# NECK CIRCUMFERENCE REFERENCE VALUES FOR APPARENTLY HEALTHY NIGERIAN ADULTS AGED 18 TO 60 YEARS

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**Abstract**

*Neck circumference (NC) is a marker of upper body subcutaneous adipose tissue distribution. Although it is commonly used in many parts of the world it appears to lack reference values as an indicator of metabolic and cardiovascular risk in the Nigerian population. A total of 2000 apparently healthy adults participated in this study. NC was measured using a non-stretchable tape between the mid-cervical spine and mid-anterior neck of each participant standing upright. In men the NC was measured just below the laryngeal prominence (Adam's apple). Data was summarized using descriptive and inferential statistics. The alpha level was set at 0.05. The Nigerian men under study had significantly higher NC values than the women (t = 36.986, p = 0.001). The mean values for men and women below 20 years, between 21 and 30 years, 31 and 40 years, 41 and 50 years, and 51 and 60 years old were 37.29 ± 1.96 cm and 32.45 ± 1.84 cm, 37.69 ± 2.16 cm and 33.12 ± 2.52 cm, 37.67 ± 2.25 cm and 32.46 ± 2.24 cm, 38.01 ± 2.49 cm and 33.36 ± 2.67 cm, and 37.59 ± 2.29 cm and 33.14 ± 1.78 cm, respectively. The 95 percentile values for men and women younger than 20 years, 31-40 years, 41-50 years, and 51-60 years were 41cm and 36 cm, 42 cm and 38 cm, 41cm and 37 cm, 43 cm and 39 cm, and 42 cm and 37 cm, respectively. Based on age-and-sex neck circumference reference values, the means and percentiles can be used as indicators of acceptable and abnormal NC values for Nigerian adults between the ages of 18 to 60 years.*

**Key words:** *neck circumference, reference value, adults, Nigerians*

## Introduction

Neck circumference (NC) - a marker of upper body subcutaneous adipose tissue distribution - is a relatively new method of differentiating between normal and abnormal fat distribution. It is observed to be significantly correlated with age, body mass, waist and hip circumferences, waist-to-hip ratio, and BMI for both sexes [1]. Neck circumference is perceived as a promising tool as it is positively correlated with the upper body trunk fat, changes in systolic and diastolic blood pressure, and with other components of the metabolic syndrome [2]. NC is an accessible, non-invasive, and economical measure that remains constant during the course of the day [1]. NC measurement can also be used as a complementary anthropometric tool to determine cardiovascular risk, and it is positively correlated with components of the metabolic syndrome and obstructive sleep apnea [3]. A study by Li et al. on Chinese adults inferred that neck circumference was significantly correlated with visceral adipose tissue as documented by CT scans [4].

Furthermore, NC is positively associated with traditional anthropometric measures of body circumferences and indices such as the body mass index (BMI, kg/m) and waist-hip ratio (WHR) as well as other physiological and biochemical measures of cardiovascular risk. The usefulness of NC has been demonstrated in some reports on relatively large groups of obese and overweight patients [1-2], and some authors found neck

circumference even superior in predicting metabolic syndrome than waist circumference measures [5]. In addition to the reported relationship between NC and cardiovascular risk factors [2] an increased neck circumference has also been observed in patients with obstructive sleep apnea (OSA) [3, 6]. The variance in OSA severity explicable by central obesity was found to be dependent on the variation in neck circumference [5, 7]. NC was also found to be a good clinical predictor of menstrual irregularity, hirsutism, infertility, insulin resistance, and polycystic ovary syndrome (PCOS) in obese pre-menopausal women [8].

In physiotherapy neck circumference can be used to assess obese patients who sometimes suffer from cardiovascular disorders. It can also be applied as a tool for assessing the effects of exercises on obese patients [9]. Neck circumference can be used in place of BMI and waist-hip ratio which have certain disadvantages. The BMI does not provide any indication of central adiposity or visceral fat, while waist circumference measurements vary with respiration and post prandial distension of abdomen [9].

Neck circumference has been found to be positively correlated with metabolic dysfunctions, including glucose intolerance, hyperinsulinemia, diabetes, increased very low-density lipoprotein (VLDL) production, oxidative stress, endothelial cell dysfunction, hypertension, vascular injury, and hypertriglyceridemia [10]. Evidence also reveals that neck circumference is a strong indicator of elevated serum triglycerides and low serum high-density lipoprotein (HDL) cholesterol compared to BMI and waist circumference in both sexes [11]. The association between neck fat and metabolic syndrome may be attributed to an excess release of free fatty acids into plasma from upper body subcutaneous fat [12].

