

# Body Composition in Subjects of Different Age and Body Mass Index

DV Muralidhara, M Ramesh Bhat, MH Naveed Ahmed

## Abstract

Ageing is an inevitable process involving complex biological and behavioral mechanisms. It brings about remarkable changes in human body composition. Several studies from the West have reported that an increase in body fat and a decrease of fat free mass occur at widely varying points of time as age advances. Our study was designed not only to explore the age related changes in body composition namely fat, fat free mass and body water in a small population of South India, but also to examine the body composition changes in chronically undernourished and overweight of obese subjects of <20 to >50 years of age as compared to a control normal group. The age at which increase of body fat and other changes in body composition occurred in these subjects were different from the previous studies and also from this own study when the data was analysed for the whole age groups without taking into consideration the nutritional status of the subjects based on body mass index. It was concluded that in states of negative or positive energy balance, the age related changes in body composition are deviated and the loss of fat free mass cannot be further compromised with ageing in the undernourished subjects and therefore results in loss of body fat.

**Key Words:** *body composition, body fat, body mass index, body water, fat free mass, chronic undernutrition, overweight/obese*

The human body may broadly considered to be made up of fat (body fat = BF) and fat free mass (FFM) which is also sometimes referred to as lean body mass (LBM).<sup>1</sup> Both components have several physiological and medical implications since variations in body composition (BC) are widely recognized in relation to age, gender, race, diet and physical activity levels, hormonal and genetic influences in health and disease conditions.<sup>2,3</sup> The use of body weight alone has very limited value in health related research. Therefore, the assessment of BF and FFM becomes important to provide information on changes in BC associated with body weight changes in studies of such nature. Ageing has been defined as 'a progressive loss of physiological capacities that culminate in death.'<sup>4</sup> It is an interesting and inevitable phenomenon involving many complex cellular and molecular processes leading to profound changes in BC to increase body weight, increase in BF and a decrease in FFM.<sup>5-9</sup> However, there are some conflicting reports demonstrating a decrease in BF mass without changes occurring in FFM.<sup>10,11</sup> Such observations of age related changes in BC, especially increase in BF have raised concerns that obesity may be an unavoidable epidemic of the 21<sup>st</sup> century in the United States as 50% of the population there are overweight

and this phenomenon has spread to other developing nations too.<sup>12</sup> Obesity leading to increased risks of developing a wide range of chronic disorders is well documented.<sup>3,13,14</sup>

Some of the studies on BC changes have certain limitations to provide little or no information on the pattern of age related BC changes throughout the whole range of adult ages. And, a comprehensive study in this area is not available for the Indian population. Therefore, the present study was undertaken for a systematic assessment of age related changes in BC in over one thousand subjects. BC was measured at a three compartment level namely, BF, FFM and total body water (TBW) in these subjects of different ages varying from 18 years to 70 years who were further sub-divided on the basis of body mass index (BMI). It is hoped that this work on a selected sample of the South Indian population will add some useful data to the existing body of literature on age-related changes in BC.

## Methods

Research ethical committee of the institute had approved the proposal to carry out this research work. One thousand and fifty two (1,052) subjects (538 males and 514 females) were included in the study. The subjects were explained the aims and objectives of the study. The participants were healthy at the time of assessment and did not suffer from any health problems in the recent past. They were college students, office-goers, housewives, retired persons and others who had odd jobs. A brief questionnaire was prepared to collect personal data which included age, religion, occupation, socio-economic status and physical activity levels. Such information collected was not pursued for further analy-

From Uni-KL Royal College of Medicine Perak, Malaysia  
Kasturba Medical College, Mangalore, India.

*Corresponding Author:*

DV Muralidhara, PhD

# 3, Jln Greentown Uni-KL Royal College of Medicine Perak 30450,  
Ipoh, Malaysia

Email: diviem@yahoo.com

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sis. However, the information was used carefully in making any judgment wherever possible or required.

Male and female subjects were divided according to age into five groups as follows: <20, 21-30, 31-40, 41-50, and >50 years. Since the number of subjects in the age group over 50 years was small, all the subjects were pooled in one group as >50 years. In each age group, subjects were further sub-divided into three groups on the basis of BMI according to a WHO report<sup>15</sup> as Undernourished (UN) (BMI <18.49), Normal (N) (BMI 18.5 to 25) and overweight or obese (OW/Ob) (BMI >25).

