International Journal of Pharmacy and Biological Sciences-IJPBS™ (2019) 9 (2): 1266-1273
Online ISSN: 2230-7605, Print ISSN: 2321-3272
Research Article | Biological Sciences | Open Access | MCI Approved
UGC Approved Journal

Identification of Risk of Cardiovascular Diseases in Asymptomatic Young Adults Using Neck Circumference

Purushottam Pramanik*
***Associate Professor in Physiology and Principal, Durgapur Government College, Durgapur, Paschim Bardhaman, West Bengal**

Received: 10 Jan 2019 / Accepted: 9 Mar 2018 / Published online: 1 Apr 2019
***Corresponding Author Email:** puru.pra@gmail.com

Abstract
Indians have high probability of having cardiovascular disease (CVD) at an early age than the Western world. World Health Organization (WHO) has recommended waist circumference (WC), marker of central obesity, as a tool for assessment of risk of CVD. The use of WC has certain limitations whereas neck circumference (NC) which has been attributed to increased cardiovascular risk as well as good marker of central obesity like WC. The objective of this study was to determine the relationship between NC and other anthropometric obesity markers and to examine the cut-off point of NC on gender basis according to existing WC cut-off levels of Asian population. This cross-sectional survey was conducted among undergraduate students of West Bengal, India. The anthropometric and BP measurements were carried out on 2400 (males-895 and females-1505) students. Body height, weight, NC, WC, Hip Circumference (HC) and Blood Pressure (BP) were measured by standard methods. BMI and Waist to Hip ratio (WHR) were estimated. Pearson's correlation coefficient was calculated to determine association between NC and other measurement variables. Receiving Operating Characteristic (ROC) curves were constructed to assess the optimum cut-off levels of NC with WC. In both sexes significant positive correlations were noted between NC and BMI, WC, WHR and blood pressure. NC $\geq$ 35. 8 cm for males and $\geq$31.45cm for females are to be considered the optimal cut-off values to determine the risk of cardiovascular disease in respect to WC. NC measurement is a simple, convenient, inexpensive and noninvasive hence could be used as a convenient for early detection of risk of cardiovascular disease in young adults.

Keywords
Neck circumference, waist circumference, blood pressure, cardiovascular disease

*****

INTRODUCTION:
Obesity is rising to pandemic proportion and economic burdens associated with it is projected to be worsen in future for both developed and developing countries. The health burden associated with obesity is due to increased risk of cardiometabolic diseases including diabetes, hypertension, dyslipidemia and coronary heart disease. CVD is number one cause of mortality in low- and middle-income countries (WHO, 2016). In India 24.8% of all deaths are attributed to CVD (Prabhakaran et al., 2016). Indians have high

probability of having CVD at an early age than the Western world (Gupta et.al., 2009). The primary step of disease prevention is risk factor identification in those who appear to be asymptomatic. Young adults often appear healthy despite having multiple risk factors for obesity related diseases. Thus, screening for risk factors during early adulthood is important for disease prevention and also offer the opportunity to establish a lifetime health-promoting habits (Baranowski et.al., 2000; Strong et.al., 1999). A traditional screening tool for health-related risk factors are body mass index (BMI), Waist circumference (WC), Hip circumference (HC) and waist to hip ratio (WHR). Out of these BMI is still the most widely used marker for defining obesity (Rothman, 2008). BMI indicates weight in respect to height but not location of body fat distribution. Thus, location of body fat may modify the health implication of BMI (Famodu et.al., 2018). Central obesity, which is measured by WC, is generally considered to be a stronger risk factor for cardiometabolic risk than overall obesity (vanPelt et.al., 2001). The measurement WC has certain limitations: first of all, it requires unclothing of subject and convenience of ambient temperature. Secondly it may vary throughout the day based on fasting-satiety status. Third one is that it may vary in case of health problems which affect the abdominal wall. The fourth one is that some people may not allow the measurement in light clothes due to socio-cultural reasons (Ozkaya et.al., 2006). Gold standard measures of obesity and body fat distribution include ultrasound, compound tomography and magnetic resonance imaging. However, these methods are expensive and are often impractical in large scale studies (Famodu et.al., 2018). Thus reliable, simple and easily implemented methods of obesity and body fat distribution are needed. Neck circumference (NC) which is an easier and faster anthropometric measurement has been suggested as an index of upper body fat distribution (Ben-Noun et.al., 2001) as well as good marker of central obesity like WC (Ozkaya et.al., 2006). Increase NC surpasses WC as marker of visceral obesity (Yang et.al., 2010). NC has been used as a biomarker of metabolic dysfunction including glucose intolerance, hyperinsulinemia (Detregiachi et.al., 2018), hypertriglyceridemia (Vallianou et al., 2013) and decrease high density cholesterol (Vallianou et al., 2013). As a result, this often-overlooked method of evaluating body fat can be useful in screening cardiometabolic risk of young adults especially for large sample when noninvasive, inexpensive and easily implemented measures are needed.

