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BODY FAT TOPOGRAPHY IN INDIAN AND TIBETAN MALES OF LOW AND NORMAL BODY MASS INDEX

MARIO VAZ*, T. T. UKYAB, R. PADMAVATHI, R. KURIYAN, S. MUTHAYYA, B. DIFFEY** AND A. V. KURPAD

Division of Nutrition,
Department of Physiology,
St. John's Medical College,
Bangalore – 560 034

and

***School of Nutrition and Public Health,*
Deakin University, Melbourne, Australia

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Abstract : Body fat topography was determined using anthropometric techniques in young, healthy, Indian and Tibetan adults. Indian subjects had significantly higher fat contents with greater abdominal obesity when compared with Tibetans matched for body mass index (BMI). This differential fat distribution may contribute, in part, to the greater cardiovascular risk of Indians. Using a cross sectional model, the data was also analysed to assess the probable changes in body fat topography with weight gain. This model suggests a preferential gain in abdominal subcutaneous fat as compared to other sites. This data may have implications while evaluating disease risks with weight gain.

Key words : body composition skinfolds abdominal obesity Indian Tibetan cardiovascular risk

INTRODUCTION

Regional body fat distribution has gained considerable attention in recent times, largely because of the association of abdominal adiposity and chronic disease (1, 2). In particular, there has been an upsurge in interest over the reported enhanced risk of South Asians for cardiovascular disease (3, 4, 5). While the risk profiles of South Asians in relation to cardiovascular disease, are being increasingly documented, there is little detailed information on the distribution of regional body fat as a potential risk factor (4).

Another issue of importance is the change in the pattern of regional body fat distribution in altered nutritional states. While changes in body fat topography has been studied to a large extent in individuals on weight loss regimens (6, 7) there has been little attempt to delineate changes in the converse situation, i.e. when thin

*Corresponding Author

individuals gain weight and move into the normal weight range. This is of particular concern to developing countries like India, where close to 50% of the adult population is underweight or undernourished (8). The nutritional transition (9) that is accompanying current economic growth, is likely to promote weight gain in previously thin individuals.

This study was performed with two objectives. Firstly, to describe regional body fat distribution in thin and normal weight Indians, and to compare them with Tibetans. Secondly, to describe the changes in body fat distribution with weight gain in thin individuals, by employing a cross-sectional model. This was done since both the extent of weight gain and the likely duration of such changes would make it particularly difficult to study individuals longitudinally.

METHODS

A total of 348 healthy, young, adult male subjects were studied. They were divided into two broad groups (Indians n=300, Tibetans n=48). The Indian subjects comprised students from various colleges in Bangalore, as well as working individuals with a variety of occupations. Subjects were recruited so as to encompass a wide range of body weights. The Tibetan subjects were monks resident at the Sera Mahayana Buddhist University at Bylakuppe, in the Mysore District of Karnataka State. The monks followed a regimental routine of classes, meditation and prayer which did not include any intense physical activity. Informed consent was obtained from all subjects, and the study was approved by the Ethical Review Committee of the medical college.

Basic anthropometry was performed on all subjects which included height measured to the nearest 0.1 cm (Nivotise Brivete – Depose, France) and weight to the nearest 0.1 kg (Soehnle Digital Scale, Germany). Body mass index (BMI) was then calculated as weight/height^2 (kg/m^2). Mid-arm circumference was also measured. Body fat distribution was determined by measuring subcutaneous skin-folds at four different sites (biceps, triceps, subscapular, suprailiac). For all anthropometric measurements, the procedures followed were those adopted at the NIH sponsored Airlie Conference on the standardisation of anthropometric measurements (10). In some subjects with greater fat masses the larger skinfolds (predominantly supra-iliac and subscapular) could not be obtained. The sum of three skinfolds (biceps, triceps and subscapular) was used to determine percent body fat and fat free mass using the age and gender specific equations of Durnin and Womersley (11). While the equations of Durnin and Womersley have been validated against hydrodensitometry for use in Indians in our laboratory (12), they also have the least bias among several equations tested on Chinese (13), and were therefore also used in the Tibetan subjects in this study.