Body weight and height was recorded using standard techniques. BMI was derived from these measurements. BC was measured using an electronic BC analyzer, Futrex-5000A (Gaithersberg, USA). The principle

of its working and the details of the procedure are referred elsewhere.<sup>16</sup> In brief, it works on the principles of reflectance and transmittance of light when it passes through fat. The arm band was placed on right biceps. This band locates the measurement site and blocks all external light that might interfere with the results. The optical measurements were made at near infra-red (NIR) wave lengths of approximately 940-950 nm that gives a direct measure of BF and TBW. FFM was calculated as the difference between body weight and fat mass.

Data collected was statistically analyzed for comparison of results using EPI INFO V software. ANOVA was used for comparison of results of various groups. Differences between sex groups were analyzed by Student's *t*-test. Results are presented as mean  $\pm$  SD. Values were considered statistically significant when  $P < 0.05$ .

**Table 1. Distribution of 538 male (M) and 514 female (F) subjects according to age group, BMI and gender**

BMI (kg/m <sup>2</sup> )	Gender	Age (Yrs)					Total	Percent
		<20	21-30	31-40	41-45	>50		
<18.49	M	26	31	14	13	38	122	23
	F	24	8	6	5	2	45	9
18.50-25.00	M	85	59	56	49	48	297	55
	F	67	71	42	33	35	248	48
>25	M	5	13	42	38	21	119	22
	F	10	22	59	64	66	221	43

**Table 2. Physical characteristics and body composition of male (M) subjects**

Age group	<20	21-30	31-40	41-50	>50	<i>P</i> and <i>F</i> values
n	116	103	112	100	107	-
Age (Yrs)	18.8 $\pm$ 0.8	26.0 $\pm$ 1.9	35.2 $\pm$ 2.7	44.7 $\pm$ 2.7	59.5 $\pm$ 6.0	0.00; 2576.7
Weight (kg)	63.0 $\pm$ 8.6	61.3 $\pm$ 10.7	70.5 $\pm$ 13.1*	70.4 $\pm$ 11.7	62.0 $\pm$ 2.2	0.00; 17.6
Height (cm)	176.0 $\pm$ 7.6	173.4 $\pm$ 5.1	172.8 $\pm$ 6.3	173.7 $\pm$ 6.2	173.4 $\pm$ 5.4	0.00; 4.53
BMI (kg/m <sup>2</sup> )	20.4 $\pm$ 2.6	20.4 $\pm$ 3.6	23.6 $\pm$ 3.9*	23.3 $\pm$ 3.6	20.6 $\pm$ 4.0	0.00; 22.73
TBF (%)	17.9 $\pm$ 5.1	21.3 $\pm$ 5.3	23.1 $\pm$ 5.7*	22.7 $\pm$ 5.5	21.0 $\pm$ 5.1	0.00; 16.4
LBM (%)	82.1 $\pm$ 5.1	78.7 $\pm$ 5.3	76.8 $\pm$ 5.6*	77.3 $\pm$ 5.5	79.1 $\pm$ 5.1	0.00; 16.8
TBW (%)	60.8 $\pm$ 3.2	58.5 $\pm$ 3.4	57.5 $\pm$ 3.9	57.6 $\pm$ 3.6	58.9 $\pm$ 3.8	0.00; 16.5

