Original Article

# Anthropometric Parameters of Armed Forces Personnel

Gp Capt R Vaidya[*], Brig R Bhalwar[+], Surg Lt Cdr S Bobdey[#]

**Abstract**

**Background: The prevalence of obesity has increased globally in the last few decades. Anthropometry is an accepted method of measuring obesity. Charts of weight for height and age as well as Anthropometric indices like Body Mass Index (BMI) are commonly used to define normal, overweight and obese individuals. Weight for height charts currently in use in the Army belong to pre-independence era. It is widely believed that these have been obtained from life insurance tables made for British / American civilian population. The World Health Organization (WHO) encourages its member countries to develop their own reference anthropometric indices.**

**Methods: Anthropometric measurements were recorded for 902 healthy Armed Forces personnel in the age range of 28 to 52 years selected by stratified random sampling. These measurements were used to obtain mean values, standard deviations, medians and percentiles for various anthropometric parameters.**

**Result: BMI for the study subjects ranged from 14.67 to 27.90 kg/m$^2$ with a mean of 20.52 Kg/m$^2$. No individual was categorized as obese using the current international cut-off of BMI >30 kg/m$^2$. With the exception of height, all other anthropometric parameters like weight, BMI, waist circumference, and waist-hip ratio were found to increase with increasing age. Correlation of BMI with waist circumference and BMI with Waist Hip Ratio in the study subjects was found to be statistically significant. The weight for height and age chart developed by this study shows an increase in weight in all age and height categories as compared to the weight for height chart currently in vogue in the Indian Army.**

**Conclusion: The weight for height and age chart calculated in our study, shows considerable variation when compared to weight for height and age chart currently being used in Indian Army. The average weight for majority of height and age categories was found to be higher than in the Indian Army chart. It is recommended that a large multi-centric study should be taken up to gather more evidence to replace the current chart.**

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**Key Words : Anthropometric parameters; Weight charts; Obesity**

## Introduction

Obesity is a chronic condition characterized by an excess of body fat [1]. Current knowledge of human obesity has progressed beyond the simple generalizations of the past. Overweight and obesity result from a complex interaction between genes and the environment characterized by long-term energy imbalance due to a sedentary lifestyle, excessive caloric consumption, or both [2]. Our understanding of how and why obesity develops is incomplete. There is overwhelming evidence to suggest that overweight and obesity are associated with increased mortality and morbidity [3, 4]. Over the past two decades there has been a dramatic rise in the prevalence of obesity throughout the world. It is estimated by the World Health Organization (WHO) that globally, over 1 billion (16%) adults are overweight and 300 million (5%) are obese. In India alone there are more than a 100 million obese individuals. These figures indicate we are truly in the midst of an obesity epidemic, which could have serious health ramifications [5].

There is a wide range of investigations from simple anthropometric measurements to magnetic resonance imaging, computed tomography and Dual Energy X-ray Absorptiometry (DEXA) which can be used to measure obesity. These investigations not only help in classifying an individual as overweight or obese but also help to predict the risk of developing complications [6]. It is however, important to determine what is the most reliable, economical and acceptable tool which can be applied universally to identify and predict at risk individuals.

WHO recommends anthropometry as the single most portable, universally applicable, inexpensive and non-invasive technique for assessing the size, proportions and composition of the human body [7]. Anthropometry reflects both health and nutritional status and predicts performance, health and survival [8]. Cut-off values of various anthropometric parameters like body mass index (BMI) and waist hip ratio (WHR), based on WHO recommendations are currently in vogue to define overweight and obesity. While some countries have their

[*]Director AFMS (Health), O/o Directorate General Armed Forces Medical Services, New Delhi 110 001. [+]Deputy Director General (Planning and training), Directorate General Armed Forces Medical Services, New Delhi 110 001. [#]OC Station Health Organization, INS Rajali

Received : 09.03.09; Accepted : 11.05.09 E-mail : rajeshvaidya@yahoo.com

own guidelines such as Canada [9] and Australia [10] most countries use WHO guidelines [7].

