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Comparison of Nutritional Status Between Tuberculosis Patients and Controls: a Study from North 24 Parganas District in West Bengal, India

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ABSTRACT

The nutritional status of tuberculosis patients (TBP) and controls (CT) was compared among adult (> 20 years) Bengalees in Shyamnagar, Barrackpore, Naihati and Jagaddal of North 24 Parganas District, West Bengal, India. The subjects included 310 men (154 TBP and 156 CT) and 246 women (128 TBP and 118 CT). The mean ages of TBP men was 36.4 years (CT = 34.5) and that of TBP women was 26.4 years (CT = 25.6). Variables compared included weight, height, fat mass, fat mass index, mid-upper arm fat area, and skinfolds. Results revealed that TBP had significantly lower means for all variables (except for height in men) compared to CT in both sexes. In men, the highest percent differences between the two groups were observed for fat mass (FM: 60.1%), fat mass index (FMI: 59.2%) and suprailiac skinfold (SUPSF: 58.8%). In women, the highest percent differences between the two groups were observed for SUPSF (59.7), mid-upper arm fat area (MUAFA: 58.1), triceps skinfold (TSF: 51.4), biceps skinfold (BSF: 51.2), FM (51.2) and FMI (49.0). Regression analyses confirmed that tuberculosis status had significant impact ($p < 0.0001$) on all anthropometric and body composition characteristics compared (except for height in men) in both sexes. Among men, tuberculosis status explained the highest percent variation in percent body fat (PBF: 57.2%), FMI (56.0%) and FM (55.6%). In women, tuberculosis status explained the highest amount of variation in PBF (67.9), TSF (63.5%), BSF (62.8), FMI (61.0) and FM (60.7). Results of contingency chi-square tests revealed that there were significant differences in the frequency of undernutrition between TBP and CT in men ($\chi^2 = 73.13361$) and women ($\chi^2 = 59.0000$). The frequencies of undernutrition were significantly more common among TBP, in both men (56.5%) as well as women (51.6%). This study provided evidence that there was significant differential amount of loss in fat and muscle measures in tuberculosis patients.

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INTRODUCTION

Approximately one-third of the world's population is infected with *Mycobacterium tuberculosis* (common name: tuberculosis) and the majority live in less developed countries (van Lettow *et al*., 2004). Anthropometric and body composition characteristics as well as nutritional status of tuberculosis patients (TBP) have been studied in several recent investigations worldwide (Macallan, 1999; Niyongabo *et al.,* 1999; Metcalf, 2005; Paton *et al*., 2004; Paton & Ng, 2006; Villamor *et al.,* 2006). These studies have reported poorer nutritional and body composition status among TBP compared to controls (CT). However, such studies are lacking from India (Macallan, 1999). The present investigation was undertaken to compare the anthropometric and body composition characteristics and nutritional status between TBP and CT among adult (> 20 years) Bengalees of North 24 Parganas District in West Bengal, India.

MATERIALS AND METHODS

A comparative study of TBP and CT was undertaken among adult (> 20 years) Bengalees of Shyamnagar, Barrackpore, Naihati and Jagaddal of North 24 Parganas District, West Bengal, India. This study was conducted at the State General Hospital of Bhatpara, Dr. B.N. Bose Hospital of Barrackpore and Naihati S.D. Hospital during December 2003 to February 2004. This study area was chosen because of the presence of several hospitals that cater to the needs of TBP. Prior ethical permission was obtained from the hospital authorities. Both medically diagnosed TBP as well as controls were recruited from these hospitals. Only individuals diagnosed (by clinicians at the hospitals) as suffering from TB were classified as TBP. The sample size of this study comprised 310 (154 TBP and 156 CT) men and 246 (128 TBP and 118 CT) women. All subjects gave their signed consent to participate in this study. Subjects were required to complete a questionnaire which had specific questions on age and ethnicity. All subjects were of Bengalee ethnicity.

All anthropometric measurements were made by a trained investigator following the standard techniques of Lohman, Roche & Martorell (1988). Height, weight, mid-upper arm circumference (MUAC), and biceps (BSF), triceps (TSF), subscapular (SUBSF) and suprailiac (SUPSF) skinfolds were measured. Technical errors of measurements were computed and they were found to be within acceptable limits (Ulijaszek & Kerr, 1999).

