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Age and Sex Variation in Measures of Body Composition Among the Elderly Bengalee Hindus of Calcutta, India

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A B S T R A C T

In the present cross-sectional study we examined 332 (171 men and 161 women) elderly (60 years and above) urban Bengalee Hindu resident in south Calcutta, India. Individuals were selected by random sampling procedure using local voter's registration list. Skin folds measures were used to compute body composition measures among them. There existed significant sex differences in various anthropometric body composition measures. Age had significant (p<0.001) negative association with all anthropometric body composition measures namely percentage of body fat (PBF), fat mass (FM), arm muscle circumference (AMC), arm muscle area (AMA) and arm fat area (AFA) in both sexes. Fat free mass (FFM) in contrast had negative but not significant age impact. Regression analyses demonstrated that age had explained substantial amount of variance of PBF (men = 32%; women = 18.2%), FM (men = 18.2%; women = 12.8%), AMC (men = 23.4%; women = 19.2%), AMA (men = 22.2%; women = 10.2%) and AFA (men = 34%; women = 31%) in both sexes. Two-way ANOVA revealed age-sex interaction only had significant effect on FFM. The present investigation vindicated that there is a significant inverse age trends in anthropometric body composition measures among the Bengalee Hindus. Moreover, there existed sexual dimorphism in the effect of age on various anthropometric body composition measures.

Key words: *ageing, body composition, anthropometry, Bengalee Hindu, India.*

Introduction

According to the 2001 census, the total aged (60 years and above) population of India is approximately 110 millions, or approximately 11% of the total popula-

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tion. This percentage will be increased to 14.8% by the year 2020[1]. Although the population of older people is increasing in India (107 millions in 1991 to 110 millions in 2001), the biological problems of ageing have not been viewed as a critical issue. Most studies in India have investigated social aspect involved in ageing process[2]. Even with the availability of so much modern techniques like magnetic resonance imaging (MRI), computerized axial tomography (CAT), bioelectrical impedance analysis (BIA), dual energy x-ray absorptiometry (DEXA), anthropometry still is the most universally applicable, inexpensive and noninvasive method available to assess the size, proportion and composition of the human body in all ages including elderly individuals[3]. Understanding the scope of age related changes in body composition in healthy adults help us to improve our knowledge and understanding of this process and assist in prevention of functional limitations and management of health status into old age[4,5]. Genetic and environmental factors such as life-style, socio-economic status access to health facilities, health conditions and differences in mortality of older people bring about differences in anthropometric and body composition characteristics between population[6].

The ageing process involves modification in nutritional and physiological changes[7]. At the same time changes in body composition show sexual dimorphism with various phases of ageing does influence anthropometric characteristics. Hence anthropometric standard derived from adult population may not be applicable to the elderly[8]. Guo et al.[4] have suggested that body composition should be measured in epidemiological and clinical studies of ageing. However, there have been very few studies from India[2,9–13] which have dealt with age trends in anthropometric characteristic among the elderly individuals. WHO Expert Committee on physical status emphasized the need for local gender and age specific reference values for the elderly[14]. However, to date, there is no detailed study on age and sex variation in body composition measures among the elderly men and women in India. In view of the above consideration the present cross-sectional investigation studied age and sex variation in anthropometric body composition measures among 332 (171 men and 161 women) elderly (60 years and above) Bengalee Hindu resident in Kalighat, South Calcutta, India.