One of the biggest constraints of using various anthropometric parameters in Indian setting is availability of cut off values. WHO itself acknowledges that the method used to establish BMI cut-off has been largely arbitrary and that the most studies in this area have been conducted among people living in Western Europe or USA [11]. BMI levels may not correspond to the same level of health risk in different individual and populations. WHO encourages member countries to establish reference data for their own populations, which would provide evidence-based guidelines for physicians, other health care practitioners and healthcare organizations for the evaluation and treatment of overweight and obesity in adults.

The Indian Armed Forces is not immune from the obesity epidemic sweeping the country. Studies indicate that there is a rising trend of obesity in the Armed Forces. Although the men in Indian Armed Forces are subjected to periodic medical examinations, the standards for body weight used to classify individual overweight are very old. The origins of the weight for height and age charts currently in use for the Army personnel are obscure. It is widely believed that these have been obtained from life insurance tables made for British/American civilian population [12]. The parameters used to define overweight and obesity in the Armed Forces have undergone frequent changes in the recent past. Cut-off levels of BMI based on WHO recommendations are currently in vogue to define overweight and obesity. Overweight and obesity not only have serious health consequences but are a cause for lowering of medical classification in Armed Forces which adversely affects a soldier's career.

It is, therefore imperative that reference anthropometric values related to overweight and obesity for the Indian Armed Forces be established based on data for the same population. This study describes various anthropometric parameters such as weight, height, waist circumference, waist-hip ratio and BMI. The study also aims to compare different anthropometric parameters as indices of obesity. This is a preliminary study. The age range of the subjects has been restricted to 28 -52 years as obesity related problems are unlikely to occur before the end of the third decade of life and a very small proportion of the Indian Armed Forces is older than 52 years. Based on the results of this study, multi-centric studies with greater sample size may be carried out to reassess the indices of obesity currently in vogue in Indian Armed Forces.

## Material and Methods

This study used a community based, cross sectional descriptive epidemiological design. The reference population was serving male personnel of the Indian Armed Forces, without any evidence of prevalent disease (SHAPE 1 and equivalent). Sample size was worked out to 1000 subjects (WHO recommends 200 subjects in each age category for development of reference anthropometric values, Technical Report Series 854). This sample was selected using "multi-stage random sampling" procedure. 902 personnel between the age of 28 years and 52 years in SHAPE-1 were selected such that there were 200 personnel each, in the age groups 28 to 32 years, 33 to 37 years, 38 to 42 years, and 43 to 47 years. Despite vigorous efforts the estimated sample of 200 persons could not achieved for the age group of 48 – 52 years because of the age profile of the Armed Forces and there were only 102 persons in this age group. Personal information including region of origin, dietary habits, alcohol and tobacco use, were obtained by an investigator administered questionnaire. These personnel were subjected to a complete physical examination, estimation of fasting blood glucose and lipid profile. Anthropometric measurement including weight, height, waist circumference and hip circumference were recorded for these personnel in accordance with the recommended measurement protocols laid down by WHO (TRS 854). Statistical analysis was carried out by using SPSS 14 software. Appropriate tests have been carried out where indicated and are given with the results.

## Results

Height and Weight Distribution: The height of the study subjects ranged from 156 to 186 cm with a mean of 171.01 cm. The age wise range, average and standard deviation of height is given in Table 1. The weight of the study subjects ranged from 49 Kg to 96.80 Kg with a mean of 70.16 Kg. The age wise range, average and standard deviation of weight is given in Table 2. The table clearly shows that the average weight of different age groups increases from younger to older age group.

Distribution of BMI: The BMI ranged from 14.67 $Kg/m^2$ to 27.90 $Kg/m^2$ with a mean of 20.52 $Kg/m^2$. The age wise range, average and standard deviation of BMI is given in Table 3. The distribution of BMI in individual age groups has been graphically depicted in Fig.1. The figure indicates that the average BMI of different age groups increases from younger to older age group.

