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ESTIMATION OF AGE CHANGES IN BODY COMPOSITION OF ADULT INDIAN WOMEN

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Abstract: *To assess the age changes in body composition and regional fat distribution, central/peripheral girths and skin fold ratios were used to visualize differences in the proportion of fat over the trunk and the extremities. The nature of the shift would indicate a tendency to store fat either appendicularly or centrally with age. The cross-sectional study was conducted on 126 endogamous Maratha women in the age range 30–70 years living in Mental Hospital in Pune City of India. Anthropometric measurements such as body weight, eight body circumferences and five skin fold thicknesses on extremities as well as the trunk were considered. Results showed that centralized obesity was more prevalent in older subjects as reported earlier (Muller et al. 1986, Garn et al. 1982, 1987). While Body Mass Index and Waist/Hip Ratio showed a well-defined increase with advancing age, Appendicular/Central Ratio was negatively correlated with age further highlighting the preponderance of central obesity as compared to appendicular fat deposition with advancing age. Indices derived from various skin fold thicknesses such as Centripetal Fat Ratio and Relative Fat Pattern Index showed negative correlation with age. It can be concluded that though obesity may be largely related to affluence, environmental factors or life style, that is, energy consumption and energy expenditure levels, a limited redistribution of body fat from appendicular to central body cannot be ruled out.*

Keywords: *Ageing; Indian women; Body composition.*

Introduction

Patterns of adipose tissue, or fat distribution are not only important descriptors of growth and development in children, but key predictors of chronic disease risk-among adults. Regional adiposity, or fat patterning, or fat distribution directly influences metabolic processes and disease initiation and progression, independent of total adiposity. For example, the relationship between central body depositions of adipose tissue and increased cardiovascular disease risk factors and mortality is well established in adults from industrial societies. Because of such recent association of body fat with the chronic diseases of well-fed societies, age-related trends in fatness over the life span are being thoroughly investigated in recent times (Roche 1979, Kapoor et al. 1980, WHO 1995).

In contrast to fatness, little is known about the age changes in the bodily distribution of fat. In two individuals of similar body weight, sum of skin fold thickness or percent body fat, can have a very different anatomical distribution of subcutaneous fat. Most individual differences in bodily distribution of fat seem to centre on the relative contrast of extremity and trunk fat (Muller and Reid 1979, Ramirez and Muller 1980, Muller and Wohlieb 1981). Numerous studies suggest that measuring the distribution of fat is as important as measuring the amount of fat (Larsson et al. 1984, Ducimetiere et al. 1989, Folsom et al. 1989a, b).

Evaluation of the major components of the body fat and lean body mass provides valuable information in a wide range of biomedical contexts. Besides reflecting on nutritional status and fitness of a population, both fat and lean body mass have special relevance in studies concerning changes in body composition during ageing and illness. It also has relevance in studies of possible changes due to physical, occupational and sports activities, as well as in studies relating bio-medical, biophysical and behavioural functions to inner body structure under different environmental conditions. Assessment of these body components with relative ease and reasonable accuracy in individuals of widely differing age groups could be, thus of great practical utility in fields of medicine, physiology, nutrition, and geriatric studies.

An attempt has been made in the present study to analyse the body composition and examine the post adulthood differences in relative fatness and regional fat patterning in adult females of India (Maharashtra state).

Material and Methods

Out of the total data collected on 266 women from a large psychiatric hospital in Pune City (India), endogamous Marathas women numbering 126 and in the age range 30 to 70 years were considered for the study. Measurements such as body weight, seven body circumferences and five skin fold thicknesses on extremities and on the trunk were performed using standard techniques as described by Weiner and Lourie (1981). Circumferences were classified into two categories: Central (C) and appendicular (A). While chest, abdomen, waist, hip circumferences were classified as central; forearm, upper arm, maximum calf, and ankle circumferences were categorised as appendicular. The A/C Ratio was calculated by dividing sum of appendicular circumferences with the sum of central circumferences (Kapoor 2000).

