Original Article

Relationship of neck circumference with metabolic syndrome

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Metabolic syndrome is a major health problem and there is need for awareness programs and lifestyle interventions for the prevention and control of metabolic syndrome. To study the relationship of neck circumference to metabolic syndrome. A total of 367 individuals above 18 years were evaluated. The mean age of the patients was 52 (±13.03) years. The study included around 58% subjects with established cardiovascular disease. Metabolic syndrome was seen in 73.3% of them. Our study shows that females with neck circumference (NC) ≥34cms, 75.4% had metabolic syndrome and male with NC ≥37cms, 54.6% had metabolic syndrome. In our study, NC moderately correlated with common indices of obesity such as body mass index, waist circumference, waist/hip ratio.

Our observations indicate that NC as an index of upper body fat distribution. Measurement of NC is a simple, time saving and least invasive measurement tool and can be used as a measure to identify metabolic syndrome risk factors in patients.

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Key words **: Metabolic syndrome, neck circumference, waist circumference.**

The metabolic syndrome (MetS) consists of a constellation of metabolic abnormalities that confer increased risk of cardiovascular disease (CVD) and diabetes mellitus (DM). The metabolic syndrome includes central obesity, hypertriglyceridemia, low level of high density lipoprotein cholesterol (HDL), hyperglycemia and hypertension[1]. The National Cholesterol Education Program's Adult Treatment Panel III report (ATP III)[1] and International Diabetes Federation criteria uses waist circumference as the anthropometric parameter to diagnose MetS[2].

In India the prevalence of MetS has ranged from 11% to 41% depending on the region and rural or urban population and criteria used[3-6]. As a large number of people are affected the condition there is a need for a practical and reliable approach to diagnose the problem.

Neck circumference is a more practical and likely better measure than waist circumference, which may be especially useful in special populations such as morbidly obese people, patients in bed rest, and pregnant women. It is a simple, convenient but less used anthropometric measure, which is correlated with waist circumference and BMI[7], and has been associated with components of metabolic syndrome[8-13]. Neck circumference may be better in situations where waist circumference is not interpretable as a measure of central adiposity because of diurnal variation, clothing, last meal, empty bladder, pregnancy, and various health conditions. All these conditions are unlikely to impact neck circumference[7].

Reports of relationship of neck circumference to MetS have been published from western countries. There are very studies on this relationship from the country[13-15]. Therefore this study was undertaken to determine the reliability of easily measurable neck circumference in comparison to waist circumference as a measure of MetS.

Aims and Objectives

- To study the relationship of neck circumference to metabolic syndrome
- To determine the reliability of neck circumference in comparison to waist circumference as a measure of metabolic syndrome (MetS) criteria

Materials and Methods

It is a cross sectional study, carried out in patient who are attending Medicine OPD or admitted in Medicine ward in a teaching hospital. The study was carried out for a period of two years from September, 2015 to August, 2017. This study was approved by the Research Ethics Board of the Institutue and informed consent was taken from the participants.

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Inclusion criteria :

Individual above 18 years with or without treatment for hypertension, diabetes mellitus and dyslipidemia were taken for the study.

Exclusion criteria :

Those with known history of unintentional weight loss due to malignancies, type 1 diabetes mellitus, chronic illness like chronic liver disease, chronic kidney disease, congestive heart failure, tuberculosis, HIV wasting syndrome, any individual with history of endocrine disorder and/or previous treatment with hormones or steroids were excluded. Pregnant and lactating mothers were also excluded.

Sample size :

A total 367 individual were taken, by taking the prevalence of MetS in Manipur was 20.5%[5] with absolute allowable error of 5%. The criteria for the metabolic syndrome according to International Diabetes Federation (IDF) was used for the study[2].