Materials and Methods

Study population

The present study was conducted during the period of May 1998 to October 1999. A cut-off point of 60 years was taken to define elderly people according to the recommendation proposed by World Health Organization (WHO) for Indians. The total population of the elderly (60 years and above) in 88 wards at Kalighat, a locality in South Calcutta, is 3150 (1748 men and 1402 women). A random sampling procedure was followed to select the subjects. An individual to be selected in the present study must have been: a Bengalee Hindu; age not less than 60 years and free from any serious disabilities. Primary information including name, address and age of randomly selected individuals were collected from local voter's registration list. The Subjects were also requested to complete a three-page questionnaire, which included a specific question on date of birth. The age computed from the date of birth (from questionnaire) was then crosschecked with the prescribed age in the local voter's registration list of 1998 (issued by state election commission), voter's identity card (issued by Govt. of India for general identification of her citizen), as well as with the age depicted in the personal horoscope. Prior to measurement, verbal information was sent to all selected individuals. The subjects were requested to make an appointment at their house. A total of 8 individuals (5 men and 3 women) were excluded because of missing data. All subjects were more or less well educated and belong to middle to upper middle class Bengalee family (ascertained from their materials possession and family income). The study population consisted of apparently healthy, retired 171 men and 161 women aged 60 years and above belong to the Bengalee Hindu population residing in 88 wards at Kalighat, South Calcutta. All participants used to live along with their families and were engaged in physical activities such as walking, shopping, household activities etc. Owing to vast ethnic and cultural heterogeneity among Indian population, it is virtually impossible for any single study with what so ever the objectives to represent more than 1 billion Indian population. Instead studies like present one could be useful to have general overview about the age trend in body composition among more than 110 millions elderly Indians. However, it is noteworthy to mention that this sample size was found to be sufficient to test for statistical analyses.

Anthropometric measurements

All anthropometric measurements were made by trained investigators using standard anthropometric technique[15]. Height and lightly clothed weight were measured to the nearest 0.1 centimeter (cm) and 0.5 kilogram (kg) respectively. Kyphotic subjects were not included in the study. Mid-upper arm circumference measurement was made to the nearest 0.1 cm using a tape measure (Triced, Shanghai, China). Skin fold thickness at Biceps, Triceps, Subscapular and Suprailiac were measured to the nearest 0.2 millimeter (mm) on the left side using a Harpenden skinfold caliper.

Body mass index (BMI) was computed as weight in kg divided by height in meter squared. Percentage of body fat (PBF) was estimated from Biceps, Triceps, Subscapular and Suprailiac skinfolds using the equation[16] validated in Asian Indians[17]. Fat mass (FM) was then calculated. The following equations were used:

$$\text{PBF} = (4.95/\text{density} - 4.5) \times 100$$

Where, for men,
density = 1.1715–0.0779 × log10 (Biceps + Triceps + Subscapular + Suprailiac);
for women,
density = 1.1339–0.0645 × log10 (Biceps + Triceps + Subscapular + Suprailiac).

$$\text{FM (kg)} = (\text{PBF}/100) \times \text{weight (kg)}$$

Fat free mass (FFM) was calculated as:

$$\text{FFM (kg)} = \text{weight (kg)} - \text{FM (kg)}$$

Arm muscle circumference (AMC) and Arm muscle area (AMA) were derived using the standard equation[18].

AMC (cm) = Mid-upper arm circumference in cm – π (Triceps skinfold in cm)

AMA (cm^2) = (Arm muscle circumference in cm)^2 /4π

Arm fat area (AFA) was calculated using the following equation[19]

AFA (cm^2) = (Triceps in cm × MUAC in cm/2) – (π × Triceps in cm^2)/4

Statistical analyses

The distribution of variables/indices was not significantly skewed. Technical error of measurements (TEM) was calculated and the result was found to be within reference values as cited by[15,20]. Therefore, TEM was not incorporated in statistical analyses. Anthropometric body composition measures were presented as mean value, standard deviation and range by gender. Student's t test was then under taken to test whether there existed any sex differences in anthropometric body composition measures. Pearson's correlation was also under taken for both sexes separately. Percent of variance explained by age of body composition variables and indices were computed using linear regression analyses for both sexes separately. Finally, two-way analysis of variance (2-way ANOVA) was utilized to test the impact of age (age group was used, Group I = 60–64 years; Group II = 65–69 years; Group III = 70 years and above) and sex on anthropometric body composition measures. All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS, Version 10). A statistical significance was set at $p<0.05$.

Results

The mean age of the elderly men and women was 69.0 years (SD = 6.4 years) and 67.0 years (SD = 6.4 years) respectively. Gender specific mean, standard deviation and range of anthropometric and body composition measures were presented in Table 1. Student's »t« test to test sex differences in the anthropometric and body composition measures revealed that men had significantly greater mean values for height, weight, BMI and FFM compared with women. Women on the other hand had significantly larger mean values for biceps, triceps, subscapular, suprailiac, PBF, FM, AMC and AMA. No significant sex difference was found for AFA (men = 20.63 vs. women = 20.15). Gender and age groups specific percentiles for skin folds (50^{th}, 85^{th}, 95^{th}) were presented in Table 2.