Commonly used simple measure of assessing obesity viz. Body Mass Index (BMI= weight (kg)/height $(m)^2$), was worked out. The Waist/Hip Ratio (W/H ratio) was used to differentiate the distribution of body fat. Skinfold measurements were performed using Harpenden's skinfold calipers. The pattern of subcutaneous fat distribution was worked out by plotting the thicknesses of skinfold at different sites in descending order. Other adiposity measures such as Relative Fat Pattern Index (RFPI= subscapular/ (subscapular+suprailiac) and Centripetal Fat Ratio (CFR=subscapular/ (subscapular +tricepss) were calculated using Statistical Package for Social Sciences (SPSS-version 10.0.1, 1989–1998).

Data Analysis and Interpretations

Means with standard deviations of various anthropometric measurements have been given age-decadewise, along with their coefficients of correlation with age and various indices for measuring body adiposity (Table 1).

Stature

Differences in means of stature between younger and older groups of women were substantial. Regression equation showed a statistically significant decrease in stature with advancing age highlighting a strong negative correlation of stature (r=-0.191*, P=0.05) with age (Table 1). Regression equation for stature on age was computed as the coefficient of correlation between the stature and age was significant. The values of coefficient were b_0= 156.50 and b_1= -0.118. Regression coefficient b_1 is significant at 5% level with p-value of 0.04 by F-test.

Table 1. Means of various anthropometric measurements and their coefficients of correlation with age.

Age Group Correlation Measurements	30–39 yrs (n= 24) Mean ± SD	40–49 yrs (n=45) Mean ± SD	50–59 yrs (n=31) Mean ± SD	60–69 yrs (n=26) Mean ± SD	Coefficient
Stature (cm)	151.64±5.30	151.53±5.96	151.01±5.43	148.04±7.54	-0.191*
Weight (kg)	46.13±5.77	46.31±7.42	48.77±9.73	47.07±12.47	0.0624
BMI	19.77±2.64	20.38±4.03	21.43±4.13	20.63±6.66	0.1789
		Circumferences (extremities)			
Mid-upper Arm (cm)	22.07±3.58	21.07±4.45	23.25±2.87	22.38±4.47	0.0388
Ankle	22.36±3.11	22.75±3.38	23.07±2.26	22.78±3.15	0.0499
Forearm	21.07±3.18	20.15±4.57	22.23±3.00	20.60±4.52	-0.0369
Maximum calf	26.46±2.92	26.47±3.38	27.28±4.23	27.70±3.27	0.1284
		Circumferences (trunk)			
Chest	77.94±5.96	79.41±6.60	82.25±8.28	82.26±11.37	0.2067*
Abdomen	77.54±7.73	79.16±11.17	79.03±7.77	80.30±11.08	0.0763
Waist	72.59±6.35	74.91±8.18	76.50±7.74	76.82±10.09	0.1646
Hip	86.36±6.49	86.33±6.79	90.33±9.44	89.55±12.15	0.1806
		Circumference Indices			
Waist/Hip Ratio	0.842± 6.20	0.86± 6.63	0.85±8.31	0.86± 7.29	0.0116
A/C Ratio	0.29± 2.29	0.28± 3.483	0.29± 2.12	0.28±3.437	-0.0947
		Skinfolds			
Biceps skinfold	7.46±3.63	7.52±3.59	7.42±3.71	8.32±5.19	0.0849
Triceps skinfold	14.07±4.65	14.06±4.64	13.98±5.29	12.08±6.05	-0.1099
Subscapular skinfold	14.07±4.76	12.93±5.26	11.46±4.49	11.94±6.41	-0.1369**
Suprailliac skinfold	13.31±4.39	11.13±5.27	11.84±5.27	10.46±5.20	-0.1520
Dorsum skinfold	1.79±0.36	1.93±0.31	1.79±0.48	1.83±0.58	-0.0099
		Skinfold Indices			
# CRF	$0.50\pm8.82\times10^{-2}$	$0.47\pm1.00\times10^{-1}$	$0.45\pm1.00\times10^{-1}$	$0.49\pm1.3\times10^{-1}$	-0.0450
##RFPI	$0.51\pm7.64\times10^{-2}$	$0.54\pm7.64\times10^{-2}$	$0.49\pm8.68\times10^{-2}$	$0.52\pm1.4\times10^{-1}$	-0.0242

CRF Centripetal Fat Ratio=subscapualr/(subscapular+triceps),
##RFPI Relative Fat Pattern Index=subscapular/(Subscapular+suprailiac),
* Significant at 0.05 level (2-tailed), ** Significant at 0.01level (2-tailed).

