

# Comparison of Body Mass Index, Body Fat Percentage and Neck Circumference as Tools for Evaluation of Obesity

Chitra Pillai<sup>1</sup>, Prasad Udhoji<sup>1</sup>, Sachin Rathod<sup>1</sup>, Kanagasabapathy Pillai<sup>2</sup>

<sup>1</sup> T N Medical College & BYL Nair Hospital, Mumbai 400008

<sup>2</sup> Seth G S Medical College & KEM Hospital, Parel, Mumbai 400012

## Correspondence to:

Chitra Pillai  
(pillai\_c@yahoo.com)

**Received: 29.08.2011**

**Accepted: 28.03.2012**

DOI: 10.5455/njppp.2012.2.167-171

## ABSTRACT

**Aims & Objective:** To assess whether Neck Circumference (NC) can be used as a tool to evaluate body mass status.

**Materials and Methods:** This study was conducted in a Medical College Hospital after obtaining necessary permission from the institute and Ethics Committee. Every subject was informed about the test, the measurements those need to be taken, the aim of the study and signed consent form was taken from every subject. Total of 228 subjects, 136 males and 92 females participated in this study. Their BMI, BFP and NC were recorded and tested for correlation of NC with BMI and with BFP. The statistical analysis was done by Linear regression analysis performed using Graph Pad Prism version 5.00 for Windows, Graph Pad Software, San Diego, California, USA.

**Results:** The correlation between the parameters was found to be significant in all the subjects and also in the male and female subjects taken separately with a p value of < 0.0001.

**Conclusion:** This result suggests that NC can be used as a screening tool for evaluation of obesity instead of BMI & BFP.

**KEY WORDS:** Body Mass Index; Body Fat Percentage; Neck Circumference

## INTRODUCTION

Overweight and obesity are the names given for ranges of weight that are more than what is generally considered healthy for any given height. These terms also indicate the weight range that shows an increase in the likelihood of certain diseases and other health problems.<sup>[1]</sup> Obesity is one of the commonest nutrition disorder of the developed nations. Now it is now dramatically increasing in the developing nations like India too. With continuation of this trend we

would end up with the heaviest adult population ever. Obesity has reached epidemic proportions in India in the 21st century, with morbid obesity affecting 5% of the country's population. This is a cause of great concern. It is well documented that obesity contributes to many health problems like cardiovascular disorders, lipid & glucose metabolism disorders etc. We now know that upper body obesity is more strongly associated with diabetes, triglyceridaemia, hypertension, hyperinsulinaemia etc.<sup>[2-4]</sup> Jean Vague<sup>[5]</sup> was the first to describe the differences in body

morphology or patterns of body fat distribution and their relationship to health risk. Loubo Ben Noun in his study on Israeli subjects found that obese individual had thicker neck.<sup>[6]</sup>

There are various methods by which body mass status can be evaluated. Measurement of weight & height, waist circumference, hip circumference, waist: hip ratio, Body Mass Index (BMI) etc though easy without need for any sophisticated instruments but require undressing. Other measures like USG, CT scan; MRI etc require sophisticated expensive instruments.<sup>[7]</sup>

BMI does not adequately describe the type of obesity. W: H ratio, though it considers both waist and hip circumference, will show normal ratio if waist & hip increase in a coordinated manner & it also requires undressing. BFP requires special instrument for measuring the body fat.<sup>[8]</sup> But NC can be measured using a measuring tape with no need for undressing. If a simple and easy to perform procedure can be devised to be used as screening test to evaluate the body mass status, identification of overweight or obese individuals will become simpler. Hence our objective was to assess whether NC can be used as a tool to evaluate body mass status though we do not underestimate the usefulness of BMI or BFP as tools for evaluation of obesity status.

## MATERIALS AND METHODS

This study was conducted in a medical college hospital in Mumbai after obtaining necessary permission from the institute and Ethics Committee approval. Every subject was informed about the test, the measurements that need to be taken, the aim of the study and signed consent form was taken from every subject. Males and females of the I MBBS students were included in the study. Detailed history and general examination was done to exclude any subject with Endocrinological disturbances, Tuberculosis, Diabetes Mellitus or any debilitating disease and females with Polycystic Ovarian Disorders.

**Body Mass Index:** BMI of each subject was calculated by using Quetelet's Index where BMI is equal to Body weight in Kg upon Height in metres. Weight was measured using an electronic weighing scale and height was measured using a standard height measuring stand stadiometer (DETECTO SCALE).

