded to the nearest 0.1cm. In men with laryngeal prominence (Adam's apple), it was measured just below the prominence. While taking this reading the participants were asked to look straight ahead with their shoulders relaxed and fallen.

The prevalence of obesity (BMI>25.0 Kg/m^2) was assessed using the proposed cut-offs for Asia-Pacific populations[1]. The MUAC was assessed using the cut-offs of Tang et al[8]. The present study assessed the overweight/obesity prevalence using the derived cut-offs of NC and indices NHtR and NWtR[5] (Hu et al 2014) among the Asian adult population.

Statistical Analysis

The data obtained were computed and analyzed using Statistical Package for Social Sciences (SPSS, version 18) computer software. In both genders, the mean and standard deviation of height, weight, NC, MUAC and BMI were calculated. Independent t-test was done to assess mean difference with respect to the anthropometric variables between sexes. Chi-square analysis was performed to assess sex differences in the prevalence of excess adiposity. A p value of < 0.05 was considered to be statistically significant, while $p \geq 0.05$ was considered to statistically not significant. In each of these subgroups, the mean anthropometric indices with normal and high NC were compared. Pearson's correlation coefficient (r) were calculated between the NC and other anthropometric indicators and indices. ANOVA was performed to compare the association of anthropometric variables with age groups (three age-groups).

Results

The sex-specific descriptive statistics of the various anthropometric variables is presented in Table-1. The mean age of the males (42.18 ± 16.45) was slightly higher than in females (39.45 ± 14.09) but the difference was not statistically significant ($p>0.05$). The mean neck circumference was 37.08 ± 3.37 in males and 37.91 ± 3.06 in females (Table 1). The mean value of height was higher among males (170.56 ± 4.60) than among females (157.54 ± 4.36) ($p<0.01$). The mean values of weight, NC and NWtR were slightly higher in females than in males but not statistically significant ($p>0.05$). The mean values of MUAC, BMI and NHtR were observed to be significantly higher in females than in males ($p<0.01$).

Table 2 reveals the prevalence of obesity among the Marwari population. The prevalence of obesity with respect to BMI ($\geq$ 25 kg/m^2) was 20.83% in males and 43.75% in females, and this was found to be statistically significant ($p<0.01$). Neck Circumference (NC) (M-16.67%; F-46.52%) and NHtR (M-11.11%; F-38.88%) was significantly higher among females than males ($p<0.01$). (Table 3)

Individuals with normal and high neck circumference are presented in Table 3. Among them, 33.3% of males and 93.0% of females were in the category of high Neck Circumference. The mean age with high Neck Circumference was 42.29 in males and 39.83 in females which was relatively higher than their normal counterparts. It is ob-

TABLE 1:
ANTHROPOMETRIC CHARACTERISTICS OF THE SUBJECTS

Anthropometric Variables		Male (N=72)	Female (N=72)
		Mean ± SD	Mean ± SD
01.	Age (yrs.)	42.18±16.45	39.45 ± 14.09
02.	Height (cm.)	170.56±4.60*	157.54 ± 4.36*
03.	Weight (kg.)	73.84±10.38	74.33 ± 9.67
04.	MUAC (cm.)	30.67±2.61*	32.05 ± 2.32*
05.	NC (cm.)	37.08±3.37	37.91 ± 3.06
06.	BMI (kg/m2)	25.40 ± 3.67*	30.05 ± 4.44*
07.	NHtR	0.21 ± 0.02*	0.24 ± 0.02*
08.	NWtR	0.50 ± 0.04	0.51 ± 0.04

*p<0.01

served that the group with high Neck Circumference had higher mean BMI, MUAC, NHtR and lower mean NWtR among both males and females compared to normal Neck Circumference subjects. (Table 4)

