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Original Article

Association of Neck Circumference with Body Composition and Cardiovascular Parameters in Young Healthy Adult Males

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ABSTRACT

Background and Aim: Increased Neck circumference is the marker of upper body obesity and identified as an indicator of future cardiovascular disease risk (CVD). Hence, in this study, we assessed the relationship of Neck circumference (NC) with basal cardiovascular and body composition (BC) parameter in young adult males. **Methods:** Sixty three healthy young adult male volunteers of age between 18 to 25 years were enrolled for this study and they were divided into two groups based on neck circumference (NC). Control group (n = 32) comprises of individuals with normal neck circumference of ≤ 35.5 cm and study group (n = 31) includes individuals with increased neck circumference of ≥ 35.5 cm. The, BC parameters was assessed by Bioimpedance Analysis (BIA) method using Quadscan 4000. And the basal cardiovascular parameters such as systolic blood pressure (SBP), diastolic blood pressure (DBP), heart rate (HR) was measured by automated sphygmomanometer and the pulse pressure (PP), mean arterial pressure (MAP) and the rate pressure product (RPP) were derived. **Results:** Data was expressed in Mean ± SD. The groups were compared using Independent Student's t test. The association between NC and various study parameters were assessed by Pearson's correlation analysis. Our study, revealed increased body fat and reduced muscle mass in individuals with increased NC. Further, we observed a positive correlation of NC with body fat (%) and negative correlation with Lean Body Mass. Cardiovascular parameters SBP, DBP, MAP and PP were elevated in subjects with increased NC. Further, positive correlation is seen with SBP, DBP, RPP and NC. **Conclusion:** Neck circumference is a readily measurable screening tool of upper-body adiposity and increased NC is associated with CVD risk.

Key words: Neck circumference, Body composition, Cardiovascular Parameters, Adult males, Healthy population.

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INTRODUCTION

Cardiovascular disease (CVD) is one of the leading causes of mortality globally and also in India.[1] Multiple risk factors are attributed to the development of CVD in Asian Indians. Among the determinants, obesity is considered as prime factor in the genesis of the disease. Obesity is conventionally measured by body mass index (BMI), waist circumference (WC) and skinfold thickness.[2] Substantial research evidence has proved that high BMI and increasing waist circumference are associated with cardiovascular disease risk.[3] Localized fat accumulation at other region of the body and its impact on cardiovascular disease risk is not explored much. Yan *et al* has revealed that excess subcutaneous adipose tissue accumulation in the neck is associated with glucose intolerance, hyperinsulinemia, hypertriglyceridemia, gout, uric acid calculus compared to lower body obesity.[4] NC is also positively correlated with WC and BMI.[5]

Normal neck circumference in healthy male is <35.5 cm.[6] Increased NC is an index of upper body fat accumulation and upper body obesity[6] whereas waist circumference indicate central fat distribution and BMI represent generalized body fat distribution.[6] Elevated neck circumference is identified as a new marker of CV risk and an alternative tool for screening cardiovascular disease among adults.[4] There is dearth of data on NC and CV risk in South Indian population. Hence, this study was undertaken to measure the CVD risk by measuring basal cardiovascular parameter and BC variables in apparently healthy young adults with normal and increased neck circumference and to find the association of NC with cardiovascular and BC parameters. Body composition (BC) analysis using bio-impedance principle is a reliable test to estimate adiposity of a person.

MATERIALS AND METHODS

Study Design and Sample Size

This cross-sectional analytical study was conducted in 63 apparently healthy male volunteers in age group

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18 - 25 years. The study was approved by the Institutional Human Ethics committee (approval ref: JIP/IEC/2020/023) dated 25.04.2020, and ethical guidelines were followed throughout the study. Written informed consent was obtained from all the participants after explaining the study procedure. The study was conducted in Department of Physiology.

Inclusion and Exclusion Criteria

Inclusion criteria

In this study, Apparently healthy young adult males of 18 to 25 years were enrolled. Control group (n = 32) comprises of individuals with normal neck circumference of ≤ 35.5 cm and study group (n = 31) includes individuals with increased neck circumference of ≥ 35.5 cm. Group classification was done based on the previous Indian study.[6]

Exclusion criteria

Subjects with comorbidities like diabetes mellitus, hypertension, cardiac disease, thyroid disorders and with history of neck abnormality, organic or psychiatric disorder, alcohol/tobacco abuse and trained athletes were excluded.