Distribution of Waist Circumference and Waist Hip Ratio: The waist circumference of the study subjects ranged from 63 to 107.50 cm with a mean of 84.61 cm. The distribution of waist circumference in all subjects as well as distribution of waist circumference in individual age groups has been graphically depicted in Fig. 2. It is observed that the average waist circumference of different age groups increases from younger to older age group. The waist hip ratio ranged from 0.69 to 1.18 with a mean of 0.91. The average waist hip ratio of different age groups was found to increase from younger to older age group.

**Table 1**

**Height distribution**

| Age Groups (years) | Minimum (cm) | Maximum (cm) | Mean (cm) | Median (cm) | Standard deviation |
|---|---|---|---|---|---|
| 28-32 | 159.00 | 186.00 | 171.76 | 172.00 | 4.99 |
| 33-37 | 157.00 | 186.00 | 172.42 | 172.00 | 5.10 |
| 38-42 | 157.00 | 185.00 | 170.91 | 170.00 | 5.60 |
| 43-47 | 156.00 | 183.00 | 169.87 | 170.00 | 4.85 |
| 48-52 | 157.00 | 184.50 | 169.22 | 169.25 | 5.54 |
| All age groups | 156.00 | 186.00 | 171.01 | 171.00 | 5.30 |

**Table 2**

**Weight distribution**

| Age Groups (years) | Minimum (Kg) | Maximum (Kg) | Mean (Kg) | Median (Kg) | Standard deviation |
|---|---|---|---|---|---|
| 28-32 | 51.20 | 88.00 | 66.62 | 66.60 | 7.07 |
| 33-37 | 53.90 | 90.60 | 68.67 | 68.90 | 7.85 |
| 38-42 | 54.50 | 96.80 | 70.90 | 70.30 | 7.89 |
| 43-47 | 53.30 | 93.70 | 72.57 | 73.05 | 7.72 |
| 48-52 | 49.00 | 95.70 | 73.90 | 73.10 | 9.73 |
| All age groups | 49.00 | 96.80 | 70.16 | 70.00 | 8.27 |

**Table 3**

**BMI distribution**

| Age Groups (years) | Minimum ($Kg/m^2$) | Maximum ($Kg/m^2$) | Mean ($Kg/m^2$) | Median ($Kg/m^2$) | Standard deviation |
|---|---|---|---|---|---|
| 28-32 | 14.88 | 25.03 | 19.39 | 19.31 | 1.94 |
| 33-37 | 15.85 | 24.96 | 19.91 | 19.86 | 2.18 |
| 38-42 | 15.89 | 27.66 | 20.77 | 20.67 | 2.15 |
| 43-47 | 15.96 | 27.32 | 21.35 | 21.53 | 2.13 |
| 48-52 | 14.67 | 27.90 | 21.80 | 21.96 | 2.52 |
| All age groups | 14.67 | 27.90 | 20.52 | 20.49 | 2.31 |

Height and Weight Percentiles: Data from study subjects was used to derive 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles of height and weight which are represented in Table 4 and 5 respectively. It is observed that weight in 50th percentile increases as we move from younger to older age group

Percentiles of BMI, Waist Circumference and Waist Hip Ratio: The percentiles of BMI are depicted graphically in Fig. 3. It is observed that BMI in the 90th percentile increases as we move from younger to older age group. The percentiles of waist circumference in the study subjects ranged from 70.03 cm at the 5th percentile to 99.40 cm at the 95th percentile. A clear rise in waist circumference was observed from the 5th to 95th percentile as we move from younger to older age group. The percentiles of waist hip ratio in the study subjects are ranged from 0.81 at the 5th percentile to 1.02 at the 95th percentile. Waist Hip Ratio percentiles also increase as we move from younger to older age group.