Pearson's correlation analysis was calculated to understand the association between the various anthropometric variables and neck circumference among both males and females (Table 4). The correlation coefficient analysis showed a strong positive, statistically significant (p<0.01) correlation between weight (r=0.82), MUAC (r=0.88), BMI (r=78), NHtR (r=0.92) with NC among females. In females, age (r=0.28) was in a significant positive correlation (p<0.05) with NC and height (r=-0.32), while NWtR (r=-0.39) has a significant negative correlation (p<0.05) with NC. Among males, age (r=-0.08) and NWtR (r=-0.19) were in a negative correlation with NC which is statistically not significant (p>0.05), and Ht (r=0.06) was in a

TABLE 2
PREVALENCE OF OBESITY AMONG THE MARWARI POPULATION:

	Anthropometric Variables	Male (n-72)		Female (n-72)		Overall sex combined (n-144)	p Value
		No.	%	No.	%		
01.	BMI (BMI ≥ 25)	30	20.83	63	43.75	93 (64.6)	< 0.01
02.	MUAC (MUAC ≥ 23, Male) (MUAC ≥ 22, Female)	72	50	72	50	144 (100)	NS
03.	NC (NC ≥ 38, Male) (NC ≥ 34, Female)	24	16.66	67	46.52	91 (63.2)	< 0.01
04.	NHtR (NHtR≥ 0.23, Male) (NHtR ≥ 0.22, Female)	16	11.11	56	38.88	72 (50.0)	< 0.01
05.	NWtR (NWtR ≤ 0.49, Male) (NWtR ≤ 0.51, Female)	23	15.97	33	22.91	56 (38.9)	NS

Table 3
Baseline characteristics according to neck circumference categories.

Anthropometric variables		Neck Circumference (Male)		Neck Circumference (Female)	
		Normal (NC<38)	High (NC≥38)	Normal (NC<34)	High (NC≥34)
01	Mean Age (yrs)	41.95	42.29	34.40	39.83
02	Total No	48 (66.7)	24 (33.3)	05 (6.9)	67 (93.0)
03	Mean BMI	23.66	28.88	24.83	30.44
04	Mean MUAC (cm)	29.33	33.35	28.08	32.34
05	Mean NHtR	0.206	0.240	0.207	0.243
06	Mean NWtR	0.514	0.490	0.540	0.510

TABLE 4
PEARSON'S CORRELATION (R) BETWEEN NC AND OTHER ANTHROPOMETRIC VARIABLES BY SEX

Anthropometric Variables		NC			
		Male (n=72)		Female(n=72)	
		r	R2	r	R2
01.	Age (yrs.)	- 0.08	0.0070	0.28*	0.08
02.	Height (cm.)	0.06	0.0036	- 0.32*	0.10
03.	Weight (kg.)	0.82**	0.6645	0.85**	0.72
04.	MUAC (cm.)	0.86**	0.7335	0.90**	0.81
05.	BMI (kg/m2)	0.78**	0.6055	0.86**	0.74
06.	NHtR	0.96**	0.9145	0.96**	0.92
07.	NWtR	- 0.19	0.0384	- 0.39*	0.15

*p<0.05; **p<0.01

non-significant (p>0.05) positive correlation with NC. (Figure 1, Figure 2)

Figure 1 (males) and Figure 2 (females) show a linear relationship between Wt, MUAC, BMI, NHtR and NC, with an increasing trend with the increase in NC. (Table 5)

The age – specific mean difference of various anthropometric variables is presented in Table 5. Among males, except for age (p<0.001), all other variables were found to be statistically not significant (p>0.05) in the three age groups. In females, the age-specific mean difference was observed to be statistically significant with respect to NC, NHtR (p<0.001) and Wt, MUAC, BMI (p<0.01) and not in the case of Ht and NWtR (p>0.05).

Discussion

The measurement of neck circumference is an easy and simple way to evaluate obesity. Beside the other conventional anthropometric variables (such as BMI, WC, HC & MUAC) for the assessment of obesity, several studies have recently tried to introduce the use of neck circumference (NC) as a simple screening measure of overweight and obesity[2,5,6,9,10]. However, normal values should be defined for each country or region and with an established method of measurements[11]. Under this circumstance, in the present study cut-offs by Hu et al[5] for NC, NHtR, NWtR (based on Asian population) were used to identify the prevalence of obesity among the Marwari population of Kolkata, West Bengal, India.

