Research Article

Studies on the correlation of anthropometric measurements with health outcomes in elderly

Abstract

Obesity is the major health problem among the elderly in both developed and developing countries. In this group, obesity results into early onset of chronic morbidity and may initiate premature mortality. The risk relationship between the obesity and chronic diseases is well known fact in the elderly. So an effort was made to assess the nutritional status of 120 elderly residents of *Baijnath* and *Panchrukhi* blocks of District Kangra, Himachal Pradesh (India). It was observed that 44.17 per cent of subjects had Grade I and Grade II obesity and according to Waist to Hip ratio majority of females (98.63%) and males (57.45%) belonged to above normal category. Sixty five per cent of subjects were suffered from metabolic diseases like diabetes, hypertension, cardiovascular diseases, gout and arthritis. Health conditions like diabetes, hypertension, heart disease, arthritis and gout were positively and significantly associated with anthropometric parameters viz. BMI, WHR, WHtR, Per cent Body Fat (PBF) and Fat Mass (FM).There is an urgent need to emphasize the importance of regular physical activity to control the weight.

Keywords: BMI, WHR, PBF, skin fold measurements, body density, body fat, AMC, AMR, FM, FFM

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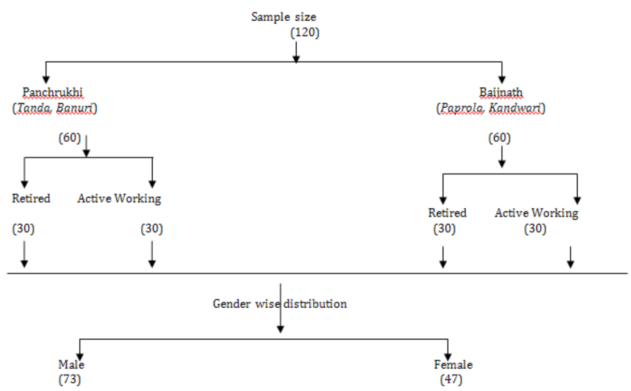
Introduction

The prevalence of obesity is increasing in the developed as well as developing countries. Central obesity in the elderly population of India is a major public health problem. Obesity is associated with significant increase in morbidity and mortality. India is gradually observing a phenomenon of greying of her population. Increase in life expectancy has resulted in growing of population of aged throughout the world and it has raised a number of issues concerning the developing world as well. Obesity is a global health problem affecting all ages. It is a major health problem among the elderly in both developed and developing countries. In elderly, obesity results into early onset of chronic morbidity and also initiate premature mortality. With the advance of age, obesity is more likely than those at younger age. The risk in the relationship between obesity and chronic diseases are well known in the elderly and it includes gait and many problems affecting various organs. India is passing through a demographic transition commonly called 'Pyramid to Pillar'. This means that number of elderly persons is increasing at a much faster pace as compare to the general population-a structure which was earlier regarded as a pyramid now shape as a pillar. Increase in life expectancy, substantial progress in health care amenities and demographic transition has brought about a fast aging of world population. Today, India is home to one out of every 10 senior citizens of the world. The nationwide dependency ratio of elderly to the general population is 13.1 per cent. Elderly people who belong to middle and higher income groups are prone to develop obesity and its related complications due to a sedentary lifestyle and decreased physical activity Despite this fast pace of ageing not much attention has been given to the needs and care of India's elderly. People are living longer, the Oldest Old, those 80 plus, are estimated to reach 48 million by 2050. The scope of this study was to estimate the prevalence of overweight and obesity and its association with various metabolic diseases. Obesity and overweight were assessed using the Body Mass Index (BMI) and Waist Circumference (WC Anthropometric measurements included weight, height and waist circumference (WC). Body Mass Index (BMI) was calculated as body weight divided by the square of the height in meters and the cut-offs set were those established by World Health Organization. The main aim of this study to find the prevalence of obesity in a rural setup among retired and active elderly and to assess the health problems due to obesity in the selected persons. And also to find the relationship of obesity with anthropometry measurements.

Materials & methods

The present study was conducted by collecting suitable representative sample of 120 elderly from two blocks viz. *Panchrukhi* and *Baijnath* representing District Kangra. The selected geriatric subjects were further sub-categorized into two groups i.e. retired (which were retired and above 60years of age) and active working (which were doing business or involved in any other kind of occupation after the age of 60years).



