*Original Research Article*

# Neck Circumference as an Indicator of Body Mass Index in Young Male and Female Adults

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## ABSTRACT

**Background:** Neck circumference is a novel measure of assessing the body fat. Several studies have used the neck circumference as a measure of estimating the adiposity and cardiovascular risk factors. The body mass index is a general indicator of the body weight, which includes both fat-mass and fat-free mass. The objective of the present study was to find the association between the neck circumference and the body mass index.

**Materials and Methods:** The study was conducted on normal healthy adults aged 18-26 years. A total number of 816 subjects were selected purposively from Amritsar, India, out of which 483 were males and 333 were females. The subjects were assessed for the height, weight, body mass index and neck circumference.

**Results:** The results of inter-correlation matrix of the studied variables showed a significant (p<0.001) correlation of the neck circumference with body mass index in both males and females. It was also observed that the males had significantly (p<0.001) higher mean values for both the neck circumference and the body mass index than females.

**Conclusion:** The neck circumference is an important indicator of the body mass index which is a measure of health.

*Keywords:* Neck circumference, body mass index, adiposity.

## INTRODUCTION

The neck circumference measurement is a novel method which has been used recently in several studies and has been proven as one of the simple, reliable and practical anthropometric measurements to assess the body fat. [1-3] It has also been associated with cardio-metabolic risk which is linked to irregular fat distribution. [4-7] Taheri *et al*. (2016) stated that neck circumference measurement was easier to implement for the clinicians as compared to other methods and it was more comfortable for children. It was also stated by the authors that neck circumference measurement was a useful and reliable tool for identifying overweight and obesity specifically the central obesity in children. [2,8] Furthermore, the inter-rater reliability of the neck circumference has been reported to be good. [2]

The body mass index BMI, also known as the Quetelet's index, is calculated by ratio of person's weight in kilograms to the square of the person's height in metres ($kg/m^2$). [9] It is generally used for categorizing the individual into different groups on the basis of a person's weight. [10] The body mass index is the most commonly used tool for assessing the underweight, overweight and obesity [11] but it is not considered as the perfect scale to assess the

obesity. **(12)** Due to limitations of the body mass index, various alternative indicators have been introduced by researchers in various studies such as waist circumference and waist-to-hip ratio, but these indicators also have their own limitations. **(8)** The body mass index has been correlated to various indices of the health by many researchers. Recently, in few studies the neck circumference has also been associated with body mass index and has been reported to reliably identify children with high body mass index. **(2)** The present study was aimed to find the association of the neck circumference with the body mass index and it was hypothesized that the neck circumference could be considered as an indicator of the body mass index.

## MATERIALS AND METHODS

The participants were selected with purposively from various collages of Amritsar, India. A total number of 816 healthy normal subjects, who were screened for inclusion and exclusion criteria, were selected for study. The sample comprised 483 males and 333 females aged 18-26 years. The study was carried out at the Department of Physiotherapy, Khalsa College, Amritsar and was approved by the institutional ethics committee. The purpose and procedure of the study was explained to the subjects and they give their consent to participate in the study by signing the 'Informed Consent' forms. The age of the subjects was calculated from the date of birth of the subjects.

**Inclusion Criteria:** The normal healthy subjects of both sexes i.e. males and females aged 18-26 years.

**Exclusion Criteria:** The subjects with any history of whiplash-associated disorders (WAD), goiter, cervical spondylosis, torticollis, any acute or chronic spasm of muscles around neck, distension of neck vessels and acute skin conditions around neck were excluded from the study.

## Procedure

All the subjects underwent the assessment for height, weight, body mass index and neck circumference measurement. The assessment of the subjects was done from 9:00 am to 4:00 pm. The measurement techniques mentioned by Lohmann *et al.* (1998) **(13)** were followed for measuring the anthropometric variables. The height was measured with the help of Stadiometer (Holtain Ltd. Crymych, Dyfed, UK) in standing position. The subjects were made to stand bare feet on the horizontal surface and the counter board of the Stadiometer was pulled down till it touched the vertex of the subjects. The reading was taken in centimetres. The measurement of the weight was done with subjects in minimal light-weight clothing and bare feet. A standard weighing machine was used for measurement and the reading of weight was taken in kilograms. The neck circumference was measured by a measuring tape at the level of base of the neck of the subjects. The body mass index was calculated by using the standard formula i.e. weight (kg)/height $(m^2)$.

## Statistical Methods

All the variables were analysed for the mean and standard deviation (descriptive statistics). The data of the males and females was compared using Student's t-test. The data was also analysed for obtaining the correlation coefficients of the neck circumference with the body mass index. A 5% level of probability was used to indicate the statistical significance.

## RESULTS

The descriptive statistics of the neck circumference and selected anthropometric variables viz. height, weight and body mass index are shown in table 1. Student's t-test showed a significant difference s ($p<0.001$) between the males and females in all the studied variables.

