Section A -Research paper

Neck circumference and neck height ratio as a marker of metabolic syndrome: A single centre cross sectional study

Dr. Venkatesh S[1], Dr. Prabhu Shankar S MD[2], Dr. Lawrence P[3] MD, Dr. Ramya N MD[4]

[1]Post graduate, Department of General Medicine, Trichy SRM Medical College Hospital and Research Centre, Irungalur, Trichy, Tamil Nadu

[2]Professor, Department of General Medicine, Trichy SRM Medical College Hospital and Research Centre, Irungalur, Trichy, Tamil Nadu

[3]Assistant Professor, Department of General Medicine, Trichy SRM Medical College Hospital and Research Centre, Irungalur, Trichy, Tamil Nadu

[4]Professor, Department of General Medicine, Trichy SRM Medical College Hospital and Research Centre, Irungalur, Trichy, Tamil Nadu

Corresponding author: Dr. Ramya N MD

Abstract

Background: Metabolic syndrome (MetS) is a cluster of metabolic problem like central obesity, high blood pressure, high blood sugar, high triglycerides, and poor high-density lipoprotein cholesterol which serves as risk for cardiovascular diseases like stroke and heart attack. It is considered that body mass index (BMI), waist circumference (WC), waist-hip ratio (WHpR), and waist-height ratio (WHtR) are the anthropometric measures that can be used to diagnose metabolic syndrome. **Aim and Objective:** The aim of the study to evaluate the role of neck circumference and neck height ratio as an independent predictors of metabolic syndrome. The objective of the study was to describe the neck circumference and neck height ratio in the population age between 30-50years and to correlate the role of neck circumference and neck height ratio in metabolic syndrome. **Materials and Methods:** A cross sectional study was done among 193 patients who fit into the eligibility criteria, neck circumference and neck height ratio were measured in the medicine department. Baseline characteristics along with the details of risk factors were collected. **Results:** Of the 193 study participants 110 (57%) were female and the overall mean age was found to be39.9±5.98 years. 67.36% were found to have central obesity based on waist circumference and only 28.49% had normal BMI. 125(64.77%) had MetS. The BMI, neck circumference, neck height ratio, waist circumference were all higher in the group with MetS compared to no Mets group and was highly significant (<0.0001). The individuals in the highest tertile of neck circumference had significantly higher central obesity and were significantly more likely to be overweight and obese (p value <0.0001). The presence of MetS which was found to be highly significant in the highest tertile of neck circumference. Neck circumference had significant positive correlation with serum total cholesterol (0.197) and triglycerides (0.238) and a significant inverse correlation was observed between neck circumference and high

density lipoprotein (HDL) (-0.323). Waist circumference, BMI, and neck height ratio also had significant positive correlation with total cholesterol, triglycerides and low density lipoprotein (LDL). **Conclusion:** The use of neck circumference as a technique for the prediction of metabolic syndrome is beneficial. It was found that neck circumference and neck to height ratio have a strong correlation with the anthropometric indices and components of metabolic syndrome.

Categories: Endocrinology/Diabetes/Metabolism, Internal medicine.

Keywords : Obesity, Hypertension, diabetes, Hyperlipidemia.

Introduction

The term "metabolic syndrome," abbreviated as "MetS," refers to a cluster of metabolic problems that, when present in a person, raise that person's risk of developing cardiovascular diseases like stroke and heart attack [1]. Central obesity, high blood pressure, high blood sugar, high triglycerides, and poor high-density lipoprotein cholesterol are the component illnesses that make up the condition known as metabolic syndrome (MetS) [2]. Among other anthropometric indices, the body mass index (BMI), waist circumference (WC), waist-hip ratio (WHpR), and waist-height ratio (WHtR) are all measures that can be used to diagnose metabolic syndrome and identify abdominal obesity [3]. It is usual practise to use waist circumference (WC) as an indicator of the prevalence of abdominal obesity and visceral fat. However, WC measurement can be adversely affected by factors such as the location of WC measurement, diurnal variation, pre-meal versus post-meal measurement, the type of garment worn during measurement, and patient stance during measurement. Other factors that can influence WC measurement include the type of garment worn during measurement and diurnal variation [4]. As a direct response to the constraints that were just discussed with regard to the WC measurement, various additional anthropometric metrics are currently being examined for their capacity for prediction. The circumference of the neck, often known as the neck circumference (NC), is a measurement that is currently the topic of several investigations [5]. This measurement was reported by several studies to be linked with obstructive sleep apnoea (OSA). Two further investigations came to the same conclusion and published it: OSA is linked to MetS. Following this, it was hypothesised that NC could serve as an additional instrument for forecasting MetS [6,7].