Anthropometry

Anthropometric measurements are considered as a tool for assessing nutritional status. Body measurements though are simple and easy to measure, at the same time provide maximum information on nutritional status of the subjects.

Height (Ht): The height was measured according to the method described by Jelliffe[1] with the help of anthropometer rod. The bare footed respondents were made to stand erect with heels, buttocks, shoulders, and back of the head touching the upright anthropometer rod at the back. The head was held comfortably erect with the arms hanging on the sides in a natural manner. Then head piece was lowered gently, crushing the hair and making contact with the top of the head. The readings were recorded to the nearest of 0.5cm. The same procedure was repeated thrice to avoid any error and then mean was taken.

Weight (Wt): The weights of the respondents were taken using the weighing balance calibrated in kilograms and grams.[1] The balance was initially standardized with known weight before use and kept in a flat surface adjusted to zero. The subjects with light clothing and without shoes were made to stand erect on the centre of the platform without any support. The body weight was determined to the nearest of 0.5kg to avoid errors using weighing machine.

Mid-upper arm circumference (MUAC): Mid upper arm circumference indicates both calorie and protein reserves and is a good indicator of nutritional status as well as over nutrition. The measurements were taken firmly around mid way marked the lateral part of the left upper arm with the subjects forearm held in horizontal position. The measurements were taken from non stretchable fibre glass tape calibrated in inches, centimetres and millimetres to the nearest 1millimetre at the marked midpoint. The mean of two readings was taken as final value.

Body mass index (BMI): Body Mass Index, a measure of body weight adjusted for height is used as an indicator of nutritional status and size of the body energy stores in adult population and includes both fat and lean tissues. The index was calculated for each of the subject as weight (kg) divided by height (m²). It was calculated by the equation given by Garrow[2] (Table 1).

Weight (kg)

BMI=------------------ =kg/m^2

Height (m^2)

Table 1 Interpretation - BMI was compared with the classification given by WHO (1998)

Classification	BMI Kg/m²	Risk of co-morbidities
Underweight	18.5	Low (but risk of other clinical problems increased)
Normal range	18.50-24.99	Average
Overweight	> 25.00	Increased
Pre-obese	25.00-29.99	Increased
Obese class-I	30.00-34.99	Moderate
Obese class-II	35.00-39.99	Severe
Obese class-III	> 40.00	Very severe

Waist and hip circumference (WHC): Waist and Hip circumference is a measurement at the level of navel, when the subject breathes quietly whereas, hip circumference was measured at the intertichantric level[3] with the help of non-stretchable tape.

Waist to hip ratio (WHR): Waist to hip ratio in Table 2 is a measurement of visceral obesity and is a strong indicator of risk of hypertension, cardiovascular disease and some other diseases like cancer etc. WHR is an indicator of abdominal obesity. It was calculated by the formula by.[4]

$$Waist\ to\ Hip\ ratio = \frac{Waist\ circumference\ (cm)}{Hip\ circumference\ (cm)}$$

Table 2 Waist to Hip Ratio (WHR)

Sex	Normal range for WHR
Male	≥0.95
Female	≥0.80

Waist to height ratio (WHtR): The normal Body Mass Index (BMI) range, as defined by WHO is quite wide and some people within this range may have an excessive central fat accumulation and elevated metabolic risks. Waist circumference is improved by relating it to height to categorized fat distribution and WHtR in Table 3 is a simple and practical anthropometric index to identify higher metabolic risks in normal and overweight people.[5]

Table 3 Waist to Height Ratio (WHtR)

Range	Interpretation
<0.50	Considered Normal
≥0.60	Considered boundary value for CVD risks

Skin fold thickness

The Harpenden Skinfold Calliper was used to measure skinfold thickness such as Triceps, Biceps, Subscapular and Suprailliac to the nearest of 0.1mm by the method as suggested by Jelliffe.[1]

Triceps skinfold thickness: It measures a double layer of skin and sub-Cutaneous fat. The measurement was taken half way down the left arm between the tip of acromial process of scapula (shoulder blade) and the olecrane on process of ulna (tip of the elbow). Measurements were taken while hanging freely at the side. The skin fold parallel to the long axis was picked up between the thumb and the forefinger of the left hand clear away from the underlying muscle. The callipers were applied to the fold little below the finger and reading was noted to the nearest of 0.1mm.

Biceps skin fold thickness: The skin fold was picked on the front of the arm directly above the centre of the orbital fossa at the same level on which the triceps skin fold was measured.