This study aimed to compare NC with other anthropometric obesity and body fat markers in young Indian adults and to determine cut-off value of NC for males and females according to pre-existing sex-specific WC cut-off levels. In the current study WC was chosen for the reference point due to its close association with abdominal obesity and cardiovascular disease.

MATERIALS AND METHODS

Subjects: It is a cross sectional institution based observational study done from July 2016 to August 2017 among undergraduate students of West Bengal, India. Recruitment of the students as study subjects was done after thoroughly explain the purpose of the study. 2400 students (895 male and 1505 females) give their consent for participation. Data was collected by interviewing each participant with the help of pre-designed questionnaires consisting of demographic details, anthropometric measurement and measurement of blood pressure.

Anthropometric measurements: Body weight was measured in light clothing and in bare feet to the nearest 0.5kg. Height was measured using anthropometric rod without footwear on to the nearest 0.1cm. Neck circumference (NC) was measured to the nearest 0.1cm just below the laryngeal prominence (Adam's apple). NC percentile was calculated for male and female student separately. Waist circumference (WC) was measured mid-way between iliac crest and lowermost margin of the ribs in quiet breathing with the subjects wearing minimal clothing. Hip circumference (HC) was measured in centimeter to the nearest 0.1cm at the horizontal level at maximal width of the hip. Waist-to-hip ratio (WHR) was calculated by dividing WC by HC. BMI was calculated by dividing weight in kilogram by the height in square meters.

Measurement of blood pressure: Blood pressure was measured with a standard mercury sphygmomanometer. Before recording the blood, pressure students were allowed to wait in separate room for 10 minutes to relieve their restlessness and anxiety. Each subject was then called one by one and pressure was measured in the sitting posture in the right upper arm. Two readings were taken at 2-minute rest intervals and their average was taken as subject's blood pressure (Famodu et.al., 2018). Normotensive, pre hypertensive and hypertensive status of blood pressure were estimated by considering National high blood pressure education program, 2005 (NIH, 2005).

Statistical analysis: Results are described as mean values ± standard deviations (SD). Pearson's correlation coefficient was used to determine the relationship between NC and various anthropometric indices. To find the optimal, maximal summation of sensitivity and specificity for NC, the receiving operating characteristic (ROC) curve analysis was done to determine cut-off point against high levels of WC for males and females. A high WC defined as >90 cm for males and > 80cm for females was describe previously for Asian Indian (Misra et. al., 2009) and Asian population (Ahmed et.al., 2016). Based on this classification subjects were divided into four groups: true positive (subjects with high WC and high NC), true negative (subjects with low WC and low NC), false positive (subjects with low WC and high NC) and false negative (subjects with high WC and low NC). Sensitivity and specificity were calculated by following equations:

Sensitivity = true positives / (true positives + false negatives); Specificity = true negatives / (true negatives + false positive).

$P < 0.05$ was considered statistically significant. All analysis was conducted using IBM SPSS for windows version 16.