In addition, the Framingham Heart Study discovered that NC was significantly related with a variety of cardiometabolic risk factors [8]. Previous research found a favourable correlation between NC and cardio metabolic risk factors and MetS in children and adults with obesity in Turkey and China [9,10]. This correlation was also found in adults in Turkey. However, there aren't many studies that look at the connection between neck circumference and MetS among Southeast Asian populations, so the data we do have are limited [11]. It has been hypothesised that the traditional anthropometric indices (such as waist circumference, body mass index, and neck circumference, for example) may have a limited capacity to identify metabolic hazards among people of different ethnicities [12]. The link between NC and MetS was assessed in a study that was carried out in Thailand, however the participants were limited to urban populations who were at least 50 years old [13]. Nevertheless, and this is very essential to note, two earlier investigations revealed a rising prevalence of MetS among persons of younger ages. This research was conducted with the intention of determining

whether or not the circumference of one's neck and the ratio of their neck circumference to their height are reliable independent predictors of metabolic syndrome. The aim of the study to evaluate the role of neck circumference and neck height ratio as an independent predictors of metabolic syndrome.

Materials and methods

A cross sectional observational study was done among the out patients of General Medicine department in a teaching institute. The study was done over a period of 3 months from August to October 2022. All the patients belonging to 30–50 years, having no co-morbidities and consented were included in the study. These patients were fixed an appointment where in the detailed anthropometric and biochemical evaluation will be done. Those patients who had history of thyroid disease or any kind of neck oedema were excluded from the study. Thus, a total of 193 participants who satisfied the criteria took part in the research. Baseline characteristics like age, gender, concomitant conditions and blood pressure were collected from the study participants. After the patient had been permitted to relax for five minutes, their blood pressure was taken. The patients were asked to remove any excess clothing, including their shoes, before anthropometric measures were obtained. A stadiometer was used to measure the patient's height while they were standing upright with their feet together. The body mass index (BMI) was determined by taking the individual's weight in kilogrammes (kg) and dividing it by their height in metres squared (m2). The neck circumference (NC) was determined by placing the upper edge of the measuring tape at the base of the neck, horizontally below the cricothyroid cartilage, with the head held erect and parallel to the wall, and the eyes looking ahead. Each subject had a single NC measurement carried out on them. Blood was obtained from the patient after they had fasted for 8 hours overnight to determine their fasting blood sugar (FBS), total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), and estimated low-density lipoprotein cholesterol (LDL-C). During the course of the previously indicated checkup appointment, the aforementioned procedure was carried out and finished. In the event that an abnormality was found during any of the investigations, the patient was scheduled for a subsequent session at which they would undergo additional evaluation and treatment.

MetS was determined to be present based on the diagnostic criteria established by the International Diabetes Federation and the American Heart Association/National Heart, Lung, and Blood Institute (IDF and AHA/NHLBI). Central obesity is defined as waist circumference > 90 cm in men or > 80 in women. To be more specific, a patient was considered to have metabolic syndrome if they fulfilled three or more of the following criteria: elevated triglyceride levels of 150 mg/dL or the use of medication for elevated triglyceride levels; reduced high-cholesterol levels of 40 mg/dL in men and 50 mg/dL in women; elevated blood pressure of 130/85 mmHg or the use of medication for hypertension; elevated fasting blood sugar levels $\geq 100 \mathrm{mg/dl}$[2].