Correlation studies revealed that age had significant ($p<0.001$) negative association with Biceps (men = –0.58; women =

TABLE 1
BODY COMPOSITION CHARACTERISTICS OF THE STUDY POPULATION (N=332)

	Men (N=171)			Women (N=161)		
Variables/indices	Mean	SD	Range	Mean	SD	Range
Age (years)**	69.0	6.4	26.00	67.0	6.4	33.00
Height (cm)***	160.8	4.8	18.00	143.2	5.7	20.00
Weight (kg)***	55.7	6.5	21.00	43.5	8.5	16.00
BMI (kg/m^2)**	21.2	2.1	5.00	20.3	3.2	6.00
Skinfolds (mm)						
Biceps**	15.2	3.5	15.00	16.2	5.3	13.00
Triceps***	17.0	4.0	9.00	18.9	5.2	17.00
Subscapular**	23.2	4.5	12.22	25.2	6.3	19.28
Suprailiac**	24.2	4.2	17.50	27.2	7.3	22.35
PBF***	29.6	2.16	9.00	38.7	4.4	18.00
FM (kg)*	16.0	3.4	14.00	17.0	5.5	21.00
FFM (kg)***	38.5	6.1	14.00	27.0	4.9	20.12
AMC (cm)***	23.0	2.4	9.00	27.9	1.9	8.21
AMA (cm^2)***	35.3	1.3	7.00	37.8	5.7	20.00
AFA (cm)	20.4	4.4	14.00	20.1	6.9	22.22

BMI = body mass index, PBF = percentage of body fat, FM = fat mass, FFM = fat free mass, AMC = arm muscle circumference, AMA = arm muscle area, AFA = arm fat area.
Kg = Kilogram, cm = Centimeter.
Significant sex difference; * $p<0.05$; ** $p<0.01$; *** $p<0.001$

TABLE 2
PERCENTILES DISTRIBUTION OF SKINFOLDS ACCORDING TO AGE AND SEX CATEGORY IN THE PRESENT STUDY

Skinfolds	Age group (Sample size: M/W)	Men			Women		
		50th	85th	95th	50th	85th	95th
Biceps 60–64	(49/56)	15.4	17.2	19.4	16.8	21.3	25.2
65–69	(49/44)	13.8	15.6	18.2	15.4	20.2	23.0
70+	(73/61)	11.2	12.4	14.0	12.0	13.2	15.4
Triceps 60–64	(49/56)	17.6	14.4	17.0	19.2	23.0	27.3
65–69	(49/44)	14.6	13.4	15.2	18.4	20.0	23.4
70+	(73/61)	13.0	12.6	14.6	17.4	19.2	22.4
Subscapular 60–64	(49/56)	23.6	26.2	28.4	25.2	27.3	30.6
65–69	(49/44)	21.2	24.2	26.0	24.6	25.2	28.4
70+	(73/61)	20.2	22.6	24.0	22.0	23.6	24.2
Suprailiac 60–64	(49/56)	24.4	27.2	28.4	26.8	28.6	33.3
65–69	(49/44)	22.0	23.6	24.6	24.2	26.4	28.6
70+	(73/61)	20.2	22.4	23.2	21.0	23.6	24.4

M = men, W = women

TABLE 3
LINEAR REGRESSION ANALYSES OF AGE WITH ANTHROPOMETRIC BODY COMPOSITION MEASURES IN THE STUDY POPULATION (N=332)$^{\Psi}$