**Body Fat Percentage:** BFP of each subject was measured using OMRON'S Body Fat Monitor which measures body fat percentage using the Bioelectrical Impedance (BI). Tissues having high water content such as muscles, blood vessels & bones are good conductors of electricity but fat tissues are not. Based on this principle Omron Body Fat Monitor Model HBF 306 applies a weak current of 50 Hz to 500 $\mu$ A to the body. The instrument measures the resistance offered to this current by fat tissue and other tissues of the body and Body fat Percentage is expressed as a direct reading.

**Neck circumference:** NC was measured using a non stretchable measuring tape at the middle of the neck between the mid cervical spine and mid anterior neck. In men with laryngeal prominence (Adam's apple) it was measured just below the prominence.<sup>[6]</sup>

## RESULTS

A sample size of 228 subjects was analyzed in this study with mean age 18.3 yrs, (SD  $\pm$  0.6756 ) and mean weight 58.63 kg, (SD  $\pm$  12.507) and mean height 166.9122cm (SD:  $\pm$  13.749). Among the subjects were 136 males with mean age of 18.4370 (SD  $\pm$  0.7082), mean weight 62.8014 kg (SD  $\pm$  12.877) and mean height of 172.3529cm (SD  $\pm$  14.8456). 92 were females with mean age of 18.1413 (SD  $\pm$  0.5852), mean weight 52.4783 (SD $\pm$  8.941) and mean height of 158.8695 (SD  $\pm$  5.912). The mean and SD for NC, BMI and BFP were calculated and tabulated. (Table No 1)

### Stastical Analysis

Done by Linear regression analysis performed using Graph Pad Prism version 5.00 for Windows, Graph Pad Software, San Diego, California, USA ([www.graphpad.com](http://www.graphpad.com))

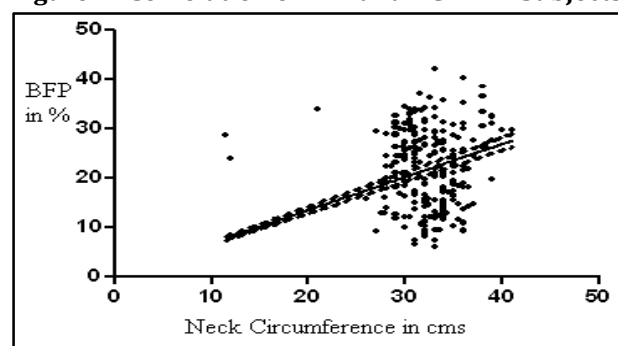
**Table-1: The mean values of age, weight, height, BMI, BFP & NC of the subjects**

|                         | Mean     | SD     | Sample Size | Std error of mean |
|-------------------------|----------|--------|-------------|-------------------|
| <b>For all subjects</b> |          |        |             |                   |
| Age                     | 18.3171  | 6.756  | 228         | 0.0448            |
| Weight                  | 58.6359  | 12.507 | 228         | 0.8283            |
| Height                  | 166.9122 | 13.749 | 228         | 0.9106            |
| BFP                     | 22.006   | 7.846  | 228         | 0.5196            |
| BMI                     | 20.7515  | 3.728  | 228         | 0.5196            |
| NC                      | 32.4507  | 3.523  | 228         | 0.2333            |
| <b>For Males</b>        |          |        |             |                   |
| Age                     | 18.37    | 0.7082 | 136         | 0.0609            |
| Weight                  | 62.8014  | 12.877 | 136         | 1.104             |
| Height                  | 172.3529 | 14.846 | 136         | 1.273             |
| BFP                     | 18.8727  | 7.043  | 136         | 0.6039            |
| BMI                     | 20.7386  | 3.811  | 136         | 0.3268            |
| NC                      | 34.1014  | 2.309  | 136         | 0.198             |
| <b>For Females</b>      |          |        |             |                   |
| Age                     | 18.1413  | 0.5852 | 92          | 0.601             |
| Weight                  | 52.4783  | 8.941  | 92          | 0.9322            |
| Height                  | 158.8695 | 5.912  | 92          | 0.6164            |
| BFP                     | 26.638   | 6.604  | 92          | 0.6885            |
| BMI                     | 20.7706  | 3.623  | 92          | 0.3778            |
| NC                      | 30.0107  | 3.599  | 92          | 0.3752            |