RESULTS:

Out of 2400 subjects 1505 (62.7 %) were female and 895 (37.3%) were male. Table1 shows the anthropometric measures in males and females.

Table 1: Subject characteristics

Variables	Males	Females
Age (years)	19.08 ± 1.35 (18-21)	18.92 ± 1.14 (18-21)
Height (cm)	166.97 ± 6.63 (142.5-189.0)	153.50 ± 6.47 (118-180)
Weight (kg)	60.36 ± 12.32 (34-110)	50.20 ± 10.14 (28-98)
BMI (Kg/m^2)	20.77 ± 1.52 (13.33-39.90)	21.34 ± 2.50 (12.44-40.05)
Waist circumference (cm)	79.85 ± 10.02 (53-119)	76.62 ± 9.23 (50.6-114)
Hip circumference (cm)	93.80 ± 11.05 (62-135)	92.93 ± 13.09 (63-134)
Waist hip ratio	0.846 ± 0.07 (0.645-1.066)	0.827 ± 0.07 (0.565-1.175)
Neck circumference (cm)	34.65 ± 2.55 (28-44)	30.90 ± 2.43 (20-47)
Systolic blood pressure (mm Hg)	124.96 ± 14.19 (82-173)	114.77 ± 13.71 (82-170)
Diastolic blood pressure (mm Hg)	76.28 ± 9.26 (46-100)	73.70 ± 9.19 (43-110)

Values are mean ± SD (Range)

Table2 represents correlation among NC and various anthropometric measures. In both sexes NC was positively correlated with height, weight, BMI, HC, WC, WHR and BMI. Significant positive correlation was noted among NC and SBP and DBP of both males and females.

Table2: Relationships between neck circumference and various anthropometric variables

Variables	Males		Females	
	r	p-value	r	p-value
BMI (Kg/m^2)	0.752	<0.001	0.505	<0.001
Waist circumference (cm)	0.696	<0.001	0.664	<0.001
Hip circumference (cm)	0.290	<0.001	0.463	<0.001
Waist hip ratio	0.408	<0.001	0.074	<0.001
Systolic blood pressure (mm Hg)	0.354	<0.001	0.404	<0.001
Diastolic blood pressure (mm Hg)	0.285	<0.001	0.370	<0.001

Fig.1 and fig.2 represent the receiving operating characteristic (ROC) curves determined from the upper body fat (neck circumference) and central obesity (waist circumference) for male and female subjects respectively (waist circumference 90 cm for males and 80 cm for females). The area under Curve (AUC) was 0.746 for males and 0.624 for females. 95% CI was 0.663-0.828 (p<0.000) for males and was 0.575-0.672 (p<0.000) for females.

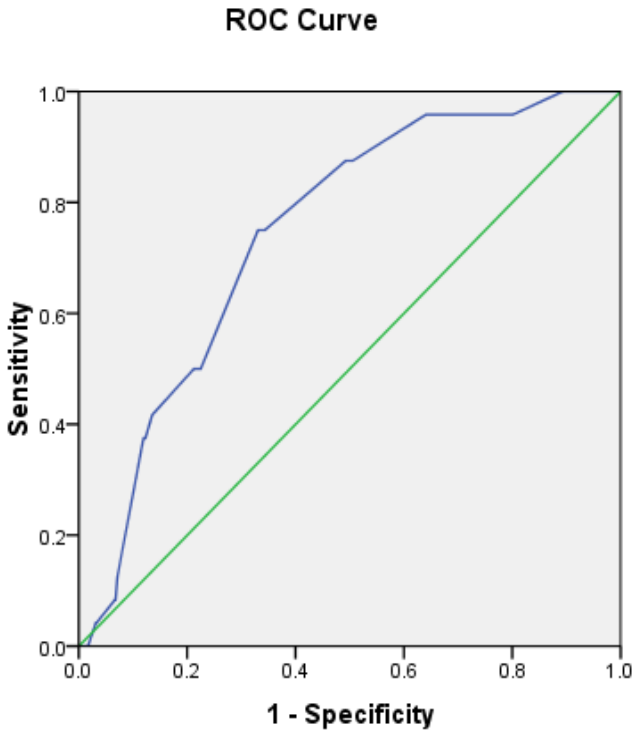

Fig.1: ROC curve for neck circumference in male subjects with abdominal obesity (waist circumference >90cm)