Subscapular skin fold thickness: The subscapular skin fold was measured just below and laterally to the angle of left scapula. The fold should be in a line running at approximately 45° to the spine, in the natural line of skin cleavage. It has the advantage of providing a uniform layer of subcutaneous fat not requiring precise localization.

Suprailliac skinfold thickness: This measurement was taken above the illiac crest in the mid auxiliary line of the subjects.

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Interpretation: The values thus obtained were interpreted as per the classification of Per cent Body Fat suggested by Deurenberg et al.,[6] as follow in Table 4.

Table 4 Interpretation

Sex	Thin	Normal	Stout obese	Extreme obese
Male	< 10%	10-20%	20-25%	25-30%>30%
Female	< 20%	30-35%	35-40%	> 40%

Percent body fat (PBF): It was calculated from the sum of Tricep, Biceps, Subscapular and Suprailliac from equation given by Durnin & Womersley.[7]

Body density=1.1599 - (0.0717* log of sum of all four skin fold).

$$\% \, Fat = \frac{4.95}{Body\ density} - 4.50 \times 100$$

Arm muscle circumference (AMC): Arm muscle circumference is calculated by the equation suggested by Linder.[8]

$$AMC\ (cm) = MUAC\ (cm) - 22/7 \times (Triceps\ skin\ fold\ in\ cm)$$

Arm Muscle Area (AMA): Arm Muscle Area is calculated by the formula given by Frisancho.[9]

$$AMA\ (cm^2) = (AMC)^2/4 \times 22/7$$

Arm Fat Area (AFA): Arm Fat Area is calculated by the equation given by Frisancho.[9]

$$AFA\ (cm)^2 = 1/4 \times 22/7\ ((MUAC)^2 - (AMC)^2)$$

Fat mass (FM): Fat Mass is calculated as

$$FM\ (kg) = PBF/100 \times Weight\ (kg)\ (PBF\ mention\ from\ section\ I\ of\ anthropometry)$$

Fat free mass (FFM): Fat Free Mass is calculated as

$$FFM\ (kg) = Weight\ (kg) - FM\ (kg)$$

Results and discussion

The results thus obtained are presented under pertinent Tables and discussed suitably.

Anthropometry: Anthropometry is an essential tool in geriatric nutritional assessment to evaluate underweight and obesity conditions, which are both important risk factors for severe diseases and disability in elderly.

Height (Ht): Height is an important tool to assess the many risk factors among elderly such as height in elderly reflects shortening of spinal column associated osteoporosis and kyphosis.

Perusal of the data of the Table 5 revealed that height of the geriatric subjects ranged from 150cm to 170cm. Majority of the males (47.95%) had height ≥170cm; followed by in the range between 160.1-165.0cm (26.03%); 165.1-170.0cm (16.44%); 155.1-160cm (6.85%) and 150.1-155.0cm (2.74%) and none of geriatric male had height ≤150cm. Among female subjects majority of female geriatric subjects (40.43%) had height between 155.1-155cm followed by 160.1-165.0cm (19.15%); 150.1-155cm (14.89%); 165.1-170.0cm (12.77%); >170cm (6.38%) and ≤150cm (6.38%). As age advances, the skeletal system undergoes structural modifications such as demineralization, which reduces the width of vertebrae and deforms the long bones of the inferior extremities. The variation in height might be due to their genetic characters as well as nutritional status at the time of adolescence. In whole, men were taller than the women and same trend was also reported by Perissinotto et al.[10]

Table 5 Distribution of subjects according to their height in cm

Variable	Male	Female	Total
≤ 150.0	00(00.00)	03 (06.38)	03 (06.38)
150.1-155	02 (02.74)	07 (14.89)	9
155.1-160	05 (06.85)	19 (40.43)	24
160.1-165	19 (26.03)	09 (19.15)	28
165.1-170	12 (16.44)	06 (12.77)	18
>170cm	05 (47.95)	03 (06.38)	38

Weight (Wt): Assessment of ideal body weight is a useful tool to check the appropriate weight for height for an individual and it gives an insight of any health risks. Data depicted in Table 6 revealed that weight of geriatric subjects ranged from 55kg to 75kg. Majority (38.36%) of male subjects have weight in the range of 55.1- 65kg; followed by 30.14 per cent (≤55kg); 27.40 per cent (65.1-75kg) and 4.11 per cent have ≥75kg. Among females majority (42.55%) of subjects had weight in the range of 55.1-65kg; followed by 27.66 per cent (≤55kg); 17.02 per cent (65.1-75kg) and 12.77 per cent have ≥75kg.

