Neck circumference as a predictor of obesity and overweight in rural central India

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ABSTRACT

Background: Neck circumference is a simple screening measure for identifying overweight and obese patients. The present study is planned to determine if NC is a valid measure of obesity in rural Indian population. **Aims:** To determine whether a single measure of NC might be used to identify overweight patients and to define NC cutoff levels for overweight and obesity according to existing BMI cutoff levels. **Settings and Design:** A prospective cross-sectional study from rural medical college at Wardha in central India. **Materials and Methods:** Main indicators included NC, weight, and height and body mass index according to WHO guidelines. **Statistical Analysis:** Chi squire test (dichotomous) and t test (continuous) had been done while making these comparisons using statistical software STATA 10.0. **Results:**Pearson's correlation coefficients indicated a significant association between changes in NC and changes in body mass index. In men, BMI correlated positively with NC (Corr.coeff = 0.59, $p < 0.01$) and weight (Corr.coeff = 0.60, $p < 0.01$). In women also, BMI correlated positively with NC (Corr.coeff = 0.74, $p < 0.01$) and weight (Corr.coeff = 0.82, $p < 0.01$). ROC analysis showed that the area under the curve (AUC) for NC and BMI >25 kg/m^2 was 0.89 for men, 0.91 for women, respectively. NC ≥ 38 cm for men and ≥ 34.7 cm for women were the best cut-off points for determining subjects with overweight. **Conclusion:** NC measurement is a simple and time-saving screening measure that can be used to identify overweight and obese patients. Patients with NC >36.6 cm for men and >32.1 cm for women require additional evaluation of overweight or obesity status.

Key-words: Neck circumference; Anthropometry; Risk factors; obesity; overweight

INTRODUCTION

Body mass Index (BMI) is a traditional measure of obesity, and individuals with values between 25 and 29.9 kg/m^2 are considered as being overweight while those with values of 30 kg/m^2 or higher as obese. According to WHO, alarming increases in obesity are being observed in Asian countries, including India.[1] Obesity is not just limited to urban and affluent society but also affects the rural places and persons belonging to the lower socio-economic strata. US preventive service task force recommends that all adults must be screened for obesity to prevent morbidity and mortality. And screening must be simple, least cumbersome, noninvasive and easily feasible like measurement of neck circumference.

Different body morphologies or types of fat distribution are related to the health risks associated with obesity. This was first shown by Jean Vague who himself used a neck skin fold in his index of masculine differentiation to assess upper-body fat distribution.[2] Neck circumference (NC), a measure of upper body obesity has been proposed as a useful indicator in different studies in the past.[3,4,5,6] These studies have shown that men with NC < 37 cm and women with NC < 34 cm have a low body mass index.[3]

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The present study is planned to determine if NC is a valid measure of obesity in our population, because NC measurement potentially has distinct cultural advantages. Due to cultural inhibitions measurement of hip, thigh or waist circumference is cumbersome in females. The specific research questions for this study are that among in-patients in medical wards, aged 35 years or more a) does a higher neck circumference also reflects a higher BMI or waist circumference; b) do those who are in highest tertile of neck circumference, as compared to those with in lowest tertile, have a higher prevalence of cardiovascular risk factors like hypertension and diabetes.

MATERIAL AND METHODS

This prospective crosssectional study was carried out in patients admitted in medicine ward in rural teaching hospital at Wardha in central India between the randomly chosen months of June and July 2009 after obtaining the approval of the institutional ethics committee. All consecutive patients admitted in medicine wards of more than 35 years of age with no known major medical condition, were included in the study. The study size of 300 patients was randomly assigned based on the number of indoor patients admitted during the stipulated two month study period. This sample size was finally found to be adequate as the statistical significance was achieved at the end of the study period.[7] Patients with known history of unintentional weight loss due to malignancy manifest cardiovascular disease, chronic infection, or a neck swelling (example goiter) or non-ambulatory patients in whom height and circumference cannot be taken was excluded. A written informed consent was taken from all participants.

All anthropometric measurements (weight, height, and neck circumference) were performed according to WHO guide lines.[8] Weight were measured in to the nearest 100 grams using calibrated spring balance without heavy clothing and bare footed with a same standardized weighing machine for all patients. Height was measured to the nearest centimeter, barefooted using a stadiometer. NC was measured to the nearest 0.1 centimeter just below the laryngeal prominence (Adam's apple) in both sexes. All circumferences were taken with the subjects standing upright, with shoulders relaxed using flexible measuring tapes. Blood pressure was recorded in the sitting position after 5 minutes of rest using standard mercury manometer. Additional questions were asked and hospital charts were reviewed to determine if the participants had history of hypertension and diabetes mellitus or dyslipidemia.