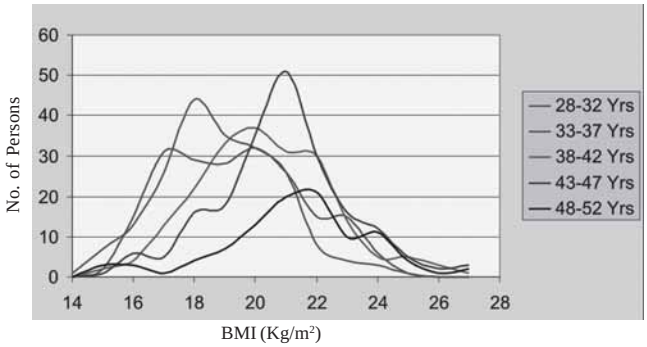


Fig. 1 : Distribution of BMI (different age groups)

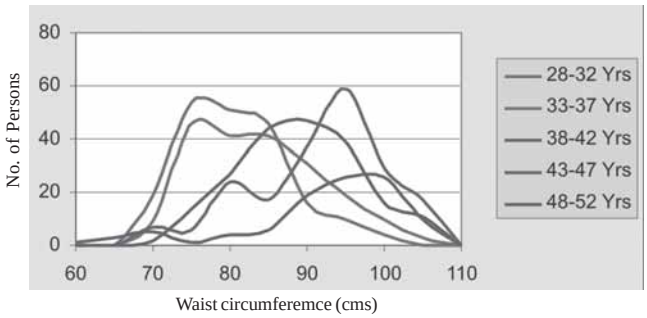


Fig. 2: Distribution of waist circumference (different age groups)

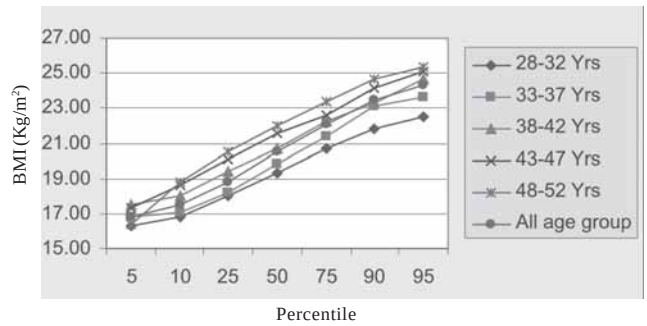


Fig. 3: Percentiles of BMI (different age groups)

Weight for Height and Age: One of the major objectives of the study was to derive reference weights for height and age for healthy Armed Forces personnel. Table 6 gives the average weight for individuals in particular age and height group. The number of individuals examined in each age group was limited to 200. No individual was found to be having height >185 cm in age group 43-47 years and 48-52 years. Therefore these cells have been left empty in the table and have been shown as insufficient data. It is observed that average weight increases with height when all age groups are considered together as well as when each age group was considered individually. It was also observed that average weight increased with increase in age in each class of height.

Correlation between different indices of Obesity: Correlation of BMI with waist circumference and BMI with waist hip ratio in the study subjects was found to be statistically significant ($p < 0.01$) using Pearson's Correlation Coefficient. This indicates that as BMI increases, both waist circumference and waist hip ratio also increase. However it was also observed that although BMI correlates with both

**Table 4**

**Percentiles of height**

| Age groups (years) | Percentiles (height in cm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 5 | 10 | 25 | 50 | 75 | 90 | 95 |
| 28-32 | 161.58 | 166.00 | 169.00 | 172.00 | 175.00 | 178.00 | 180.00 |
| 33-37 | 164.50 | 166.00 | 169.00 | 172.00 | 175.88 | 179.00 | 181.48 |
| 38-42 | 163.00 | 164.00 | 167.50 | 170.00 | 175.38 | 178.50 | 180.95 |
| 43-47 | 161.00 | 163.50 | 167.00 | 170.00 | 173.50 | 176.00 | 178.00 |
| 48-52 | 159.65 | 162.15 | 165.00 | 169.25 | 173.00 | 175.35 | 179.93 |
| All age groups | 162.00 | 164.50 | 167.50 | 171.00 | 174.50 | 178.00 | 179.93 |

