

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 including, Socio-demographic, Anthropometric and Biochemical was collected through interview based structured questionnaire which was designed through review of literature of previous studies. 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.

Apparently healthy young adults may have CVD related multiple risk factors. Therefore if these risk factors are screened as early as possible then these young adults can be prevented from CVDs and promoted their health life style (7, 8). 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 34% in male and 49% in females, obesity is 21% so obesity as one of the common illnesses among Pakistani adult population (9, 10) .

Comparatively novel parameter is neck circumference (NC), which has been reported as the marker for the assessment of metabolic syndrome (MetS)(11, 12), and CVD risk factors. Several studies indicate the association of CVD risk factors with age, cigarette smoking, sedentary life style and obesity (9). BMI and WC are widely used for the assessment of obesity, however, recently Neck Circumference, which is a quick and easy anthropometric parameter have been reported for the assessment of MetS, obesity and CVD risk factors (11, 13-19). 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(14). Shaheed Benazirabad District is located at the northern part of the Sindh province and consists on seven Tehsils.

The novelty of this research is different from other studies is this that, cut off values of neck circumference for this study have been taken from an Indian research paper which describes only association of Basal Metabolic Index (BMI) and Waist Circumference (WC) with neck circumference. However this study has further established the association between already described factors and some other CVD factors which were not given in the Indian research

paper as Age, Height, Weight, Waist –to-Hip Ratio, Lipid profile, Fasting Blood Sugar and Blood Pressure (20)

MATERIAL AND METHODS:

This observational cross-sectional study was carried out on 610 male and female healthy young adults living in Shaheed Benazir Abad District of Sindh whose age was 18-35 years.

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 genders i-e males and females aged 18-35 years. **Exclusion Criteria:** The age below 18 and above 35 were excluded from this study. The screening or examination

procedures that were carried out before confirming and excluding these cases from the 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 containing height chart in centimeters, without any shoes, heels together. **Body Mass Index (BMI):** It was determined by utilizing the equation $BMI = \text{Weight (kg)} / \text{Height (m)}^2$. **Waist circumference (WC):** It was estimated in cm to the closest 0.1 cm, at the umbilicus, toward the finish of expiration with individual breathing quietly. **Hip Circumference (HC):** It was estimated in cm to the closest 0.1 cm, at the degree of more prominent trochanter, with legs near one another by using stretchable measuring tape. **Waist-to-Hip Ratio (WHR):** The waist to hip ratio was determined by dividing waist circumference with hip circumference $WHR = \text{waist circumference} / \text{hip circumference}$. **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)(21).

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 (22). 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%). The healthy subjects were divided into three age groups 18-23, 24-29, and 30-35 years, the number of males was greater in age group 30-35 years 134(42.8%) whereas the number females was higher in age group 18-23 years 222(74.7%) as shown in Table 1. The mean age of males was 27.76 ± 5.57 years and mean age of females was 22.44 ± 4.92 years. The mean BMI of males was 25.74 ± 5.14 Kg/m² and of females was 24.76 ± 4.93 Kg/m². The means waist circumference (WC) of males was 89.83 ± 13.58 cms and of females was 73.63 ± 12.17 cms. The mean Hip circumference (HC) of males was 96.29 ± 11.44 cms and of females were 90.64 ± 10.05 cms. 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 subjects, neck circumference was weakly positively correlated with height ($r=0.188$), strongly correlated with weight ($r=0.785$) strongly correlated with BMI ($r=0.816$), strongly correlated with WC ($r=0.801$), strongly correlated with HC ($r=0.773$) and strongly correlated WHR ($r=0.609$). Where as in female subjects neck circumference was positively moderate correlated with WHR ($r=0.463$) and positive strongly correlated with weight ($r=0.701$), BMI ($r=0.763$), WC ($r=0.784$), HC ($r=0.686$). All values are significant, however height was not significantly correlated with NC in females ($P>0.05$).

In Table 3 Chi square revealed significant difference in frequencies of neck circumference categories ($p<0.05$). FBS (≥ 100 mg/dl), increased SBL (≥ 130 mmHg), DBP(≥ 85 mmHg), Cholesterol (≥ 200 mg/dl) TG (≥ 150 mg/dl), HDL (<40 mg/dl), LDL (≥ 100 mg/dl), VLDL (≥ 30 mg/dl) with increased NC (>36.5 cm in male. However no significant ($p>0.05$) association of LDL. Chi square also revealed significant difference in frequencies of neck circumference categories ($p<0.05$). FBS (≥ 100 mg/dl), increased SBL (≥ 130 mmHg), DBP(≥ 85 mmHg), Cholesterol (≥ 200 mg/dl) TG (≥ 150 mg/dl), HDL (<40 mg/dl), LDL (≥ 100 mg/dl), VLDL (≥ 30 mg/dl) with increased NC (>32.5 cm in females. However no significant ($p>0.05$) association of LDL.