Total subcutaneous adiposity (sum of four skinfolds, SUMSF) was computed as:

SUMSF (mm) = BSF + TSF + SUBSF + SUPSF.

Body mass index (BMI) was computed following the standard formula: BMI = weight (kg)/height (m^2). The following World Health Organization (WHO, 1995) recommended BMI cut-off points were utilized to determine the nutritional status of the subjects:

Nutritional status	BMI (kg/m^2)
Undernutrition	< 18.5
Normal	18.5 – 24.9
Overweight	25.0 – 29.9

Percent body fat (PBF) was calculated using Siri's (1956) equation:

$$PBF = (4.95/density - 4.50) \times 100$$

Density was derived following Durnin & Womersley's (1974) age and sex-specific equations using the SUMSF.

Fat mass (FM), fat free mass (FFM), fat mass index (FMI) and fat free mass index (FMI) were computed using following standard equations:

FM (kg) = (PBF/100) x Weight (kg)
FFM (kg) = Weight (kg) – FM (kg)
FMI (kg/m^2) = FM (kg) / height^2 (m^2)
FFMI (kg/m^2) = FFM (kg) / height^2 (m^2)

Mid-upper arm muscle area (MUAMA) and mid-upper arm fat area (MUAFA) were calculated using the standard equations of Gibson (1990):

$$\text{MUAMA} = \frac{[\text{MUAC} - (\pi \times \text{TSF})]^2}{4\pi}$$

$$\text{MUAFA} = \frac{\text{TSF} \times \text{MUAC}}{2} - \frac{\pi \times (\text{TSF})^2}{4}$$

where TSF and MUAC are triceps skinfold and mid-upper arm circumference, respectively.

Total body water (TBW) was computed using Watson, Watson & Batt (1980) formulae for each sex separately:

Men:
TBW = 2.447 – (0.09156 x age) + (0.1074 x Height) + (0.3362 x Weight)

Women:
TBW = - 2.097 + (0.1069 x Height) + (0.2466 x Weight)

where age is in years, height in cm and weight in kg.

The distributions of most of the variables were not significantly skewed enabling the application of parametric statistics. Student's t tests were performed to test for the differences in mean values between TBP and CT in each sex separately. Percent difference was computed with the following formula:

Percent Difference (%) = (Mean CT – Mean TBP) / Mean CT

Linear regression analyses (TB status coded as: 1 = yes; 2 = no) were undertaken to test for the impact of TB status on anthropometric and body composition variables. TB status was used an independent variable. Chi-square tests (Fischer's exact test) were performed (each sex separately) to test for differences in nutritional status between TBP and CT. All statistical analyses were performed with SPSS software package. Statistical significance was set at $p < 0.05$.

RESULTS

There were no significant differences in mean ages between TBP (men: mean = 36.4 years, sd = 16.3; women: mean = 26.4, sd = 11.1) and CT in each sex (men: mean = 34.5 years, sd = 12.1; women: mean = 25.6, sd = 16.8). The mean (sd) and differences in anthropometric and body composition characteristics between TBP and CT among men are presented in Table 1. The mean values in TBP were significantly ($p < 0.001$) lower than those in CT for all variables except height. The highest percent differences between the two groups were observed for FM (60.12) and FMI (59.21) and SUPSF (58.82).

The mean (sd) and differences in anthropometric and body composition characteristics between TBP and CT among women are presented in Table 2. The mean values in TBP were significantly ($p < 0.001$) lower than those in CT for all variables. The highest percent differences between the two groups were observed for SUPSF (59.71), MUAFA (58.06), TSF (51.40), BSF (51.19), FM (51.22) and FMI (48.99).

Results of linear regression analyses of TB status (independent variable coded as: 1 = TBP, 2 = CT) and anthropometric and body composition characteristics (dependent variable) in men are presented in Table 3. Results revealed that TB status had significant impact ($p < 0.0001$) on all anthropometric and body composition

characteristics except height. TB status explained the highest percent variation in PBF (57.2%), FMI (56.0%) and FM (55.6%).