**Table 5**

**Percentiles of weight**

| Age groups (years) | Percentiles (weight in Kg) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 5 | 10 | 25 | 50 | 75 | 90 | 95 |
| 28-32 | 55.62 | 57.00 | 61.43 | 66.60 | 71.00 | 76.90 | 78.10 |
| 33-37 | 56.02 | 58.40 | 62.40 | 68.90 | 74.40 | 78.97 | 81.80 |
| 38-42 | 58.00 | 60.83 | 65.43 | 70.30 | 76.00 | 79.88 | 85.50 |
| 43-47 | 59.02 | 63.50 | 67.10 | 73.05 | 78.08 | 82.00 | 83.80 |
| 48-52 | 52.92 | 63.93 | 68.18 | 73.10 | 81.00 | 85.70 | 90.96 |
| All age groups | 56.73 | 59.60 | 64.48 | 70.00 | 76.00 | 80.30 | 83.77 |

**Table 6**

**Average weight (in Kg) for Height and Age**

| Height (cm) | Age groups (year) | | | | | All age groups |
|---|---|---|---|---|---|---|
| | 28-32 | 33-37 | 38-42 | 43-47 | 48-52 | |
| < 164.9 | 62.99 | 62.25 | 67.64 | 68.66 | 67.25 | 66.48 |
| 165-169.9 | 63.76 | 68.02 | 68.23 | 70.93 | 68.74 | 68.19 |
| 170-174.9 | 66.96 | 67.59 | 70.86 | 73.43 | 79.37 | 70.56 |
| 175-179.9 | 71.19 | 71.88 | 73.24 | 74.64 | 81.23 | 72.92 |
| 180-184.9 | 72.77 | 75.05 | 77.01 | 92.00 | 81.40 | 76.14 |
| >185 | 77.50 | 76.00 | 91.40 | *** | *** | 82.46 |

*** insufficient data.

indices, it correlated better with waist circumference (r = 0.883) as compared to waist hip ratio (r = 0.660). Correlation of waist circumference with waist hip ratio was also found to be statistically significant (r=0.852, p <0.01)

## Discussion

Overweight and obesity represent a rapidly growing threat to the health of populations in an increasing number of countries. Indeed, they are now so common that they are replacing more traditional problems such as under nutrition and infectious diseases as the most significant causes of ill-health. However since no similar study has ever been done especially in Indian Armed Forces personnel, not much data was available for comparison.

In the study sample, distribution of height appeared to follow a Gaussian curve. It was also observed that very few subjects had height below 165 cm because of high level physical standards being followed at the time of entry into the Armed Forces. The average height in each age group was found to be similar to each other indicating that the age groups are similar in terms of height. The average weight of the study subjects increased as we move from lower age group to higher age group category. It is also observed that the average height in different age groups are almost similar but weight seems to increase with increase in age. This study found a positive correlation of age with weight. Similarly the weight for height and age chart currently in use, allows greater weight for older person of the same height category, thus indicating extra allowance of weight had been catered for older age groups.

In the present study, average BMI ranged from 14.67 to 27.90 kg/m$^2$. It may be important to note that no individual qualified as obese (BMI >30 kg/m$^2$). This may be explained by the fact that by virtue of being in Armed Forces a high degree of fitness level is maintained among the troops. It was also observed that average BMI appeared to increase as we moved from lower to higher age category. This is because with height almost similar

in all age category and weight increasing with age, BMI would also follows a similar path as it is a product of weight divided by height square. Average waist circumference increased from lower to higher age category. This indicates that an increase in weight with age results in increase in the abdominal girth. In our study subjects it was seen that average waist hip ratio increases as we move from lower to higher age category. This further emphasizes that an increase in weight with age results in increase in abdominal girth rather than more uniform increase in the whole body size.

By calculating the frequency distribution of different anthropometric parameters in 902 subjects 5$^{th}$, 10$^{th}$, 25$^{th}$, 50$^{th}$, 75$^{th}$, 90$^{th}$, and 95$^{th}$ percentiles were derived for each parameter. Except for height in which the 50$^{th}$ percentile is almost same for each age category all the other parameters (BMI, waist circumference and waist hip ratio) show an increase in values of 50$^{th}$ percentile when we move from lower to higher age category. All the anthropometric parameters under consideration except height seem to increase with age.