The study was started after obtaining proper approval from the institutional ethical committee (1064/TSRMMCH&RC/ME-1/2022-IEC No:1092). A written informed consent was obtained from each participant before including them in the study. The purpose of the study was clearly explained to the participants and the right to withdraw from the study at any

given point of time without any loss in patient care was also explained. The data obtained was maintained confidentially. The data collected was entered in MS excel and SPSS software was used for analysis. The frequency and percent-age distributions are used to express qualitative variables. Quantitative variables are provided with the range, mean and standard deviation. Unpaired t-test and Mann-Whitney U-test was used for between-group comparisons of continuous variables and chi-square test was used to find association between variables.

Results

A total of 431 individuals were screened of which 193 who fulfilled the eligibility criteria were included in the study. Majority 110(56.99%) were female participants with only 83 (43.1%) being male. The overall mean age of the study participants was found to be 39.9±5.98 years. Taking into consideration the fasting blood sugar (FBS) and glycated hemoglobin (HbA1c) values 26(13.4%) and 69(35.75%) were found to be prediabetic and diabetic respectively (Table 1). Only 55(28.49%) of the study participants had a normal BMI and almost 130(67.36%) of the study participants were found to have central obesity (figure 2). Majority (52.34%) of the participants had neck circumference of 35-37.5 cm (Table 1 & figure 1). Hypertriglyceridemia and low HDL were found in 35.23% and 46.11% of the study participants respectively (Table 1).Of the total study participants,125(64.77%) had metabolic syndrome and 68(35.23%) had no metabolic syndrome(Table 2). The mean age and weight were slightly higher among people having metabolic syndrome compared to no metabolic syndrome group and was found to be significant. The mean of BMI, neck circumference, waist circumference and the neck height ratio were all higher in the metabolic syndrome group compared to no metabolic syndrome group and was found to be highly significant. The blood pressure and lipid profiles were also found to be significantly higher in the metabolic syndrome group compared to those with no metabolic syndrome group (Table 2).The individuals in the highest tertile of neck circumference had significantly higher central obesity and were significantly more likely to be overweight and obese. They were also found to have significantly low high -density lipoproteins and the presence of metabolic syndrome which was found to be highly significant (Table 3). Neck circumference had significant positive correlation with serum total cholesterol and triglycerides and a significant inverse correlation was observed between neck circumference, waist circumference, HDL,BMI and neck height ratio had significant positive correlation with total cholesterol, triglycerides and LDL(Table 4).

Baseline characteristics		**Frequency n (%)**
Diabetes	Normoglycemia	98(50.78)
	Prediabetic	26(13.47)

	Diabetic	69(35.75)
Blood pressure	Normotensive	107(55.44)
	Hypertensive	86(44.56)
Lipids	Hypertriglyceridemia	68(35.23)
	Low HDL	89(46.11)

Table 1: Frequency distribution of baseline characteristics of the study participant.
HDL- High density lipoprotein