**Table 3. Physical characteristics and body composition of female (F) subjects**

Age group	<20	21-30	31-40	41-50	>50	<i>P</i> and <i>F</i> values
n	101	101	107	102	103	-
Age (Yrs)	18.7 $\pm$ 0.8	25.5 $\pm$ 1.9	34.3 $\pm$ 2.8	45.0 $\pm$ 2.4	58.4 $\pm$ 5.6	0.00; 2558.6
Weight (kg)	52.9 $\pm$ 7.8	55.6 $\pm$ 7.3	62.9 $\pm$ 11.5*	63.7 $\pm$ 9.3	64.7 $\pm$ 8.8	0.00; 35.0
Height (cm)	160.2 $\pm$ 6.3	157.0 $\pm$ 3.5	158.1 $\pm$ 6.8	158.0 $\pm$ 6.7	158.0 $\pm$ 5.2	0.00; 4.0
BMI (kg/m <sup>2</sup> )	20.6 $\pm$ 2.8	22.6 $\pm$ 3.3	25.2 $\pm$ 4.5*	25.6 $\pm$ 3.6	25.9 $\pm$ 3.2	0.00; 43.3
TBF (%)	29.7 $\pm$ 3.4	29.0 $\pm$ 4.6	32.2 $\pm$ 4.7*	31.4 $\pm$ 4.7	31.8 $\pm$ 4.2	0.00; 10.4
LBM (%)	70.3 $\pm$ 3.4	71.0 $\pm$ 4.6	67.8 $\pm$ 4.7	68.6 $\pm$ 4.7	68.2 $\pm$ 4.5	0.00; 10.5
TBW (%)	53.6 $\pm$ 2.3	54.2 $\pm$ 3.1	52.0 $\pm$ 3.3	52.7 $\pm$ 3.6	52.2 $\pm$ 2.8	0.00; 9.7

\* Significantly different from <20 years age group

## Results

The distribution of subjects under different age groups and BMI is shown in Table 1. Based on BMI as an indicator, 55% of the males were normal, 23% were undernourished and 22% were overweight/obese subjects. Among the females, 43% were overweight or obese, 48% were normal and 9% were undernourished. Physical characteristics such as age, body weight, BMI and the data on BC for male and female groups under each age category are shown in Tables 2 and 3 respectively. The average age of the subjects was in the range of 18 to 60 years. The differences in body weight and BC between male and female groups are also given in these Tables.

With increasing age from <20 years, BF also increased up to 4<sup>th</sup> decade of life (31-40 years) in both male (from 18% to 23%) and female (from 30% to 32%) groups by 5% and 3% respectively, with a corresponding increase in body weight and BMI (Tables 2, 3). In the age group of >50 years, there was a small decline in BF and BMI in males only.

The BC data that was further analyzed in relation to BMI (as N, UN and OW/obese) for male and female subjects in each age group are shown in Tables 4 and 5 respectively. It was noted that the peaking of BF by 3% in male subjects occurred during the 3<sup>rd</sup> decade (21-30 years of age) of life and plateaued thereof except in the undernourished groups (BMI <18.5) where the BF was lower after the 3<sup>rd</sup> decade despite the body weight and BMI remaining almost constant in different age groups. The increased body weights were seen only in overweight/obese groups after 31 years of age whereas in the undernourished and normal groups, the body weight was almost the same across different age groups. These findings are different as compared to whole group of an age category as shown in Table 2.

In the case of females, body weight, BF and BMI changes were not significantly different among different age group subjects of the UN group (BMI <18.5). Slight changes in body weight and BMI in older normal and overweight/obese group was recorded but the changes in BF were not significant in these three groups of N, UN and overweight/obese subjects across different age groups.

**Table 4.**  
Body composition in UN male subjects (BMI <18.5)

Variable	Age group (Yrs)				
	<20	21-30	31-40	41-50	>50
Body weight (kg)	53.5±6.3	49.6±4.1	49.8±4.9	51.2±3.6	50.0±3.9
BMI	17.1±1.0	16.3±1.4	17.3±0.9	17.2±1.0	16.4±1.4
TBF%	12.9±4.3	17.2±3.6*	15.0±3.3	14.9±2.9	16.2±3.5
LBM%	87.2±4.3	82.8±3.6*	85.0±3.3	85.1±2.9	83.8±3.5
TBW%	64.0±2.9	61.4±2.3	62.9±2.1	62.9±2.0	61.9±2.4
n	26	31	14	13	38

Body composition in normal male subjects (BMI 18.5 – 25)

Variable	Age group (Yrs)				
	<20	21-30	31-40	41-50	>50
Body weight (kg)	65.1±6.7	63.9±6.7	66.7±7.3	67.6±7.7	63.9±6.9
BMI	21.0±1.75	21.2±1.7	22.3±1.9	22.2±1.9	21.4±1.8
TBF%	19.1±4.2	21.8±4.4*	21.8±4.8	21.9±4.9	22.1±2.8
LBM%	80.9±4.2	78.2±4.4	78.0±4.8	78.2±4.9	78.1±2.9
TBW%	60.1±2.9	58.1±2.8	58.5±3.3	58.1±3.3	58.3±2.2
n	85	50	58	49	48