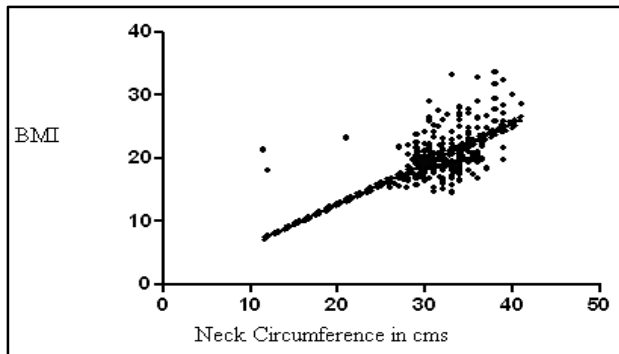
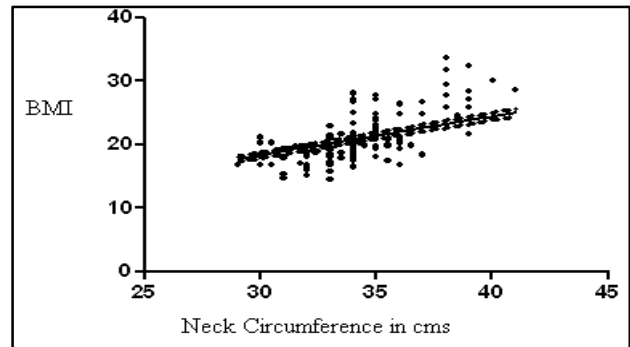
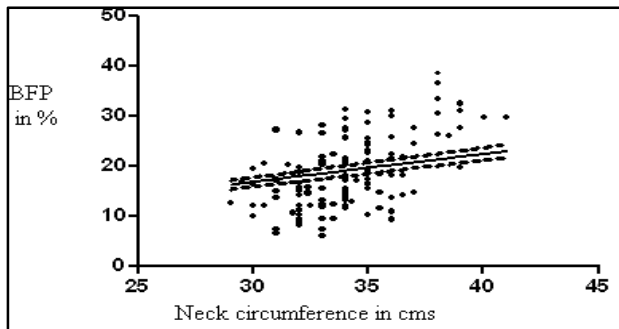
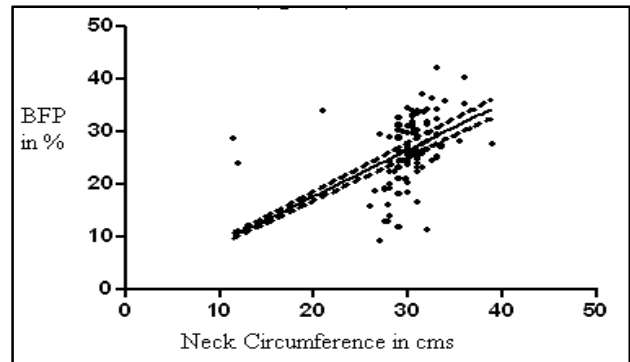
**Table-2: Correlation of BFP & BMI with NC in All Subjects**

|                                  | BF%              | BMI (Kg/M <sup>2</sup> ) |
|----------------------------------|------------------|--------------------------|
| Best-fit values                  |                  |                          |
| Slope                            | 0.6711 ± 0.01647 | 0.6368 ± 0.007168        |
| Y-intercept when X=0.0           | 0.0              | 0.0                      |
| X-intercept when Y=0.0           | 0.0              | 0.0                      |
| 1/slope                          | 1.490            | 1.570                    |
| 95% Confidence Intervals         |                  |                          |
| Slope                            | 0.6388 to 0.7034 | 0.6228 to 0.6509         |
| Goodness of Fit                  |                  |                          |
| Sy.x                             | 8.144            | 3.533                    |
| Is slope significantly non-zero? |                  |                          |
| t                                | 40.75            | 88.84                    |
| DF                               | 228.0            | 227.0                    |
| P value                          | < 0.0001         | < 0.0001                 |
| Deviation from zero?             | Significant      | Significant              |
| Data                             |                  |                          |
| Number of X values               | 228              | 228                      |
| Maximum number of Y replicates   | 1                | 1                        |
| Total number of values           | 228              | 228                      |
| Number of missing values         | 0                | 0                        |
| Runs test                        |                  |                          |
| Points above line                | 116              | 96                       |
| Points below line                | 113              | 132                      |
| Number of runs                   | 83               | 101                      |
| P value (runs test)              | < 0.0001         | 0.0736                   |
| Deviation from linearity         | Significant      | Not Significant          |