Body weight

Means of weight of younger and older age groups of women when compared showed a marginal increase till sixth decade followed by a decline. Regression equation showed a non-significant positive correlation with age (Table 1).

Body Mass Index

Body mass index showed a well-defined increase with advancing age (Table 1). Coefficient of correlation of BMI with age though statistically non-significant, was positive. Regression equation (b_1) also showed that BMI increased with advancing age (Table 2).

Table 2. Correlation coefficient of BMI, appendicular and central circumferences with age.

Measurements	Correlation Coefficient			
	Age	BMI	Appendicular	Central
Age	1.000	0.179	-0.146	-0.118
BMI	0.179	1.000	0.385*	0.561*
Appendicular girths	-0.146	0.385*	1.000	0.958*
Central girths	-0.118	0.561*	0.958*	1.000

* Significant at 0.01 level (2-tailed).

Appendicular circumferences

Means of appendicular circumferences (midarm, forearm and maximum calf) between younger and older groups of women showed differences, the values being higher in the oldest age groups indicating increase with age in most of them exception the forearm which showed a negative correlation with age (Table 1).

Central body circumferences

Means of central girths (chest, abdomen, waist, hip) also showed differences when younger and older groups of women were compared, the values being higher in the older ages indicating an increase in all of them with advancing age. Coefficient of correlation, was both positive, though statistically non-significant (Table 1). Regression equation for chest on age was computed as the coefficient of correlation between chest and age was significant. The values of coefficient were b_0=73.8853 and b_1=0.1317. Regression coefficient b1 is significant at 5% level with p-value of 0.03 by F-test.

Appendicular/Central Ratio (A/C Ratio)

Appendicular/Central Ratio is influenced when there is a change in either appendicular girths or in central girths. In the present study increase in central girths seemed responsible for negative correlation with age of Appendicular/Central Ratio (Table 1).

Skinfolds

The means of skinfold thicknesses (triceps, subscapular, suprailliac and dorsum) showed differences between younger and older groups of women highlighting their negative correlation with age. Regression equation for subscapular skinfold on age was computed as the coefficient of correlation between subscapular skinfold and age was significant highlighting more subcutaneous fat in the upper trunk region (Table 1). The values of coefficients were b_0=29.9954 and b_1=-0.1168 which is non-significant. The pattern of subcutaneous fat distribution in these women was as follows: suprailiac >subscapular >triceps >biceps > and dorum (Figure 1).

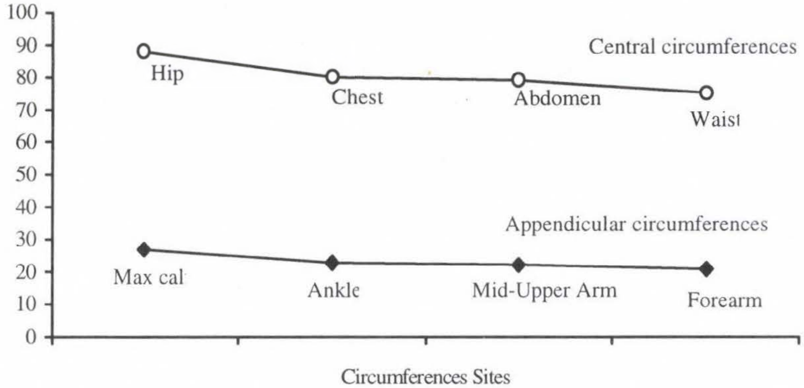

Figure 1: Profile of circumferences (appendicular and central) in women.