Despite the usefulness and relevance of neck circumference in relation to obesity and metabolic abnormalities, its cut off values used for the Nigerian population are derived from foreign populations. Researchers have reported that ethnicity is one of determinants of adipose tissue deposit in terms of site and part of the body [13]. There have been very few of studies on reference values of neck circumference among the general Nigerian population or any of its subsets. The used NC values are derived from foreign populations, which may not be exactly applicable in Nigeria. It is, therefore, essential to determine the reference values of neck circumference specifically for the Nigerian population, in particular, for the working population of 18-60 years of age.

## Methods
### Participants
The participants were apparently healthy male and female Nigerian adults.

### Inclusion Criteria
Participants who were apparently healthy adults between 18 to 60 years of age, who gave their consent to participate were eligible for the study.

### Exclusion Criteria
Apparently healthy adults that did not fall within the age range and did not give their consent to participate in the study.

### Study Design
A cross sectional design was used to determine the reference values of neck circumference.

### Sample and Sampling Techniques
A sample of convenience was used to recruit apparently healthy adults from Ile-Ife, Osun State, Nigeria.

### Sample Size
The sample size was calculated using William G. Cochran's formula [14]:
$N = [Z^2pq] \div e2$
where:
Z – confidence interval, i.e. 95% confidence level (1.96);
p - estimated proportion of target population which has the attribute and is equal to 0.5;
q - 1.0-p;
e - the desired level of precision put at 0.022;
$n = [(1.96)2 \times (0.5) (0.5)] \div (0.022)$
By inserting the variable in the formula n was equal to 1984, thus a total of 2000 individuals

were recruited for the study, with 400 participants in each age bracket: 18 to 20 years, 21 to 30 years, 31 to 40 years, 41 to 50 years, and 51 to 60 years.

*Site of Study*
The study was carried out in the Department of Medical Rehabilitation, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria.

*Measurement tools*
The following measurement tools were used:

- Non-stretchable tailor's tape for measuring neck circumference (Goldfish Company, China);
- Stadiometer for measuring body height, consisting of a vertical graduated rod with an adjustable horizontal head plate, with the measuring range from 4.5 to 81 inches (M120, Maa International, India);
- Bathroom weighing scale calibrated in kg for measuring body mass (Laica Medical Ltd, China).

*Procedure*
Ethical approval was obtained from the Health Research and Ethical Committee of the Institute of Public Health (HREC) of the College of Health Sciences of Obafemi Awolowo University in Ile Ife. The aims the study were explained to the participants and their maximum cooperation was solicited that they would not suffer adverse effects following the study. After verification of eligibility, socio-demographic and physical data such as age and sex were obtained from the participants.

*Measurements*
Neck circumference (cm) was measured by placing a tape measure directly on the skin on the mid anterior neck just below the laryngeal prominence and then extended all the way around the neck. The participants were not wearing any clothing around the neck and stood erect with the head in the Frankfort horizontal plane, with the examiner facing the participant's left side [15].

Body height (cm) was measured with the participant standing barefoot in front of the vertical rod of the stadiometer, with the head in the Frankfort horizontal plane, the arms hanging freely by the sides of the trunk, with the palms facing the thighs and the heels together. The movable horizontal head plate was then placed on the vertex of the participant's head [15].

Body mass (kg) was measured with the participant standing barefoot wearing only light clothing on the weighing scale [15].

*Calculations*
Body mass index (BMI) was calculated by dividing the participant's body mass by the square of body height (kg/m2).

*Data Analysis*
Data was summarized using descriptive and inferential statistics. The Pearson product-moment correlation coefficient was used to check for the relationship between neck circumference and BMI. Mean, medial, 25th, 50th, 75th and 95th percentiles were calculated. Reference values were obtained using the 95th percentile. The alpha level was set at p = 0.05.

## Results

*Participants' physical characteristics*
Table 1 presents the physical characteristics of participants. The mean age, body mass, and neck circumference were 35.57 ± 13.66 years, 63.46 ± 13.27 kg, and 35.31 ± 3.30 cm, respectively. The minimum neck circumference was 29.00 cm, while the maximum was 45.00 cm.

**Table 1.** Physical characteristics of participants (N = 2000).

| Variable | Min | Max | Mean ±SD |
|---|---|---|---|
| Age (years) | 18.00 | 50.00 | 31.38 ± 10.27 |
| Body mass (kg) | 37.00 | 88.00 | 60.92 ± 9.17 |
| Body height (m) | 1.40 | 1.99 | 1.65 ± 0.08 |
| BMI (kg/m2) | 13.20 | 35.00 | 22.17 ± 2.82 |
| Neck circumference (cm) | 25.00 | 50.00 | 34.50 ± 2.57 |

Note: Min = minimum; Max = maximum; SD = standard deviation; BMI = body mass index; n = number of participants; kg = kilogram; m = meter; cm = centimeter

*Comparison between the physical
characteristics of male and female participants*
Table 2 shows comparisons between male and female anthropometric variables. There was a statistically significant difference between the neck circumference of male and female participants (t = 36.968, p = 0.000), but no significant difference between the BMI of male and female participants (t = -0.963, p = 0.336).

