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Fat Distribution Pattern as a Risk Factor for Chronic Disease among the Tribals of Northeast India

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A B S T R A C T

The objective of this study was to investigate the effect of pulmonary tuberculosis on the body fat distribution pattern and the sensitivity of different skinfold sites with disease and treatment among the adult tribals of Manipur, Northeast India. A total of four anthropometric measurements and skinfold thickness at five different sites were taken for the study. The indices of adiposity like body mass index, waist hip ratio and grand mean thickness were computed. The cross sectional sample included tuberculosis (TB) patients (n=167) at different stages of treatment and healthy non patients as controls (n=80). The subjects ranged in age from 20–40 years. Wasting of muscle mass and decrease in fat mass because of chronic disease (TB) and overall improvement in these components along with redistribution of fat with TB treatment was observed.

***Key words**: fat distribution, tuberculosis, treatment, tribals, northeast India*

Introduction

Tuberculosis as one of the chronic diseases is on the rise throughout the world and is one of the most important causes of death among adults in developing countries. In 1993, the World Health Organization declared TB to be a »global health emergency«[1]. Pulmonary TB, a chronic infectious disease caused by Mycobacterium tuberculosis is characterized by prolonged cough, hemoptysis, chest pain and dyspnea. Systemic manifestation of the disease include fever, malaise, anorexia, weight loss, weakness and night sweats[2].

The wasting of soft tissues as a cardinal sign of TB even in ancient time led to speculation that the impact of this disease eventually extends beyond the lungs. The notion that a certain kind of body build predisposes a person to tuberculosis dates back to Hippocrates[3]. The risk of developing tuberculosis was found to be more among tall and thin individuals than those who were short and heavy set[4–7]. It was also found that malnutrition predisposes a person to tuberculosis[8–10]. Besides all these, socio-economic status is also one of the important factors which contribute to the rise of tuberculosis[11–14].

Numerous studies suggested that assessing the distribution of fat is as important as measuring the amount of fat[15–18]. Fat distribution pattern is associated with many cardiovascular risk factors[19–22]. Research in fat distribution has shown that fat deposits at different sites vary in its metabolic function[15,23].

Chronic disease is one of the factors which influences the total body fat content and its distribution pattern over the body. The body contour fat patterning has drawn considerable attention recently because of its association with several diseases[15,24–26]. The importance of the body fatness and its distribution lies in the epidemiological studies and as a clinical marker of health risk among populations[27]. However, very less is known about subcutaneous fat distribution and tuberculosis[28]. Weight loss with a concomitant loss of body fat and nutritional depletion are observed frequently in patients with pulmonary tuberculosis, but the effect of this chronic disease on fat distribution at various sites of the body has not been paid much attention to. Thus, the present study was conducted to investigate the effect of tuberculosis on

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the body fat distribution pattern among the tribals of Northeast India.

Materials and Methods

The present study was carried out in Manipur which lies in the North-Eastern region of the Indian Sub-continent, between 23°50' latitudes and 25°30' North and 93°10' and 94°30' East longitudes, bordering Myanmar in the East, Nagaland in the North, Assam and Mizoram in the West. According to the census 2001[29], Manipur has a population of around 2,388,634 out of which the tribal population accounts for approximately 30% of the total population.

In the tribal life the principal links for the whole society are based on kinship. Lineages, clans and other social groupings tend to be the main corporate units and »they are often the principal units for land ownership, for economic production and consumption«[30]. The tribals have their own traditional customs and customary laws. In Manipur two sharply distinct adaptive patterns- shifting cultivation (*jhuming*) and settled wet cultivation are practiced. In general, the tribal economic systems are basically self-sufficient and that these are subsistence economies but due to modernization and education, the quality of life has improved to a considerable extent. The staple food of the tribals of Manipur is rice. They also consume red meat in large amount.