Body fat distribution pattern was analysed in three different ways. Firstly, by assessing each individual skin fold in absolute terms (i.e. mm). Secondly by ascertaining the relative contribution of each skinfold to the sum of all four skinfolds. Thirdly, by partitioning subcutaneous fat distribution into that related to the extremities (biceps and triceps) and that related to the trunk (subscapular and suprailiac).

For the purpose of analysis, the Indian subjects were divided into quintiles on the basis of BMI. The cut-offs for these groups are indicated in Table I. The Tibetan subjects were then assigned into BMI groups based on the quintiles for Indians. This was done to ensure comparison of fat distribution patterns between the two groups while controlling for BMI. None of the Tibetan subjects fell within the lower two quintiles for BMI.

All data are presented as mean ± SD. Differences in the various skinfolds across the BMI groups were assessed for each group separately using a One-way ANOVA, with post-hoc tests (Scheffe). Inter-group differences in body fat distribution for the upper three BMI groups were ascertained using a Two-way ANOVA (i.e. BMI group x group). The null hypothesis was rejected at $P < 0.05$.

RESULTS

Table I summarises the general and whole body anthropometric characteristics of the two groups, divided into BMI

TABLE I : Whole body anthropometric characteristics in Indians and Tibetans divided into five groups based on the BMI quintiles for Indians.

BMI cut-off	*I* *< 17.44*	*II* *17.44–18.83*	*III* *18.84–20.08*	*IV* *20.09–22.15*	*V* *>22.15*
Indians					
(n=300)					
sample	58	59	60	64	59
Age (yr)	22.0 ± 4.8	21.0 ± 4.5	20.9±4.4	21.2±3.7	21.5 ± 3.7
BMI (kg/m^2)	16.6 ± 0.7	18.2 ± 0.4	19.6±0.3	20.9±0.6	24.2 ± 1.83
Weight (kg)	47.5 ± 4.9	51.8 ± 4.5 a	56.2±4.2 a,b	61.1±4.5 a,b,c	70.5 ± 7.3 a,b,c,d
Height (cm)	168.9 ± 8.1	168.7 ± 6.9	169.3±6.3	170.7±5.8	170.8 ± 6.4
MAC (cm)	22.6 ± 1.3	23.9 ± 2.0 a	25.0±2.0 a,b	26.4±1.6 a,b,c	29.7 ± 2.4 a,b,c,d
Tibetans					
(n=48)					
sample			10	11	27
Age*			22.1±3.1	23.9±3.6	25.5 ± 3.6 c
BMI			19.6±0.3	20.7±0.4	24.8 ± 3.2
Weight			56.7±5.1	59.5±3.3	70.6 ± 11.0 c,d
Height			169.9±7.3	169.6±4.4	168.5 ± 4.2
MAC*			26.6±1.3	27.4±1.2	30.5 ± 3.0 c,d

BMI, Body mass index; MAC, Mid arm circumference

* = $P < 0.05$, for difference between Indians and Tibetans (Two-way ANOVA)

Differences across the BMI quintiles assessed using a One - Way ANOVA, with Scheffe (Post-hoc)

a = $P < 0.05$ vs. Group I

b = $P < 0.05$ vs. Group II

c = $P < 0.05$ vs. Group III

d = $P < 0.05$ vs. Group IV

quintiles. Within each group the subjects were age matched across BMI quintiles. The Tibetan subjects in Group IV and V were, however, marginally older ($P < 0.05$) than their Indian counterparts in the same BMI groups.

A comparison of the two groups revealed significant differences in the absolute values of all the four skinfolds; the values in the Tibetans being uniformly lower than those of the Indians. (Table II). This was reflected in a lower percent fat and fat mass in

TABLE II : Body fat topography in Indians and Tibetans.