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. The values of TLC (≥ 200 mg/dl) 53.5%, TG (≥ 150 mg/dl) 51.2%, HDL (≥ 40 mg/dl) 29.8% and VLDL (30 mg) 51.2% were increased in those whose neck circumference was ≥ 36.5 cms in males and ≥ 32.5 cms in the females according to the Asian cut off (20).

Table 1: Distribution of participants according to age and gender.

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 \pm SD (Range) Correlation (r) of NC with lipid profile, blood pressure, fasting blood sugar and anthropometric indices		Female (n=297) 48.7 % Mean \pm SD (Range) Correlation (r) of NC with lipid profile, blood pressure, fasting blood sugar and anthropometric indices	
Age (years)	27.76 \pm 5.57 (18-35)	0.496**	22.44 \pm 4.92 (18-35)	0.469**
Weight (kg)	69.70 \pm 15.77 (42-122)	0.785***	58.69 \pm 13.08 (29-112)	0.701***
Height (cm)	164.11 \pm 7.00 (143-188)	0.188*	156.23 \pm 7.97 (135-188)	0.001
BMI (kg/m ²)	25.74 \pm 5.14 (15.6-42.8)	0.816***	24.00 \pm 4.93 (13.6-38.8)	0.763***
WC (cm)	89.83 \pm 13.58 (63-134)	0.801***	73.63 \pm 12.17 (47-107)	0.784***
HC (cm)	96.29 \pm 11.44 (72-140)	0.733**	90.64 \pm 10.05(67-124)	0.686***
WHR	0.93 \pm 0.05 (0.77-1.05)	0.609**	0.80 \pm 0.08 (0.79-1.06)	0.463**
FBS (mg/dl)	103.71 \pm 35.86 (65-352)	0.358**	90.91 \pm 20.90 (68-332)	0.437**
SBP (mm Hg)	122.37 \pm 13.35(90-160)	0.589**	113.38 \pm 14.15 (70-180)	0.552**
DBP (mm Hg)	83.25 \pm 8.72 (70-120)	0.586**	76.49 \pm 9.36 (60-120)	0.672***
TC (mg/dl)	179.92 \pm 54.50 (72-379)	0.602***	161.84 \pm 52.29 (68-283)	0.672***
TG (mg/dl)	171.90 \pm 105.89 (40-745)	0.606***	123.96 \pm 68.31 (42-396)	0.610***
HDL-C (mg/dl)	34.57 \pm 8.29 (10-82)	- 0.434**	36.93 \pm 7.75 (12-59)	- 0.526**
LDL-C (mg/dl)	154.26 \pm 56.47 (60-297)	0.590**	140.14 \pm 44.57 (64-286)	0.592**
VLDL-C (mg/dl)	34.38 \pm 21.17 (08-149)	0.606***	24.79 \pm 13.66 (8.4-79.2)	0.610***

*SD (Standard Deviation), r (Pearson's Correlation Coefficient), BMI= Body Mass Index, WC= Waist Circumference, HC= Hip Circumference, WHR= Waist-to-Hip Ratio, FBS= Fasting Blood Sugar, SBP= Systolic Blood Pressure, DBP= Diastolic Blood Pressure, TC= Total Cholesterol, TG= Triglycerides, HDL-C= High Density Lipoprotein Cholesterol, LDL-C= Low Density Lipoprotein Cholesterol, VLDL-C= Very Low Density Lipoprotein Cholesterol. Weak correlation= 0.1-0.39, Moderate correlation= 0.4-0.59, Strong correlation= >0.6. *P<0.05 Significant, **P<0.01 Very significant, ***P<0.001 Extremely 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 ≥100 mg/dl	131 (71.6) 21(16.2)	52(28.4) 109 (83.8)	93.49	<.0001	212 (92.6) 28 (41.2)	17 (7.4) 40 (58.8)	89.31	<.0001
SBP <130 ≥130 mmHg	137 (75.7) 15 (11.4)	44 (24.3) 117 (88.6)	126.44	<.0001	220 (90.2) 20 (37.7)	24 (9.8) 33 (62.3)	77.17	<.0001
DBP <85 ≥85 mmHg	131 (73.6) 21 (15.6)	47 (26.4) 114 (84.4)	103.53	<.0001	207 (96.3) 33 (40.2)	08 (3.7) 49 (59.8)	120.18	<.0001
CHOLE: <200 mg/dl ≥200	137 (72.1) 15 (12.2)	53 (27.9) 108 (87.8)	107.28	<.0001	200 (94.8) 40 (46.5)	11 (5.2) 46 (53.5)	91.81	<.0001
TG <150 ≥150 mg/dl	126 (75.4) 26 (17.8)	41 (24.6) 120 (82.2)	103.61	<.0001	198 (93.8) 42 (48.8)	13 (6.2) 44 (51.2)	79.78	<.0001
HDL <40 mg/dl ≥40	54 (78.3) 98(40.2)	15 (21.7) 146 (59.8)	31.25	<.0001	108 (99.1) 132 (70.2)	01 (0.9) 56 (29.8)	37.08	<.0001
LDL <100 mg/dl ≥100	25 (62.5) 127(46.5)	15 (37.5) 146 (53.5)	3.56	>.05	16 (94.1) 224 (80.0)	01 (5.9) 56 (20.0)	2.06	>.05
VLDL <30 mg/dl ≥30	126 (75.0) 26 (17.9)	42 (25.) 119 (82.1)	101.47	<.0001	199 (93.4) 41 (48.8)	14 (6.6) 43 (51.2)	77.32	<.0001