**Table 1: Descriptive statistics of the neck circumference and selected anthropometric variables in normal healthy males and females**

| Variables | Males (n=483) | | Females (n=333) | | t value | p value |
|---|---|---|---|---|---|---|
| | Mean | S.D. | Mean | S.D. | | |
| Height (cm) | 173.48 | 6.61 | 159.43 | 6.16 | 30.705 | **<0.001** |
| Weight (kg) | 68.44 | 12.04 | 54.29 | 10.42 | 17.421 | **<0.001** |
| Body mass index (kg/m$^2$) | 22.70 | 3.53 | 21.33 | 3.80 | 5.264 | **<0.001** |
| Neck circumference (cm) | 38.43 | 2.62 | 32.81 | 2.15 | 32.335 | **<0.001** |

The correlation coefficients of the neck circumference with the body mass index in males and females were shown in table 2. It was observed that in both the males and females, the neck circumference had a statistically significant positive correlation with the body mass index (p<0.001).

**Table 2: Correlation coefficients of the neck circumference with the body mass index and selected anthropometric variables in males and females**

| Variables | Males (n=483) | | Females (n=333) | | Combined (n=816) | |
|---|---|---|---|---|---|---|
| | r | p | r | p | r | p |
| Age (years) | 0.142 | **<0.002** | 0.012 | 0.830 | 0.098 | **<0.005** |
| Height (cm) | 0.261 | **<0.001** | 0.297 | **<0.001** | 0.672 | **<0.001** |
| Weight (kg) | 0.618 | **<0.001** | 0.648 | **<0.001** | 0.745 | **<0.001** |
| Body mass index (kg/m$^2$) | 0.570 | **<0.001** | 0.567 | **<0.001** | 0.503 | **<0.001** |

## DISCUSSION

The present study was done with an aim of finding the association between neck circumference and body mass index. The rationale to take neck circumference measurement was due to the reasons like the convenience of measurement at this anthropometric site, simplicity in measurement and non-invasiveness. The other strong reason behind working on the neck circumference measurement was the scarcity of the scientific investigations done on the relationship between neck circumference and body mass index. A considerably large sample size was taken for this purpose which included both males and females ages 18-26 years. It has been reported in several studies recently that neck circumference is a potentially useful, simple, non-invasive and cost-effective screening tool which can be used as an indicator of the overweight and obesity. [14]

The results of the study showed that there was a significant difference between the mean vales of the males and females or all the variables. The mean value for the neck circumference in males (n=483) was 38.43 ± 2.62 cm and that for the females (n=333) was 32.81 ± 2.15 cm, which showed a significant difference (p<0.001). The males presented with higher mean value for the neck circumference than females and the mean value of neck circumference in females was 85% of the mean value in males. This difference has been reported by researchers in previous studies also. [14] Tseh *et al*. (2016) in a study conducted to find out the relationship between neck circumference and abdominal adiposity in young adult males and females. The researchers reported that the females were having 86% of the males mean value for the neck circumference. [15] In children also, this difference in the mean value of the neck circumference in boys and girls persists. Kondolot *et al*. (2017) studied 874 boys and 892 girls aged 2-6 years from all socioeconomic levels. According to the study results, the boys in all the age groups from 2-6 years had higher mean value for the neck circumference as compared to the girls. [16] The body mass index in the present study was also observed to be higher in males than in females. The males had a mean value for body mass index of 22.70 ± 3.53 kg/m$^2$ and the mean value of the same in the females was 21.33 ± 3.80 kg/m$^2$ and showed a significant difference in both the genders. It was also found that the males had higher mean values for height and weight than the females. The mean value of the height was 173.48 ± 6.61 cm in males and 159.43 ± 6.16 cm in females. The mean value for the weight in the males was 68.44

± 12.04 kg and 54.29 ± 10.42 kg in females. The body mass index has also been reported to be higher in males as compared to females by many studies.

The inter-correlation matrix analyses showed that the neck circumference had a significant (p<0.001) and positive correlation with the body mass index in both males and females as well as in combined values of the males and females. The r value in the males was 0.570 and in females was 0.567 with p value <0.001. The neck circumference has been associated to the obesity in recent several studies. Famodu *et al*. (2017) stated that the neck circumference closely correlated with the upper body obesity and can be used as a supporting evaluation method in addition to other health measures in obesity and its co-morbidities. [14] Laasko *et al*. (2002) also revealed a positive correlation of neck circumference with the body mass index. The researchers also concluded that the neck circumference was associated with the abdominal and general obesity. [17] In another study, conducted by Hatipoglu *et al*. (2010) in 412 boys and girls, a strong correlation was observed between the neck circumference and the body mass index. [1]

It is noteworthy that most of the studies conducted to study the associations of the neck circumference with other anthropometric variables and obesity, the body mass index of the subjects was higher and the subjects were having weight for height above the normal range. However, in the present study, the subjects with all the ranges of the body mass index i.e the underweight, normal weight, and the obese subjects all were included in the study. The neck circumference was observed to be significantly and positively correlated with the body mass index in all the ranges. So, it can be established from the study results that the neck circumference is an indicator of the body mass index.

## CONCLUSION

It can be concluded from the study results that the neck circumference

correlates positively and significantly with the body mass index in both males and females aged 18-26 years. Therefore, a strong association was observed in the neck circumference and the body mass index. As the neck circumference was strongly correlated with the body mass index of all the ranges, it can be stated that the neck circumference is an indicator of the body mass index. The study also observed a higher mean value of neck circumference in the males than in the females.

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