Original Research Article

Association of Neck Circumference with Other Anthropometric Indices and Cardiovascular Risk Factors in Healthy young Adults

ABSTRACT

Objectives: To study the importance of neck circumference (NC) for the early detection of cardiovascular disease (CVD) risk factors and to determine the association of NC with other anthropometric parameters and CVD risk factors.

Methodology: This cross-sectional study was conducted from July 2018 to June 2019. Total 610 healthy young adults male and females, aged from 18 to 35 years and permanent residents of Shaheed Benazir Abad District of Sindh were randomly selected. Those who had any type of illness, known diabetes and on any medication were excluded from this study. The data was collected through pretested interview based structured questionnaire. Blood pressure was measured by using sphygmomanometer. The blood sample was collected in the morning timings while participants were fasting. The blood sample was analyzed for fasting blood sugar and lipid profile using standard kit methods and according to manufacturer's instructions. Neck circumference was measured at the upper edge of the thyroid ligament by a non-versatile measuring tape. Consent was obtained before collecting the data, SPSS 18 version was used for the statistical analysis of data.

Results: Out of total 610, 313 (51.3%) were male participants and 297 (48.7%) were female participants. In male, NC was positively correlated with SBP (r=0.589), DBP (r=0.586), FBS (r=0.358), TG (r=0.606), LDL (r=0.590) and VLDL (r=0.606), however, NC was negatively correlated with HDL-C (r=-0.434). Similarly, in female, the NC was positively correlated with SBP (r=0.552), DBP (r=0.672), FBS (r=0.437), TG (r=0.610), LDL (r=0.592) and VLDL (r=0.610) and LDL(r=0.590) however, NC was also negatively correlated with HDL-C (r=-0.-526) in females. All other CVD risk factors showed significant association with increased NC in both male and female participants.

Conclusion: Neck circumference is positively correlated with CVD risk factors in both male and female participants, NC is easy and quick to measure and it can be used as an alternative of other anthropometric parameters.

KEYWORDS: Anthropometric parameters, Neck circumference, cardiovascular diseases risk factors

INTRODUCTION

In spite of the current preventive and treatment measures cardiovascular illnesses (CVD) remains the key cause of morbidity and mortality (1). It has been estimated that CVD would cause the death of nearly 24 million by year 2023(2). It has been reported that among all the illnesses, globally, CVDs are the main leading cause of morbidity and mortality and its prevalence is increasing at alarming rate, around 80 to 86% of these deaths occurs in the low and middle income countries (LMICs)(3-6). Large population from developing countries continue to suffer from the burden of cardiac diseases, these countries include Bangladesh, India, Sri Lanka Nepal and Pakistan(5). Pakistan is a developing nation with huge burden of cardiac diseases, these diseases are mainly due obesity and other modifiable risk factors.

Modifiable risk factors are common in all age groups however, these are lesser in young adults, these factors are also highly prevalent in male and female in young adults.

In Pakistan thousands of people die each year due to cardiac diseases, it has been reported that the common illness among Pakistani adult population includes hypertension 41%, diabetes 10%, high cholesterol 17.3%, dyslipidemia (males, 34%; females, 49%) prevalence of obesity is 21% (7, 8) .

Comparatively novel parameter is NC, which has been reported as the marker for the assessment of metabolic syndrome (MetS)(9, 10), and CVD risk factors. Several studies indicate the association of CVD risk factors with age, cigarette smoking, sedentary life style and obesity (7). BMI and WC are used for the assessment of obesity, however, recently Neck Circumference, quick and easy anthropometric parameter have been reported for the assessment of MetS, obesity and CVD risk factors (9, 11-17). The purpose of this study is to assess the association of neck circumference with various CVD risk factors. Neck circumference is one the easiest and less time-consuming method to assess the overweight or obese people as compare to usual anthropometric measurement(12). Shaheed Benazirabad District is located at the northern part of the Sindh province and consists on seven Tehsils.