Hypertension were diagnosed when systolic BP >140 mmHg and/or diastolic BP >90 mmHg or a known hypertensive patient. BMI (weight in Kg)/ (height in meters)^2 was calculated and overweight and obesity were considered when BMI between 25–29.9 kg/m^2 and more than 30 kg/m^2 respectively. Diabetes were labeled when history of diagnosis is present or fasting blood glucose ≥126 mg/dl and post parandial more than 200 mg%. Waist size more than 102 cm in men and >88 cm in women according to the third report of National Cholesterol Education Program (ATP-3) were considered abnormal.[9]

Statistical Analysis

All enrolled patients admitted in medicine wards were analyzed with waist circumference, BMI, as continuous variable and presence of hypertension, diabetes, age, sex as dichotomous variables. NC (continuous variable) was the key outcome in our study. Meaningful cut offs of BMI (25–30 as overweight) and more than 30 as obesity in our analysis had been used as derived variables. We had plotted NC against BMI, waist, age and determine correlation between them. Estimate of the prevalence of risk factors in lowest tertile of NC vs highest tertile of NC had been calculated. Chi squire test (dichotomous) and t test (continuous) had been done while making these comparisons. We had done linear regression with NC as a predictor variable and age, BMI, sex, waist circumference as explanatory variables. Formula used was NC = m1age +m2BMI+M3waist circumference+m4 hyperension+m5 diabetes+….C. All statistical analysis was done by using statistical software STATA 10.0.

RESULTS

A total of 203 pateints were enrolled, among them 120 were male and 83 were female. Mean age were almost similar in both sex 53.3 yrs (SD 12.7) for men and 52.93 yrs (SD12.3) for women. Men were heavier and taller than women. BMI were similar in both the groups. Mean neck circumference in men was 35.5 cm (SD 4.85) and in women was 31.29 cm (SD 3.37) Table 1.

On comparison between BMI and NC it was found that 31 men had NC of > 36.6 cm with BMI of 25 kg/m^2 and only 2 men had this circumference with BMI of more than 30 kg/m^2. In women group 16 had NC of more than 32.1 cm with BMI of 25 kg/m^2 and 4 had BMI of >30 kg/m^2 with same neck circumference (Table 2a & 2b). In men, BMI correlated positively with NC (Corr.coeff = 0.59,

Table 1: Characteristics of subjects

	Men(n=120)		Women(n=83)	
Variables	**Mean**	**S.D**	**Mean**	**S.D**
Age(yr)	53.3	12.7	52.93	12.3
Weight(kg)	52.6	12.7	46	13.2
Height(cm)	163.3	6.3	150.8	6.1
NC(cm)	1.01	0.81	1.00	0.81
BMI(kg/m^2)	19.62	4.172	19.8	5.72

Table 2a: Comparison of BMI and NC in Men

BMI(kg/m^2)	Men (120)	NC < 33.4	NC=33.4-36.6	NC > 36.6
25	109	39	39	31
25–30	9	0	1	8
>30	2	0	0	2
Total	120	39	40	41

Table 2b: Comparison of BMI and NC in Women

BMI(kg/m^2)	Women(82)	NC < 29.1	NC=29.1-32.1	NC > 32.1
25	69	27	26	16
25-30	9	0	2	7
>30	4	0	0	4
Total	82	27	28	27

Table 3: Relationship between NC and various variables. Pearson's correlation coefficients

	Men (NC cm)		Women (NC cm)	
Variables	**Corr.coeff**	**P value**	**Corr.coeff**	**P value**
Age(yr)	0.01	p=0.91	−0.08	P=0.46
Weight(kg)	0.60	p<0.01	0.82	P<0.01
Height(cm)	0.23	p=0.01	0.02	P=0.80
BMI(kg/m^2)	0.59	p<0.01	0.74	p<0.01

$p < 0.01$), weight (Corr.coeff = 0.60, $p < 0.01$), height (Corr. coeff = 0.23, p =0.01). In women also, BMI correlated positively with NC (Corr.coeff = 0.74, $p < 0.01$), weight (Corr.coeff = 0.82, $p < 0.01$), height (Corr.coeff = 0.02, p =0.80). (Table 3). ROC analysis showed that the area under the curve (AUC) for NC and BMI >25 kg/m^2 was 0.89 for men, 0.91 for women, respectively. NC ≥ 38 cm for men and ≥ 34.7 cm for women were the best cut-off points for determining subjects with overweight,(Table 4).

