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Variations in Relative Fatness and Regional Distribution of Body Fat at High Altitude and in Plains: A Study on Adult Females

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There are lots of variations in the size, shape and form of human body. Much of these variations in human form reflects inter individual differences in the regional distribution of fat, muscle and bone rather than overall differences of body composition. From limb radiographs, Tanner et al. (1959) noted that the mass of the three tissue components apparently varies relatively independently, both in athletes and in sedentary adults.

Inter-individual differences in the regional distribution of body fat are seen with respect to both the relative proportions of deep and superficial fat, and variations in the distribution of subcutaneous fat over the body surface. In particular, a centralized pattern of fat deposition can be distinguished from a peripheral accumulation of fat. The pattern of regional fat distribution seems relatively stable within a given person over periods as long as five year (Garn et al., 1988), but is influenced by age, sex, nutritional status, habitual activity patterns and possibly ethnic background.

Bogin and Mac Vean (1981) suggested that the functional significance of accumulated fat varies with its location, in particular, a centralised deposition of fat helped to protect vital organs against extremes of temperature. Reports from several early investigators (Pett and Ogilivie, 1956; Young et al., 1963; Shephard et al., 1969; Parizkova, 1977) showed almost no increase of triceps skinfold readings 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.

Shephard et al. (1969), commented that the greatest age-related gains occured in the subcutaneous tissue of the lower part of the trunk (waist, abdominal and suprailiac folds). Cronk and Roche (1982) found that until the age of 18 years, thickness of triceps skinfold of males exceeded that of the subscapular region but the trend reversed between the ages of 18 and 50 years. As the subjects become older, there may even be a reduction of fat in the extremities, concurrent with the deposition of fat over the trunk. Garn et al. (1988) commented that, possibly on account of the greater total amount of body fat and the higher proportion of subcutaneous fat, the regional distribution of fat is more stable in women then in men. It is well established that a central or centripetal distribution of adipose tissue, in which there is a relative excess on the trunk is related to high blood pressure and high levels of plasma lipids, and is a risk factor for some cardiovascular and metabolic diseases, particularly diabetes mellitus (Lapidus et al., 1984; Ducimetiere et al., 1986; Kissebah et al., 1988; Larsson, 1988). The association between adiposity and CHD has been studied extensively, yet controversy remains regarding the best way to measure fat mass (Manson et al., 1987, Bouchard et al., 1993) and how strongly it is associated with coronary risk (Despres, 1990). Less is known about the importance of fat distribution and how age related changes in adiposity may affect the relation with risk in older population. There have been few studies of fat distribution, (Reynolds, 1951; Skerlj et al., 1953; Garn, 1954; Borkan and Norris, 1977; Satwanti et al., 1980; Rimm et al., 1995; Joyce and Kapoor, 1996), and still fewer are on mother-child distribution of subcutaneous fat (Kapoor et al., 1985; Wardle et al., 1996) and on level of physical activity and fat distribution (Brown and Jones, 1977; Bhalla et al., 1983; Satwanti et al., 1984; Depres et al., 1985) and also on ethnic variation on fat distribution (Satwanti et al., 1977; Stevens et al., 1992; Wardle et al., 1996; Kapoor et al., 1999). It was observed on comparsion of Asian and European females, that Asian females stored more fat subcutaneously. The same was found for Indian soldiers in compar-

ison to Europeans (Jones et al., 1976). Fat distribution pattern seemed to change according to pregnancy stages (Kapoor et al., 1997). Virtually no work could be located in literature focussing on regional fat distribution pattern among the people in plains and at higher altitude.

The purpose of this research was to examine the relative fatness and regional fat patterning in adult females living in plains and at high altitude.

MATERIALS AND METHODS

Young and apparently healthy females were studied in two different environmental conditions. One group was studied in Chopal in Shimla district of Himachal Pradesh. They ranged in age from 16 to 32 years. The village was situated at a latitude 30° 58', longitude 77° 36' and at a height of 8,000 ft. The subjects were mostly attending cutting and tailoring classes and some worked in weaving mill. A total of 50 women were studied and for the sake of convenience this group has been referred to as "high altitude" group in the present text.