Anthropometric Measurements

Height (in centimeters) was recorded, using a stadiometer – Easy care™ (NO: 26 SM) mounted on the wall. The subjects were instructed to wear loose clothing and remove the footwear. Subjects were made to stand erect, facing the researcher, with their arms hanging freely on the sides, gluteal region, shoulder blade, and occipital protuberance touching the wall and their head aligned in the Frankfort plane. Height was measured to the nearest 0.1 cm. Bodyweight was measured to the nearest 0.5 kg using digital weighing machine – Charder Electronics, Taichung, Taiwan 2013. Prior to the measurement the subjects were instructed to empty their pockets and to remove their footwear. The subject was instructed to stand erect and arms abducted from their body and waist circumference (in centimeters) and hip circumference (in centimeters) were measured in the horizontal plane using non elastic measuring tapes. Waist circumference (WC) was taken midway between the lowest ribs and the iliac crest, at the end of tidal expiration. Hip circumference (HC) was measured at around the widest portion of the gluteal region.[7] The neck circumference was measured as the distance around the neck in a horizontal plane at the level of the most prominent portion of the thyroid cartilage (Adam's apple) with the head held in erect position and eyes facing forward.[8] International Society for Advancement of Kinantropometry protocol was followed for the measurement of all anthropometric parameters.[7]

Body Composition Analysis

BC parameters were analyzed by using a multifrequency bioelectrical impedance analysis (BIA) method using Bodystat QuadScan 4000 (Bodystat) device. It is a quick, simple and noninvasive procedure. Measurements were taken as per standard protocol.[9] The subjects were asked to lie down in supine position and four surface electrodes were attached. Two signal introducing electrodes were placed on the right dorsum of hand and foot close to metacarpophalangeal and metatarsophalangeal joints respectively. Two voltage sensing electrodes were applied on the right side, pisiform prominence of the wrist and in the foot, between medial and lateral malleolus of the ankle, through which an imperceptible electrical current was sent through the body. The recording was done after 10 min of supine rest, the participants detail such as the height, weight, HC and WC were entered in the device. Impedance was measured from resistance and reactance. BIA parameters were obtained, by using in-built predictive equations of the equipment.[10]

Cardiovascular Parameters

Basal Cardiovascular parameters were measured by automated sphygmomanometer – AccuSure™ (TMB1490-A). The participants were made to sit in an upright posture in an armed chair and the Riva Rocci cuff was tied on the arm, 2cm above the cubital fossa, with the cuff being neither tight nor too loose. After 5 min of rest, the blood pressure and heart rate were recorded. From SBP, DBP & HR, PP (PP = SBP – DBP); MAP (MAP = DBP+ 1/3 PP) and RPP (RPP = SBP * HR* 10^{-2}) were derived.

Statistical Analysis of Data

Statistical analysis was done in IBM SPSS version 21.0 (Statistical package for social sciences – SPSS Software Inc., Chicago, IL, USA). The normality of data was analyzed using Kolmogorov–Smirnov normality test. Values were expressed as Mean ± Standard Deviation (SD), as all the study parameters were distributed normally. Comparison of body composition parameters, cardiovascular parameters between the two groups (increased neck circumference and normal neck circumference group) was done using unpaired Student's t test. The association of neck circumference (NC) with various study parameters such as BC and cardiovascular parameters were tested by the Pearson's correlation analysis. All statistical analysis was carried out at 5% level of significance and P value <0.05 was considered as statistically significant.

RESULTS

Table 1 shows the comparison of body composition parameters between young adults with increased neck circumference and normal neck circumference group. There was no significant difference in age between two groups (P = 0.202). All anthropometric indices like weight (P < 0.001), waist circumference (P < 0.001), hip circumference (P < 0.001), BMI (P < 0.001), waist-hip ratio (P = 0.006), were significantly higher in increased neck circumference group compared to that of control group. Body composition parameters like body fat (P < 0.001), dry lean mass (P < 0.001), body cell mass (P < 0.001), BFMI (P < 0.001), FFMI (P < 0.001) and phase angle (P = 0.017) were found to be significantly higher in increased neck circumference group compared to that of control group. Whereas, lean weight (P < 0.001) was found to be significantly lower in increased neck circumference group compared to that of control group.

Table 2 shows the comparison of cardiovascular parameters between young adults with increased neck circumference and normal neck circumference group. SBP (P = 0.003), DBP (P = 0.042) and MAP (P = 0.011) and PP (P = 0.005) were significantly higher in the increased neck circumference group compared to that of control group.

Table 3 shows the correlation of neck circumference with body composition parameters. In our study, weight (Kg) (r = 0.859, P <0.001), waist (cm) (r = 0.796, P <0.001), hip (cm) (r = 0.788, P <0.001), BMI (kg/m^2) (r = 0.818, P <0.001), WHR (r = 0.496, P <0.001), Body fat (%) (r = 0.671, P <0.001), dry lean mass (Kg) (r = 0.734, P <0.001), body cell mass (kg) (r = 0.671, P <0.001), BFMI (Kg m^{-2}) (r = 0.734, P <0.001) and FFMI (Kg m^{-2}) (r = 0.802, P = 0.001) were found to be significantly positive correlated with neck circumference and lean weight (%) (r = -0.671, P <0.001) was significantly negatively correlated with neck circumference.