FBS= Fasting Blood Sugar, SBP= Systolic Blood Pressure, DBP= Diastolic Blood Pressure, TC= Total Cholesterol, TG= Triglycerides, HDL-C= High Density Lipoprotein Cholesterol, LDL-C= Low Density Lipoprotein Cholesterol, VLDL-C= Very Low Density Lipoprotein Cholesterol. P<0.0001 (Extremely significant), X²= Chi square.

DISCUSSION:

Evidence has shown that raised serum triglycerides, BMI, WC and reduced level of HDL are strongly reflect the elevated neck circumference (NC)(23). The present study indicates the connection between the variations in NC and variations of few variables of the CVD factors. The cut off of 36.50 cm in males and 32.50 cm in females from the population of Asian Indian origin were used in this study (20). Many studies on anthropometric measurement have been undertaken, but none have compared NC to other anthropometric measurements or its relationship with CVD risk factors in Pakistan. Hingorjo- et al has conducted study in youngsters (18-20 years) to find out the Neck Circumference as marker of obesity but he did

not compared with lipid profile, Fasting blood sugar and Blood pressure (24) 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. Few studies have exclusively investigated modifiable CVD risk factors among young adults (25)

Neck circumference was positively correlated with BMI, WC, HC, waist-to-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 (26).

In this study, there is moderate 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 had a negative weak correlation with age in men ($r= -0.08$, $p=0.09$), (27). Chaitanya Patil et al has showed that there is non-significant weak correlation of NC with age in males ($r=0.119$, $p=0.10$) but in females non-significant negative weak correlation was observed ($r=0.006$, $p=0.92$). This difference in correlations may be due to the difference in age groups <20 and >60 (20). A positive correlation of NC with height in males ($r=0.188$, $p<0.001$), but a negative correlation of NC with height occurred in another study ($r=-0.21$, $p<0.001$) (26).

There is a strongly positive correlation of NC with BMI in males (0.816 , $p<0.001$) but in females it had a moderately positive correlation (0.763 , $p<0.001$). Similarly, Ben noun et al reported 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 (26). Also, 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 (27). 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 ($r=0.703$) (28), thereby having practically the same results with this study. Ismail Ozkaya et al has also 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 (18).

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 (27), 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 of males ($r=0.686$, $p=0.01$) and females ($r=0.479$, $p=0.01$). NC was also shown

to be higher in males than females in their study. This disparity could be attributed to the fact that there were 319 males and 838 females among the subjects investigated (18). Correlation of NC with hip circumference was significantly positive in this study (males, $r=0.733$, $p<0.001$ and females, $r=0.686$, $p<0.001$). In line with this, 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 (18).

Correlation of NC with waist-to-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 (18).

Furthermore, in this study a positively significant correlation between NC and SBP was found in both genders (male, $r=0.589$, females, $r=0.552$) and correlation between NC and DBP was (male, $r=0.586$, females, $r=0.672$) $p=0.001$ 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 $r= -0.03$ (29). Ben has find out the correlation of NC with SBP and DBP as (male, $r=0.53$, females, $r=0.69$) and (male, $r=0.55$, females, $r=0.65$) $p=0.0001$ for both factors (30). 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, $r=0.189$) $p>0.01$ (31).

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 (29) 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, $r=0.21$, $p=0.001$ and females, $r=0.44$, $p=0.0001$) (30), in another study it was very weakly positive correlation (male, $r=0.177$, $p<0.01$ and females, $r=0.180$, $p<0.05$) (31).

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 (30). 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 (31).

In this study NC was strongly correlated to other anthropometric parameter such as BMI, WC, HC and Waist-to-hip ratio and risk factors for CVD such as BFS, SBP, DBP, and lipid profiles elevated level from normal shows more than 50% NC was abnormal ≥ 36.5 cm in male and ≥ 32.5 cm in female according to Indian Asian cut off values. 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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