Body composition in overweight/Ob male subjects (BMI >25)

Variable	Age group (Yrs)				
	<20	21-30	31-40	41-50	>50
Body weight (Kg)	77.2±5.7	77.8±4.7	82.5±8.3	80.6±6.8	79.4±7.1
BMI	26.2±0.8	26.8±1.4	27.4±2.5	26.9±1.5	26.5±1.2
TBF%	25.2±2.8	28.7±2.3*	27.5±2.8	26.4±3.4	27.4±2.4
LBM%	74.8±2.8	71.4±2.3	75.5±2.8	73.6±3.4	72.6±2.4
TBW%	56.3±1.5	53.7±1.5	54.3±2.0	55.3±2.3	54.7±1.7
n	5	13	42	38	21

\* Significantly different as compared to <20 years age group

**Table 5.**  
Body composition in UN female subjects (BMI <18.5)

Variable	Age group (Yrs)				
	<20	21-30	31-40	41-50	>50
Body weight (kg)	45.1±3.9	44.6±1.6	44.8±3.0	45.4±5.0	42.0±2.8
BMI	17.2±0.9	17.2±0.8	17.6±0.8	17.7±0.8	17.8±0.4
TBF%	25.8±2.5	21.2±4.0	25.1±3.8	25.4±4.3	21.0±8.1
LBM%	74.2±2.5	78.7±3.9	75.0±3.8	74.6±4.3	79.1±8.1
TBW%	56.3±1.6	59.8±2.4	56.7±2.4	56.3±2.6	59.2±5.1
n	24	8	6	5	2

Body composition in normal female subjects (BMI 18.5 – 25)

Variable	Age group (Yrs)				
	<20	21-30	31-40	41-50	>50
Body weight (kg)	53.8±6.2	54.0±5.0	54.7±7.5	57.3±7.3	57.1±6.1
BMI	21.0±1.0	21.7±1.7	21.9±2.1	22.7±1.8	23.1±1.5
TBF%	30.5±2.3	28.7±3.9	30.7±4.3	30.0±3.1	30.1±3.2
LBM%	69.5±2.3	71.3±3.9	69.3±4.3	70.0±3.1	69.9±3.2
TBW%	53.1±1.6	54.4±2.6	53.0±2.9	53.4±2.2	53.4±2.3
n	67	71	42	33	35

Body composition in overweight/Ob female subjects (BMI >25)

Variable	Age group (Yrs)				
	<20	21-30	31-40	41-50	>50
Body weight (kg)	64.9±5.2	65.0±4.6	70.5±7.8	68.4±6.3	69.4±5.7
BMI	25.9±0.8	27.3±1.8	28.3±3.1	27.7±2.3	27.6±2.5
TBF%	33.7±3.5	33.0±2.5	34.0±4.0	32.7±4.9	33.1±3.7
LBM%	66.3±3.5	67.0±2.5	66.1±4.0	67.3±4.9	66.9±3.7
TBW%	50.8±2.2	51.4±1.8	50.9±3.0	52.1±4.0	51.4±2.5
n	10	22	59	64	66

## Discussion

Body composition is relatively stable in good health conditions. But several factors affect it. Increase of body weight with age is also associated with significant changes in BC,<sup>5-11,17-20</sup> especially an increase in BF,<sup>21</sup> redistribution of adipose tissue,<sup>19,22</sup> increase in visceral fat relative to subcutaneous fat and development of central adiposity,<sup>8,19,23,24</sup> decrease in muscle and bone mass.<sup>7,9</sup> Such decreases in muscle mass leads to reductions in basal metabolic rate (BMR), diminished muscle strength and lowered immunocompetence.<sup>25-29</sup> However, research has shown that loss of FFM can be prevented in the elderly by certain measures such as physical exercise and hormone therapy.<sup>30,31</sup> There are a few studies with conflicting data showing a decrease in BF mass without changes in FFM (rather than an increase in BF and a decrease in FFM as reported by others) among the Ariaal nomads and Turkana males of Kenya<sup>10,11</sup> who were experiencing limited food availability. This could be ascribed to chronic undernutrition which would lead to development of lesser muscle mass. Such states of negative energy balance would not allow to compromise for further reductions in muscle

tissue (or FFM) as they age, while at the same time, continued subsistence activity may also help maintain muscle mass. The resultant effect of such responses will naturally be a progressive loss of adipose tissue with ageing.