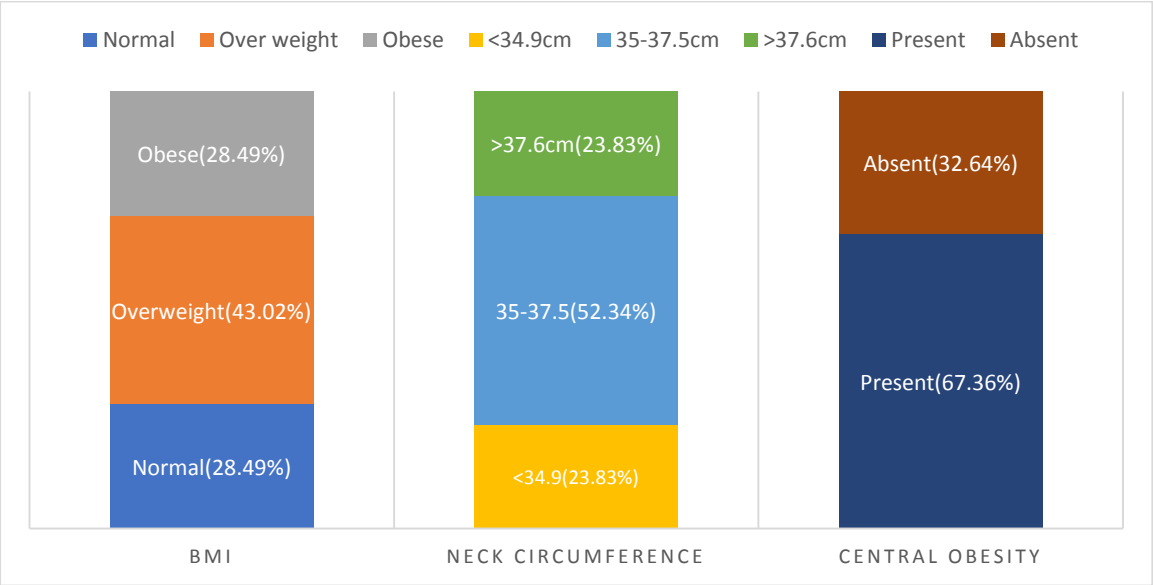

Figure 1: Distribution of study participants according to anthropometric measurement.

Characteristics	MetS (N=125)		No MetS (N=68)		p value
	Mean	SD	Mean	SD	
Age	41.42	4.93	39.67	5.59	0.0259
Height (cm)	156.67	9.95	162.69	8.97	<0.0001
Weight (kg)	74.42	15.62	67.08	10.82	0.0007
BMI (Body mass index)	30.53	5.44	25.29	4.10	<0.0001
Neck circumference (cm)	36.04	1.94	33.81	2.62	<0.0001
Neck height ratio	23.03	0.94	20.78	1.18	<0.0001

Waist circumference	95.17	9.41	83.73	10.20	<0.0001
SBP (systolic blood pressure)	138.67	46.34	120.07	28.97	0.0030
DBP (Diastolic blood pressure)	94.33	30.26	73.61	20.03	<0.0001
Triglycerides*	147.17	321	100.97	208.90	0.8689
Total cholesterol	179.58	52.10	165.25	41.20	0.0002
HDL (High density lipoprotein)	40.75	9.86	51.91	12.95	<0.0001
LDL (low density lipoprotein)	144.50	28.46	121.91	36.96	<0.0001
FBS*(Fasting blood sugar)	123.17	110.39	104.19	90.01	0.1012

Table 2: Baseline characteristics with regards to occurrence of metabolic syndrome p value <0.05 is considered to be significant, p value <0.001 is highly significant, *Mann-Whitney-U-test.

Characteristics		Neck circumference in cm			p value
		<34.9 (46)	35-37.5 (101)	>37.6 (46)	
Central obesity	Present	14	71	45	<0.001
	Absent	34	30	1	
BMI(Body mass index)	Normal	34	20	1	<0.001
	Over weight	10	58	15	
	Obese	2	23	30	
Blood pressure	Normotensive	25	58	24	0.435
	Hypertensive	21	43	22	
Blood sugar	Normal	23	49	26	0.358
	Pre/Diabetic	23	52	20	
Triglyceride	Normal	36	64	25	<0.001
	Hypertriglyceridemia	10	37	21	
HDL (High density lipoprotein)	Normal	30	54	20	0.041
	Low	16	47	26	
MetS (Metabolic syndrome).	Present	16	70	39	<0.001
	Absent	30	31	7	

Table 3: Association of baseline characteristics with distribution of neck circumference. p value <0.05 is considered to be significant, p value <0.001 is highly significant.