A total of 247 adult tribal males were included in the present study, out of which 167 adults were suffering from tuberculosis, while 80 subjects were disease free and were apparently healthy adults. The former group was taken as test group whereas the latter as controls. All confirmed cases of pulmonary TB who have not started the TB treatment were termed as BST, all those who were confirmed as having taken treatment regularly for two months were grouped as 2MOT and those who were declared as having taken full treatment as ACT (6 to 8 months of treatment). A group of young healthy adults confirmed as never having any type of TB were taken as control group (CG). The grouping was done in consultation with doctors based on their experience of TB disease, the patients and its treatment. The guidelines for selection were laid down and all volunteers fitting into that guideline frame were accepted as part of the study. A well informed written consent from the subjects for their willingness to participate in the present study was taken before the measurements were taken.

Each subject was measured for weight, height, waist circumference, hip circumference and skinfold thickness at biceps, triceps, subscapular, suprailiac and calf posterior sites. All the measurements were taken by following the techniques described by Weiner & Lourie (1981)[31]. The various indices for assessing regional and general adiposity viz.: waist-to-hip ratio (WHR), body mass index (BMI) calculated as body weight in kg divided by height in meter square [BMI=wt(kg)/height(m^2)] and grand mean thickness (GMT) was also computed. Waist/hip circumference ratio (WHR) has been used to differentiate the distribution of body fat on lower and upper body. The ratio of waist/hip circumference (WHR) was introduced as a simple index of body fat distribution and was subsequently found to be a more sensitive index of metabolic abnormalities in the obese than the use of neck, bust, waist or hip circumference measurements alone[33–35]. For lower body fat predominance the ratio is <0.73 indicating femoral gluteal fat deposits and for upper body fat the dominance, the ratio is >0.80[36].

To study the responsiveness of various skinfold sites towards accumulation of fat as a consequence of TB treatment each skinfold thickness was expressed as percent of grand mean thickness (%GMT). The profile of subcutaneous fat distribution over the body surface was obtained by arranging the various skinfold sites in ascending order of their thickness.

Descriptive statistics were done for height, body weight, BMI, WHR, skinfold thicknesses and GMT in subjects at different stages of TB treatment and healthy controls. The t-test was used for comparison between the different groups of subjects. The differences between the test groups and healthy controls in respect of the indicators of fatness were tested by one way analysis of variance (ANOVA). All data was analyzed using SPSS 13.0 version.

Results

Table 1 presents the means and standard deviations of body weight, height, waist circumference, hip circumference, body mass index and waist hip ratio among the subjects in different groups. The mean values of body weight, height and BMI were found to be lowest among

TABLE 1
BASIC DATA OF THE SUBJECTS

Subjects		BW (kg)	Ht (cm)	WC (cm)	HC (cm)	BMI (kg/m^2)	WHR
BST(n-62)	$\bar{X}$±SD	46.8±6.64	161.6±5.88	64.6±4.94	78.8±4.70	17.9±2.18	0.82±0.05
2MOT(n-55)	$\bar{X}$±SD	50.1±6.13	163.5±5.23	68.4±5.6	80.3±5.13	18.7±2.14	0.85±0.05
ACT(n-50)	$\bar{X}$±SD	51.8±6.09	163.5±4.93	66.4±5.16	79.7±4.8	19.4±2.0	0.83±0.05
CG(n-80)	$\bar{X}$±SD	57.4±5.82	163.9±5.71	71.0±7.63	84.5±5.93	21.4±2.12	0.84±0.06

CG – healthy controls, BST – before starting treatment, 2MOT – after two months of treatment, ACT – After completion of treatment
BW – body weight, Ht – height, WC – waist circumference, HC – hip circumference, BMI – body mass index, WHR – waist hip ratio