Discussion

The changes in fatty tissue, particularly in the axial portions of the body produce the characteristic age changes in body form. Of all structural alternations of the body that result from changes in tissue components, changes in the amount and distribution of internal and subcutaneous body fat produces the most visible effects. The increase in body weight accompanied by noticeable changes in various girth measurements is believed to be one of the earliest signs of morphological ageing. Decline in weight somewhere around seventh decade is also often reported (Kleemier 1959, WHO 1995).

Various studies have documented that pattern of change in weight is quite different and it varies by sex too. It is greatly influenced by ecological conditions, and completely different trends have been observed in urban, rural, tribal, and other simple societies (Rossman 1977, Friedlaender and Rhoades 1982, Malina et al. 1982). Weight change during ageing is a complex phenomenon, which involves simultaneous changes in several tissues as well as a redistribution of subcutaneous fat. However, reduction in body water content has been reported as an important cause of decline in weight after 65 years. Partially it may be due to a decline in muscle cell mass, and in cell mass in general, which is generally more pronounced in men (Steen et al. 1985).

The general comparison of results of the present study as well as some earlier studies show that unlike age-related changes in most linear anthropometric measurements (stature, sitting height), weight changes with age may not be the same in populations (WHO 1995). In affluent countries, the average weight of both men and women increases through middle age. It continues to increase till 6^{th} or 7^{th} decades of life before declining. While in men it tends to plateau at around 65 years and generally declines thereafter; in women, the weight increases are frequently greater and the plateau occurs about ten years later than in men before it starts declining. This is also supported by longitudinal observations which show that weight gain in younger adulthood may be greater than that reported by cross-sectional studies (Borkan et al. 1982, Friedlaender and Rhoads 1982, Bagga 1998). While such studies imply that a significant increase in weight with age may be a natural or normal tendency, this pattern may not apply equally to all societies because in non-European indigenous populations, such as Australian Aborigines, the increase in average weight in the middle years is not evident, but the decline at older ages is (WHO 1995). Data on underprivileged populations are, however, limited. In the present study a marginal decline was registered in last (seventh) decade.

More recently a comparative study on Indian rural and urban women of a similar endogamous population (Kunbi Maratha) has reported more body weight, larger body circumferences and more marked deposition of subcutaneous fat on the extremities and trunk, at all ages in urban women, as compared to the rural agriculturist-economically weaker women of the same endogamous population (Hussain, Unpublished). The differences persisted till the oldest age group, reflecting upon the changes in their way of life, which seemed to determine this trend. A similar trend of significant weight increase till seventh decade was observed in well fed and relatively sedentary group of Indian (Punjabi) women, while the reverse was found true in the relatively physically active and moderate eater group of Brahmins (Bagga 1998). The difference in the overweight status of the former group (Punjabi) was maintained through all ages and it increased to 15 kg, in the seventh decade before it registered a decline.

Since the present study was on the residents of a mental asylum, the full nutritional needs were not expected to be fulfilled in that particular setting. The minimal gain in weight by sixth decade followed by a marginal decline, and increase in circumferential measurements followed the trend observed in women from developed countries (Noppa et al. 1980). The subjects were given breakfast and two square meals supposedly having approximately 1800 calories a day (as per hospital's diet chart), all at fixed hours. The patients were sedentary with minimal energy expenditure. A minimal or a token increase in weight till the end of sixth decade follows the trend in affluent populations.

Increased abdominal girths as reported in the present Maratha women and in most of the earlier studies suggest that partly it could be due to deposition of intra-abdominal and subcutaneous fat with age, as also reported by Pařízková and Eilselt (1980), Borkan and associates (1985), and Bagga (1998). Hussain (unpublished) also observed the increased abdominal girths in both urban as well as in rural groups of women till the age of 60 years. Some researchers (Noppa et al. 1980, Pařízková and Eiselt 1980) feel that an age-related decrease in the muscular tone of the abdominal wall might also be partially responsible for some such increase.

Redistribution of body fat

Cross-sectional studies show a slow, progressive redistribution of body fat in elderly, with subcutaneous fat on the limbs tending to decrease and intra-abdominal fat (inner fat) to increase (WHO, 1995). The former is reflected in decline in various skinfolds (Rossman 1977, Chumlea et. al. 1989) and the latter (inner fat) by an increase in some circumferences and their ratios. Rate of accumulation of "inner fat", otherwise, a phenomenon is quite inaccessible to traditional anthropometry (WHO 1995).