TABLE 5
ASSOCIATION OF ANTHROPOMETRIC VARIABLES WITH AGE GROUPS (RESULTS OF ANOVA)

Anthropometric Variables		(18 – 34) years	(34 – 50) years	(50 – 66) years	Overall Mean	Range	F-value
MALE							
1.	Age (yrs.)	23.75 ± 2.79	46.31± 3.64	59.51± 4.66	42.18± 16.45	19-65	639.534*
2.	Height (cm.)	171.38 ± 4.08	168.93 ± 4.73	170.65 ± 4.95	170.56 ± 4.60	159.5 - 180.5	1.4843
3.	Weight (kg.)	75.55 ± 12.01	72.71 ± 9.84	72.68 ± 8.81	73.84 ± 10.38	55.2 - 102.5	0.6496
4.	MUAC cm.)	31.26 ± 2.94	30.58 ± 2.24	30.10 ± 2.38	30.67 ± 2.61	24.6 - 36.7	1.4279
5.	NC (cm.)	37.47 ± 3.98	37.26 ± 3.55	36.55 ± 2.50	37.08 ± 3.37	33.1 - 46.1	0.5366
6.	BMI(kg/m2)	25.77 ± 4.44	25.45 ± 3.06	24.98 ± 3.12	25.40 ± 3.67	19.65 - 38.67	0.3145
7.	NHtR	0.21 ± 0.02	0.22 ± 0.02	0.21 ± 0.01	0.21 ± 0.02	0.184 - 0.283	0.5611
8.	NWtR	0.50 ± 0.03	0.51 ± 0.06	0.50 ± 0.04	0.50 ± 0.04	0.437 - 0.715	0.7829
FEMALE							
1.	Age (yrs.)	23.25 ± 3.30	45.79 ± 3.22	57.46 ± 3.13	39.45 ± 14.09	19-64	638.007*
2.	Height (cm.)	158.42 ± 3.57	156.20 ± 4.02	158.48 ± 5.79	157.54 ± 4.36	148.6 - 168.6	2.3742
3.	Weight (kg.)	71.13 ± 8.81	78.48 ± 8.80	72.29 ± 10.48	74.33 ± 9.67	48.6 - 99.7	5.0417**
4.	MUAC (cm.)	31.14 ± 2.13	33.10 ± 2.04	31.70 ± 2.49	32.05 ± 2.32	26.8 - 36.2	5.9771**
5.	NC (cm.)	35.21 ± 1.65	38.61 ± 1.87	41.60 ± 2.25	37.91 ± 3.06	32.2 - 46.4	59.814*
6.	BMI(kg/m2)	28.37 ± 3.63	32.22 ± 3.88	28.97 ± 5.29	30.05 ± 4.44	19.74 - 41.12	6.8920**
7.	NHtR	0.23 ± 0.01	0.25 ± 0.02	0.23 ± 0.02	0.24 ± 0.02	0.203 - 0.289	9.3105*
8.	NWtR	0.51 ± 0.05	0.50 ± 0.03	0.52 ± 0.03	0.51 ± 0.04	0.422 - 0.681	0.9995