In women (Table 4), it was observed that TB status had significant impact ($p < 0.0001$) on all anthropometric and body composition variables. TB status explained the highest amount of variation in PBF (67.9%), TSF (63.5%), BSF (62.8%), FMI (61.0%) and FM (60.7%).

Contingency chi-square tests were performed for each sex separately to test for the association of TB status with nutritional status. Results revealed that there were significant differences in the frequency of undernutrition between TBP and CT in men ($\chi^2 = 73.13361$) and women ($\chi^2 = 59.0000$). The frequencies of undernutrition were significantly more common among TBP, in both men (56.5%) as well as women (51.6%). Figures 1 (men) and Figure 2 (women) present the distribution of subjects according to nutritional status in TBP and CT.

DISCUSSION

Malnutrition predisposes to tuberculosis, and tuberculosis causes 'consumption' (Schwenk & Macallan, 2000). Recent studies have investigated anthropometric and body composition characteristics as well as nutritional status of tuberculosis patients in several countries worldwide (Macallan, 1999; Niyongabo *et al*., 1999; Metcalf, 2005; Paton *et al.,* 2004; Paton & Ng, 2006; Villamor *et al.,* 2006).

In the present investigation, there was clear evidence that TBP had significantly lower mean values of anthropometric and body composition characteristics. The frequency of undernutrition (BMI < 18.5 kg/m^2) was also significantly higher among TBP. Similar findings have been reported in earlier studies worldwide.

More importantly, this study provided evidence that there was differential amount of loss in fat and muscle measures in TBP. In general, differences in mean values of fat measures (PBF, FM, FMI, MUAFA) were much more compared to differences in non-fat muscle measures including fat free mass (FFM), fat free mass index (FFMI) and mid-upper arm muscle area (MUAMA), in TBP than in CT in both sexes. Figure 3 provides a comparison of the percent differences in fat and non-fat measures between TBP and CT in both sexes. The differences were generally greater in men. These results are in concordance to findings of earlier studies in other countries.

These results implied that the impact of TB is much more pronounced on fat as compared to non-fat measures in both sexes. However, it must be pointed out here that the present study was case control in nature which can only highlight the differences in anthropometric and body composition characteristics between TBP and CT. To better understand the actual process dealing with changes in these variables, prospective studies are needed not only from India but also from other developing countries were tuberculosis is common. These prospective studies should be conducted on normal individuals who are at high risk of developing tuberculosis. These subjects should be tracked so as to elucidate the changes in anthropometric, body composition and nutritional characteristics concomitant to the onset of tuberculosis. Such studies are lacking.

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Table 1. Comparison of anthropometric and body composition characteristics between male TBP and CT

Characteristics	*TBP (n = 154)*	*CT (n = 156)*	*Percent Difference (%)*	*T*
Height (cm)	162.6 (5.5)	163.0 (6.6)	0.24	- 0.56
Weight (kg)	48.4 (4.0)	57.1 (6.8)	15.27	- 13.68*
MUAC (cm)	20.0 (3.8)	23.7 (2.7)	15.76	- 10.05*
BMI (kg/m^2)	18.3 (1.5)	21.5 (2.5)	14.89	- 13.71*
BSF (mm)	4.0 (1.6)	7.5 (2.0)	46.67	- 17.22*
TSF (mm)	4.9 (1.7)	9.3 (2.3)	47.31	- 19.17*
SUBSF (mm)	7.2 (2.4)	13.8 (4.6)	47.83	- 15.88*
SUPSF (mm)	5.6 (2.1)	13.6 (5.1)	58.82	- 18.09*
SUMSF (mm)	21.7 (7.3)	44.2 (12.8)	50.90	- 18.96*
PBF (%)	8.9 (4.3)	18.9 (4.4)	53.11	- 20.36*
FFM (kg)	43.9 (3.4)	46.0 (4.0)	4.45	- 4.828*
FFMI (kg/m^2)	16.6 (1.2)	17.4 (1.6)	4.08	- 4.538*
FM (kg)	4.4 (2.3)	11.1 (3.5)	60.12	- 19.698*
FMI (kg/m^2)	1.7 (0.9)	4.2 (1.3)	59.21	- 19.837*
TBW (kg)	31.9 (2.7)	33.6 (2.9)	5.08	- 5.312*
MUAFA (cm^2)	4.7 (1.9)	10.5 (3.4)	54.66	- 18.341*
MUAMA (cm^2)	28.1 (8.1)	34.8 (7.4)	19.25	- 4.265*