Dependent Variables	B	S.e. B	Beta	T	R^2
			(Men = 171)		
PBF	–0.124	0.051	–0.289	–7.878***	0.320
FM	–0.121	0.069	–0.161	–0.178*	0.182
AMC	–0.213	0.040	–0.219	–2.180*	0.234
AMA	–0.164	0.052	–0.225	–1.878*	0.222
AFA	–0.120	0.039	–0.270	–2.228**	0.340
			(Women = 161)		
PBF	–0.210	0.024	–0.412	–7.436***	0.182
FM	–0.242	0.031	–0.349	–6.343***	0.128
AMC	–0.174	0.045	–0.228	–2.028*	0.192
AMA	–0.104	0.028	–0.210	–1.656*	0.102
AFA	–0.249	0.043	–0.310	–5.245**	0.310

BMI = body mass index, PBF = percentage of body fat, FM = fat mass, AMC = arm muscle circumference, AMA = arm muscle area, AFA = arm fat area.
Independent variable = age in years.
B = regression coefficient, T = value flagging significance level of regression coefficient, s.e.B = standard error of regression coefficient.
Significant at; *$p< 0.05$; ** $p<0.01$; *** $p<0.001$
$^{\Psi}$ = Only significant results were presented.

–0.39), Triceps (men = –0.60; women = –0.41), Subscapular (men = –0.43, women = –0.37), Suprailiac (men = –0.47; women = –0.38), PBF (men = –0.56; women = –0.42), FM (men = –0.42; women = –0.35), AMC (men = –0.48; women = –0.43), AMA (men = –0.47; women = –0.31) and AFA (men = –0.58; women = –0.55) in both sexes. Negative but not significant age trend was evident for FFM in both sexes.

Gender specific linear regression studies were also and results (only significant ones) were presented in Table 3. Results revealed that age had explained substantial amount of variance of PBF (men = 32%; women = 18.2%), FM (men = 18.2%; women = 12.8%), AMC (men = 23.4%; women = 19.2%), AMA (men = 22.2%; women = 10.2%) and AFA (men = 34%; women = 31%) in both sexes. Analysis of variance (ANOVA) using age (age group was used) and sex further demonstrated significant age-sex interaction for FFM only (result was not shown).

Discussion

Many studies[2,7,16,21–26] have already reported information on health nutritional status and body composition among elderly individuals utilizing anthropometry from different parts of the world. However, only few studies so far undertaken to deal with the age trends in anthropometric characteristics among the elderly individuals from India[2,9–13]. Moreover, to date, no detailed investigation has been undertaken from India on elderly of both sexes to study age and sex variation in anthropometric body composition. The present cross-sectional study provides unique data on age and sex variation of anthropometric body composition measures of elderly urban Bengalee Hindus.

The result of this study show, for the first time, that a significant decreasing age trend exists in the anthropometric body composition measures among elderly Bengalee Hindus of both sexes. Ghosh et al[2] have already reported similar negative age trend in adiposity and central body fat distribution among elderly Bengalee Hindus of Calcutta. Results of the present study are in concordance with studies from other parts of the world [4,16,22,24,25–27] that have also reported a similar negative age trend of anthropometric and body composition measures in both sexes. The significant sex differences observed in anthropometric and body composition measures in the present study was almost similar to those reported in other studies on elderly[4,21–23,27–31]. Concomitant with ageing, differences occur in body proportion, structure as well as metabolic and physiological variables[32]. However, the differences vary between different ethnic groups and sexes. Further research is needed on both sexes from other ethnic groups in India to validate whether a negative age trend, similar to the present one, exists among these groups.

There existed sex differences in the age trend observed in this study. Various factors like levels of physical activity and sex hormones have been suggested as the probable cause for this sex difference[5]. The bio-medical mechanisms underlying the variance in boy composition and their changes with passage of time in men and women require further study. Longitudinal studies investigating the interaction between anthropometric and body composition measures with hormones are needed to fully understand the sex difference observed in the dynamics of the ageing process. The etiological implications of changes in body composition with ageing can only be investigated using the longitudinal studies[2]. No such study has been under taken from India.