The second group of 230 subjects were studied in Delhi and they ranged in age from 16 to 32 years. They were either students or teachers belonging to middle class families. All the subjects were apparently healthy and were not very active physically.

All the subjects were measured using the standardised techniques of Weiner and Laurie (1969) for stature, body weight, eight body circumferences and ten skinfold thicknesses. The circumferences were classified into two categories: Central (C) and Appendicular (A). Waist, abdomen and hip circumferences were classed as central while upper arm, wrist, thigh and ankle circumferences as appendicular. The A/C ratio was calculated by dividing sum of appendicular circumferences with the sum of central circumferences. The ratio was calculated to find out the relative proportion of fat deposited centrally or appendicularly in two groups of subjects.

Besides the A/C ratio, The BMI (body mass index) which is the most commonly used index of obesity during the last decade was also worked out for both the groups. This index was chosen because of its simplicity in assessing obesity using weight and stature and which are the most common measurements in clinical setting and in health related surveys. This index adjusts weight for stature and larger values indicating obesity are associated with increased mortality rates in adulthood.

Numerous studies suggest that measuing the distribution of fat is as important as measuring the amount of fat. (Larsson et al., 1984; Ducimetiere et al., 1986; Lapidus and Bengtsson, 1988; Peiris et al., 1989; Folson et al., 1989a,b). Body fat distribution can be evaluated by anthropometry, DXA, computed tomography and magnetic resonance imaging (MRI). Anthropometric measures include ratios and principal component analysis of various body circumferences and skinfold thicknesses. Regional measure of body fatness include waist/hip ratio, skinfold thickness at various sites over the body's surface, ratio of trunk to extremity skinfold thickness (trunk/extremity), and sum of trunk skinfold thicknesses, and by graphical plotting of skinfold thickness at various body sites. The waist/hip circumference ratio was determined in the present subjects, because of its relationship to risk factors for cardiovascular diseases and the occurrence of these diseases (Ashwell et al., 1982; Mueller et al., 1991). The waist/hip ratio has been used to differentiate the distribution of body fat. For lower body fat predominance, the ratio is < 0.73 and for upper body fat predominance, the ratio is >0.80 (Hartz et al., 1984). Besides waist/hip ratio for studying fat distribution, ten skinfold thicknesses were taken over the surface of the body using. Holtain skinfold calipers which exerted a constant pressure of 10 gm/mm^2 over the contact surfaces.

The pattern of subcutaneous fat distribution was worked out by plotting the thickness of skinfold at different sites in descending order of their thickness for Delhi females. The magnitude of the skinfold thickness at the ten sites in high altitude females was plotted accordingly.

RESULTS

The means and standard deviations of stature and body weight are reported in table 1 along with that of the age. The mean age of both the groups is found to be similar. The high altitude adult females are shorter and lighter than the Delhi females.

Table 1: Basic data of the subjects

Variable	*Females from Plains (n=230)*		*Females from High altitude (n=50)*	
	Mean	*±SD*	*Mean*	*±SD*
Age (years)	21.3	4.3	21.5	4.4
Stature (cm)	153.8	5.6	152.0	6.3
Body weight (kg)	45.8	8.3	42.0	6.0

The mean values of body circumferences, waist/hip ratio, A/C ratio and body mass index (BMI) are presented in table 2. Except for waist circumference, all other circumferences showed lower values among high altitude females. The waist/hip ratio was slightly higher (0.75) in higher altitude females in comparison with Delhi females (0.72). On the other hand A/C ratio was found to be lower (0.43) for high altitude females than for Delhi females (0.50). The BMI value was also lesser (18.2) in high altitude females as compared to Delhi females (19.4).