Table 4 shows the correlation of neck circumference with cardiovascular parameters. In our study, SBP (r = 0.389, P = 0.002), DBP (r = 0.325, P = 0.009), MAP (r = 0.369, P = 0.003), PP (r = 0.317, P = 0.011) and RPP (r = 0.291, P = 0.021) were found to be significantly positive correlated with neck circumference.

Table 1: Comparison of anthropometric and body composition parameters between young adults with increased neck circumference and normal neck circumference group.

Parameters	Control group Normal neck circumference (n=32)	Study group Increased neck circumference (n=31)	Test statistics	P value
Age (Years)	20.16 ± 1.19	20.58 ± 1.40	-1.291	0.202
Weight (Kg)	58.99 ± 7.28	81.93 ± 16.50	-7.098	<0.001
Height (cm)	172.05 ± 6.73	173 ± 7.67	-7.195	<0.001
Waist (cm)	77.17 ± 5.60	93.58 ± 13.79	-6.147	<0.001
Hip (cm)	88.45 ± 5.60	103 ± 11.40	-6.390	<0.001
BMI (kg/m^2)	19.98 ± 2.74	27.34 ± 5.01	-7.195	<0.001
WHR	0.87 ± 0.04	0.90 ± 0.04	-2.870	0.006
Lean Weight (%)	84.89 ± 3.46	78.90 ± 6.41	-4.584	<0.001
Body Fat (%)	15.10 ± 3. 46	21.09 ± 6.41	-4.584	<0.001
Dry Lean Mass (Kg)	14.01 ± 3.92	21.18 ± 3.56	-7.585	<0.001
Body Cell Mass (Kg)	28.84 ± 2.77	35.53 ± 4.52	-7.045	<0.001
BFMI (Kg m^{-2})	3.04 ± 0.92	6.06 ± 3.03	-5.297	<0.001
FFMI (Kg m^{-2})	16.97 ± 2.24	21.29 ± 2.16	-7.783	<0.001
Phase Angle (degree)	6.14 ± 0.69	6.62 ± 0.85	-2.462	0.017

Data are expressed as mean±SD. BMI: Body mass index; WHR: Waist to hip ratio; BFMI: Body fat mass index; FFMI: Fat free mass index. BMI: Weight (kg)/ height (m^2); WHR: Waist (cm) / hip (cm); BFMI: Body fat (Kg) / height (m$^{2)}$; FFMI: Lean weight (Kg) / height (m^2). P<0.05 is considered as statistically significant.

Table 2: Comparison of cardiovascular parameters between young adults with increased neck circumference and normal neck circumference group.

Cardiovascular Parameters	Control group Normal neck circumference (n=32)	Study group Increased neck circumference (n=31)	Test statistics	P value
Mean HR (ms)	71.06 ± 8.51	72.06 ± 13.22	-0.359	0.721
SBP (mm Hg)	112.75 ± 6.63	120.18 ± 11.84	-3.08	0.003
DBP (mm Hg)	69.78 ± 4.87	72.96 ± 7.14	-2.07	0.042
MAP (mm Hg)	84.10 ± 4.96	88.70 ± 8.48	-2.63	0.011
PP (mm Hg)	42.97 ± 5.12	47.22 ± 6.30	-2.94	0.005
RPP (mm Hg/min)	79.97 ± 11.06	86.43 ± 19.89	-1.58	0.120

Data are expressed as mean±SD. HR: Heart rate; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; MAP: Mean arterial pressure; PP: Pulse pressure; RPP: Rate pressure product. P<0.05 is considered as statistically significant.

Table 3: Correlation of neck circumference with body composition parameters.

Body composition parameters	Neck circumference (n=63)	
	r	P value
Weight (Kg)	0.859	<0.001
Waist (cm)	0.796	<0.001
Hip (cm)	0.788	<0.001
BMI (kg/m^2)	0.818	<0.001
WHR	0.496	<0.001
Lean Weight (%)	-0.671	<0.001
Body Fat (%)	0.671	<0.001
Dry Lean Mass (Kg)	0.734	<0.001
Body Cell Mass (Kg)	0.802	<0.001
BFMI (Kg m^{-2})	0.671	<0.001
FFMI (Kg m^{-2})	0.734	<0.001
Phase Angle (degree)	0.233	0.066

BMI: Body mass index; WHR: Waist – to – hip ratio; BFMI: Body fat mass index; FFMI: Fat free mass index. BMI: Weight (Kg)/ height (m^2); WHR: Waist (cm) / hip (cm); BFMI: Body fat (Kg) / height (m$^{2)}$; FFMI: Lean weight (kg) / height (m^2). P<0.05 is considered as statistically significant correlation.