TABLE 2
SKINFOLD THICKNESSES AND GRAND MEAN THICKNESS OF THE SUBJECTS

Subjects		BSF (mm)	TSF (mm)	CPSF (mm)	SSSF (mm)	SISF (mm)	GMT (mm)
BST(n-62)	$\bar{X}$±SD	3.8±1.08	6.0±1.15	5.6±1.78	7.0±1.55	6.0±1.62	5.7±0.96
2MOT(n-55)	$\bar{X}$±SD	4.0±0.98	7.7±1.57	7.9±2.90	8.9±2.58	8.2±2.95	7.3±1.80
ACT(n-50)	$\bar{X}$±SD	4.0±1.09	7.2±1.67	7.6±2.66	8.4±1.89	7.9±2.85	7.0±1.63
CG(n-80)	$\bar{X}$±SD	5.2±1.49	9.8±2.56	10.8±3.94	11.1±3.62	11.9±4.55	9.8±2.66

CG – healthy controls, BST – before starting treatment, 2MOT – after two months of treatment, ACT – After completion of treatment. BSF – biceps skinfold thickness, TSF – triceps skinfold thickness, CPSF – calf posterior skinfold thickness, SSSF – subscapular skinfold thickness, SISF – suprailiac skinfold thickness, GMT – grand mean thickness

the TB patients who have not started treatment (BST) and increased gradually with treatment. However, the mean values of waist circumference, hip circumference and WHR though found to be least among TB patients before starting treatment increased significantly till two months of treatment. The mean values of body weight, height, waist circumference, hip circumference and body mass index were found to be highest among the healthy controls. Whereas, the mean value of waist hip ratio was found to be the highest among TB patients after two months of treatment.

The means and standard deviations of skinfold thickness at biceps, triceps, calf posterior, subscapular, suprailiac and grand mean thickness are given in Table 2. The skinfold thickness at all the sites and grand mean thickness showed increase in the mean values from before starting treatment group till two months of treatment group and then a decline till completion of treatment. The mean values of the skinfold thicknesses and grand mean thickness were found to be highest among the healthy controls.

Table 3 shows the significance of the difference in various adiposity indices between the TB patients and healthy controls. The TB patients at all stages of treatment showed significantly lower values of grand mean thickness and body mass index as compared to the healthy controls ($p<0.001$). The grand mean thickness ($p<0.001$), body mass index ($p<0.05$) and waist hip ratio ($p<0.01$) showed significant increase till two months of treatment. The overall response to treatment was evident in the significant increase ($p<0.001$) in the mean values of grand mean thickness and body mass index from the time of starting treatment till completion of treatment.

Table 4 displays the ANOVA test in the grand mean thickness, body mass index and waist hip ratio between TB patients and healthy controls. The ANOVA test showed significant difference for grand mean thickness ($F=55.02$; $p<0.01$) and body mass index ($F=35.26$; $p<0.01$) among TB patients and healthy controls.

The distribution pattern of subcutaneous fat in TB patients at different stages of treatment and healthy controls are displayed in Figure 1. The distribution of subcu-

TABLE 3
SIGNIFICANCE OF THE DIFFERENCE IN VARIOUS ADIPOSITY INDICES BETWEEN THE TB PATIENTS AND HEALTHY CONTROLS

Subject	value of 't' with level of significance		
	GMT	BMI	WHR
BST & CG	11.49***	9.57***	1.93
2MOT & CG	5.93***	7.12***	1.78
ACT & CG	6.59***	5.4***	0.50
BST & 2MOT	6.31***	2.05*	3.27**
2MOT & ACT	0.96	1.56	1.66
BST & ACT	5.34***	3.64***	1.32

*$p<0.05$, **$p<0.01$, ***$p<0.001$
CG – healthy controls, BST – before starting treatment, 2MOT – after two months of treatment, ACT – After completion of treatment.