**Table 2.** Comparison between physical characteristics of male and female participants (N = 2000) (independent t-test).

| Variable | Male Mean ± SD | Female Mean ± SD | t | p |
|---|---|---|---|---|
| Age (years) | 31.39 ± 10.27 | 31.34 ± 10.32 | -0.108 | 0.914 |
| Body mass (kg) | 60.71 ± 8.98 | 61.10 ± 9.35 | 0.856 | 0.392 |
| Body height (m) | 1.66 ± 0.09 | 1.65 ± 0.08 | -1.715 | 0.087 |
| BMI (kg/m2) | 21.99 ± 2.69 | 22.34 ± 2.94 | 2.400 | 0.017** |
| NC (cm) | 34.57 ± 2.54 | 34.46 ± 2.61 | -0.825 | 0.409 |

Note: SD = standard deviation; BMI = body mass index; NC = neck circumference

*Relationship between neck circumference, age,
body mass, body height, and BMI*
Table 3 presents the relationships between neck circumference, age, body mass, body height and BMI. There was a significant relationship between neck circumference and age ($r = 0.192$, $p < 0.01$), body mass ($r = 0.676$, $p < 0.01$), and body height ($r = 0.535$, $p < 0.001$).

**Table 3.** Relationships between neck circumference and age, body mass, body height, and BMI (N = 2000).

| | Age | Body Mass | Body Height | NC |
|---|---|---|---|---|
| Body mass (kg) | 0.402** | | | |
| Body height (m) | 0.135** | 0.530** | | |
| NC (cm) | 0.269** | 0.582** | 0.522** | |
| BMI (kg/m2) | 0.356** | 0.733** | 0.181** | −0.256** |

Note: NC = neck circumference; ** = statistically significant at 0.001 (2 tailed), * = statistically significant at 0.05 (2-tailed).

*Neck circumference percentile with sex and age*
Table 4 demonstrates the 25th, 50th, 75th, and 95th percentiles of neck circumference by sex and age. The 95th percentile of male participants between 18 and 20 years was 41.00, 21 and 30 years - 42.00, 31 and 40 years - 41.00, 41 and 50 years - 43.00, and 51 and 60 years - 42.00. The 95th percentile of total neck circumference was 41.00.

**Table 4.** Neck circumference percentiles with sex and age groups (n = 1200).

| Variable (years) | Min | 25th | 50th | Median | Mean ± SD | 75th | 95th | Max |
|---|---|---|---|---|---|---|---|---|
| Women | | | | | | | | |
| 18-20 | 29.00 | 31.00 | 32.00 | 32.00 | 32.45±1.84 | 33.75 | 36.00 | 39.00 |
| 21-30 | 29.00 | 31.00 | 33.00 | 33.00 | 33.12±2.52 | 35.00 | 38.00 | 42.00 |
| 31-40 | 29.00 | 31.00 | 32.00 | 32.00 | 32.46±2.24 | 33.00 | 37.00 | 42.00 |
| 41-50 | 29.00 | 32.00 | 33.00 | 33.00 | 33.36±2.67 | 35.00 | 39.00 | 44.00 |
| 51-60 | 30.00 | 32.00 | 33.00 | 33.00 | 33.14±1.78 | 35.00 | 37.00 | 37.00 |
| Total | 29.00 | 31.00 | 33.00 | 33.00 | 32.87±2.24 | 34.00 | 37.00 | 44.00 |
| Men | | | | | | | | |
| 18-20 | 31.00 | 36.00 | 38.00 | 38.00 | 37.29±1.96 | 38.00 | 41.00 | 42.00 |
| 21-30 | 33.00 | 36.25 | 38.00 | 38.00 | 37.69±2.16 | 39.00 | 42.00 | 44.00 |
| 31-40 | 31.00 | 36.00 | 38.00 | 38.00 | 37.67±2.25 | 39.00 | 41.00 | 44.00 |
| 41-50 | 32.00 | 36.00 | 38.00 | 38.00 | 38.01±2.49 | 39.00 | 43.00 | 45.00 |
| 51-60 | 33.00 | 36.00 | 37.00 | 37.00 | 37.59±2.29 | 39.00 | 42.00 | 44.00 |
| Total | 31.00 | 36.00 | 38.00 | 38.00 | 37.68±2.27 | 39.00 | 42.00 | 45.00 |
| All participants | 29.00 | 33.00 | 35.00 | 35.00 | 35.31±3.29 | 38.00 | 41.00 | 45.00 |

Note: Min = minimum; Max = maximum; SD = standard deviation

## Discussion

The study provided reference values of neck circumference (NC) among apparently healthy Nigerian adults. The neck circumference in the male and female participants was found to be more than 30 cm. This is in agreement with results by Ojoawo et al. who reported that for this population, the mean neck circumference for men was more than 30 cm [16]. Another study by Onat et al. in Turkey showed the mean neck circumference of men and women to be also more than 30 cm [5].