Table 4: NC(cm) cutoff levels for determining the subjects with BMI>25 kg/m^2 using ROC analysis: in both Men and Women

	Men	Women
NC cut off	38	34.7
Sh	81.8	76.9
Sp	84.4	94.2
LR+	5.24	13.46
LR−	0.21	0.24
Area Under the Curve	0.89	0.91

Table 5: Percentage of hypertension and diabetes in both sex

	Hypertension		Diabetes	
Sex	**Present**	**Absent**	**Present**	**Absent**
Men	28(23.33)	92(76.67)	28(23.33)	92(76.67)
Women	24(28.92)	59(71.08)	10(12.05)	73(87.95)
Total	52(25.62)	151(74.38)	38(18.72)	165(81.28)

Numbers in parenthesis denote percentages

Among cardiovascular risk factor we had taken only hypertension and diabetes as lipid profile was not feasible in every patients. Hypertension were present in 28 men (23.33%) and 24 women (28.92%). Diabetes were present in 28 men (23.33%) and 10 women (12.05%),(table 5). 12 men (46.15%) with NC of more than 38 cm had hypertension, p =0.02 and 7 women (50%) with NC of more than 34.7cm had hypertension, p=0.05. 9 men (34.62%) with NC of more than 38 cm had diabetes, p =0.12 and 3 women (21.43%) with NC of more than 34.7cm had diabetes, p =0.23 (table 6).

DISCUSSION

We hypothesized that NC (primary outcome measure) could be a predictor of obesity and overweight in rural Indian population and that higher tertile of neck circumference may be associated with higher prevalence of cardiovascular risk factors like hypertension and diabetes (secondary outcome measure). Our hypothesis was confirmed by this study. After adjustment for age, weight and height, significant association was found

Table 6: Association of neck circumference with hypertension and diabetes in both sex.

	Men			Women		
	NC>=38	**NC<38**	**P Value**	**NC>=34.7**	**NC<34.7**	**P Value**
Total=203	26	94	14	69		
Hypertension	12(46.15)	16(17.02)	0.022	7(50)	17(24.64)	0.056
Diabetes	9(34.62)	19(20.21)	0.124	3(21.43)	7(10.14)	0.237

between NC and conventional overweight and obesity indexes. We also found that higher tertile of NC correlated positively with the presence of cardiovascular risk factors like hypertension and diabetes.

BMI is age and sex dependent when used as an indicator of body fat deposition, although it is ethnicity independent in black and white adults.[10] It is usually used to assess overweight and obesity and to monitor changes in body weight. Although obesity results in metabolic abnormalities, upper body obesity is more strongly associated with glucose intolerance, hyperinsulinemia, diabetes, hypertriglyceridemia, gout and uric calculus disease than lower body obesity.[11,12] Therefore, in this study overweight- and obesity-related variables were compared primarily with BMI values. NC is also related to cardiovascular risk factors in severely obese men and women.[13,14]

In a first cross sectional study by Ben – noun *et al*.[3] in 2001 which was done to identify overweight or obese patients solely by measuring the circumference of the neck, it was seen that Men with NC >37 cm and women with NC >34 cm are not to be considered overweight. In this study they used a test sample and a second validation sample included 979 subjects (460 men and 519 women), who visited a family medicine clinic in a southern Israeli urban district for any reason. They observed that NC >37 cm for men and >34 cm for women were the best cutoff levels for determining the subjects with BMI >25.0 kg/m^2 using the receiver output curve analysis. In the validation unrelated group, the test characteristics were excellent with 98% sensitivity, 89% specificity, and 94% accuracy for men, and 100% sensitivity, 98% specificity, and 99% accuracy for women. In this study we also observed same characteristics as NC 38 cm for men and 34.7 cm for women identified subjects with BMI >25.0 kg/m^2 with 75% to 86% sensitivity for men and 63% to 93% for women, 80% to 90% specificity for men and 80% to 100% for women.

Ben Noun *et al*.[6] once again in 2004 observed relationship between changes in neck circumference and changes in blood pressure. In this longitudinal cohort study the study group was comprised of 364 subjects (155 men and 209 women) with no known major medical conditions who were not receiving any medication therapy. They found that Changes in systolic BP and diastolic BP correlated positively with changes in NC and other components of the metabolic syndrome.