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MATERIAL AND METHODS:

This cross-sectional observation study was conducted on 610 healthy young adults aged 18-35 years male and females of Shaheed Benazir Abad District of Sindh. They were randomly selected from the different localities of Shaheed Benazirabad District Sindh, which include both urban and rural settings. Out of which 313 were males and 297 were female after approval of ethical committee. The purpose and procedure of the study was explained to the subjects and written consent was taken. **Inclusion Criteria:** The healthy young adults of both sexes i-e males and females aged 18-35 years. **Exclusion Criteria:** The age below 18 and above 35 were excluded from this study. Those who were suffering from CVD, known cases of diabetes mellitus and hypertension were also excluded from study. Those who were on any medication or drug addicts, pregnant or breast feeding, had a history of neck disease e.g., thyroid disorder, neck surgery or neck malignancy were also excluded from this study.

ANTHROPOMETRIC MEASUREMENTS:

Weight: It was estimated in kilograms (kg) to the closest 0.5 kg on a convenient weighing scale with the subject in light dress and without shoes. **Height:** It was estimated in centimeters (cm) to the closest 0.1 cm with the subject remaining against the vertical wall without any shoes, heels together**. BMI:** It was determined by utilizing the equation: BMI= Weight (kg)/Height (m)2 **WC:** It was estimated in cm to the closest 0.1 cm, at the umbilicus, toward the finish of expiration with individual breathing quietly. **HC:** It was estimated in cm to the closest 0.1 cm, at the degree of more prominent trochanter, with legs near one another. WhR: **NC:** It was estimated in centimeters (cm) to the closest 0.1 cm with the head erect and eyes looking ahead, evenly at the upper edge of the thyroid ligament by a non-versatile measuring tape (SECA 200)(18).

BIOCHEMICAL MEASUREMENTS:

At morning venous blood sample after an overnight fast (10-12 hours) was drawn and centrifuged for 15 minutes at 2200-2500 rpm. Fasting blood sugar was estimated by using glucose oxidase-peroxidase method (19). Lipid parameters such as total cholesterol (TG), Triglyceride (TG), high density lipoprotein cholesterol (HDL-C), low density lipoprotein cholesterol (LD-C), and very low-density lipoprotein cholesterol (VLD-C) and fasting blood glucose (FBG) were estimated by a standard enzymatic method on an autoanalyzer (Microlab 300).

RESULTS:

An observation based cross sectional study was conducted on 610 healthy young adult males and females of Shaheed Benazirabad district of Sindh, Pakistan. Among 610 healthy young adults' males were 313(51.3%) and females were 297(48.7%). Age of the health subjects were divided in three groups 18-23, 24-29, and 30-35 years, males were greater in age group 30-35 years 134(42.8%) whereas females were higher in age group 18-23 years 222(74.7%) as shown in Table 1. The mean age of male was 27.76±5.57 and mean age of female was 22.44±4.92 years. The mean BMI of males was 25.74±5.14 and of females was 24.76±4.93 Kg/m^2. The means waist circumference (WC) of males was 89.83±13.58cms and of females was 73.63±12.17cms. The mean Hip circumference (HC) of males was 96.29±11.44 and of females were 90.64±10.05cms. There is no significant difference between genders for BMI but there is significant difference between WC and HC.

Table 2 Shows Pearson's correlation between NC and others continuous variables including body weight, Height, BMI, WC, HC and Waist-hip Ratio (WHR). In male participants, Neck circumference was positively and significantly correlated ($P<0.05$) with weight (r=0.785), Height (r=0.188), BMI (r=0.816), WC (r=0.801), HC (r=0.773) and WhR (r=609). In female all other parameters were significantly ($P<0.05$) correlated such as Weight (r=0.701), BMI (r=0.763), WC (r=0.784), HC (r=0.686), WhR (r=0.463), however, height was not significantly correlated ($P>0.05$) with NC.

Table 3 shows the distribution of participants according to increased and decreased neck circumference in both male and female participants. CVD risk factors were significantly higher ($P< 0.05$) in the male participants having the neck circumference ≥36.5. Similarly, CVD risk factors were significantly higher in female participants with neck circumference ≥32.5. In male participants with increased neck circumference, FBS (≥100 mg/dl) was found 109(83.8%), SBP (≥130 mmHg) 117(88.6%), DBP (≥85 mmHg) 114(84.4%). In female participants FBS (>100 mg/dl) was found 40(58.8%), SBP (≥130 mmHg) 33(62.3%), DBP (≥85 mmHg) 49(59.8%).