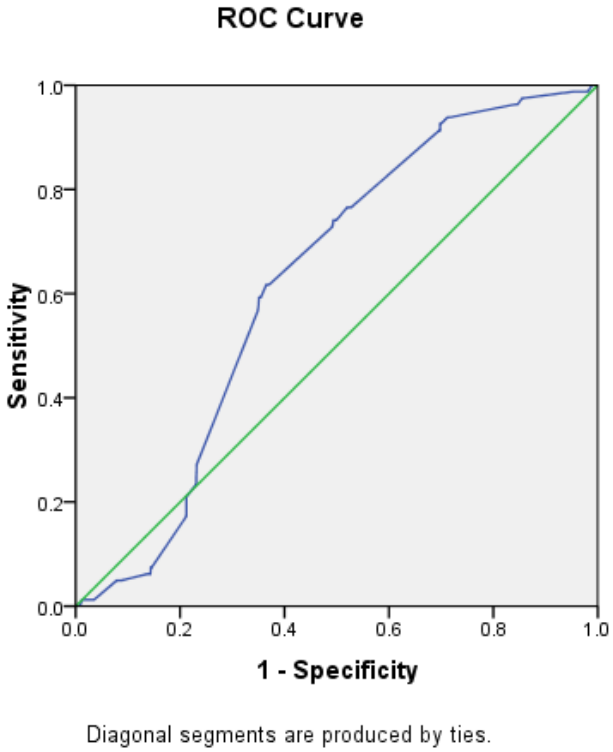

Fig.2: ROC curve for neck circumference in female subjects with abdominal obesity (waist circumference >80cm)

Using ROC analysis (table-3 and 4) a neck circumference ≥ 35.8cm in males and NC ≥ 31.45 cm in female subjects were the optimal cut off levels for determining subjects with central obesity (> 90 cm in males and > 80 cm for female subjects).

Table-3: Neck circumference cut-off levels for determining the subjects with waist circumference 90 cm in males

Cut-off (cm)	Sensitivity	Specificity	Cut-off (cm)	Sensitivity	Specificity
27.0000	1.000	0.000	35.2500	0.750	0.657
28.5000	1.000	0.003	35.5500	0.750	0.668
29.2500	1.000	0.011	**35.8000**	0.750	0.669
29.75 00	1.000	0.013	36.2500	0.500	0.775
30.2500	1.000	0.039	36.6500	0.500	0.786
30.6500	1.000	0.049	36.9000	0.500	0.788
30.9000	1.000	0.059	37.2500	0.417	0.865
31.2500	1.000	0.100	37.5500	0.375	0.877
31.7500	1.000	0.107	37.7000	0.375	0.879
32.1000	0.958	0.199	37.9000	0.375	0.881
32.3500	0.958	0.200	38.25000	0.125	0.929
32.5500	0.958	0.210	38.7000	0.083	0.932
32.8000	0.958	0.212	38.9500	0.083	0.933
33.2000	0.958	0.339	39.2500	0.032	0.968
34.4500	0.958	0.340	39.7500	0.042	0.969
33.5500	0.958	0.355	40.2500	0.000	0.983
33.7000	0.958	0.356	40.7500	0.000	0.985
33.9000	0.958	0.359	41.5000	0.000	0.992
34.0500	0.875	0.495	42.5000	0.000	0.995
34.3000	0.875	0.496	43.5000	0.000	0.998
34.7000	0.875	0.506	45.0000	0.000	1.000
34.9500	0.875	0.507			