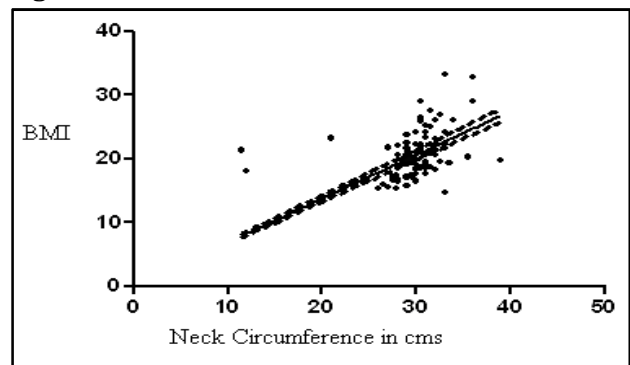
Correlation among the various parameters was calculated. The result of statistical analysis showed BFP & NC and BMI & NC in all the subjects showed significant correlation with a p value of <0.0001 at a confidence interval of 95%. Both BFP & NC and BMI & NC in males showed a significant correlation with a p value < 0.0001 at a confidence interval of 95%. BFP & NC and BMI & NC in females showed significant correlation with a p value of <0.0001 at a confidence interval of 95% (Table 2 to 4 & Figure 1 to 6)

**Figure-1: Correlation of BFP and NC in All Subjects****Table-3: Correlation of BFP & BMI with NC in Males**

|                                  | BF%              | BMI (Kg/M <sup>2</sup> ) |
|----------------------------------|------------------|--------------------------|
| Best-fit values                  |                  |                          |
| Slope                            | 0.5587 ± 0.01609 | 0.6104 ± 0.007637        |
| Y-intercept when X=0.0           | 0.0              | 0.0                      |
| X-intercept when Y=0.0           | 0.0              | 0.0                      |
| 1/slope                          | 1.790            | 1.638                    |
| 95% Confidence Intervals         |                  |                          |
| Slope                            | 0.5271 to 0.5902 | 0.5955 to 0.6254         |
| Goodness of Fit                  |                  |                          |
| Sy.x                             | 6.412            | 3.044                    |
| Is slope significantly non-zero? |                  |                          |
| t                                | 34.73            | 79.94                    |
| DF                               | 135.0            | 135.0                    |
| P value                          | < 0.0001         | < 0.0001                 |
| Deviation from zero?             | Significant      | Significant              |
| Data                             |                  |                          |
| Number of X values               | 136              | 136                      |
| Maximum number of Y replicates   | 1                | 1                        |
| Total number of values           | 136              | 136                      |
| Number of missing values         | 0                | 0                        |
| Runs test                        |                  |                          |
| Points above line                | 60               | 55                       |
| Points below line                | 76               | 81                       |
| Number of runs                   | 56               | 52                       |
| P value (runs test)              | 0.0217           | 0.0061                   |
| Deviation from linearity         | Significant      | Significant              |

**Figure-2: Correlation of BMI and NC in All Subjects****Figure-4: Correlation of BMI and NC in Males****Figure-3: Correlation of BFP and NC in Males****Figure-5: Correlation of BFP and NC in Females****Table-4: Correlation of BFP& BMI with NC in Females**

|                                  | BF%              | BMI (Kg/M <sup>2</sup> ) |
|----------------------------------|------------------|--------------------------|
| Best-fit values                  |                  |                          |
| Slope                            | 0.8825 ± 0.02230 | 0.6866 ± 0.01285         |
| Y-intercept when X=0.0           | 0.0              | 0.0                      |
| X-intercept when Y=0.0           | 0.0              | 0.0                      |
| 1/slope                          | 1.133            | 1.456                    |
| 95% Confidence Intervals         |                  |                          |
| Slope                            | 0.8381 to 0.9269 | 0.6611 to 0.7122         |
| Goodness of Fit                  |                  |                          |
| Sy.x                             | 6.465            | 3.725                    |
| Is slope significantly non-zero? |                  |                          |
| t                                | 39.57            | 53.43                    |
| DF                               | 91.00            | 91.00                    |
| P value                          | < 0.0001         | < 0.0001                 |
| Deviation from zero?             | Significant      | Significant              |
| Data                             |                  |                          |
| Number of X values               | 92               | 92                       |
| Maximum number of Y replicates   | 1                | 1                        |
| Total number of values           | 92               | 92                       |
| Number of missing values         | 0                | 0                        |
| Runs test                        |                  |                          |
| Points above line                | 46               | 39                       |
| Points below line                | 46               | 53                       |
| Number of runs                   | 44               | 48                       |
| P value (runs test)              | 0.3006           | 0.7080                   |
| Deviation from linearity         | Not Significant  | Not Significant          |