It is reported that most gains in body weight occur between 29 and 35 years of age in men and in women between 45 and 49 years.<sup>20</sup> The time at which the changes in BF and FFM occur is reported to be highly variable.<sup>32-35</sup> In men, BC changes markedly from the age of 50-54 years and above<sup>19</sup> where as in women it occurs between 40 and 49 years of age.<sup>8</sup> According to some studies, increase of BF with age also varies widely from 20 to 70 years of age.<sup>32-35</sup> There are studies that have reported a stable FFM until 60-70 years of age in men and women<sup>8,29</sup> after which only a decline was seen in male subjects. On the contrary, some studies have shown loss of FFM after 40 years of age<sup>7,29</sup> while a few others have reported peaking of FFM between 35 and 45 years.<sup>35</sup> Such variations in BC changes and peaking time points may be explained on the basis of differences in ethnicity, method of BC determination, diet and life style, socio-economic conditions and so on.

The changes in BC are shown to be associated with altered hormonal status<sup>30,31,36-38</sup> such as estrogen deficiency and growth hormone deficiency,<sup>2,30,31,38</sup> metabolic adaptations, lactation, altered physical activity levels,<sup>22,39</sup> reductions in energy expenditure and/or increased levels of energy intakes,<sup>8</sup> menopause<sup>29</sup> and the inevitable periods of stress in life. Testosterone is also reported to have an important role in energy balance and therefore can affect changes in BC.<sup>10</sup>

Most of the studies cited above have their data analysed for a particular age group without taking into consideration the differences in nutritional status of the subjects. BMI criteria can simply be used as a basis of nutritional status. The data for the male or female subjects in each age category (without further subdivision on BMI criteria) of this study as shown in Table 2 and 3 may not pick up the differences, if any, in BC or the differences in the time of peaking of body fat or other differences that may be existing. This is because of the possibility of the data being contaminated from mixed subjects of different nutritional status. Therefore, in this study the male and female subjects were further subdivided into three grades as normal, undernourished and overweight/obese subjects on the basis of BMI to examine such differences and the results are shown in Table 4 and 5. One of the important findings on this basis was that the peaking of BF occurred during the fourth decade of life (31-40 years) when the data was analyzed for the age group as a whole (Table 2 and 3) whereas the peaking was recorded during the 3<sup>rd</sup> decade (21-30 years) of life when the data was analyzed for each age group on the basis BMI (Table 4 and 5). Such BMI based analysis of each age group have also revealed the differences in relation to changes in body weight, BMI and BC particularly in the UN male group and the three female groups as compared to whole group analysis.

BMI is also said to reflect the development of FFM between the ages of 6 and 20 years and the loss of FFM after 65 years in both sexes. In our study, the changes in FFM were slight at the peaking of BF in UN males but did not observe any significant changes in FFM in females of different age groups on BMI criteria.

TBW contributes to 45 to 70% of body weight with an average of 62%. Age related changes also occur with TBW. TBW tends to decrease with increase in age. In this study, TBW was within normal range though the UN showed a little higher value as compared to other groups.

## Conclusions

It is always ideal to carry out longitudinal studies for a better understanding of the age related changes in BC. But the practical difficulties of conducting such studies are quite apparent and therefore, most studies are cross-sectional in this regard.

The age related changes in human BC is rather a complex phenomenon involving both physiological and behavioral factors. In the present study, unlike the previous studies from the West, the peaking of BF was at different points of time when the data was analyzed for an age group as a whole and compared with the results of subgroups analyzed on BMI basis.

Regular, planned and guided physical activity can reduce/prevent obesity related health problems and age related changes in BC. There is no pharmacological intervention or substitutes that promise improvement of health in the elderly than does exercise.<sup>9</sup> Furthermore, it is proved that caloric restriction is beneficial in many of the age related pathological conditions and can reduce accumulation of fat mass during aging process, thereby avoiding insulin resistance that is associated with obesity.<sup>40</sup>

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