Table 6 Distribution of subjects according to their Weight in Kg

Variable	Male	Female	Total
≤55	22 (30.14)	13 (27.66)	35
55.1-65	28 (38.36)	20 (42.55)	48
65.1-75	20 (27.40)	08 (17.02)	28
≥75.1	03 (04.11)	06 (12.77)	9

Body Mass Index (BMI): Among all anthropometric measurements, the BMI represents the easier and most frequently used index to identify subjects at risk for under or over nutrition. But it does not reflect regional distribution of fat or any change in fat distribution in the elderly. The value for BMI is generally considered to be as a measurement of fatness, while it also gives information about fat free mass. Data on BMI depicted in Table 7a which reveals that 15.00 per cent of retired subjects have BMI ≤18.5 considered underweight; 36.67 per cent within normal range (18.6-24.9); 30.00 per cent have Grade I obesity (25.0-29.9); 18.33 per cent have Grade II obesity (30.0-39.9) and none of retired subject belongs to Grade III morbid obesity i.e. ≥40. In case of active working elderly 10.00 per cent of subjects were considered underweight (≤18.5); 50.00 per cent have normal BMI (18.6-24.9); 21.67% is considered as Grade I obese and 18.33 per cent considered as Grade II obesity and none of active working subject have Grade III morbid obesity. A significant difference was observed between BMI of retired and active working geriatric subjects. It is clear from the data that most of active working belonged to normal category as compared to retired geriatric subjects. A combination of excessive energy intake and lack of physical activity is thought to explain most cases of obesity or one more reason for enhanced

BMI among elderly could be due to more fat mass than metabolically active muscle mass and further adoption of sedentary life style. Increased intake of nutrients coupled with sedentary lifestyle had resulted in decreased energy expenditure, which ultimately resulted in weight gain. According to survey majority of retired subjects were doing regular exercise but among them majority was performed it for less than half an hour, while majority of active working subjects were performed it for more than half an hour. Occupational stress is one of the factors for working geriatric subjects and this is one of the predisposing factors responsible for the occurrence of obesity.

Table 7 Distribution of subjects on the basis of body mass index

Range	*Classification	Geriatrics		Total
		Active working	Retired	
≤18.5	Under weight	06 (10.00)	09 (15.00)	15
18.6-24.9	Normal	30 (50.00)	22 (36.67)	52
5-29.9	Grade I obesity	13 (21.67)	18 (30.00)	31
30-39.9	Grade II obesity	11 (18.33)	11 (18.33)	22

X^2= 1.38 D.F.= 3.

Figures in the parentheses indicate percentages.

*WHO classification (1998).

a) On the basis of Occupation.

Range	*Classification	Geriatrics		Total
		Male	Female	
≤18.5	Under weight	08 (10.96)	07 (14.89)	15
18.6-24.9	Normal	32 (43.84)	20 (42.55)	52
25.0-29.9	Grade I obesity	21 (28.76)	10 (21.28)	31
30.0-39.9	Grade II obesity	12 (16.44)	10 (21.28)	22

X^2= 1.55 D.F.= 3

Figures in the parentheses indicate percentages.

*WHO classification (1998).

b) On the basis of Gender.

As is clear from the same Table 7b that 10.96 per cent of males belonged to underweight category i.e. ≤18.5; 43.84 per cent have normal BMI (18.6-24.9); 28.76 per cent have Grade I obesity (25.0-29.9) and 16.44 per cent have Grade II obesity (30.0-39.9). Among female subjects (14.89%) were underweight; 42.55 per cent were normal; 21.28 per cent have Grade I obesity; 21.28 per cent have Grade II obesity and none of subject male or female have Grade III obesity. There was no significant difference found among BMI of geriatric male or female subjects. After menopause, decreased oestrogen levels lead to reduced metabolic activity and may accelerate the development of female obesity. Even though the decrease in fat free mass is greater for elderly, women possess relatively greater fat mass and less lean mass when compared with men. This association could also be attributed to societal determinants such as economic growth, media advertisements, the stress of a fast-paced society and the family structure. A further study should be conducted to investigate this phenomenon. Earlier Perissinotto et al.,[10] and a team of pioneer scientists had also observed that there was higher prevalence of obesity in women than in men. Later on Saava et al.,[11] also reported that the majority of females were obese and a minimum of them were undernourished. In 2005[12] also concluded that the prevalence of overweight among elderly persons was high for both men and women.