TABLE 4
ANOVA TEST FOR INDICES OF ADIPOSITY BETWEEN THE TB PATIENTS AND HEALTHY CONTROLS

Variables	F-value with level of significance
Grand mean thickness	55.02**
Body mass index	35.26**
Waist hip ratio	3.07

**$p<0.01$

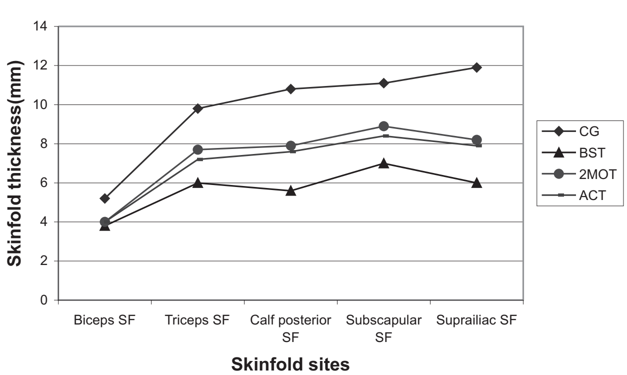

Fig. 1. Distribution pattern of subcutaneous fat in TB patients and healthy controls. CG – healthy controls, BST – before starting treatment, 2MOT – after two months of treatment, ACT – After completion of treatment, SF – skinfold.

taneous fat pattern differed in the TB patients and healthy controls indicating the varied response of different skinfold sites leading to fat redistribution with treatment. Although the site of minimum fat stores remained biceps skinfold thickness the site of maximum fat stores was subscapular among the TB patients in different stages of treatment. However, among healthy controls, suprailiac was the site of maximum subcutaneous fat deposition. The distribution pattern of subcutaneous fat in TB patients at different stages of treatment and healthy non TB patients was as follows:

CG : Biceps < Triceps < Calf posterior < < Subscapular < Suprailiac

BST: Biceps < Calf posterior < Triceps < < Suprailiac < Subscapular

2MOT : Biceps < Triceps < Calf posterior < < Suprailiac < Subscapular

ACT : Biceps < Triceps < Calf posterior < < Suprailiac< Subscapular

Figure 2 presents the responsiveness of different skinfold sites for fat loss with TB disease (BST *vs* CG). Suprailiac was found to be the most sensitive site followed by calf posterior site towards fat depletion. However, biceps, subscapular and triceps sites were found to be more resistant towards fat change.

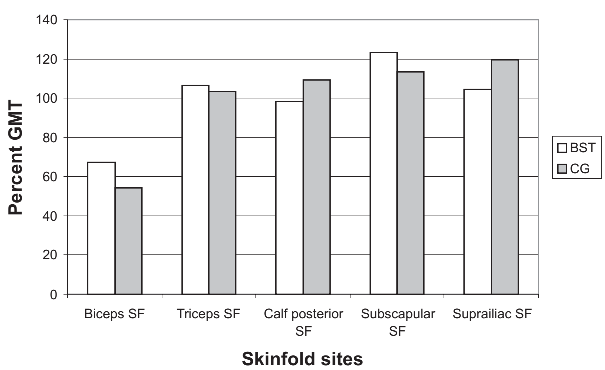

Fig. 2. Responsiveness of different skinfold sites for fat loss with TB disease (BST vs CG). CG – healthy controls, BST – before starting treatment, SF – skinfold.

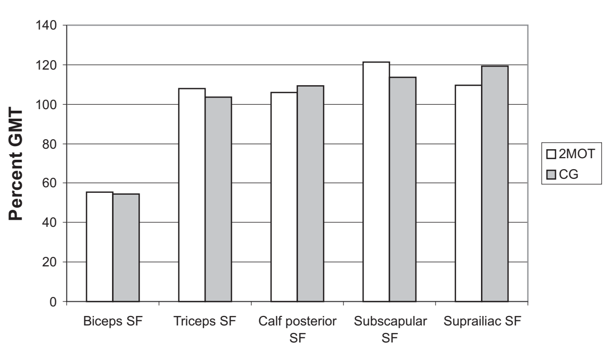

Fig. 3. Responsiveness of different skinfold sites for fat gain with TB treatment (2MOT vs CG). CG – healthy controls, 2MOT – after two months of treatment, SF – skinfold.