*p<0.001, **p<0.01

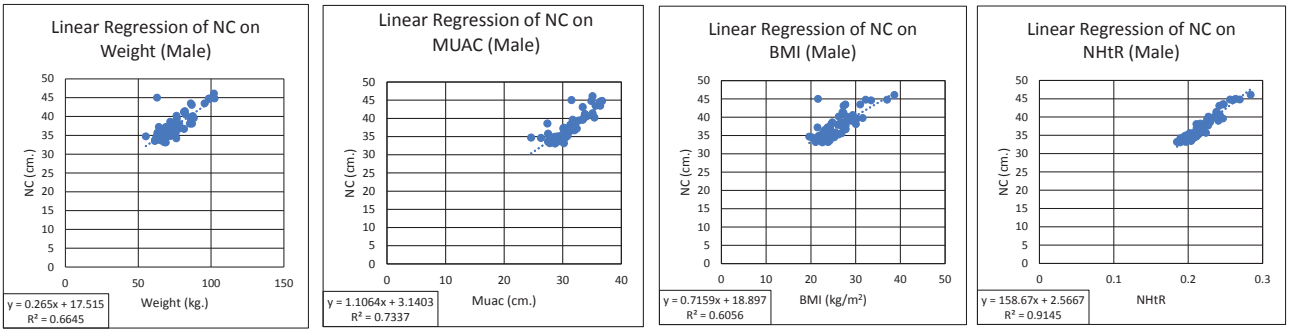

Fig. 1. Association of NC with anthropometric variables (Males).

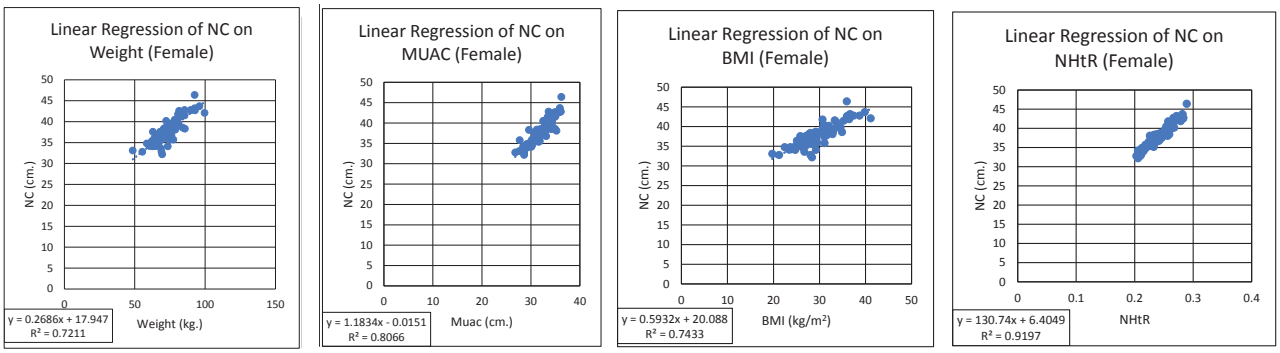

Fig. 2. Association of NC with anthropometric variables (Females).

The present study showed that individuals (both male and female) with high neck circumference had higher BMI, MUAC and NHtR compared to subjects with normal neck circumference. This is in alignment with several other studies worldwide[4,5,12]. NC plays a potential role as an adiposity marker for the determination of the prevalence of excess obesity compared to other conventional anthropometric variables (BMI, MUAC)[2,9,13,14,15].

The present study reveals the high prevalence of overall and regional adiposity using the conventional anthropometric variables (such as BMI & MUAC) and also NC, NHtR, NWtR. A significant sex difference is also observed. The females of the present study exhibit more body adiposity than their male counterparts. This is in congruence with other studies from India[10,16-19] which also reported greater proportion of overall and regional adiposity among females.

The analysis showed an existence of strong associations between NC and other conventional anthropometric variables for obesity. Positive associations of NC with weight, BMI, MUAC and NHtR in both sexes ($p<0.01$) were found. Several researchers already reported similar associations of NC with BMI, WC, HC and WHR [2,6,9-11,14,20,21].

In females, but not in males, the age-specific mean difference (ANOVA) was found to be statistically significant with respect to weight, MUAC, BMI ($p<0.01$) and NC and NHtR ($p<0.001$). Thus, females tend to become obese with age. There may be certain specific contributing factors in females which are not manifested in males, but they remain unclear. No significant age-specific mean difference is observed among males. This finding is in contrast with the study of Kowalkowska et al[22] who reported that higher general adiposity in men than in women, and in older age groups.