Risk factors	NC	WC	NHtR	BMI
SBP (Systolic blood pressure)	0.139	0.202	0.173	0.126

DBP (Diastolic blood pressure)	0.071	0.175	0.126	0.109
FBS (Fasting blood sugar)	0.123	0.136	0.092	0.123
HbA1c	0.084	0.110	0.082	0.099
Total cholesterol	0.197	0.227	0.210	0.180
Triglyceride	0.238	0.258	0.225	0.223
LDL (low density lipoprotein)	0.138	0.247	0.166	0.239
HDL (High density lipoprotein)	-0.323	-0.246	-0.289	-0.262

Table 4: Correlation between anthropometric indices and cardio-metabolic risk factors.

Discussion

According to the findings of this descriptive cross-sectional study based on population-based data among adults, NC has a very strong association with MetS. In the cohort that we used for our research, the mean NC of patients who had metabolic syndrome was considerably higher than the mean NC of patients who did not have metabolic syndrome (36.04 1.94 cm versus 33.81 2.62 cm, respectively). In addition, a prior study that was conducted in Brazil discovered that the mean NC was substantially higher in MetS (37 cm) than in non-MetS. (33.8 cm) [14]. The comparability of these studies' findings lends credence to the usefulness of NC in estimating the likelihood of developing MetS. We found that ideal gender-specific NC cut offs for the prediction of MetS in this cohort were 38.73 cm in males and 35.14 cm in women, similar to the findings of a prior study (38 cm for men and 33 cm for women) [12]. But the findings of a study conducted in Brazil stated the NC cut off values for the prediction of MetS in both men and women should be raised to higher levels (>40 cm in males and >36 cm in women) [15].

In the Turkish population, it was also discovered that the NC cut off values for the prediction of MetS were significantly higher[9].In a manner analogous to that of WC, the observed variation in ideal NC cut-offs may be explained by variances in body size and anthropometric norms among races and populations. For this reason, it is recommended that ethnicity- and/or country-specific NC cut offs be used for both genders in the process of predicting cardiometabolic disorders. It is generally known, based on the findings of prior research, that obesity is connected[16]. With metabolic syndrome and cardiovascular risk factors, such as diabetes, high blood pressure, raised triglyceride levels, and insulin resistance[9].The body mass index, waist circumference, and hip to waist ratio are three common anthropometric indices that are used to indicate obesity and predict cardiometabolic risks[17]. On the other hand, sub cutaneous fat in the upper body has been identified as a pathogenic fat depot and has been found to have a stronger association with metabolic syndrome and cardiovascular risk factors than central body fat[18].This fat can be directly assessed by NC, which has been shown to have a positive correlation to MetS and is considered to be an independent predictor[19]. The assessment of NC was revealed to provide a better prediction when paired with the standard anthropometric measures; nevertheless, another investigation demonstrated that NC alone improves the prediction of incident cardiovascular disease risk factors over BMI and WC. NC has been proposed as a straightforward, forward-thinking, and practically applicable anthropometric measure in a growing number of investigations. For an NC

measurement, unlike a WC assessment, there is no need to remove any clothing, and there are also a far lower number of potential confounding factors [20]. Abdominal distension that is caused by gas or that occurs after a meal, as well as fluctuations in WC that are caused by respiratory factors, might have a negative impact on WC. Even after adjusting for visceral adipose tissue (VAT) and BMI, the Framingham Heart Study found that NC was linked with cardiovascular risk factors [21].This was the case even though NC was associated with cardiovascular risk factors. The findings of our study show that NC has a substantial correlation with the outcomes of cardiometabolic risks, which is in line with the findings of other studies that have been done in the past [22].