It seems, therefore, that with an increase in NC, the likelihood of risk factors for cardiovascular disease also increases. A significant negative correlation was found between NC and height among women, but not in men. This finding can be explained by differences in bodily structures between men and women especially in rural area of India.

These observations indicate that NC as an index of upper body fat distribution can be used to identify overweight and obese patients. Results of these studies, performed by various set of investigators, have not been externally validated. In India study about neck circumference as a measure of obesity and overweight has not been done. NC measurement potentially has distinct cultural advantages. Due to cultural inhibitions measurement of hip, thigh or waist circumference is cumbersome in females. In contrast measurement of NC is a simple, time saving, and least invasive measurement tool.

Strengths and limitations

This study adds to the current literature by showing that neck circumference is a correlate of obesity and overweight. One of the limitations of our study is that our results may not be generalizable to other racial or ethnic groups because this observational study has been done in rural low socioeconomic group. Since our study was a hospital based study, results may overestimate the true correlation between NC and obesity. A final limitation is that neck circumference is a proxy for upper-body fat; we did not have radiographic measures to directly quantify this fat deposition.

Implications for further research

Upper-body fat deposition as in neck circumference is less cumbersome, easily measured fat depot, which may be an important predictor of obesity and overweight ultimately leading to preventable risk like diabetes, hypertension and metabolic syndrome. This fat depot may lead to a better understanding of the differential effects of adiposity in men and women. However further studies are needed to examine the relationship between neck circumference and obesity in community setting as this study has been done in rural low socioeconomic group (hospital based).

CONCLUSION

NC may be used as a simple and time-saving screening measure to identify overweight and obese patients. Men with NC <36.6 cm and women with NC <32.1 cm are not to be considered overweight. Patients with NC >36.6 cm for men and >32.1 cm for women require additional evaluation of overweight or obesity status.

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REFERENCES

1. Misra A, Misra R, Wijesuriya M, Banerjee D. The metabolic syndrome in South Asians: continuing escalation & possible solutions. *Indian J Med Res* 2007; **125**: 345–54.
2. Vague J. The degree of masculine differentiation of obesities: a factor determining predisposition to diabetes, atherosclerosis, gout, and uric calculous disease. *Am J Clin Nutr* 1956; **4**: 20–34.
3. Ben-Noun L, Sohar E, Laor A. Neck circumference as a simple screening measure for identifying overweight and obese patients. *Obes Res* 2001; **9**: 470–7.
4. Ben-Noun LL, Laor A. Relationship between changes in neck circumference and cardiovascular risk factors. *Exp Clin Cardiol* 2006; **11**: 14–20.
5. Ben-Noun L, Laor A. Relationship of neck circumference to cardiovascular risk factors. *Obes Res* 2003; **11**: 226–31.
6. Ben-Noun LL, Laor A. Relationship between changes in neck circumference and changes in blood pressure. *Am J Hypertens* 2004; **17**: 409–14.
7. Schlz KF, Grimes DA. Sample size calculation in randomized trials: mandatory and mystical. *Lancet* 2005; **365**: 1348–1353.
8. Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. *World Health Organ Tech Rep Ser* 1995; **854**: 1–452.
9. National Cholesterol Education Program Expert Panel on Detection E, Treatment of High Blood Cholesterol in A. Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) final report. *Circulation* 2002; **106**: 3143–421.
10. Gallagher D, Visser M, Sepulveda D, Pierson R, Harris T, Heymsfield SB. How useful is body mass index for comparison of body fatness across age, sex, and ethnic groups? *Am J Epidemiol*. 1996; **143**: 228–39.
11. Kissebah AH, Vydelingum N, Murray R, *et al*. Relation of body fat distribution to metabolic complications of obesity. *J Clin Endocrinol Metab* 1982; **54**: 254–60.
12. Peiris AN, Struve MF, Mueller RA, Lee MB, Kissebah AH. Glucose metabolism in obesity: influence of body fat distribution. *J Clin Endocrinol Metab*. 1988; **67**: 760–7.
13. Onat A, Hergenc G, Yuksel H, *et al*. Neck circumference as a measure of central obesity: associations with metabolic syndrome and obstructive sleep apnea syndrome beyond waist circumference. *Clin Nutr* 2009; **28**: 46–51.
14. Rosner Preis Sarah, Massaro Joseph M, Hoffmann Udo, D'Agostino Ralph B Sr, Levy Daniel, Sander J, Robins, *et al*. Neck Circumference as a Novel Measure of Cardiometabolic Risk: The Framingham Heart Study. *J Clin Endocrinol Metab*, 2010; **95**(8): 3701–10.