Thereafter, Swami et al.,[13] also observed that over weight/obesity was higher among females (42.1%) than males (20.9%). Results of present study are in accordance with earlier studies.

Waist to hip ratio (WHR): Waist to Hip Ratio Table 8 is an index of the central obesity, associated with cause of most of the metabolic diseases. This is the best method to use to look at the fat distribution of the body. Depending on the region that predominates (hips or waist region) risk about cardiac, hypertension, diabetes and strokes can be predisposed. Data regarding waist to hip ratio of geriatric subjects has been shown in Table 4. A significant ($p<0.05$) difference was found between male and female geriatric subject's Waist to Hip ratio. Only 8.51 per cent female geriatric subjects belonged to normal range (0.70-0.849); 34.04 per cent belonged to 0.85-0.949 and 57.45 per cent belonged to ≥0.95. Among male geriatric subjects 26.03 per cent fall in normal range (0.85-0.949) and 72.60% had WHR 0.95 or above. Data reveals that majority of females had higher value for WHR because in post menopausal period there is a decrease in hip circumference among elderly women which has also been reported by other studies Groot et al.[14]

Table 8 Distribution of subjects according to waist to hip ratio

Variable	Classification**	Male	Female	Total
0.70-0.849	Normal (female)	01 (01.37)	04 (08.51)	5
0.85-0.949	Normal (male)	19 (26.03)	16 (34.04)	35
Above 0.95		53 (72.60)	27 (57.45)	80

Significant at $p<0.05$ x^2= 21.171 D.F. = 2

Figures in the parentheses indicate percentages

**Classification derived by Rockville (1993)

One of the reasons of increased WHR among elderly is metabolic changes such as lean tissue loss, a decrease in total body water and more of central distribution of adiposity which was also observed by Enzi et al.,[15] & Schwartz[16] in their independent work.

A high prevalence of abdominal obesity was also reported among females by Misra et al.[17] Santos & Sichieri et al.,[12] also reported that prevalence of inadequate waist to hip ratio and waist circumference among women was approximately twice that of men and it become as high as three times that of men in the 80 plus year of age. These studies are in accordance with present findings.

Waist to height ratio (WHtR): A non-significant difference was found between retired and active working geriatric subjects' waist to height ratio (WHtR). Hsieh et al.,[5] reported boundary line for the risk of cardiovascular diseases as WHtR ≥0.50. According to the data gathered regarding WHtR as depicted in Table 9 which revealed that majority of retired (86.67%) and active working (85.00%) subjects have a risk of developing cardio vascular disease. Only 13.33 per cent retired and 15.00 per cent of active working were fall into normal category. A non-significant difference was observed among the occupation and risk of cardiovascular disease. Elderly who engaged in regular physical activity might have less subcutaneous fat and higher serum HDL cholesterol level than the sedentary individuals. The elderly with a higher frequency of physical activity showed a further lowering of coronary heart disease risk factors and abdominal obesity although physically active groups might increase their muscle amount accompanied by loss of fat. Therefore, it is important to encourage geriatric group to increase their physical activities, reminding them that "a little physical activity is better than none and to a degree, more is better than less" in reducing cardiovascular disease risk factors and improving general health.

Table 9 Distribution of subjects according to waist to height ratio

Variables/ Geriatric	Normal	At risk	Total
Retired	08 (13.33)	52 (86.67)	60
Active working	09 (15.00)	51 (85.00)	60

X^2= 0.069 D.F.= 1

Figures in the parentheses indicate percentages

Percent body fat (PBF): Data related to per cent body fat is depicted in Table 10. Data reveals that majority of male geriatric subjects (41.10%) were recognized as obese (26-30%); followed by 24.66 per cent as normal (10-20%); 21.92 per cent as extra obese (≥30%); 9.59 per cent as stout (20-25%) and 2.74 per cent as thin (≥10%). The difference between male and female per cent body fat was observed significant at p<0.05. Majority of females (55.32%) were observed as stout (31-35%); followed by 21.28 per cent as normal (20-30%); 19.15 per cent as thin (≥20%); 4.26 per cent as obese (36-40%) and none of them fall in the category of extra obese. With advancing age, there is a general trend to accumulate body fat both relative and absolute due to an increase in one's ability to mobilize stored fatty acids from the adipose tissues for energy fuels resulting in less fatty acids being burns up and as people get older, most of them reduce their physical activity level without much change in their food intake. An increasing prevalence of overweight and obesity has a direct influence on associated co-morbidities like hypertension, dyslipidemia, Type 2 Diabetes mellitus, the metabolic syndrome and cardiovascular diseases. Same trend was also reported by Zambomi et al.,[18] Calle et al.[19] & Gupta et al.[20]