* $p < 0.001$
Standard deviation is given in parentheses

Table 2. Comparison of anthropometric and body composition characteristics between female TBP and CT

Characteristics	*TBP (n = 154)*	*CT (n = 156)*	*Percent Difference (%)*	*T*
Height (cm)	151.4 (5.9)	154.8 (5.1)	2.19	- 4.78*
Weight (kg)	42.4 (5.2)	52.1 (7.9)	18.78	- 11.64*
MUAC (cm)	19.2 (3.3)	22.9 (2.7)	16.21	- 9.63*
BMI (kg/m^2)	18.5 (2.2)	21.7 (2.9)	14.86	- 9.91*
PBF (%)	16.5 (3.8)	27.3 (3.6)	39.62	- 22.77*
BSF (mm)	4.1 (1.4)	8.4 (1.9)	51.19	- 20.13*
TSF (mm)	5.2 (1.9)	10.7 (2.3)	51.40	- 20.67*
SUBSF (mm)	7.5 (2.3)	14.8 (3.8)	49.32	- 18.07*
SUPSF (mm)	5.6 (1.9)	13.9 (4.5)	59.71	- 18.64*
SUMSF (mm)	22.4 (7.0)	47.8 (11.2)	53.14	- 21.23*
FFM (kg)	35.3 (4.2)	37.7 (4.4)	6.25	- 4.29*
FFMI (kg/m^2)	15.4 (1.9)	15.7 (1.6)	1.83	- 1.29*
FM (kg)	7.0 (2.1)	14.5 (3.7)	51.22	- 19.50*
FMI (kg/m^2)	3.1 (0.9)	6.0 (1.4)	48.99	- 19.60*
TBW (kg)	26.5 (2.4)	29.6 (2.1)	10.48	- 10.76*
MUAFA (cm^2)	4.8 (2.3)	11.5 (3.2)	58.06	- 19.01*
MUAMA (cm^2)	25.3 (5.4)	30.7 (7.1)	17.62	- 3.49*

* $p < 0.001$
Standard deviation is given in parentheses

Table 3. Regression analyses of TB status (1= yes, 2= no) with anthropometric and body composition characteristics among men

Variable	*B*	*seB*	*Beta*	*Adj. R^2*	*t*
Height	0.384	0.692	0.032	0.002	0.56
Weight	8.719	0.637	0.615	0.376	13.68*
MUAC	3.724	0.372	0.497	0.244	10.05*
BMI	3.201	0.233	0.616	0.377	13.71*
BSF	3.469	0.202	0.700	0.488	17.20*
TSF	4.360	0.228	0.737	0.541	19.13*
SUBSF	6.559	0.414	0.670	0.447	15.82*
SUPSF	8.013	0.445	0.716	0.511	18.01*
SUMSF	22.402	1.186	0.733	0.535	18.89*
PBF	10.047	0.497	0.757	0.572	20.36*
FFM	2.046	0.424	0.265	0.067	4.83*
FFMI	0.710	0.156	0.250	0.060	4.54*
FM	6.673	0.339	0.747	0.556	19.70*
FMI	2.487	0.125	0.749	0.560	19.84*
TBW	1.708	0.321	0.290	0.081	5.31*
MUAFA	5.724	0.312	0.723	0.520	18.34*
MUAMA	6.693	1.569	0.236	0.053	4.27*

* $p < 0.0001$
TB status used as an independent variable

Table 4. Regression analyses of TB status (1= yes, 2= no) with anthropometric and body composition characteristics among women