In our study, we calculated cut offs for the neck circumference for both men and women to be 38.73 cm and 35.14 cm respectively and neck height ratio in order to predict MetS. The greatest predictors for detecting MetS were men with a neck height ratio of >23.17 cm/m or higher and women with a ratio of >22.61 cm/m or higher. When compared to NC, the overall neck height ratio had a greater odds ratio for predicting the presence of MetS. These findings were similar to the study done by Olan et al., showing NC cut off of 39 and 35cm[9], while Chitra selvan et al., in their study in India revealed a NC cut off of 34.9cm and 31.25cm men and women respectively and a NHtR of 21.17cm and 20.48cm in male and female participants which was slightly in a lower range compared to our study[23]. These variations in results might be due to the difference in body composition of study population pertaining to specific areas.

Conclusion:

Neck circumference is an easy measurement tool useful for the prediction of metabolic syndrome. It was found that neck circumference and neck to height ratio have a strong correlation with the anthropometric indices and components of metabolic syndrome like the lipid levels, blood pressure, blood sugar, abdominal circumference. The cut offs for neck circumference for both men and women was 38.73 cm and 35.14 cm respectively and the cut off for the neck height ratio for detecting metabolic syndrome in men was 23.17 cm/m or higher and for women 22.61 cm/m or higher. Our study shows that the reliability of neck height ratio as a predictor of metabolic syndrome and the idea of considering it to be better index than neck circumference with regards risk factor prediction and in terms of determining the likelihood of developing future cardiovascular disease.

Additional information

Disclosures

Human subjects: consent was obtained or waived by all participants in this study. Institutional Ethics committee, Trichy SRM Medical college Hospital & Research Centre issued approval 1064/TSRMMCH&RC/ME-1/2022-IEC No:192. Approved. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of Interest:** In compliance with the ICMJE unform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that they have no financial support was received from any organization for the submitted work. **Financial relationships**: All authors have declared that they have no financial relationships at present

or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could have appear to have influenced the submitted work.

References:

1. Samson SL, Garber AJ. Metabolic syndrome. Endocrinology and Metabolism Clinics. 2014 Mar 1;43(1):1-23.
2. Grundy SM. Metabolic syndrome update. Trends in cardiovascular medicine. 2016 May 1;26(4):364-73.
3. Sagun G, Oguz A, Karagoz E, Filizer AT, Tamer G, Mesci B. Application of alternative anthropometric measurements to predict metabolic syndrome. Clinics. 2014;69:347-53.
4. Valsamakis G, Chetty R, Anwar A, Banerjee AK, Barnett A, Kumar S. Association of simple anthropometric measures of obesity with visceral fat and the metabolic syndrome in male Caucasian and Indo-Asian subjects. Diabetic medicine. 2004 Dec;21(12):1339-45.
5. Mastroeni SS, Mastroeni MF, Ekwaru JP, Setayeshgar S, Veugelers PJ, Gonçalves MD, Rondó PH. Anthropometric measurements as a potential non-invasive alternative for the diagnosis of metabolic syndrome in adolescents. Archives of Endocrinology and Metabolism. 2019;63:30-9.
6. Mazzuca E, Battaglia S, Marrone O, Marotta AM, Castrogiovanni A, Esquinas C, Barcelò A, Barbé F, Bonsignore MR. Gender-specific anthropometric markers of adiposity, metabolic syndrome and visceral adiposity index (VAI) in patients with obstructive sleep apnea. Journal of sleep research. 2014 Feb;23(1):13-21.
7. Tażbirek M, Potoczny J, Strójwąs K, Pierzchała W, Barczyk A. Anthropometric factors in the assessment of obstructive sleep apnea risk in patients with metabolic syndrome. Advances in Pulmonary Medicine: Research and Innovations. 2019:35-41.
8. Preis SR, Massaro JM, Hoffmann U, D'Agostino Sr RB, Levy D, Robins SJ, Meigs JB, Vasan RS, O'Donnell CJ, Fox CS. Neck circumference as a novel measure of cardiometabolic risk: the Framingham Heart study. The journal of clinical endocrinology & metabolism. 2010 Aug 1;95(8):3701-10.
9. Onat A, Hergenç G, Yüksel H, Can G, Ayhan E, Kaya Z, Dursunoğlu D. Neck circumference as a measure of central obesity: associations with metabolic syndrome and obstructive sleep apnea syndrome beyond waist circumference. Clinical nutrition. 2009 Feb 1;28(1):46-51.
10. Zhou JY, Ge H, Zhu MF, Wang LJ, Chen L, Tan YZ, Chen YM, Zhu HL. Neck circumference as an independent predictive contributor to cardio-metabolic syndrome. Cardiovascular diabetology. 2013 Dec;12(1):1-7.
11. Consultation WE. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet (London, England). 2004 Jan 10;363(9403):157-63.
12. Limpawattana P, Manjavong M, Sopapong R. Can neck circumference predict metabolic syndrome? An experience from a university community. Endocrine Practice. 2016 Jan 1;22(1):8-15.