Table 10 Distribution of subjects according to percent body fat

Variable for males	Variable for females	*Classification	Geriatrics		Total
			Male	Female	
>10%	>20%	Thin	02 (02.74)	09 (19.15)	11
10-20%	20-30%	Normal	18 (24.66)	10 (21.28)	28
20-25%	1-35%	Stout	07 (09.59)	26 (55.32)	33
26-30%	36-40%	obese	30 (41.10)	02 (04.26)	32
≥30%	≥40%	Extra obese	16 (21.92)	00 (00.00)	16

X^2= 28.483 (significant at p< 0.05) D.F. = 4

Figures in the parentheses indicate percentages

*Deurenberg et al.[6]

Bisai et al.,[21] also reported that per cent body fat in 87.33 percent of subjects were found to be in higher range than normal and associated with coronary heart disease.

Kusumaratna & Hidayat[22] studied 296 older persons in Jakarta in the year 2008 found that males were more obese than the females. These findings are co-credence with present results.

Arm muscle area (AMA), arm fat area (AFA) and arm muscle circumference (AMC): The data pertaining to mean Arm Muscle Area (AMA), Arm Fat Area (AFA) and Arm Muscle Circumference (AMC) is depicted in Table 11a. Data reveals that retired geriatric subjects have 27.61cm, 63.80cm^2 and 14.99cm^2 mean AMC, AMA and AFA respectively; 24.10cm, 62.39cm^2 and 14.32cm^2 were mean value of AMC, AMA and AFA respectively of active working geriatric subjects. A significant difference was observed between retired and active working AMC at p<0.05, while AMA and AFA have no significant difference. Elderly population showed reduction of arm fat mass due to increase in centralization of body fat, especially among women folks.

Mean AMC, AMA and AFA were reported as 23.0cm, 35.3cm^2 and 20.4cm^2 for men and 27.9cm, 37.8cm^2 and 20.1cm^2 for women respectively by Ghosh (23). Data from same Table 11b also reveals that male geriatric subjects have 26.15cm, 59.74cm^2 and 14.25cm^2 mean AMC, AMA and AFA respectively; 24.79cm, 50.08cm^2 and 15.67cm^2 were mean value of AMC, AMA and AFA respectively of female geriatric subjects. There was no significant difference observed among male and female geriatric subject's AMC, AMA and AFA. Though these factors may influence the bone, fat and muscle composition of the upper arm and the measurements vary by age, gender and obesity. Bisai et al.,[21] also reported mean value as 26.8±8.7 for AMA for above 60yr Savar females. Menezes & Marucci[22] reported that mean AMC and AMA were higher in men than women (p<0.05). These studies are in line with present findings.

Fat mass (FM) and fat free mass (FFM): Fat Free Mass includes all non-fat portion of the human body as well as some essential fat deposits associated with bone marrow, the central nervous system and integral organ. Whereas, fat mass mainly consist of subcutaneous fat deposited in the adipose tissue just beneath the skin.

The data regarding Fat mass and Fat free mass is depicted in Table 12a No significant difference was observed between retired and active working subject's Fat Mass (FM) and Fat Free Mass (FFM). The mean FM 16.71kg and 14.69kg was observed among retired and active working subjects respectively and 44.82kg and 42.95kg was the mean FFM among retired and active working subjects respectively. The values for FFM were higher because that the subjects which were surveyed had higher Fat Free Mass components like skeletal mass, bone minerals, fibrous or connective tissue etc.

Table 11 Distribution of subjects according to mean Arm Muscle Area (AMA), Arm Fat Area (AFA) and Arm Muscle Circumference (AMC)

Variables/Geriatrics	AMC(cm^2)	AMA(cm)	AFA(cm^2)
Retired	27.61	63.8	14.99
Active working	24.1	62.39	14.32
t-value	2.187*	1.91	0.63

*significant at $p<0.05$

a) On the basis of Occupation.