Though statistically non-significant, relatively more differences for central girths (r= -0.118) compared to that of limbs (r=-0.146) with age in Maratha women of present study were seen. Sums of appendicular girths (A) and of central girths(C) registered statistically significant correlation (0.958) as can be seen in Table 2.

Body Mass Index (BMI)

Correlation showed that body mass index increased with advancing age (Table 1). As compared to weight, which showed a marginal increase till 6^{th} decade followed by a decline, BMI showed a continuous increase, which can be partially due to a significant decline in stature (Bagga, unpublished).

Like weight average body mass index (BMI) in industrialized populations tends to increase in middle age and stabilizes somewhat earlier in men than in women. In men, the plateau may begin at 50–60 years or even at 70 years of age; in women it starts at 70 years or later. Both sexes generally show a decrease in average BMI after 70–75 years of age (Rossman 1977, Waaler 1984, 1988). These trends have been observed in Europeans and populations of European ancestry, but tend to vary with environmental and genetic factors among different ethnic groups (WHO 1995). Data from US National Health and Nutrition Examination Survey NHANES Nos. I and II have shown that BMI is more highly correlated with subcutaneous fat (estimated by subscapular skinfold) in younger than in older men and women, and with muscle mass in older than in younger adults (Micozzi and Harris 1990).

BMI may have different significance in elderly individuals and young adults, because of the reduction in height with age. In the present study a gradual increase in Body Mass Index was observed at all ages. Since data on 70 years and above population was not available, comments on changes after seventh decade are not possible. It has been emphasized that BMI may not decline with age, indeed, it may be higher at age 70 and above, than at younger ages. This is because of the age-related changes in both height (decline) and weight (increase) and morphological changes in the vertebral column that result from osteopenia and increased curvature because with extensive vertebral changes, height measurement may not be accurate (WHO 1995).

Waist/Hip Ratio, Appendicular–Central Ratio, Central Fat Ratio and Relative Fat Pattern Index

Increases in Waist-Hip Ratio, decline in Appendicular–Central Ratio, Centripetal Fat Ratio (CRF) and in Relative Fat Pattern Index (RFPI) with advancing age were well supported by statistical measures used.

Waist/Hip Ratio: Waist/Hip ratio showed a positive correlation with age. Though no consensus is available on the cutoff points for waist/hip ratio, which has frequently been used for assessing regional fat distribution, use of waist/hip ratio > 1.0 for males and that of > 0.80 for females has been suggested earlier and used often (Bjornotorp 1985). Women in the present study showed lower body fat predominance, waist/hip ratio being in the range of 0.84–0.86 in all age groups, which was more than suggested value.

Appendicular/Central Ratio: The A/C ratio of unity would indicate equal amount of fat being distributed in the extremities and over the trunk region. Barring the differences due to bone and muscle development, any shift in this ratio would indicate a tendency to store fat either peripherally or centrally (Kapoor 2000). A/C ratio observed in the present study (range 0.28–0.29), suggest that women under study stored relatively more fat centrally (abdomen, waist and hip) influencing the A/C ratio, which registered a decline. Within trunk also they showed predominance of lower trunk fat. This particular type of fat distribution could be partially because of sedentary life style of women under study. Also, there is a general tendency of women to store more fat on the lower body, especially on the hips (WHO 1995). In the extremities the maximum fat was registered in the calf region (Figure 1).

Skinfolds: The skinfold thickness comprises a double fold formed from the skin and (at least in theory) all of the underlying subcutaneous fat. The thickness contributed by the double layer of skin can conveniently be examined on the dorsum of hand where there is almost no subcutaneous fat (Roberts et al. 1975).