Table 2: Means and standard deviations of the circumference measurements (cm) along with waist/hip ratio, A/C ratio, and Body Mass Index

Variable	*Females from Plains*		*Females from High altitude*	
	Mean	*±SD*	*Mean*	*±SD*
Chest circumference	67.3	5.8	66.7	4.9
Waist circumference	62.5	6.1	63.2	5.0
Abdomen circumference	77.1	7.5	76.1	6.1
Hip circumference	87.0	7.0	84.2	4.9
Upper arm circumference	24.9	3.1	22.1	2.3
Wrist circumference	14.6	1.0	14.3	0.7
Thigh circumference	48.4	5.8	41.0	3.0
Ankle circumference	19.5	1.4	18.5	1.0
Waist/Hip ratio	0.72	-	0.75	-
A/C ratio	0.50	0.01	0.43	0.02
Body Mass Index	19.4	-	18.2	-

The mean values of skinfold thickness at ten sites have been shown in table 3. Except for iliac crest skinfold thickness, rest of the skinfold thickness values were higher among Delhi females.

Table 3: Means and standard deviations of skinfold thicknesses (mm)

Variable	*Females from Plains*		*Females from High altitude*	
	Mean	*±SD*	*Mean*	*±SD*
Biceps SF	6.2	3.2	5.0	2.3
Triceps SF	14.9	5.8	10.7	3.3
Subscapular SF	14.1	5.5	10.4	3.5
Iliac crest SF	10.6	5.1	11.4	5.1
Chest SF	10.1	4.2	6.5	1.8
Front of thigh SF	27.4	7.7	13.5	3.3
Posterior calf SF	21.2	6.8	10.1	2.4
Midaxillary SF	12.4	4.7	7.6	3.3
Abdomen-I SF	22.5	6.6	9.3	3.2
Chin SF	6.7	2.1	6.0	1.5

SF = Skinfold thickless

For studying the pattern of subcutaneous fat distribution over the body, the skinfold thickness at ten sites were plotted in descending order of their thickness for both the group of females (Fig.1). Although the sites of maximum subcutaneous fat stores (front of thigh) and minimum subcutaneous fat stores (biceps) remained same, in high altitude females the pattern of subcutaneous fat distribution changed in between. The pattern in Delhi females was Front of thigh > Abdomen-I > Calf posterior > Triceps > Subscapular > Midaxillary > Iliac crest > Chest > Chin >Biceps where as among high altitude females the pattern was Front of thigh > Iliac crest > Triceps > Subscapular > Calf posterior > Midaxillary > Chest > Chin > Biceps.

DISCUSSION

The main focus of the present research is on relative fatness and regional distribution of fat from anthropometry among adult females living in two contrasting environments, namely plains (Delhi) and High altitude (Chopal).

Obesity in most general sense is excess of fat in the body. There are numerous ways to assess it namely by concept of overweight, weight adjusted for stature, from skinfold thicknesses, from under water weighing, from