Variables/Geriatrics	AMC(cm)	AMA(cm^2)	AFA(cm^2)
Male	26.15	59.74	14.25
Female	24.99	50.08	15.67
t-value	1.08	1.39	0.67

b) On the basis of Gender.

From the same Table 12b it was cleared that the mean FM 16.01kg and 17.98kg was observed among male and female subjects respectively and 40.67kg and 32.43kg was the mean FFM among male and female subjects respectively. Various factors like level of physical activity and sex hormones might be the probable cause for this sex discrimination. The present results were in accordance with Ghosh[23] and reflect that mean FM as 16.0kg for men and 17.0kg for women and mean FFM as 38.5kg for men and 27.0kg for women. The bio-medical mechanism underlying the variance in body composition and their changes with passage of time in men and women require further study.

Table 12 Distribution of subjects according to mean fat mass and fat free mass

Variables/Geriatrics	Fat mass	Fat free mass
Retired	16.71	44.82
Active working	14.69	42.95
t-value	1.672	1.104

a) On the basis of Occupation.

Variables/Geriatrics	Fat mass	Fat free mass
Male	16.01	40.67
Female	17.98	32.43
t-value	0.94	0.46

b) On the basis of Gender.

Correlation between health and anthropometric parameters

Diabetes: As is evident from the Table 13 Diabetes have a significant ($p<0.05$) and positive correlation with BMI ($r=0.853$) and Waist to Height Ratio (WHtR) ($r=0.207$). Diabetes was also found positively correlated with WHR ($r=0.020$), PBF ($r=0.063$), AMC ($r=0.115$), AMA ($r=0.126$), AFA ($r=0.133$), FM ($r=0.029$) and FFM ($r=-0.050$). Increased body fat is generally associated with an increase in the risk of metabolic diseases such as Type 2 *Diabetes mellitus,* hypertension and dyslipidemia. In addition, many of the geriatric subjects with these metabolic diseases are either overweight or obese. Type 2 diabetes is associated with insulin resistance. Insulin is an important hormone that delivers glucose (sugar) to our cells. When a person is overweight, the cells in the body become less sensitive to the insulin that is released from the Beta cells of pancreas. There is some evidence that fat cells are more resistant to insulin than muscle cells. If a person has more fat cells than muscle cells, then the insulin becomes less effective overall and glucose remains circulating in the blood instead of being taken in to the cells to be used as energy and resulted into hyperglycemia. Vazquezet et al.,[24] reported the pooled relative risks for incident of Diabetes were associated with Body Mass index, Waist Circumference and Waist/Hip ratio, respectively. This gives credence to the present work. Mahanta & Mahanta[25] studied the history of *Diabetes mellitus* with special reference to Body Fat Percentage and found that BMI was four times higher in diabetic subjects than control groups (95%CI -2.49-7.20, $p<0.001$).

Responsible factors for the complications among geriatric group such as diets, physical activities as well as work and functional status are of more of concerns and should be included in further studies.

Hypertension: Hypertension was found highly significant ($p<0.01$) and positively correlated ($r=0.398$) with BMI. It was also found significant ($p<0.05$) and positively correlated with WHR ($r=0.219$) and WHtR ($r=0.192$). Hypertension was also found positively correlated with PBF, AMC and FM, however correlation was non-significant. High blood pressure is twice as common in adults who are obese than in those who are at a healthy weight. Obesity is regarded as the chronic inflammation by adipocyte-secreted agents and this may account for the development of the metabolic syndrome. In other words, pro-inflammatory cytokines, specific hormones and free fatty acids that are secreted by adipose tissue resulted into hypertension by affecting the renin-angiotensin aldosterone system. These agents also affect dyslipidemia and insulin resistance.

Same observations were also reported by White et al.,[26] who stated that correlations of Body Mass Index, Waist to Hip ratio and Skin fold measurements with diastolic hypertension varied with age and sex. Sonika[27] reported that BMI, WHR and WHtR were highly significant and positively correlated with diastolic blood pressure in hypertensive men. Bays et al.,[28] were found that increased BMI was associated with increased prevalence of hypertension and diabetes. Tyagi & Kapoor[29] found a statistically significant positive correlations between indices of adiposity (BMI and WHR) and blood pressure ($p<0.01$). These results are in line with present findings.