Plasma glucose was estimated using glucose oxidase method using GLUC-PAP manufactured by Randox Laboratories Limited, 55 Diamond Road, Crumlin, County Antrim, BT29 4QY, United Kingdom. Lipid profile was estimated by enzymatic method using Vitros chemistry, Ortholand Diagnostics Inc, Rochester, NY, USA.

Observations

The study included total of 367 patients. Males accounted for 199 (54.2%) and females accounted for 168 (45.8%) of the cases. The mean age of the patients was 52 (±13.03) years. Two-hundred and twelve (57.8%) subjects belonged to age group below 60 years and 155(42.2%) patients were above 60 years.

At study entry diabetes was already diagnosed in 122 (33.2%) of the study population, significantly higher in females (44% *versus* 24.1%; p<0.001). Hypertension was seen in 223 (60.8%) which was significantly higher among females (68.5% *versus* 54.3%; p=0.006). Dyslipidemia was seen in 6 (1.6%) of the patients, but no gender difference was seen (1.8% *versus* 1.5%). The most common clinical diagnosis was cerebrovascular accident (CVA) which was present in 42.8% of the patients followed by acute coronary syndromes (ACS) in 14.9% of the patients.

Systolic BP above 140mmHg was seen in 44.7% (164) of the patients and found to be significantly in females (51.2% *versus* 39.2%; p=0.007). Diastolic BP above 100mmHg was found in 9% (33) of the patients. BP>130/85mmHg as required for metabolic syndrome diagnosis in our study was present in 243 (66.2%) of the patients.

Waist circumference for diagnosis of MetS according IDF criteria was met by 58.9% of the patients. Among males 64 (32.2%) met the IDF cut-off of ≥90cm in waist circumference. Whereas, among females 152 (90.5%) met the IDF cut-off of ≥80cm. For waist/hip ratio 75.5% of the patients had waist/hip circumference ratio cut off ≥0.90 for male; ≥0.85 for female and the difference between males and females was found to be significant p<0.001 (57.8% *versus* 96.4%). Out of 367, 352 (95%) of the patients had a neck circumference (NC) between 30-40cm. BMI of 46.6% of patients were below 25kg/m^2 and 53.4% of the patients had BMI above 25kg/m^2. There was no significant difference in BMI between sexes.

Fasting BG criteria for MetS (≥100 mg%) was met by 54.1% and 35.1% of them had FBG ≥126mg/dl, diagnosed as DM according to ADA criteria. Serum triglyceride cut-off of ≥150mg% was met by 43.9% of patients whereas HDL cut off value below 40 for males and below 50 for females was found in 73.8% of patients. Mean cholesterol value was 161.79±49.86mg/dl, triglycerides was 145.17±70.31mg/dl, HDL was 37.47±9.57mg/dl, LDL of 107.44±35.52mg/dl. In patients of metabolic syndrome, average FBG was 145.15±75.75mg/dl, average triglyceride was 161.90±72.62 mg/dl, HDL was 35.90±8.73 mg/dl, LDL 113.61±37.02mg/dl. Correlation of MetS with all these four parameters were statistically highly significant, p-value <0.001, except for cholesterol levels.

Among 367 patients, 269 patients had MetS according to IDF criteria for MetS. Metabolic syndrome was present in 71.9% of male and 75% of females. Metabolic syndrome was present in 83.6% of T2DM patients, 63.5% of hypertensive patients. Among females with NC <34cms, 24.6% had MetS, whereas among females with NC ≥34cms, 75.4% had MetS. Among males with NC<37cms, 45.4% had MetS, whereas among NC≥37cms, 54.6% had MetS. This correlation was highly significant p<0.001.