	I	*II*	*III*	*IV*	*V*
Indians					
Percent fat	10.4±3.1	12.8±3.3 a	14.4±3.6 a	17.0±3.8 a,b,c	22.5±4.1 a,b,c,d
Fat mass (kg)	4.9±1.6	6.7±2.0 a	8.1±2.1 a	10.4±2.5 a,b,c	15.9±3.7 a,bc,d
Skinfolds (mm)					
Biceps	3.1±0.8	3.5±0.9	4.0±1.5	4.4±1.5 a	6.4±3.0 a,b,c,d
Triceps	5.6±1.7	7.2±2.6	8.7±3.3 a	10.3±3.4 a,b	15.7±5.3 a,b,c,d
Subscapular	7.7±1.7	9.3±2.6	10.9±3.1 a	12.8±3.9 a,b	19.6±6.7 a,b,c,d
Supra-iliac	7.5±3.3	9.8±3.9	12.4±5.6 a	14.0±5.5 a,b	22.6±8.6 a,b,c,d
Extremity/trunk ratio	0.55±0.1	0.57±0.1	0.56±0.56	0.56±0.1	0.51±0.12
Tibetans					
Percent fat*			10.8±1.8	13.0±2.3	18.4±5.1 c,d
Fat mass*			6.1±0.7	7.8±1.7	13.5±5.8 c,d
Skinfolds (mm)					
Biceps*			2.8±0.5	3.1±0.4	4.6±2.0 c,d
Triceps*			6.3±1.7	7.2±1.8	11.2±5.7 c
Subscapular*			8.0±1.4	10.1±1.8	15.8±6.7 c,d
Supra-iliac*			5.2±1.1	7.0±4.7	12.9±8.3 c,d
Extremity/trunk Ratio			0.7±0.2	0.62±0.1	0.57±0.1 c

symbols and statistical analysis as for Table I

TABLE III : Percent contribution of each skinfold to the total in Indians and Tibetans.

	I	*II*	*III*	*IV*	*V*
Indians					
Biceps	13.2±2.8	12.4±2.8	11.6±2.9	11.3±2.6	10.2±2.7 a,b
Triceps	23.3±3.7	23.7±4.2	23.9±3.7	24.3±3.4	23.0±4.2
Subscapular	32.9±3.7	31.5±4.1	31.0±3.6	30.5±3.9	28.9±4.6 a
Supra-iliac	30.6±5.7	32.4±4.7	33.4±5.0	34.0±5.6	37.9±6.8 a,b,c
Tibetans					
Biceps			12.7±1.7	11.7±2.3	10.7±1.6 a
Triceps*			28.1±4.6	26.8±4.4	25.4±3.4
Subscapular*			36.0±5.8	37.5±4.5	36.5±4.9
Suprailiac*			23.2±3.6	24.0±9.1	27.4±6.1

Symbols similar to that used in Table I.

the Tibetans when compared with the Indians. In terms of relative fat distribution (Table III), the percent contribution of the biceps skinfold to the sum of the four skinfolds was similar in the two groups ($P > 0.05$), that of the triceps and subscapular was greater in the Tibetans ($P < 0.01$), while that of the supra-iliac was higher in the Indians when compared with the Tibetans ($P < 0.01$). The distribution of subcutaneous fat in the trunk was also different in the two groups; for Indians the subscapular skinfold was consistently less than that of the supra-iliac ($P < 0.01$), while the converse was true for the Tibetans ($P < 0.01$).

An analysis of the distribution of subcutaneous fat between the trunk and the extremities suggests that in Indians there is a relatively high proportion of truncal subcutaneous fat even in the lower BMI range (Table II). In contrast, the Tibetans in the mid BMI range had a significantly larger proportion of their body fat in the extremities. At the highest BMI quintile, the Tibetans demonstrated a considerable gain in truncal fat but continued to have extremity to trunk fat ratios that were higher than their Indian counterparts in the same BMI quintile. There was a significant negative correlation between the ratio of extremity to trunk fat and BMI in both groups, consonant with a preferential gain in trunk fat with increasing BMI. The strength of the correlation was, however, relatively low in both groups (Indians $r = -0.17$, $P < 0.05$, Tibetans $r = -0.33$, $P < 0.05$).