Heart disease: Heart disease was found significantly and positively correlated with BMI ($r= 0.211$), WHR ($r=0.180$), WHtR ($r=0.217$), FFM ($r=0.199$) and AMC ($r=0.210$). While rest of anthropometric parameters viz. PBF, AMA, AFA and FFM were found positively correlated but correlation was non-significant. High waist to hip ratio had increased risk of death stroke, ischemic heart disease, diabetes, hypertension and hyperlipidemia.

Obesity is associated with high triglycerides and decreased HDL cholesterol. Cholesterol, a fat-like substance carried in blood stream, is found in all of the body's cells. Liver produces all of the cholesterol as body needs to form cell membranes and to make certain hormones.

Extra cholesterol enters the body with consumption of animal foods (meats, eggs and dairy products) which are rich in cholesterol and low in fiber. Although the excessive consumption of saturated fats like fat in milk products, fat from red meat and tropical oils such as coconut oil is the main culprit for the elevation of blood cholesterol level. Too much Low-Density Lipoprotein (LDL or "bad cholesterol") in the blood causes plaque to form on artery walls, leading to atherosclerosis. When plaque builds up in the coronary arteries that supply blood to the heart, then the risk of having a heart attack increases. Increased Waist Circumference was associated with dyslipidemia, hypertension and abnormal serum glucose, whereas an increased Body Mass Index was only associated with dyslipidemia.

Table 13 Correlation between Health and Anthropometric parameters

Metabolic disorder/anthropometry parameter	Diabetes	Hypertension	Heart disease	Arthritis	Gout
Body Mass Index (BMI)	0.853*	0.398**	0.211*	0.006	0.042
Waist to Hip Ratio (WHR)	0.02	0.219*	0.180*	0.019	0.107
Waist to Height Ratio (WHtR)	0.207*	0.192*	0.217*	0.014	0.008
Per cent Body Fat (PBF)	0.063	0.032	0.145	0.036	0.043
Arm Muscle Circumference (AMC)	0.115	0.127	0.210*	0.026	0.073
Arm Muscle Area (AMA)	0.126	-0.02	0.115	0.024	0.06
Arm Fat Area (AFA)	0.133	-0.056	0.051	0.007	0.028
Fat Mass (FM)	0.029	0.019	0.199*	0.007	0.035
Fat Free Mass (FFM)	-0.05	-0.036	0.038	0.116	0.006

*Significant at $p<0.05$ **Significant at $p<0.01$

Fava et al.,[30] observed that of all these risk factors responsible for cardiovascular disease, reduced high density lipoprotein cholesterol level and hypertension were those more strongly associated with higher BMI in both men and women. Kato et al.,[31] explained the relationship between body fat distribution and cardiovascular diseases. The present work is in line with studies done earlier by different scientists.

Arthritis and gout: Arthritis and gout has a positive but non-significant correlation with all the anthropometric parameters. Presumably, excess adipose tissue on weight bearing joints would be more burdensome on the weaker bones of geriatric group. Furthermore, a decrease in sex hormones (such as estrogen) in female elderly might lead to a weakening of their bone density. Results are in same line as observed by Abbate and his co-workers[32] and confirm that BMI and weight are strongly associated with radiographic knee osteoarthritis in women.

Zakkak et al.,[33] concluded that BMI is an independent risk factor for self reported arthritis. Maintaining a healthy weight may delay the onset of arthritis. Obese people often have hyperuricemia, which frequently leads to painful attacks of gout. It has been suggested that increased serum uric acid and gout occurrence are closely associated with an increase in visceral fat accumulation. Choi et al.,[34] reported that higher adiposity and weight gain are strong risk factors for gout.[35]

Most of these recent studies continue to show that increasing level of obesity is associated with increasingly greater risks of coronary artery disease (as well as an increasing incidence of high blood pressure, diabetes, stroke, arthritis, some forms of cancer and premature death). This gives credence to the present work.

Conclusion

From the ongoing discussion it is inferred that diabetes was found to be positively and significantly correlated with BMI and WHtR. Whereas, Hypertension and heart diseases are also found to be positively and significantly correlated with BMI, WHtR, WHR and fat mass. Elderly should be educated to maintain a healthy body weight, reducing physical inactivity, consuming foods which are rich in fiber, vitamins and minerals and low in fats especially saturated fats.

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Conflict of interest

The author declares no conflict of interest.

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