Bold values indicate optimum cut-off NC level based on maximum of (sensitivity + specificity) for determining subjects with central obesity (WC ≥ 90 cm and NC ≥ 35.8 cm) for males

Table-4: Neck circumference cut-off levels for determining the subjects with waist circumference 80 cm in female subjects

Cut-off (cm)	Sensitivity	Specificity	Cut-off (cm)	Sensitivity	Specificity
22.5000	1.000	0.003	29.7000	0.926	0.302
23.5000	1.000	0.004	29.8500	0.914	0.302
24.5000	1.000	0.005	29.9500	0.914	0.303
25.3000	1.000	0.011	30.0500	0.765	0.473
25.8000	1.000	0.011	30.1500	0.765	0.475
26.2500	0.988	0.019	30.2500	0.765	0.475
26.7500	0.988	0.020	30.3500	0.765	0.480
27.2000	0.988	0.039	30.4500	0.765	0.480
27.4500	0.988	0.040	30.5500	0741	0.501
27.5500	0.988	0.044	30.6500	0.741	0.502
27.7000	0.988	0.045	30.7500	0.741	0.503
27.8500	0.988	0.046	30.8500	0.741	0.506
27.9500	0.988	0.048	30.9500	0.728	0.508
28.1000	0.975	0.141	31.0500	0.617	0.629
28.2500	0.975	0.143	31.1500	0.617	0.632
28.3500	0.975	0.143	31.2500	0.617	0.633
28.4500	0.975	0.145	31.3500	0.617	0.634

28.5500	0.963	0.154	**31.4500**	0.617	0.635
28.7000	0.963	0.155	31.5500	0.593	0.645
28.8500	0.963	0.156	31.6500	0.593	0.648
28.9500	0.963	0.159	31.7500	0.593	0.649
29.0500	0.938	0.284	31.8500	0.580	0.650
29.1500	0.938	0.285	31.9500	0.569	0.651
29.3000	0.938	0.286	32.1000	0.272	0.768
29.4500	0.938	0.288	32.2500	0.247	0.769
29.5500	0.926	0.301			

Bold values indicate optimum cut-off NC level based on maximum of (sensitivity + specificity) for determining subjects with central obesity (WC ≥ 80 cm and NC ≥ 31.45 cm) for females

Hypertensive status of male and female subjects on the basis of neck circumference and waist circumference are represented in table 5.

Table-5: Hypertensive status of male and female subjects on the basis of neck circumference and waist circumference

Subjects	Neck circumference (cm)		waist circumference (cm)	
	≤ cut-off value	>cut-off value	≤ cut-off value	>cut-off value
Males	6.3%	23.4%	10.1%	23.9%
Females	2.0%	8.7%	2.8%	8.7%

Cut-off NC levels: 35.8cm for male and 31.45 cm for female; Cut-off WC levels: 90 cm for male and 80 cm for female

DISCUSSION:

Results of this study show a strong positive correlation of NC with BMI, WC, and HC in both male and female subjects. These findings were supported by several studies that examined the association of NC with conventional measurement of obesity (Yang et.al., 2010; Onat et.al., 2009). Similar correlation have investigated by researchers in same age group students (Hingorjo et.al., 2012).

WC, marker of central obesity is strongly associated with cardiovascular risk. World Health Organization (WHO) has recommended WC as a tool for assessment of risk of CVD (WHO, 2008). WC has various disadvantages. On the other hand, NC is easy, less cumbersome and practical method. NC is positively correlated with cardiovascular risk factors like high blood triglycerides level, Low HDL-cholesterol (Vallianou et.al., 2014), high LDL-cholesterol (Zhou et. al., 2013) and blood pressure (Pramanik and Roychoudhury, 2018). In this study we noted that percentage of hypertension, risk factor for cardiovascular disease is more in subjects with high NC.