For the Indians, there was a significant though differential increase in skinfold thickness at various sites across the BMI quintiles (Table II). The percentage increase from BMI quintile I to V was lowest for the biceps skinfold (106.5%), intermediate for subscapular (154.5%) and highest for triceps (180.4%) and supra-iliac (201.3%). These increments in the skinfolds accompanied a corresponding increase in weight of 48.4%.

DISCUSSION

The data from this study demonstrates that Indians have a greater fat content, which is preferentially located in the abdomen when compared with BMI matched Tibetans. The Indians of this study also had higher fat contents than that reported for Caucasians of similar BMI, the difference being as high as 100% greater for the supra-iliac skinfold (13). The pattern of fat distribution in the Tibetans of this study was remarkably similar to that reported for ethnic Chinese of similar body size (13). These findings are important since they provide a basis for at least part of the enhanced risk of Indians with regard to cardiovascular disease. Superficial skinfolds taken from the trunk are important correlates of cardiovascular disease morbidity (14, 15). This may, in part, be because of the cross-correlation of the supra-iliac skinfold and intra-abdominal fat. Intra-abdominal fat provides the more direct link between obesity and the patho-physiological mechanisms leading to disease (1, 2). The findings of this study are particularly pertinent, in that while other studies have demonstrated that the higher cardiovascular risk of Indians is associated, among other things with a higher BMI than other oriental groups (16), we have demonstrated that Indians have a higher abdominal adiposity even when controlling for BMI.

The basis for the greater fat content and its preferential location in the abdomen of Indians is unclear. The apparently greater predisposition to adiposity among Indians and the higher distribution of fat in the abdomen may, in part, be genetic. It has been estimated that the genetic contribution to fat topography may be as high as 30% (17). However, even when there is a genetic component, it is generally recognised that this effect may be exacerbated or attenuated by non-genetic, environmental factors. In this context, various lifestyle behaviours including physical activity, smoking and alcohol consumption have been ascribed a role in the determination of the distribution of body fat (1). Physical activity is unlikely to have been a factor in our study since the Tibetan subjects who had a lower fat mass were largely sedentary.

Many countries in the developing world are undergoing nutritional transitions. This transition is associated with a shift in the structure of the diet, reduced physical activity and rapid increases in the prevalence of obesity (9). In India approximately half the adult population has a BMI of less than 18.5 (8). Thus it is conceivable that individuals in India will make the transition from low BMI's to a range within the recommended norms before presenting clinically with frank obesity. This study, despite the limitations of a cross-sectional design, provides a model for understanding the pattern of fat distribution during the process of a shift from a low BMI to one within the normal range. The gain in body weight from BMI quintile I to quintile V for Indians was approximately 23 kgs. The corresponding fat gain was 11 kg, marginally lower than the 12.42 kgs that would have been predicted from overfeeding experiments in our laboratory (18). Using data from cadaver studies (19), we estimate that the visceral fat content of the lowest BMI quintile is 0.91 kg in comparison to 2.95 kg in quintile V, corresponding to a visceral fat gain of 324.7%. Visceral abdominal fat gain provides the anatomical correlate, at least in part, for the enhanced morbidity associated with weight gain (1, 2). This data therefore suggests that as previously thin individuals, gain weight, there is a considerable increase in body fat content, particularly in the abdomen. It is conceivable that these individuals are at increased risk of cardiovascular morbidity, despite the absence of frank obesity, an assumption borne out by a recent, carefully executed case-control study in Indians (20).

In summary, this study demonstrates that Indians have an enhanced body fat content and preferential distribution of fat around the abdomen compared with Tibetans. The data also suggests, using a cross-sectional model, that weight gain in thin individuals is associated with considerable abdominal fat gain. The true impact of weight gain within lower BMI ranges, on chronic disease risk associated with the accumulation of abdominal fat, needs to be assessed by prospective studies.

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