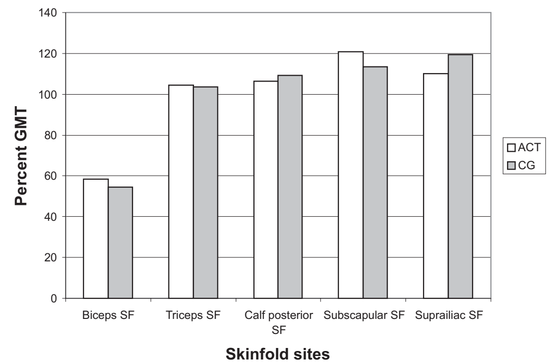

Fig. 4. Responsiveness of different skinfold sites for fat gain with TB treatment (ACT vs CG). CG – healthy controls, ACT – After completion of treatment, SF – skinfold, GMT – grand mean thickness.

During the regular treatment for TB under DOTS, an increase in subcutaneous fat was observed which was most noticeable at suprailiac and calf posterior sites (Figure 3). Although the suprailiac and calf posterior remained most sensitive sites for subcutaneous fat gain (Figures 3 and 4), the difference between TB patients and healthy controls kept on decreasing with duration of treatment.

Discussion and Conclusion

Body weight is a measure of gross body mass i.e. skeleton, muscles and fat and also is a good indicator of nutritional status of an individual or a group of individuals.

In the present study the disease free healthy control group was found to be heaviest, followed by subjects who had completed their treatment. Thus, with TB, a depletion of fat and wastage of muscles has been noticed, which bring about a decrease in body weight as observed among patients who had not started their treatment. Similar findings were found in a study among 823,199 Navy recruits[4]. The study also found morbidity (TB) to be 3 times greater for underweight than for overweight men. In the present study it was further found that proper treatment and improved diet certainly showed an impact on the body weight[37].

In the present study body mass index (BMI) a widely used method to assess the fatness in human beings was noticed to be lowest among the subjects who had not started TB treatment, thereby indicating degeneration of the body's soft tissues with chronic disease[8,38]. The increase in BMI with treatment could only be due to increase in body mass with proper medication as advised by doctors. The present findings was also supported by the study done by Tverdal (1986)[5], among 1717655 subjects, where he found that incidence of pulmonary TB decreased with increasing body mass index (BMI) for both sexes and all age groups, which was mainly attributed to be due to the weight component.

Waist circumference is an index of deep adipose tissue[39] and is related to fat free mass[40]. Waist to hip circumference ratio (WHR) is an indicator of the degree of masculine distribution of adipose tissue: the higher the WHR, the more masculine the pattern of adipose tissue distribution and the greater the risk of diseases such as noninsulin dependent diabetes mellitus[36,41]. In the present study, the WHR was found to be least among TB patients (BST) and a significant increase was observed till two months of treatment ($p<0.01$). The increase in WHR with TB treatment has been brought by the more sensitive behaviour of suprailiac site for fat accumulation. This also suggests that a central deposition of adipose tissue is a response to stress acting through the adrenal cortex[42]. According to the WHR values[36], the TB patients and healthy subjects had more androidal pattern of fat deposition.

Skinfold thickness measured at different body sites gives an account of relative fatness for comparison purposes and also indicate the distribution pattern of subcutaneous fat over the entire body. The purpose of assessing the profile of fatness among subjects who were at different stages of treatment and the healthy control group was to visualize the changes if any in the subcutaneous fat distribution pattern due to the effect of TB and its treatment. The skinfold thickness taken at various sites were significantly higher in disease free healthy controls as compared to the TB patients at all stages of treatment. This indicates that the healthy controls had better energy reservoir, better nutritional status than the subjects who had TB and who were under TB treatment. An improvement in energy storage is seen over time with treatment among TB patients as seen in increasing skinfold thickness levels with different stages of treatment (i.e., BST, 2MOT & ACT).