ROC curve analysis of NC with metabolic syndrome, showed area under the curve was 74.5%. The cut off for NC was >35.5cms, sensitivity of 62.8% and specificity of 77.6% as shown in figure. ROC curve analysis of waist circumference with MetS, showed area under curve was 71.8%. The cut off for waist circumference was >89cms, sensitivity of 95% and specificity of 57.1%. ROC curve analysis of hip circumference with MetS, showed area under the curve was 61.4%. The cut off for hip circumference was >98cms, sensitivity of 46.5% and specificity of 73.5% ROC curve analysis of waist/hip circumference ratio with MetS, with area under curve being 61.4%. The cut off for waist/hip ratio was >0.89cms, sensitivity of 75.5% and specificity of 57.1%

Discussion

In the present study MetS was seen in 73.3% of the subjects studied. This very high prevalence is most likely due to inclusion of a large number of stroke cases in the study. In this study, we looked into the association between neck circumference and MetS. We found that NC had

positive correlation with systolic and diastolic BP. NC also positively correlated with BMI.

Recent studies have shown that central adiposity rather than total body fat is a more serious clinical entity. Unfortunately, BMI is a poor descriptor of central adiposity[17]. In our study, NC strongly correlated with common indices of obesity such as BMI, WC, W/H ratio indicating that NC could be a useful screening tool for high BMI in adults. Relationships between obesity and health risks vary between populations. Asians are more susceptible so have lower BMI threshold than other populations, with an action for overweight defined at 23kg/m^2.[17]

Table 1 — *Comparison of clinical variables in relation to metabolic syndrome*

Variables	Metabolic syndrome			
	No (n=269)	Yes (n=98)	Total	P value
Age in years	58.64±14.74	58.82±14.07	58.77±14.23	0.915
Neck circumference	34.12±2.34	36.12±2.34	35.59±2.50	0.001**
SBP (mmHg)	139.61±19.47	142.16±22.32	141.48±21.60	0.319
DBP (mmHg)	85.10±14.63	87.38±13.62	86.77±13.91	0.165
Height (cm)	160.35±6.91	161.01±7.29	160.83±7.19	0.434
Weight (kg)	65.14±10.50	66.88±11.55	66.41±11.29	0.193
Waist circumference	82.48±10.88	90.82±11.31	88.59±11.78	<0.001**
Hip circumference	94.55±10.60	98.97±11.36	97.79±11.32	0.001**
Waist hip ratio	0.87±0.05	0.92±0.05	0.91±0.05	<0.001**
BMI (kg/m^2)	25.31±3.52	25.81±4.19	25.68±4.02	0.297

Comparison done using Student 't' test. ** - highly significant
SBP- Systolic blood pressure; DBP- Diastolic blood pressure; BMI- Body mass index

In our study, MetS was present in 71.9% of male and 75% females. This was almost similar to the Indian study by Nagendran *et al*[14]. The higher prevalence of MetS in the present study compared to previous study from our population is probably due to inclusion of a large proportion of patients with CVA and ACS in the present study which is in contrast to inclusion of apparently healthy nurses in the previous study.

Among females with NC<34cms, 24.6% had MetS, whereas among females with NC≥34cms, 75.4% had MetS. Among males with NC<37cms, 45.4% had MetS, whereas among NC≥37cms, 54.6% had MetS. The difference in free fatty acid storage between men and women may account for the stronger association we found between neck circumference and MetS risk factors among women.

All individual parameters of MetS risk factor ie, BMI, WC, W/H ratio, SBP, DBP, FBS, HDL and TG except hip circumference, total cholesterol were highly significant in patient with abnormal NC when compared with those with normal. For all risk factors, women exhibited a larger effect size in risk factor levels per SD increment in NC than men. This finding can be explained by differences in structures between men and women especially in India. It seems, therefore, that with increase in NC, the likelihood of risk factors for metabolic diseases also increases.

Correlation of MetS with NC, waist circumference and waist-hip ratio were highly significant. Our study confirmed previous findings in adults done by Ben Noun *et al*[8] who found that NC strongly correlated with BMI and could indeed be used as an additional and practical screening tool for identifying males and females who are obese (Table 1 & 2).

In the Framingham Heart Study which included 2732 subjects (mean age -57 years), NC was positively associated with risks of type 2 diabetes mellitus, hypertension, decreased HDL cholesterol, and increased triglyceride.