Variable	*B*	*seB*	*Beta*	*Adj. R^2*	*t*
Height	3.387	0.708	0.293	0.082	4.79*
Weight	9.782	0.841	0.597	0.354	11.64*
MUAC	3.711	0.385	0.525	0.272	9.63*
BMI	3.224	0.325	0.536	0.284	9.91*
PBF	10.817	0.475	0.825	0.679	22.77*
BSF	4.310	0.212	0.794	0.628	20.37*
TSF	5.532	0.418	0.798	0.635	20.67*
SUBSF	7.358	0.399	0.763	0.580	18.43*
SUPSF	8.314	0.433	0.775	0.599	19.18*
SUMSF	22.402	1.186	0.733	0.535	18.89*
FFM	2.354	0.548	0.265	0.067	4.30*
FFMI	0.287	0.223	0.082	0.003	1.29*
FM	7.427	0.381	0.780	0.607	19.50*
FMI	2.940	0.150	0.782	0.610	19.60*
TBW	3.101	0.288	0.567	0.319	10.76*
MUAFA	6.694	0.352	0.773	0.595	19.01*
MUAMA	5.401	1.546	0.218	0.044	3.49*

* $p < 0.0001$
TB status used as an independent variable

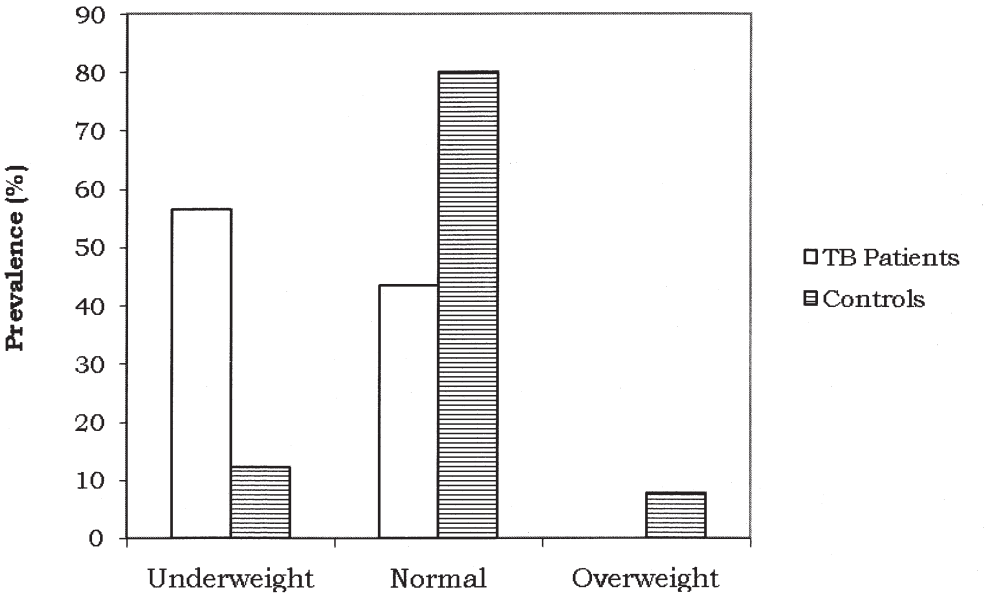

Figure 1. Nutritional status of the male subjects based on BMI

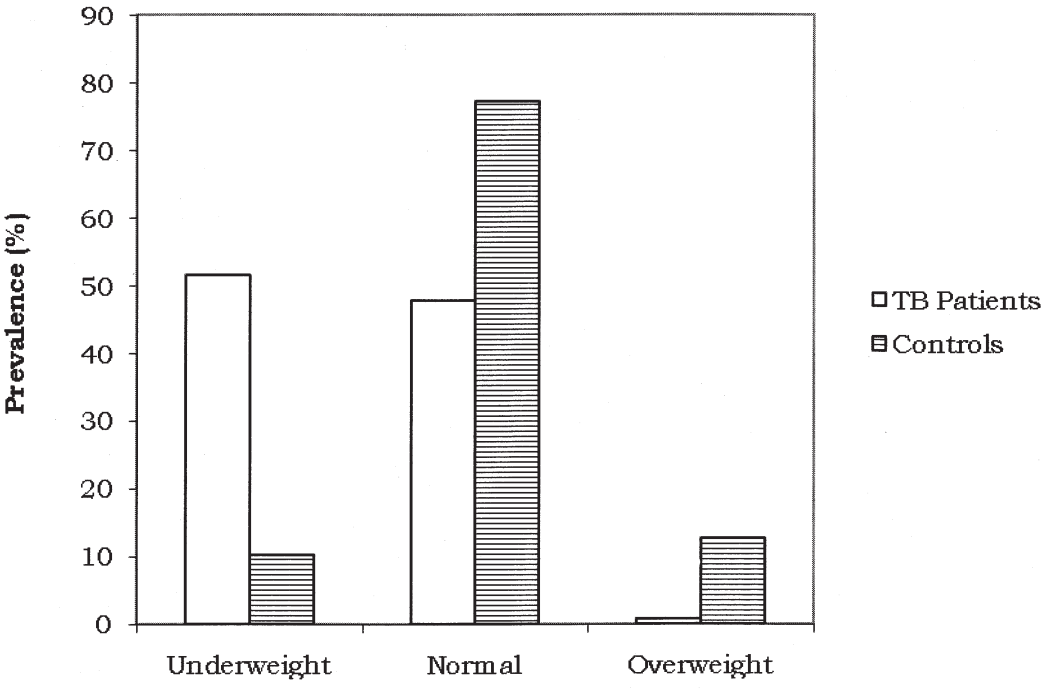

Figure 2. Nutritional status of the female subjects based on BMI

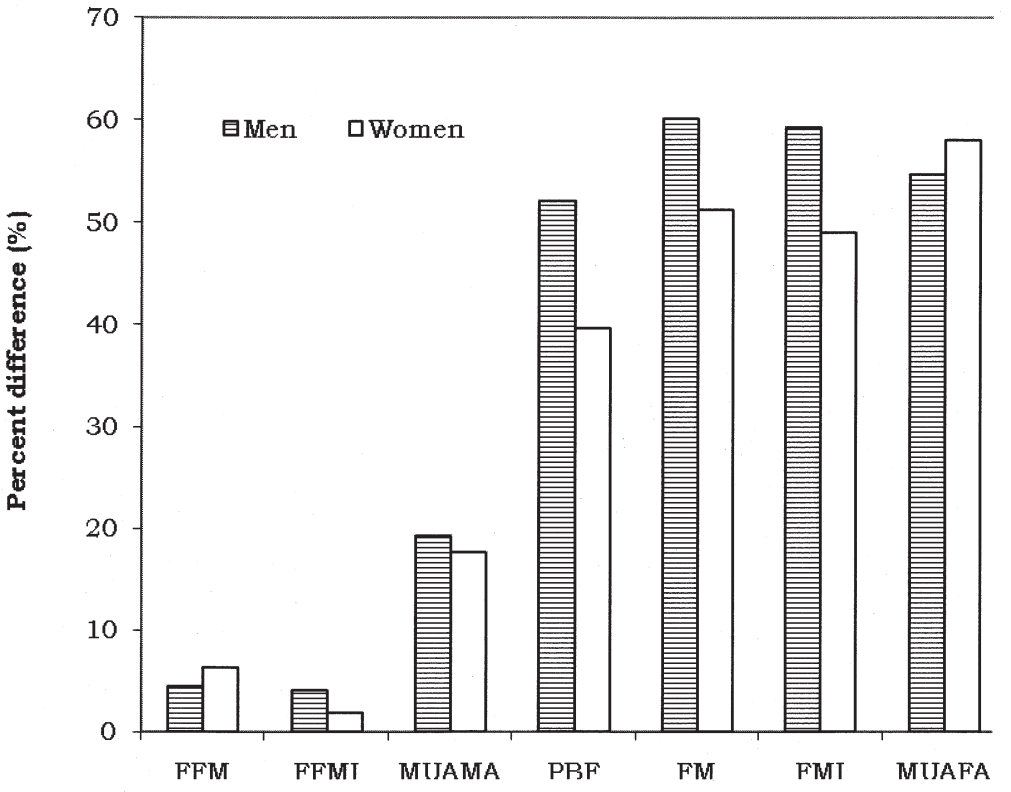

Figure 3. Comparison of percent differences in fat and non-fat body composition measures between TBP and CT

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