Correlation studies revealed that in both sexes age had significant ($p<0.01$) negative impact on all anthropometric body composition measures except FFM. FFM was decreasing with increasing age in both sexes yet association of age with FFM didn't reach significant level. 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 (CNS) and internal organ[3]. Whereas PBF and FM are mainly of subcutaneous origin and are deposited in the adipose tissue just beneath the skin. Skinfold is the most appropriate way to measure this subcutaneous fat. In the present study also skinfolds namely Biceps, Triceps, Subscapular, and Suprailiac were used to calculate the PBF and FM. Both these skinfolds had significant inverse age trend in both sexes and there by marked the decreasing values of PBF and FM. The loss of subcutaneous fat is mainly due to the age related loss of collagen fibers, which provide matrix for adipocytes of adipose tissue[32]. On the other hand, FFM components (Skeletal mass, bone minerals, fibrous or connective tissue etc.) are all very essential (at least in compare to subcutaneous fat) in maintaining body's equilibrium even in older age. This might be the cause of why in the present study dynamics of ageing was faster in fat mass than in fat free mass (negative but not significant association with increasing age). Furthermore, percent of variance explained by age for body composition measures were much greater among men as compared with women. This fortified the sex differences in the effect of age on various anthropometric body composition measures. The change in sex hormone with increasing age could be the probable cause of why the ageing process is more pronounced among male gender. Results of the two-way ANOVA using age and sex as categorical variables further demonstrated the significant age-sex interaction for FFM only. It imply that in addition to significant effect of age and sex on body composition measures, their interaction (age × sex) also had considerable impact on body's fat free mass components such as skeletal mass, bone minerals etc.

However, cross-sectional study like present one can only draw tentative conclusion regarding body composition variation in old age. To further our knowledge in geriatric body composition other variables such as diets, physical activities as well as work and functional status are needed to include in the study. Result of the present investigation indicate that it is utmost essential to understand the underlying factors involved in the causation of this significant negative trend that could have serious health implications particularly in clinical nutrition and serious disability associated with increasing age. Further studies are needed on other ethnic groups residing in rural as well as urban areas of India to determine whether a similar phenomenon exists among them. Results obtained from such studies could be utilized to formulate national primary health care strategies for elderly people. At present no such health policy exists in India. Physical changes during ageing process in people of different genetic origin, different life styles, including food habits, exposed to similar environment conditions provide an unusual opportunity to examine such changes. Moreover, Investigations should be undertaken among the Indian Diaspora worldwide to elucidate if they also show age trends in body composition similar to sedentes in India or the native population of the respective countries. Such studies would generate valuable information on the 'nature- nurture' interaction involved in the ageing process of body composition.

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RAZLIKE U MJERENJU SASTAVA TIJELA IZMEĐU MUŠKARACA I ŽENA KOD STARIJIH BENGALSKIH HINDUSA IZ KALKUTE, INDIJA

S A Ž E T A K

U ovoj presječnoj studiji pregledali smo 332 bengalska Hindusa iz urbanog dijela južne Kalkute, Indija (171 muškarca i 161 ženu) starije životne dobi (60 i više godina). Ispitanici su odabrani nasumično, koristeći lokalni popis birača. Mjerenja kožnih pregiba korištena su za računanje sastava tijela. Pronađena je statistički značajna razlika među spolovima u različitim antropometrijskim mjerama sastava tijela. Dob je, u oba spola, imala značajan (p<0,001) negativni učinak na sva antropometrijska mjerenja sastava tijela, a posebice na postotak tjelesne masti (PBF), ukupnu masu masnog tkiva (FM), opseg ruke (AMC), mišićnu površinu presjeka ruke (AMA) i masnu površinu presjeka ruke (AFA). Nasuprot tome, bezmasna masa tijela (FFM) imala je nesignifikantan negativan odnos s dobi. Regresijska analiza pokazala je da dob u oba spola objašnjava značajan postotak varijance PBF (32% u muškaraca i 18,2% u žena), FM (18,2% u muškaraca i 12,8% u žena), AMC (23,4% u muškaraca i 19,2% u žena), AMA (22,2% u muškaraca i 10,2% u žena), AFA (34% u muškaraca i 31% u žena). Dvosmjerna analiza varijance pokazala je da interakcija dobi i spola ima značajan učinak jedino na FFM. Ova studija ukazuje na postojanje značajnog negativnog dobnog trenda u antropometrijskim mjerama sastava tijela kod bengalskih Hindusa. Štoviše, utvrđen je i spolni dimorfizam u učinku dobi kod nekih mjera sastava tijela.