There is an important ethnic influence in the prevalence of overweight and obesity[11]. Different populations may have different genetic, social, geographic characteristics, as well as different levels of food availability, physical activities and other factors relevant to the development of obesity. It is not easy to arrive at conclusions that would be the same for all populations. However, the neck circumference measurement seems to be a good indicator of obesity for all of them.

Studies have recommended the use of NC due to its good predictive nature in excess adiposity [6,10,23]. The present study also affirms the relative use and predictability of NC as an easy screening measure of excess adiposity pattern.

Several studies reported different population-specific cut-offs to assess the prevalence of excess adiposity using NC [6,10,13]. The present study assessed the overweight/obesity prevalence using the derived cut-offs of NC and indices among the Asian population[5].

Conclusions

Overweight and obesity are a major public health problem among the Indian populations, including the Marwari population of Kolkata. Neck circumference is found to be a useful marker of obesity. It is a simpler and more practical anthropometric parameter that does not depend on clothing or last meal. The results of this study show that individuals (both males and females) with high neck circumference had higher BMI, MUAC and NHtR compared to subjects with normal neck circumference. The females of the present study exhibited greater proportion of overall and regional adiposity, which is in congruence with various other studies. Moreover, in females the age specific mean difference (ANOVA) was found to be statistically significant with respect to weight, BMI, MUAC, NC and NHtR. The present study showed the existence of strong associations between neck circumference and other conventional anthropometric variables for obesity, such as weight, BMI, MUAC and NHtR. Hence, it is apparent from the study that neck circumference can be used independently as a screening measure for the assessment of excess adiposity. It seems to be a simple, assessable anthropometric measurement and a good predictor of excess adiposity. The present study instigates the use of NC as a screening tool and further research that would derive population specific NC cut-off values of different ethnic groups.

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Authors' contributions

SC carried out the data acquisition, dataset tabulation, statistical analysis and drafted the manuscript. MG conceived and designed the study, analyzed the data and helped to draft the manuscript. The authors declare that there is no conflict of interest regarding the publication of the paper.

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OPSEG VRATA KAO POKAZATELJ PRETILOSTI: ISTRAŽIVANJE U POPULACIJI MARWARI, KOLKATA, ZAPADNI BENGAL, INDIJA

S A Ž E T A K

Prekomjerna težina i pretilost predstavljaju ozbiljan zdravstveni problem i važan su kriterij za predikciju kroničnih bolesti. Opseg vrata (NC) je važna antropometrijska mjera i indikator distribucije potkožnog masnog tkiva u gornjem dijelu tijela. U radu se predlaže opseg vrata kao koristan pokazatelj prekomjerne težine i pretilosti u usporedbi s drugim konvencionalnim antropometrijskim mjerama koje se koriste u odraslim populacijama Indije. Istraživanje je obuhvatilo 144 ispitanika (72 M i 72 Ž) iz populacije Marwari, koji žive u Kolakati u Indiji. Standardnim postupkom ispitanicima su izmjereni visina, težina, opseg nadlaktice (MUAC) i opseg vrata (NC). Izvršena je procjena učestalosti prekomjerne težine i pretilosti na temelju standardnih referentnih vrijednosti indeksa tjelesne mase (BMI). Provedene statističke analize su pokazale da su srednje vrijednosti MUAC, BMI i NHtR (omjer vratnog opsega i visine) statistički značajno više u žena, kao i prevalencija pretilosti procijenjena na temelju indeksa tjelesne mase. Prevalencija pretilosti procijenjena na temelju NC i NHtR također je bila statistički značajno viša u žena u odnosu na muškarce. U oba spola utvrđena je statistički značajna pozitivna korelacija između težine, MUAC, BMI, NHtR i NC, a u žena je utvrđena i značajna korelacija između dobi i NC, NHtR, težine, MUAC i BMI. Ovi podaci pokazuju da je opseg vrata jednostavna, pristupačna mjera za predikciju prekomjernog masnog tkiva i procjenu pretilosti.