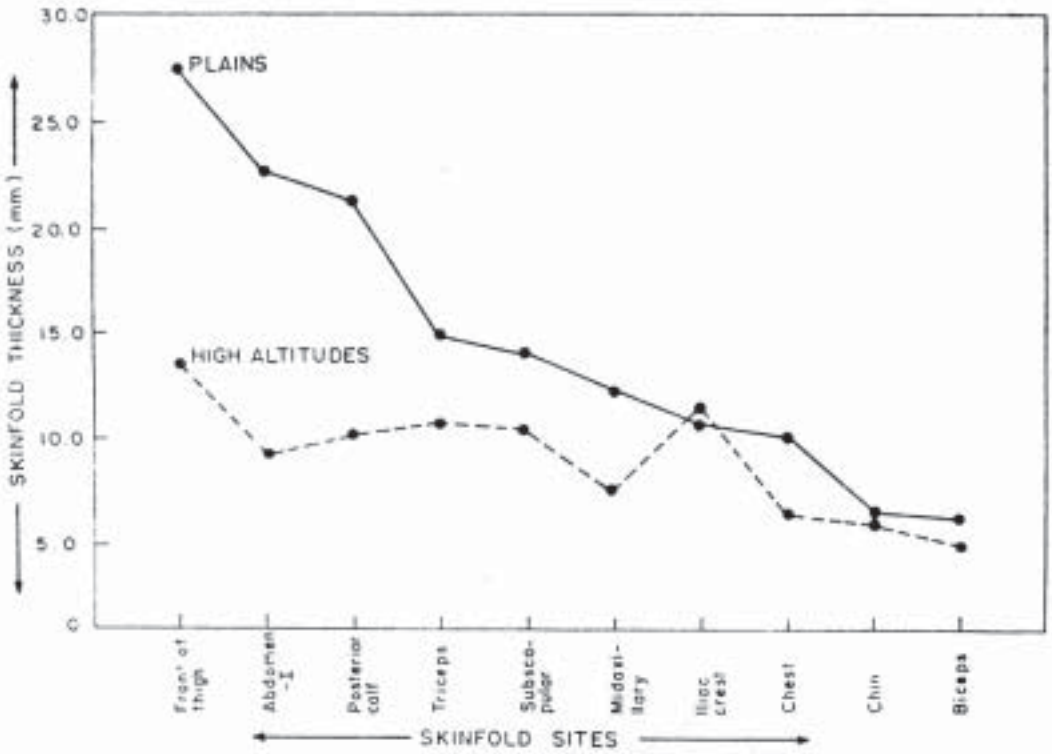

Fig. 1. Profile of fatness among plains and high altitude females

bioelectric impedance, dual energy X-ray absorptiometry etc. In the last decade body mass index (BMI = weight in kg divided by stature^2 in m) is most commonly used as an index of obesity. Canadian guidelines for healthy weight recommend the cut points for BMI as (i) BMI > 27 for increasing risk of developing health problems, (ii) 25<BMI<27 for increasing risk of developing health problems in some people (iii) 20<BMI<25 for good weight for most people and (iv) BMI>20 for potentially increasing health problems in some people. No consensus is made on the cutpoints for waist/hip ratio which has frequently been used for assessing regional fat distribution, Bjorntorp (1985). However use of waist/hip ratio>1.0 for males and that of >0.80 for females has been suggested.

Among the present subjects, the high altitude females are leaner than plains females as adjudged both by thickness of skinfolds at various sites, and also by BMI.

The high altitude females showed relatively upper body fat predominance (waist/hip ratio = 0.75) as compared to Delhi females with a value of 0.72 thereby indicating lower body fat predominance. The high altitude females also showed relative predominance of central fat (A/C ratio = 0.43) as compared to Delhi females (A/C ratio = 0.50). 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. Going by the value of A/C ratio it is quite clear that high altitude adult females store relatively more fat centrally as compared to females in plains. Within the trunk, they also showed predominance of upper trunk fat. This particular type of fat distribution pattern could be a requirement for protecting the vital organs against excess cold at high altitude and also to provide protection while moving over the rough terrain of mountainous area.

The distribution pattern of subcutaneous fat was depicted from profiles of fatness in both the groups. It also depicted the intra and inter-group variations in fat fold thickness. Not only the thickness of skinfolds varied in both the groups (Delhi females being fatter), the ranking of skinfold thickness at the ten sites also varied in these groups under study. The high altitude females although shared a common site of maximum fatness (front of thigh) and of minimum fatness (biceps) with plains females, the rankings of skinfold thickness changed in between. The pattern of subcutaneous fat was found to be more uniform in high altitude females and also relatively more fat seem to be in the trunk region.

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KEY WORDS Females. Fatness. Fat Distribution. Plains. High Altitude.

ABSTRACT To know the relative fatness and fat distribution pattern using body measurements in two different environmental settings, young adult females in plains and at high altitude were studied. The high altitude females were found to be lighter and leaner as compared with females in plains. The BMI was lower in high altitude females and they also displayed relatively upper body fat predominance. The high altitude females were found to store more fat centrally as compared with females in plains. This typical fat storage pattern could be providing them some advantage against their stressful environment.

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