Weight for height and age chart, has been devised based on average weight in relation to height for each age category. This chart when compared to weight for height chart currently in vogue in the Indian Army clearly shows an increase in weight in all age and height categories. For example as per old scale, individuals in height category 178 cm should to have an ideal weight for 28-32 yrs as 68.5 Kg , for age 33-37 as 70.5 Kg, for age 38-42 as 71.5 kg, for age 43-47 as 72 kg and for age >48 as 72.5 Kg. In our study the average weight for height category 175-179.9 cm was found to be for 71.19 Kg for age group 28-32 yrs, 71.88 Kg for age group 33-37 years, 73.24 Kg for age group 38 -42 years, as 74.64 kg for age group 43-47 years, and as 81.23 kg and age >48 years. The 5$^{th}$ and 95$^{th}$ percentile of weight for height in each age category was also calculated but has not been presented as the number of subjects in some categories was very small. As discussed earlier not only the origin of currently used weight for height and age chart is obscure but it has been primarily based on American/ British population who are inherently different from Indian population. The difference in weight seen between our study and weight for height and age chart in use indicates a need for revision of the current recommended weights for Indian Armed Forces personnel.

Excessively high levels of body fat are a risk to health. However, the distribution of fat may be as important as total fat, with excess abdominal fat associated with greater health risk. Direct measures of body fat are expensive and to date, impractical for widespread use. Currently BMI is considered as one of the better measures to estimate body fat. BMI however does not provide an estimate of distribution of fat. To estimate the fat distribution, particularly those of abdominal fat, circumference measures like waist circumference and waist hip ratio are often used. In this study we found that all these anthropometric parameters correlate well with each other. Similar association between indices of obesity has been reported by other studies. Gupta et al [13] reported that body mass index correlated significantly with waist circumference and waist-hip ratio in a study involving 458 individuals from urban India. The Danish prospective cohort study reported a strong positive correlation between WC and BMI (r=0.87 for men, r=0.86 for women) [14]. Zafar et al [15] found strong positive correlation between BMI and WHR for males (r=0.690, p<0.0001) and females (r=0.620, p<0.0001) in a study of 483 medical students using partial correlation controlled for age. Another study in Bangalore by Kurpad et al [16] of 207 male subjects reported that waist circumference correlated better with BMI (r=0.82, p<0.001) as compared with WHR (r=0.34, p<0.001).

## Conclusion

The main observations in regards to distribution of anthropometric parameters are that the distribution of height, weight and BMI in 902 subjects followed almost a Gaussian distribution. No individual was found to have BMI >30 kg/m$^2$. This means out of 902 subjects not even one individual qualified as obese as per global standards. Older age groups were found to have higher 5$^{th}$, 10$^{th}$, 25$^{th}$, 50$^{th}$, 75$^{th}$, 90$^{th}$, and 95$^{th}$ percentile of weight, BMI, WC and WHR as compared to younger age groups. The weight for height and age chart calculated in our study, shows considerable variation when compared to weight for height and age chart currently being used in Indian Army. The average weight for majority of height and age category was found to be higher than in the Indian Army chart. All the three under study indices of obesity (BMI, WC and WHR) correlated well with each other. It was also observed that BMI correlated better with WC as compared to WHR.

This study was primarily conducted to derive reference weights of healthy Armed Forces personnel and to compare with the existing reference weights which have not been revised in last 50 years, and whose source is obscure. It is evident from the results that the current average weights are considerably more than those recommended in the old scale. Therefore it is recommended that a large multi-centric study should be taken up and more evidence based weight for height and age charts be devised to replace the current chart.

## Conflicts of Interest

None identified

## Intellectual Contribution of Authors

*Study Concept* : Gp Capt R Vaidya, Brig R Bhalwar
*Drafting & Manuscript Revision* : Surg Lt Cdr S Bobdey
*Statistical Analysis* : Gp Capt R Vaidya
*Study Supervision* : Brig R Bhalwar

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