**Figure-6: Correlation of BMI and NC in Females**

## DISCUSSION

The result of the study shows that NC correlated significantly with BMI and also with BFP in all the subjects, male and female taken together as well as when taken individual sex wise. The literature shows studies in adults as well as children with similar findings.<sup>[6,9,10]</sup> Ben -Noun et al<sup>[6]</sup> in his study of 979 subjects (460 and 519 Israeli men and women) showed a strong positive relation between NC & BMI for both men and women in his test samples. Olubukola O. Nafiu et al<sup>[9]</sup> showed in their study of 1102 children, (52% male and 48% females) NC was significantly correlated with age, BMI, and waist circumference in both boys and girls, although

the correlation was stronger in older children. NibalHatipogulu et al<sup>[10]</sup> in their study of four hundred twelve overweight and obese patients (208 girls and 204 boys) and 555 healthy children (284 girls and 271 boys) aged 6–18 years showed a significant and positive correlations between BMI-NC, BMI-WC and WC-NC ( $p < 0.001$ ). BMI and BFP are already used as a measures of obesity to identify the risk score with regards to cardio vascular and metabolic disorders, Insulin resistance etc. Measuring NC can be used as a simple, easy to measure screening test to evaluate body mass status of individuals and identify overweight or obese individuals on whom additional evaluation can be performed. The cut off value for NC to classify overweight and obesity is not available for different age groups of Indian population Hence the need to study a larger sample of all the age groups of Indian population is necessary.

## CONCLUSION

This result suggests that NC can be used as a screening tool for evaluation of obesity instead of BMI & BFP.

## REFERENCES

1. Centre for disease control and prevention. Defining overweight and obesity. Available from : <http://www.cdc.gov/obesity/adult/defining.html>
2. Kaplan N.M. The deadly quartet, upper body obesity, glucose intolerance, hypertriglyceridemia and hypertension. Arch Intern Med 1989; 149(7); 1514- 1520
3. Sheldon E. Litwin. Which measures of obesity best predict cardiovascular risk? J. Am Coll Cardiol. 2008; 52; 616-619; doi: 10.1016/j.jacc.2008.05.017 <http://content.onlinejacc.org/cgi/content/full/52/8/616>
4. Robert H.Eckel . Obesity and Heart Disease: A Statement for Health care Professionals From the Nutrition Committee, American Heart Association. Robert H. Eckel, M.D. for the Nutrition Committee. Circulation. 1997;96;3248-3250. doi: 10.1161/01.CIR.96.9.3248
5. Enzi G., Busetto L., Inelmen E.M., Coin A., Sergi G., Historical perspective: Visceral obesity and related comorbidity in Joannes Baptista Morgagni's 'De sedibus et causis morborum per anatomen indagata. Int J Obes Relat Metab Disord 2003;Apr(4); 534-5 PMID: 12664088 [Pubmed-indexed for MEDLINE]
6. Liuobov (Louba) ben- Noun, Erza Sohar and Arie Laor. Neck circumference as a simple screening measure for identifying overweight and obese patients. Obesity Research; 2001; 9 (8); 470-477. doi: 10.1038/oby.2001.61
7. Jacob C. Seidell and Katherine M. Flegal. Assessing obesity : Classification and epidemiology. British Medical Bulletin; 1997; 53(2); 238 -252
8. Shea J.L., King M.T., Yi.Y., Gulliver W., Sun G., Body fat percentage is associated with cardiometabolic dysregulation in BMI- defined normal weight subjects. Nutr Metab Cardiovasc Dis. 2011; Jan 5. [Epub ahead of print] ; PMID:21215604 [Pubmed – as supplied by publisher]
9. Olubukola O. N., Constance B., Joyce L., Terri Voepel-Lewis, Shobha Malaviya and Tremper K.. Neck circumference as a screening measure for identifying children with high Body mass Index. Pediatrics; 2010; 126(20; e306-e310. doi 10.1542/peds.2010-0242
10. Nibal Hatipogulu, Mazicioglu M., Kurtoglu S. and Kendirici M.. Neck circumference: an additional tool of screening overweight and obesity in childhood. Eur J Pediatr; 2010;169 (6); 733-739. doi: 10.1007/s00431-009-1104z

**Cite this article as:** Pillai C, Udhoji P, Rathod S, Pillai K. Comparison of body mass index, body fat percentage and neck circumference as tools for evaluation of obesity. Natl J Physiol Pharm Pharmacol 2012; 2:167-171.

**Source of Support:** Nil

**Conflict of interest:** None declared