The cut off value of neck circumference of the total population was ≥ 41.00 cm. The cut off value for the total female population was ≥ 37.00 cm, while the cut off value for the entire male population ≥ 42.00 cm. Oluremi et al. in their study of a US population found the cut off mark for NC in young adults to be ≥ 38 cm and ≥ 33.5 cm in men and women, respectively [17]. A study by Ben-Noun et al. revealed the NC cut off levels to be ≥ 39.5 cm for Israeli men and ≥ 36.5 cm for Israeli women with their BMI ≥ 30 kg/m2 [1]. Chaitanya et al. in their study of an Indian population reported their cut off mark for NC to be ≥ 36.5 cm and ≥ 32.5 cm for men and women, respectively [9]. A study on an adolescent population in Brazil by Roberta et al. found the cut off mark of NC for overweight to be ≥ 31.25 cm and ≥ 34.25 cm in girls and boys, respectively; whereas the cut off values for obesity to be ≥ 32.65 cm and ≥ 37.95 cm in girls and boys, respectively [18].

The NC cut off values for women in this study in the age groups of 18 to 20 years, 21 to 30 years, 31 to 40 years, 41 to 50 years, 51 to 60 years were found to be 36.00 cm, 38.00 cm, 37.00 cm, 39.00 cm, and 37.00 cm, respectively. The cut off values for men in this study in the age groups of 18 to 20 years, 21 to 30 years, 31 to 40 years, 41 to 50 years, 51 to 60 years were 41.00 cm, 42.00 cm, 41.00 cm, 43.00 cm, and 42.00 cm, respectively. This implies that values above these cut off marks may predispose individuals to chronic non-communicable disease such as obstructive sleep apnea, obesity, diabetes, metabolic conditions, pregnancy-induced hypertension, some hormonal diseases, hypertension and other cardiovascular conditions. Ben-Noun et al. reported that neck circumference was positively correlated with

overweight and obesity [2]. Sjostrom et al. (1995) found that neck circumference was associated with cardiovascular risk factors in severely obese men and women. An increase in NC means the likelihood of risk factors for cardiovascular disease also increases [19]. Davies et al. [3] observed that variations in neck circumference were closely correlated with sleep apnea, and were a powerful physical sign of patients with obstructive sleep apnea (OSA). According to Cizza et al. neck circumference was positively associated with the severity of OSA, independently of visceral obesity, even in non-obese patients [20]. Hingorjo et al. noted that neck circumference had a strong positive correlation with other anthropometric measures of obesity and could, therefore, be a useful obesity marker [21]. Joshipura et al. found that neck circumference showed higher associations with prediabetes, low high-density lipoprotein cholesterol (HDL-C), triglycerides, insulin resistance, fasting plasma glucose levels, and systolic and diastolic blood pressure [22], thus considering NC to be a significant risk indicator of central obesity, metabolic conditions, and cardiovascular conditions. Ojoawo et al. found a significant correlation between neck circumference and systolic and diastolic blood pressure [16], whereas according to Dixson et al. NC was a good clinical predictor of menstrual irregularity, hirsutism, infertility, insulin resistance, and polycystic ovary syndrome (PCOS) in obese pre-menopausal women [8].

The findings of the present study indicate a significant correlation between neck circumference and age, body mass, body height, and the BMI. This may imply that as a person grows older, his or her neck circumference increases. This may be due to the increasing body mass or BMI with age. The neck circumference of male participants was found to be significantly longer than of female participants. Ben-Noun et al. found a strong correlation between neck circumference and age, body mass, waist circumference, waist-hip ratio and BMI in both men and women [2]. Onat et al. found positive correlations between neck circumference and age, waist circumference, waist-hip ratio, and BMI [5]. Laakso et al. reported positive correlations between neck

circumference and waist circumference, waist-hip ratio, and BMI [23]; while Chaintaya et al. noted a positive correlation between neck circumference and BMI, waist circumference, hip circumference, body mass, waist-hip ratio, body height, and systolic blood pressure [9].

**Conclusion**

This study provided reference values of neck circumference among the Nigerian population measured with a non-stretchable measuring tape. There was a significant correlation between participants' neck circumference, age, body mass, body height, and BMI. The neck circumference cut off values for Nigerian men and women amounted to 42.00 cm and 37.00 cm, respectively.

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