The association of NC with lipid profile was also found, as in male participants with increased neck circumference, the prevalence of TC (≥200 mg/dl) was found at 87.8%, TG (≥150 mg/dl) 82.2%, HDL (≥40 mg/dl) 59.8%, LDL (≥100 mg/dl) 53.5% and VLDL (30 mg) 82.1%. In female participants all parameters of lipid profile are associated with NC except LDL. TLC (≥200 mg/dl) 53.5%, TG (≥150 mg/dl) 51.2%, HDL (≥40 mg/dl) 29.8%, VLDL (30 mg) 51.2%. These values were increased in those whose neck circumference was ≥36.5cms in male and ≥32.5cms in the female according to the Asian cut off (20).

Table 1: Socio-demographic characteristics of study subjects.

Variable Gender	Variable Age in years	Frequency	Percentages	Total
Male	18-23	81	25.9	313
	24-29	98	31.3	
	30-35	134	42.8	
Female	18-23	222	74.7	297
	24-29	37	12.5	
	30-35	38	12.8	
Total				610

Table: 2 Correlation coefficients between Neck circumference and Cardiovascular risk factors.

Variables	Male (n=313) 51.3 % Mean ± SD (Range)	Correlation (r) of NC with lipid profile, blood pressure, fasting blood sugar and anthropometric indices	Female (n=297) 48.7 % Mean ± SD (Range)	Correlation (r) of NC with lipid profile, blood pressure, fasting blood sugar and anthropometric indices
Age (years)	27.76±5.57 (18-35)	0.496**	22.44 ±4.92 (18-35)	0.469**
Weight (kg)	69.70 ± 15.77 (42-122)	0.785**	58.69 ± 13.08 (29-112)	0.701**
Height (cm)	164.11 ± 7.00 (143-188)	0.188**	156.23 ± 7.97 (135-188)	0.001
BMI (kg/m^2)	25.74 ± 5.14 (15.6-42.8)	0.816**	24.00 ± 4.93 (13.6-38.8)	0.763**
WC (cm)	89.83 ± 13.58 (63-134)	0.801**	73.63 ± 12.17 (47-107)	0.784**
HC (cm)	96.29 ± 11.44 (72-140)	0.733**	90.64± 10.05(67-124)	0.686**
Waist hip ratio	0.93 ± 0.05 (0.77-1.05)	0.609**	0.80 ± 0.08 (0.79-1.06)	0.463**
FBS (mg/dl)	103.71 ± 35.86 (65-352)	0.358**	90.91 ± 20.90 (68-332)	0.437**
SBP (mm Hg)	122.37 ± 13.35(90-160)	0.589**	113.38 ± 14.15 (70-180)	0.552**
DBP (mm Hg)	83.25± 8.72 (70-120)	0.586**	76.49± 9.36 (60-120)	0.672**
TC (mg/dl)	179.92 ± 54.50 (72-379)	0.602**	161.84 ± 52.29 (68-283)	0.672**
TG (mg/dl)	171.90± 105.89 (40-745)	0.606**	123.96 ± 68.31 (42-396)	0.610**
HDL-C (mg/dl)	34.57 ± 8.29 (10-82)	- 0.434**	36.93 ± 7.75 (12-59)	- 0.526**

LDL-C (mg/dl)	154.26 ± 56.47 (60-297)	0.590**	140.14 ± 44.57 (64-286)	0.592**
VLDL-C (mg/dl)	34.38 ± 21.17 (08-149)	0.606**	24.79 ± 13.66 (8.4-79.2)	0.610**

BMI (Body Mass Index, NC (Neck Circumference), WC (Waist Circumference), HC (Hip Circumference), FBS (Fasting Blood Sugar), SBP (Systolic Blood Pressure), DBP (Diastolic Blood Pressure), TC (Total Cholesterol), TG (Triglyceride), LDL-C (Low Density Lipoprotein Cholesterol), HDL-C (High Density Lipoprotein Cholesterol), VLDL-C (Very Low Density Lipoprotein Cholesterol), SD (Standard Deviation), r (Pearson's Correlation Coefficient), *p<0.01,(Significant), **<0.001 (very Significant

Table 3. Association of Neck Circumference with lipid profile, Fasting Blood sugar and Blood pressure.