The current study suggests that NC is a potential indicator for measuring central obesity in young adults in India. NC is well established indicator of obesity, but its evaluation is limited in young generation of India where preventive measures is vital for maintenance of health. Very few studies have reported the cutoff values of NC in respect to WC. An NC > 35.75 cm for males and >31.45 cm in females were calculated as cutoff point for those with central obesity (WC > 90cm in males and >80 cm in females). A study on Chinese living in USA (Famodu et.al., 2018) suggested that NC > 38 cm for males and >33.5 cm in females as cutoff point for those with central obesity (WC >102cm in males and >88 cm in females). NC > 35.5 cm in males and >32cm in females were selected as cutoff point for overweight/obesity (Hingorjo et.al., 2012). A study in USA suggested NC >38 cm in males and > 35 cm in females as cutoff points (in adults with type-2 diabetes (Yang et.al., 2010). Comparable to our study of using WC as the reference point (WC > 90cm in males and >80 cm in females) a study in Bangladesh found cutoff points > 35.25 cm in males and > 31.25 cm in females (Qureshi et.al., 2017). Thus, the varied cutoff levels found in studies suggest the need to develop standard values for different ethnicities.

This study has several limitations: firstly, it comprised college students aged 18-22 years that cannot be generalized over the whole population. Secondly, age specific cutoff points were not determined. Thirdly, urban and rural stratification was not done. Additionally, this was a cross sectional study. Despite these limitations we were able to make assumption regarding usefulness of NC in diagnosing central obesity and cardiovascular disorders among young Indian adults. Although the new cut off values are laid down through this study, longitudinal studies are called for to validate these values that define centrally obese for young Indian adults.

CONCLUSION:

In conclusion our results agree with recent literatures and suggest the use of NC as a predictor of obesity especially abdominal obesity which is closely associated with cardiovascular disease. Unlike WC, NC measurement is fast method applicable to everyone and in every environment without being affected by fasting-satiety status, breathing phase, the ambient temperature and socio-cultural limitation. It is low cost, reliable, non-invasive tool and should be consider as a screening test for early detection of risk of cardiovascular disorder in young adults. Our results also suggest that NC > 35.8 cm in males and NC > 31.5 cm in females are to be consider as centrally obese and having a risk of cardiovascular disorder like hypertension.

REFERENCES:

Ahmad N, Adam SI, Nawi AM, Hassan MR, Ghazi HF. Abdominal obesity indicators: waist circumference or waist-to-hip ratio in Malaysian adults population. Int J Prev Med. 2016: 7: 82.

Baranowski T, Mendlein J, Resnicow K, Frank E, Cullen KW, Baranowski J. Physical activity and nutrition in children and youth: an overview of obesity prevention. Prev Med. 2000; 31: s1-s10.

Ben-Noun L, Sohar E, Laor A. Neck circumference as a simple screening measure for identifying overweight and obesity patients. Obes Res. 2001; 9(8): 470-477.

Detregiachi CRP, Quesada K, Barbalho SM, deCassia Mulato D, Moris M, Minardi T, Nogueira VE, Bernardo FF. Association between neck circumference and glycemia in adolescents. Diabetes Mellitus. 2018; 8: 61-69.

Famodu OA, Barr ML, Colby SE, Zhou W, Holaskova I, Leary MP, Byrd-Bredbenner C, Mathews AE, Olfert MD.Neck circumference positively relates to cardiovascular risk factors in college students. Int J Env Res Pub Health. 2018; 15: 1480-1487.

Gupta R, Misra A, Vikram Nk, Kondal D, Gupta SS, Agarwal A et al. Younger age of escalation of cardiovascular risk factors in Asian Indian subjects. BMC Cardiovasc Disord. 2009: 9(1): 28

Hingorjo MR, Qureshi MA, Mehdi A. Neck circumference as a useful marker of obesity: A comparison with body mass index and waist circumference. JPMA. 2012; 62: 36-40.

Misra A, Chowdey P, Makkar BM, Vikram NK, wasir JS, Chandha D, et al. Consensus statement for diagnosis of obesity, abdominal obesity and metabolic syndrome for Asian Indians and recommendations for physical activity, medical and surgical management. J Assoc Physicians India. 2009; 57: 163-170.