Table 2 — *Neck circumference in relation to other metabolic risk factors*

Neck circumference	Karl Pearson correlation co-efficient r-value	p-value
BMI	0.432	<0.001**
Waist circumference	0.468	<0.001**
Hip circumference	-0.006	0.902
Waist/hip ratio	0.412	<0.001**
SBP(mmHg)	0.254	<0.001**
DBP(mmHg)	0.102	0.024*
FBG(mg/dl)	0.342	<0.001**
Total cholesterol (mg/dl)	0.012	0.602
LDL(mg/dl)	0.389	<0.001**
HDL(mg/dl)	-0.176	<0.001**
Triglycerides(mg/dl)	0.287	<0.001**
Age in years	0.024	0.524

BMI- Body mass index; SBP- Systolic blood pressure; DBP – Diastolic blood pressure; FBG- Fasting blood glucose; LDL- Low density lipoprotein cholesterol; HDL- High density lipoprotein cholesterol

After further adjustments for BMI and waist circumference, NC remained associated with type 2 diabetes mellitus[16]. Similar results were observed in a Turkish Adult Cohort Study in 1912 middle-aged and elderly individuals[18]. Using ROC curve analysis the cut off for NC was >35.5cms, sensitivity of 62.8% and specificity of 77.6% in our study. NC significantly correlated with all parameters of MetS risks in both genders (Fig 1).

Conclusion

Our observations indicate that NC as an index of upper body fat distribution can be used to identify MetS. NC>37cm for males and >34cm for females was the best cut off levels for determining the overweight/obese subjects; they are more prone for MetS and require additional evaluation.

Measurement of NC is a simple, time saving and least invasive measurement tool. NC may be used as a screening

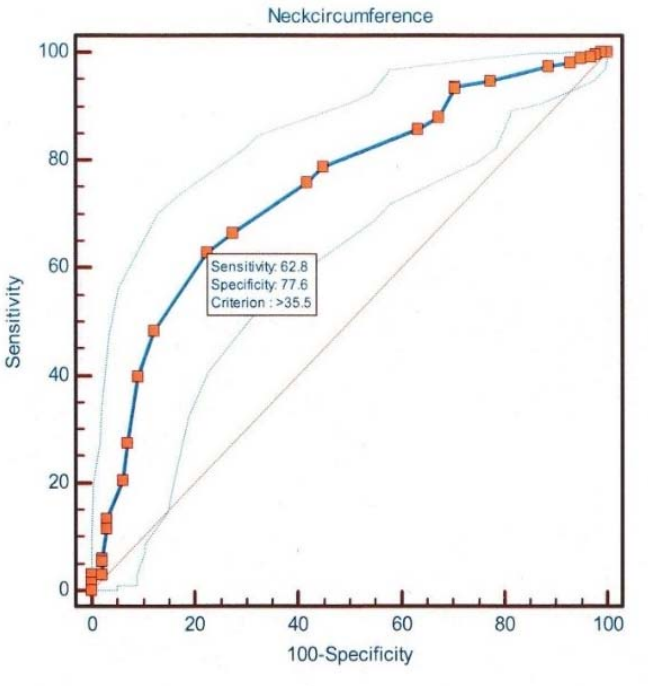

Fig 1 — ROC analysis curve of Neck Circumference

measure to identify MetS risk factors in patients.

Limitations of the study :

The present study has certain limitations : (i) this cross sectional design study limited extension of its interpretation to the causality of associations. And (ii) all the participants were from the same health examination center, and a selective bias could not be excluded.

Despite these limitations, our study has the advantage of introducing a simple and inexpensive method to predict metabolic risks in a large population. However, because the study was limited to the representatives of the study sample and cross sectional study design, further longitudinal studies in representative populations are required to obtain more conclusive results to establish NC as a basic criterion in the diagnosis of MetS.

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