Among TB patients (BST) all the skinflold thicknesses were found to be least and this could be a reflection for decreased energy stores due to depletion of fat with chronic disease. The situation changed during the course of treatment. A continuous increasing body weight with treatment can be attributed to increase in muscle mass as well as subcutaneous fat. Fat re-distribution start manifesting itself from the time treatment started. There is loss of trunkal as well as extremity fat from the time a person is infested with the disease.

The increase in BMI, an index of overweight/obesity and a simultaneous increase in the GMT of skinfold thickness with TB treatment would entail this increase in body weight due to increase in fatness. In the present study healthy controls were found to have higher values of all the five skinfold thicknesses as compared to the TB patients (BST, 2MOT & ACT) and subsequent increase in fatness with TB treatment. All the skinfold thicknesses, indices of fatness, profile of subcutaneous fat distribution and sensitivity of each skinfold site showed an increasing fat deposition on trunkal region with treatment.

Sensitivity of the five skinfold sites towards fat depletion in BST and accumulation in 2MOT and ACT showed variation at different sites in different stages of treatment. Suprailiac was found to be the most sensitive site towards fat loss followed by calf posterior. This phenomenon of increase in trunkal fat with impaired health condition and nutritional intake, if continued undetected may become detrimental to health due to metabolic disorders like type II diabetes.

The grand mean thickness (GMT) values were found to increase with treatment and the highest value was found in disease free healthy subjects. The increase in fatness level is mainly due to improved health status of the present subjects. The greater variability observed in subcutaneous fatness among disease free controls could be attributed to variability in nutrition intake, physical and recreational activity. Such variability would ensure lots of variation in energy intake and consumption. It is well established that people show a decrease in their total body fat content with increasing level of physical activity or a decrease in energy intake[43]. The lesser variability among patients especially those patients who were diagnosed cases but had not started treatment may be due to poor nutritional intake, lack of physical activity, anorexia, etc. which comes with chronic diseases[7,9]. There is no doubt that one of the symptom of tuberculosis is anorexia or loss of appetite which would cause a loss in body weight with a concomitant decrease in body fat which was noticeable in the present subjects. The decrease in energy intake might be due to less food intake or improper and or unbalanced diet. It can be influenced by less food availability, poor eating habits or anorexia.

Thus, with disease a general depletion of fat stores and muscle wastage was observed and with treatment the body regained fat, muscle strength and body mass. Selected anthropometric indices in properly designed studies can be used as important tools in TB treatment strategies.

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OBRAZAC DISTRIBUCIJE MASNOĆA KAO RIZIČNOG FAKTORA KOD KRONIČNIH OBOLJENJA MEĐU PLEMENIMA SI INDIJE

S A Ž E T A K

Cilj ove studije bio je istražiti utjecaj plućne tuberkuloze na distribuciju masnoća te osjetljivost različitih kožnih nabora na bolest i liječenje među odraslim pripadnicima plemena Manipur u sjeveroistočnoj Indiji. Sveukupno su vršena četiri antropometrijska mjerenja te mjerenja kožnih nabora na pet različitih mjesta. Indikacije pretilosti (indeks tjelesne mase, odnos struk-kukovi) su također računate i mjerene. Uzorak je uključivao ispitanike koji boluju od tuberkuloze (N=167) u različitim stadijima liječenja te zdrave ispitanike kao kontrolnu skupinu (N=80). Starost ispitanika bila je između 20 i 40 godina. Zamijećen je gubitak mišićne mase i masnoća zbog kroničnog oboljenja te opće poboljšanje tih komponenata zajedno sa redistribucijom masnoća za vrijeme liječenja.