The decrease of skinfold measurements (triceps, subscapular, suprailliac) between 50–70 years observed in women in the present study, in view of a corresponding increase in upper and lower limb circumferences during the same period, signifies, according to Pařízková and Eiselt (1982) and Noppa and associates (1980), to the growth of adipose tissue at the expenses of lean muscle mass. This could be observed from measurements of all circumferences on limbs in these women. These findings in the present sample support the hypothesis of a reduced muscle mass in the limbs with age. Age changes in the upper arm circumference, however, seemed more related to the pattern seen in the trunk showing an increase. Such results were reported earlier by Škerlj and Brožek (1953) and later by Borkan and associates (1985) who suggest that ageing in upper arm may be more related to the pattern seen in trunk than are age changes in the legs.

Reports from several early investigations (Pett and Ogilvie 1956, Young et al. 1965, Shephard et al. 1969b, Pařízková 1977) showed almost no increase of tricepss skinfold reading over the entire span of adult life. Since people generally become fatter as they get older, this implies a selective regional deposition of subcutaneous fat. In the present study the thickness of the tricepss decreased with age and subscapular skinfold exceeded that of the triceps region, between the ages of 30 and 70 years (Figure 2). Shephard (1991) also commented that as subjects become older, there might even be a reduction of fat in the extremities, concurrent with the deposition of fat over the trunk.

As dorsal skinfold of the hand is a site where the component of fat is normally negligible or lacking, it actually reflects the state of body collagen (Dequekar 1969, Bourliere 1970b). In the present study women showed increased (non-significant) differences of dorsum skinfold with advancing age as suggested by Hall (1984). The rapid reduction in all skinfold thicknesses found at ages above 50 in the present study could also be partially due to loss of collagen.

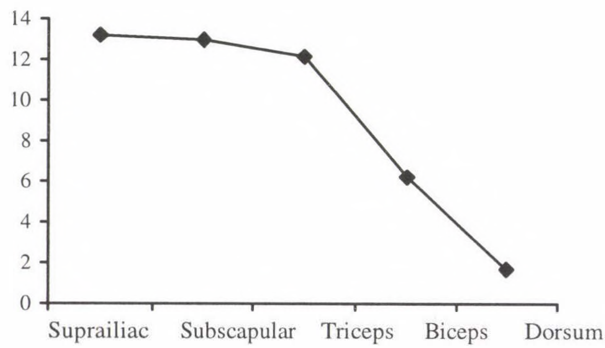

Figure 2: Profile of fatness among the Maratha women.

It can be concluded that women between 40–70 years in the present study have their fat more centrally located and on the upper body than the younger adults do. Since changes are observed chiefly at 40–49 years, they are consistent with the observation that the shift to a more centralized distribution of body fat in women takes place by around menopausal age (Muller et al. 1986). This differential rate of fat deposition could be responsible for the apparent difference in the body contours of the younger and older subjects. Increased centralization of body fat with ageing has been reported in several studies (Škerlj 1954, Mueller 1982, Borkan et al. 1985, Muller et al. 1986, Bagga 1998). It has been shown that groups of North West Territories Canadian Indians, who no longer hunt, have an increased deposition of fat on the trunk as compared to the limb (Norgan 1987).

Since this pattern differed in relatively sedentary females in the present study, the findings strengthen the suggestion that changes in the disposition of fat with age may be more related to the lifestyle of the subjects and also influenced by the level of activity of the subjects under study.

Centripetal Fat Ratio (CFR) and Relative Fat Pattern Index (RFPI): CFP, based on the subscapular and triceps skinfolds, was negatively correlated with age. However, it is statistically non-significant. Any change, increase or decrease in the triceps skinfold would be responsible for influencing the CFR and any change in Relative Fat Pattern Index (RFPI) can be simply attributed to change in suprailiac skinfold. If suprailiac increases RFPI increases. Decrease in suprailiac skin fold decreases the RFPI. In the present study, since suprailiac values registered a gradual decline, the RFPI values also registered a negative correlation with advancing age.

As has been commented by Ulijaszek (1998), majority of our information on body fat composition and changes in total body fat and fat patterning is based on indirect methods of assessment; this knowledge is dependent on the accuracy of these indirect methods. Moreover, indirect measures of body fat mean that we only have estimates of the relationship between superficial (subcutaneous) fat and deep body fat, and these estimates are based on the accuracy of the assumptions about the relationship between different aspects of total body composition.

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