13. Nestel P, Lyu R, Low LP, Sheu WH, Nitiyanant W, Saito I, Tan CE. Metabolic syndrome: recent prevalence in East and Southeast Asian populations. Asia Pacific journal of clinical nutrition. 2007 Jun 1;16(2).
14. Pereira DC, Araújo MF, Freitas RW, Teixeira CR, Zanetti ML, Damasceno MM. Neck circumference as a potential marker of metabolic syndrome among college students. Revista latino-americana de enfermagem. 2014 Nov;22:973-9.
15. Stabe C, Vasques AC, Lima MM, Tambascia MA, Pareja JC, Yamanaka A, Geloneze B. Neck circumference as a simple tool for identifying the metabolic syndrome and insulin resistance: results from the Brazilian Metabolic Syndrome Study. Clinical endocrinology. 2013 Jun;78(6):874-81.
16. Luo Y, Ma X, Shen Y, Xu Y, Xiong Q, Zhang X, Xiao Y, Bao Y, Jia W. Neck circumference as an effective measure for identifying cardio-metabolic syndrome: a comparison with waist circumference. Endocrine. 2017 Mar;55(3):822-30.
17. Kumar NV, Ismail MH, Mahesha P, Girish M, Tripathy M. Neck circumference and cardio-metabolic syndrome. Journal of Clinical and Diagnostic Research: JCDR. 2014 Jul;8(7):MC23.
18. Namazi N, Larijani B, Surkan PJ, Azadbakht L. The association of neck circumference with risk of metabolic syndrome and its components in adults: A systematic review and meta-analysis. Nutrition, Metabolism and Cardiovascular Diseases. 2018 Jul 1;28(7):657-74.
19. Silva CD, Zambon MP, Vasques AC, Rodrigues AM, Camilo DF, Antonio MÂ, Cassani RS, Geloneze B. Neck circumference as a new anthropometric indicator for prediction of insulin resistance and components of metabolic syndrome in adolescents: Brazilian Metabolic Syndrome Study. Revista Paulista de Pediatria. 2014;32:221-9.
20. Hingorjo MR, Zehra S, Imran E, Qureshi MA. Neck circumference: a supplemental tool for the diagnosis of metabolic syndrome. JPMA. 2016;66(1221).
21. Cizza G, de Jonge L, Piaggi P, Mattingly M, Zhao X, Lucassen E, Rother KI, Sumner AE, Csako G, NIDDK Sleep Extension Study. Neck circumference is a predictor of metabolic syndrome and obstructive sleep apnea in short-sleeping obese men and women. Metabolic syndrome and related disorders. 2014 May 1;12(4):231-41.
22. Bochaliya RK, Sharma A, Saxena P, Ramchandani GD, Mathur G. To Evaluate the Association of Neck Circumference with Metabolic Syndrome and Cardiovascular Risk Factors. The Journal of the Association of Physicians of India. 2019 Mar 1;67(3):60-2.
23. Selvan C, Dutta D, Thukral A, Nargis T, Kumar M, Mukhopadhyay S, et al. Neck height ratio is an important predictor of metabolic syndrome among Asian Indians. Indian J Endocr Metab 2016;20:831-7.