CVD risk factors	MALE		X^2	P-VALUE	FEMALE		X^2	P-VALUE
	<36.5 (152) 48.6%	≥36.5 (161) 51.4%			<32.5(240) 80.8%	≥32.5(57) 19.2%		
FBS								
<100	131 (71.6)	52(28.4)	93.49	<.0001	212 (92.6)	17 (7.4)	89.31	<.0001
≥100	21(16.2)	109 (83.8)			28 (41.2)	40 (58.8)		
SBP			126.44	<.0001			77.17	<.0001
<130	137 (75.7)	44 (24.3)			220 (90.2)	24 (9.8)		
≥130	15 (11.4)	117 (88.6)			20 (37.7)	33 (62.3)		
DBP			103.53	<.0001			120.18	<.0001
<85	131 (73.6)	47 (26.4)			207 (96.3)	08 (3.7)		
≥85	21 (15.6)	114 (84.4)			33 (40.2)	49 (59.8)		
CHOLE:			107.28	<.0001			91.81	<.0001
<200	137 (72.1)	53 (27.9)			200 (94.8)	11 (5.2)		
≥200	15 (12.2)	108 (87.8)			40 (46.5)	46 (53.5)		
TG			103.61	<.0001			79.78	<.0001
<150	126 (75.4)	41 (24.6)			198 (93.8)	13 (6.2)		
≥150	26 (17.8)	120 (82.2)			42 (48.8)	44 (51.2)		
HDL			31.25	<.0001			37.08	<.0001
<40	54 (78.3)	15 (21.7)			108 (99.1)	01 (0.9)		
≥40	98(40.2)	146 (59.8)			132 (70.2)	56 (29.8)		
LDL			3.56	<.059			2.06	<.151
<100	25 (62.5)	15 (37.5)			16 (94.1)	01 (5.9)		
≥100	127(46.5)	146 (53.5)			224 (80.0)	56 (20.0)		

VLDL			101.47	<.0001			77.32	<.0001
<30	126 (75.0)	42 (25.)			199 (93.4)	14 (6.6)		
≥30	26 (17.9)	119 (82.1)			41 (48.8)	43 (51.2)		

DISCUSSION:

The present study indicates the connection between the variations in NC and variations of few variables of the CVD factors. The cut off of 36.50cm in males and 32.50cm in females from the population of Asian Indian origin were used in this study (20). Many studies are conducted on anthropometric measurement but no any studies are conducted to compare the NC with other anthropometric measurement and its association with CVDs risk factors in Pakistan discussion

The current study shows a correlation between neck circumference (NC) and cardiovascular disease (CVD) risk factors in addition to the variations in NC and these factors. NC was positively correlated with BMI, WC, HC, waist hip ratio. NC also showed positive correlation with FBS, SBP, DBP, lipid profile (TC, TG, LDL-C and VLDL-C). However,

HDL-C negatively and significantly correlated with neck circumference, however this finding is not consistent with other study, which reports non-significant correlation with NC (21).

In this study, there is moderately positive correlation of NC with age in both genders (male, r=0.496 and females, r=0.469) but according to Qun Yan et al NC was negatively weak correlation with age in men (r= -0.08, *p*=009), (22), Chaitanya Patil et al has showed that there is nonsignificant weak correlation of NC with age in males (r=0.119, p=0.10) but in females it was negatively weak nonsignificant (r=0.006, p=0.92) this difference in correlations may be due to the difference in age groups <20 and >60 (20). The positive correlation of NC with height in males (r=0.188, *p*=<0.001), but it was negative correlation of NC with height in other study (r=-0.21, *p*=<0.001) (21).

There is a strongly positive correlation of NC with BMI in males (0.816, *p*=<0.001) but in females it is moderately positive correlation (0.763, *p*=<0.001), same results are showed by others as Ben noun et al has found that the correlation between NC and body mass index in males and females was (r=0.828, *p*=<0.000) and (r=0.710, *p*=<0.000) respectively (21), according to Qun Yan, the neck circumference was correlated with BMI (r=0.70, p=0.000 and r=0.73, p=0.000) in men and women respectively (22). The study conducted by Hingorjo in Karachi has showed that the correlation of NC with BMI was strongly positive in males

(r=0.861) whereas it was moderately positive in females (r=0.703), (23) almost results are comparable in this study. Ismail Ozkaya et al has showed positive correlation of NC with BMI (r=0.684, *p*=0.01) and (r=0.482, *p*=0.01) in males and females respectively (16).