Table 4: Correlation of neck circumference with cardiovascular parameters.

Cardiovascular Parameters	Neck circumference (n=63)	
	r	P value
Mean HR (beats per min)	0.173	0.175
SBP (mm Hg)	0.389	0.002
DBP (mm Hg)	0.325	0.009
MAP (mm Hg)	0.369	0.003
PP (mm Hg)	0.317	0.011
RPP (mm Hg/min)	0.291	0.021

HR: Heart rate; BP: Systolic blood pressure; DBP: Diastolic blood pressure; MAP: Mean arterial pressure; PP: Pulse pressure; RPP: Rate pressure product. P<0.05 is considered as statistically significant correlation.

DISCUSSION

The objective of the study was to explore the impact of increased neck circumference on cardiovascular diseases risk in young healthy adult male subjects. In our study, the mean age was comparable between normal and increased neck circumference group. Weight, waist circumference, hip circumference, WHR and BMI was found to be significantly increased in the individual with increased neck circumference when compared to the control group. BMI alone is not a good prognostic indicator, as it fails to differentiate the tissue mass into fat mass and fat-free mass.[10,11]

Hence in our study, we have measured the body composition by BIA technique to study the different tissue compartments. BC analysis revealed, higher fat percentage, dry lean mass (DLM), body cell mass, BFMI, FFMI, phase angle and reduced lean body mass (LBM) in the individual with increased neck circumference, when compared to the control group. The above-stated observation suggests an imbalance between fat and muscle mass in individuals with increased neck circumference. The mineral and protein content of the body are reflected by DLM.[12] LBM includes DLM and body water, though the principal component of LBM is skeletal muscle mass (SMM).[13] Therefore, reduced LBM denotes poor muscle mass. Phase Angle expressed in

degree reflects the integrity of the cell membrane. Normal range of PA in healthy subjects, was found to be between 5° and 7°.[14,15]

Neck circumference is an emerging marker of upper body adiposity.[11] Increased neck circumference carries the risk of cardiometabolic disease, the exact mechanism is not known. However, Yan *et al.* Postulated that the increased lipolytic activity is seen in individuals with increased neck circumference, causing free fatty acids mediated endothelial dysfunction, insulin resistance, oxidative stress, vascular injury, and development of metabolic syndrome.[11]

The other major findings of the study were significant increase in SBP and DBP in individual with increased neck circumference compared to healthy volunteers. MAP, PP being a derived, was also significantly increased in individual with increased neck circumference. The other CV risk indicator RPP showed a non-significant increase in persons with increased NC. RPP reflects the cardiac muscle workload and energy consumption.[16]

Subcutaneous fat accumulation in the upper body has been recognized to increase the lipolytic activity and free fatty acid release in the circulation specially in obese people.[17] Elevated free fatty acid levels can lead to increased release of various inflammatory cytokines, leading to vascular endothelial damage with subsequent reduction in the synthesis of nitric oxide hence predispose the subjects to cardiovascular disease particularly hypertension. Furthermore, the development of hypertension is attributed to angiotensinogen. The adipose tissue forms the major source of tissue derived angiotensinogen, its active form Angiotensin II causes vasoconstriction and elevates the blood pressure.[18–20] Hence, individuals with increased neck circumference suffer from deleterious effect of vascular injury, oxidative stress, increased strain to the cardiac tissue making them highly susceptible to future cardiometabolic disease.[18,21]

CONCLUSION

In this preliminary work, we observed that the elevated neck circumference carries the risk of development of CVD. Hence measuring NC is considered as simple screening tool of upper-body adiposity and an early marker of CV risk.

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CONFLICT OF INTEREST

The authors declare they have no conflict of interest.

ABBREVIATIONS

CVD: Cardiovascular Disease; **BMI:** Body Mass Index; **WC:** Waist Circumference; **HC:** Hip Circumference; **WHR:** Waist/Hip Ratio; **NC:** Neck Circumference; **BC:** Body Composition; **BIA:** Bioelectrical Impedance Analysis; **LBM:** Lean Body Mass; **SMM:** Skeletal Muscle Mass; **BCM:** Body Cell Mass; **DLM:** Dry Lean Mass; **BFMI:** Body Fat Mass Index; **FFMI:** Fat Free Mass Index; **PA:** Phase Angle; **SBP:** Systolic Blood Pressure; **DBP:** Diastolic Blood Pressure; **MAP:** Mean Arterial Pressure; **PP:** Pulse Pressure; **RPP:** Rate Pressure Product; **VLDL:** Very Low-Density Lipoprotein; **TG:** Triglycerides.

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