National High Blood Pressure Education Program Working Group on high blood pressure in children and adolescents. The fourth report on the diagnosis, evaluation and treatment of high blood pressure in children and adolescents. May 2005. NIH publication No. 055267. http.//www.nhibi.nih.gov/health/prof/heart/hbp /hbp-ped. Pdf.

Onat A, Hergenc G, Yuksel H, Can G, Ayhan E, Kaya Z, Dursunoglu D. Neck circumference as a measure of central obesity; associations with metabolic syndrome and obstructive sleep apnea syndrome beyond waist circumference. Clin Ntr. 2009; 28: 46-51.

Ozkaya I, Tunckale A. Neck circumference positively related with central obesity and overweight in Turkish University students: a preliminary study. Cent Eur J Public Health. 2006; 24(2): 91-94.

Prabhakaran D, Jeemon P, Roy A. Cardiovascar diseases in India. Circulation. 2016; 133(16): 1605-1620.

Pramanik P, Roychoudhury A. General and neck obesity are independent determinants of hypertension among undergraduate students: evidence. IOSR J Dental Med Sci. 2018; 17(7): 46-52.

Qureshi NK, Hassan MI, Akter N, Rahman MM, Sultana MM, Ashrafuzzman SM, Latif ZA. Indian J Endocrinol Metab. 2017, 21: 803-808.

Rothman KJ. BMI-related errors in the measurement of obesity. Int J Obes (Lond). 2008; 32 suppl3: s56-s59.

5. Strong JP, Malcom GT, McMahan CA, Tracy RE, Newman WP, III Herderick EE, Cornhill F. Prevalence and extent of atherosclerosis in adolescent and young adults: implications for prevention from the pathological determinants of atherosclerosis in youth study. JAMA. 1999; 281: 727-735.

Vallianou NG, Evangelopoulos AA, Bountzioka V et al. Neck circumference is correlated with triglycerides and inversely related with HDL cholesterol beyond BMI and waist circumference. Diabetes Metab Res Rev. 2014; 32(30): 13-23.

Vallianou NG, Evangelopoulos AA, Bountziouka V, Vogiatzakis ED, Bonou MS, Barbetseas J, Avgerinos PC, Panagiotakos DB. Neck circumference is correlated with triglyceride and inversely related with HDL-cholesterol beyond BMI and waist circumference. Diabetes Metab Res Rev. 2013; 29: 90-97.

Van Pelt RE, Evans EM, Sehechtman KB, Ehsani AA, Kohrt WM. Waist circumference vs body mass index for prediction of disease risk in post-menopausal women. Int J Obes. 2001; 25(8): 1183-1188.

Yang L, Samarasinghe YP, Kane P, Amiel SA, Aylwin SJ. Visceral adiposity is closely correlated with neck circumference and represent a significant indicator of insulin resistance in WHO grade-III obesity. Clin Endocrinol (Oxf). 2010; 73: 197-210].

Yang GR, Yuan SY, Fu HJ, Wan G, Zhu LX, Bu XL, Zhang JD, Du XP, et al. Neck circumference positively related with central obesity, overweight and metabolic syndrome in Chinese subjects with type-2

diabetes: Beijing Community Diabetes study 4. Diabetes Care. 2010; 33: 2465-2467.

www.who.int[internet]. World Health Organization: cardiovascular disease factsheet [2016 Sep 28]. Available from: http://www.who.int/cardiovasculardiseases/en.

World health Organization: waist circumference and waist-hip ratio: report of WHO expert consultation. 2008[cited 2017 Jan21]. Available from http://apps.who..int/iris/bitstream/10665/44583/1/9789241501491_eng.pdf

Zhou J, Ge H, Zhu M, Wang L, Chen Li, Tan Y, Chen Y, Zhu H. Neck circumference is an independent predictive contributor to cardio-metabolic syndrome. Cardiovascular Diabetologica. 2013; 12: 76-82.