Correlation of NC with waist circumference is strongly positive in both genders (males, r=0.801, *p*=<0.001 and females, r=0.784, *p*=<0.001), according to Qun Yan, the neck circumference was correlated with waist circumference (r=0.73, p=0.000 and r=0.72, p=0.000) in males and females respectively (22), Chaitanya Patil et al has showed that there is significantly positive correlation of NC with waist circumference in males (r=0.556, p=<0.01) but in females it was (r=0.614, p=<0.01) whereas NC is more higher in females than in males (20), Ismail Ozkaya et al has also showed positive correlation of NC with waist circumference (r=0.686, *p*=0.01) and (r=0.479, *p*=0.01) in males and females respectively in this study NC was greater in males than females this difference may be due to the to reason that number studied subjects males (319) and (838) females (16)

Correlation of NC with hip circumference is significantly positive (males, r=0.733, *p*=<0.001 and females, r=0.686, *p*=<0.001), Chaitanya Patil et al has showed that there is significantly positive correlation of NC with hip circumference in males (r=0.519, p=<0.01) and (r=0.519, p=<0.01) in females (20), Ismail Ozkaya et al has also showed positive correlation of NC with hip circumference (r=0.646, *p*=0.01) and (r=0.556, *p*=0.01) in males and females respectively (16).

Correlation of NC with waist/hip ratio is (r=0.609, *p*=<0.001) in males and (r=0.463, *p*=<0.001) in females. Ismail Ozkaya et al has also showed positive correlation of NC with waist/hip ratio (r=0.646, *p*=0.01) and (r=0.246, *p*=0.01) in males and females respectively, but there was weak correlation in females (16).

Furthermore, in this study a positively significant correlation between NC and SBP was found in both genders (male, r=0.589, females, r=552) and correlation between NC and DBP was (male, r=0.586, females, r=672) *p*=0.001 for both genders. Similar results were showed by the Alfadhli et al, they have observed a positively significant correlation between NC and SBP in males (r=0.4, p=<0.01) and females (r=0.1, p=<0.05) same for DBP in males (r=0.1 p=<0.01 but in females it was negatively nonsignificant r= -0.03 (24). Ben has find out the correlation of NC with SBP and DBP as (male, r=0.53, females, r=69) and (male, r=0.55, females, r=65) *p*=0.0001for both factors (25). But correlation of NC was weakly positive with SBP and DBP in a study (male, r=0.250, females, r=0.225) and (male, r=0.261, females, r=189) *p*=>0.01 (26).

There is a weak positive correlation of NC with fasting blood sugar (males, r=0.358, females, r=0.437), but it was significantly very weak in males and non-significant strong in females in a study conducted by the (24) in which (males, r=0.1, females, r=0.6), blood sugar was took

randomly. According to the Ben-Noun et al the correlation of NC with FBS was (male, r=0.21, p=0.001and females, r=0.44, p=0.0001) (25), in another study it was very weakly positive correlation (male, r=0.177, p=<0.01and females, r=0.180, p=<0.05) (26).

The correlation of NC with lipid profile was positively significant with all except HDL-C, whereas NC was significant negatively correlated with HDL-C. According to the Ben-Noun et al the correlation of NC with lipid profile was also significantly positive with all except HDL- C like current study but NC was very weakly nonsignificant negative correlated (males, r= -0.09, p=0.192, females, r= -0.07, p=0.178) with HDL-C (25). Zhou et al found the weakly positive correlation of NC with lipid profile significant with all except HDL-C, like current study NC was also significant negatively correlated with HDL-C (26).

In this study NC was strongly correlated to other anthropometric parameter such as BMI, WC, HC and Waist-hip ratio and risk factors for CVD such as BSF, SBP, DBP, and lipid profiles elevated level from normal shows more than 50% NC was abnormal $\geq$ 36.5 cm in male and $\geq$32.5 cm in female according to Asian cut of value. Abnormal NC was found more in percentage in male than female.

Many people die every year in Pakistan due to many cardiac diseases. This study shows strongly correlation between NC and CVD risk factors in healthy young adults. So, NC is simple safe, non-invasive technique for early detection of CVD risk factors. Therefore, very good number of morbidity and mortality due to CVD can be prevented.

Conclusion: NC was strongly associated with other anthropometric indices and in elevated CVD risk factors. So, neck circumference is an independent index for early finding of CVD risk factors in healthy young adults.

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