
ORIGINAL ARTICLE**Weight variation over a period of time among tuberculosis patients on treatment and its association with tuberculosis outcomes: A longitudinal study***Gayathri G Nair¹, Umayorubhagom Ashok², Sulakshana S. Baliga^{3*}**¹Department of Paediatrics, ²Department of Community Medicine, Sri Lakshmi Narayana Institute of Medical Science Medical College & Hospital, Puducherry-605502, India, ³Department of Community Medicine, Jawaharlal Nehru Medical College, KLE Academy of Higher Education and Research, Belagavi-590010 (Karnataka) India*

Abstract

Background: Malnutrition is made worse by Tuberculosis (TB), which makes the illness more severe. Gaining weight while undergoing treatment reduces the impact of the illness, lowers the danger of dying, converts sputum sooner, improves drug absorption, lowers the recurrence rate, and lowers the spread of tuberculosis in malnourished contacts. **Aim and Objective:** To assess weight variation over a period of time among tuberculosis patients on treatment and its association with tuberculosis outcomes. **Material and Methods:** Between July 2022 and December 2022, 261 TB patients were included from the TB Center in our district using the universal sampling technique. We inquired about sociodemographic information, weight gain and the success and failure of treatment results. **Results:** Mean weight of the successful outcome group at baseline, 2 months completion and 6 months completion was 43.55 ± 7.09 , 44.49 ± 6.89 and 46.04 ± 6.91 . Mean weight of the unsuccessful outcome group at baseline, 2 months completion and 6 months completion was 40.12 ± 4.45 , 37.73 ± 2.77 and 36.59 ± 3.0 . Mean Body Mass Index (BMI) of the successful outcome group at baseline, 2 months completion and 6 months completion was 16.81 ± 2.75 , 17.19 ± 2.73 and 17.8 ± 2.78 . Mean BMI of the unsuccessful outcome group at baseline, 2 months completion and 6 months completion was 15.8 ± 2.02 , 15.22 ± 1.47 and 14.77 ± 1.64 . Both were statistically significant. ($p < 0.001$) **Conclusion:** From baseline to the second month and from the second month to the sixth month, the treatment successful group's mean body weight and BMI increased in comparison to the treatment unsuccessful outcome group.

Keywords: Longitudinal, Tuberculosis outcome, Weight gain variation

Introduction

Being a contagious disease, Tuberculosis (TB) is one of the main causes of illness and death in the globe. Prioritizing above HIV/AIDS [1], TB is the most common infectious agent-related cause of mortality. Around 10.7 million cases of TB were reported in 2022, a 4.6% [2] rise from 10.2 million cases in 2021. Between 2021 and 2022, the newly diagnosed cases of TB increased by 3.7% [3]. Undernutrition is made worse by TB, which in turn makes the disease more severe [4]. Muscle protein loss is traditionally linked to TB and happens for three reasons [5]. The first is reduced food dietary

consumption due to loss of appetite and the degree of this condition often reflects the seriousness of the underlying clinical condition. Due to fever, TB also raises the rate of metabolism; however, this rise is countered by a decrease in energy consumption from decreased activity before the onset of clinical recovery following therapy. Finally, breakdown of muscle brought on by TB is influenced by the response during the acute phase, which results in the breakdown of proteins and an imbalance of nitrogen in the body [6].

In India, families from lower- and middle-class backgrounds have more chances of acquiring TB because they are more likely to experience chronic undernutrition, lack of access to food, and treatment delays [7]. In these individuals, low nutritional status is made worse by TB. Greater attention should be paid to inadequate nutrition and inability to increase weight in patients with active TB, since these situations are significantly associated with a variety of unfavourable outcomes [8]. Inability to gain weight can worsen TB sickness and reduce antibody formation in the body. The likelihood of dying from TB is higher in patients who do not gain weight. This risk is present in both adult and paediatric patients, HIV seropositive and seronegative patients, and patients with both drug-sensitive and those with TB resistant to drugs [9]. In our country, individuals with TB who weighed less than 34 kg had a roughly fivefold higher chance of dying from the disease than those who weighed above 35 kg [10].

Another cause of concern for the development of medication induced liver damage, a significant adverse effect of anti-tuberculosis medication, is inadequate nutrition. Individuals with a Body Mass Index (BMI) of less than 18 kg/m^2 are five times more likely to experience medication induced liver damage [11]. Hepatic failure caused by drugs may cause therapy to be stopped or neglected [12]. Absence of weight increase can also affect how medications work in the body and cause some medications, such as rifampicin, to be at lower levels. Insufficient weight gain over the course of therapy was linked to an increased chance of recurrence. Additionally, contacts of TB patients are susceptible to contracting the disease, and inability to obtain a balanced diet on a daily basis and malnutrition can significantly raise this risk. Gaining weight while undergoing therapy

may result in a reduction in the severity of the illness, a lower chance of mortality, an earlier conversion of sputum, a lower risk of medication-induced liver damage, improved drug absorption, a lower relapse rate, and a fewer new cases among undernourished contacts. It is seen that weight increase during the first few months of therapy might predict treatment success [12]. The study was aimed to assess weight variation over a period of time among TB patients on treatment and its association with TB outcomes.

Material and Methods

In this longitudinal study patients listed with the TB Centre in our district were enrolled from the beginning of July 1st 2022 through June 30th 2023. Patients were enrolled during the second half of the year (July to December) and during the following half of the year (January to June) treatment outcomes were monitored. Two-hundred sixty one TB patients who had registered for treatment at District TB Centre, Belagavi between July to Dec 2022 were included as study participants using universal sampling method. The study used universal sampling method where all eligible TB patients receiving treatment during the study period were included till the entire accessible population meeting the inclusion criteria were enrolled. No separate sampling technique was required. Prior sample size estimation was not done because all eligible patients treated during the study period were included using universal sampling. Final sample size was identified by the number of eligible patients who were put on treatment during the study period. Interviews with participants were conducted either at the initial stages of their treatment or shortly after their test results came. Information regarding clinical and anthropometric data was taken as per the treatment registers available with the TB supervisors under the National Tuberculosis Elimination

Programme (NTEP). During the interactions between the patients and the provider, information was gathered. After the intensive period or the second month of medication, first follow-up was conducted. A subsequent follow-up was done six months after the treatment was completed. We inquired about the social and demographic characteristics, changes in weight, and positive and negative treatment results of the patients. Sputum microscopy was utilised to identify pulmonary TB patients. To determine medication susceptibility to rifampicin, a cartridge-based nucleic acid amplification assay was used. The health supervisor was contacted if a study participant died during the study phase. Patients enrolled in the NTEP for tuberculosis therapy from July to Dec 2022, those who have received anti-tuberculosis medication for at least two weeks, and the patients who were willing to receive treatment through our district tuberculosis centre were included. Those who were unwilling to participate, patients who were to be transferred outside of the study area, those with incomplete data, and patients showing resistance to one or more than one TB drugs including isoniazid and rifampicin were excluded. Predesigned and pretested questionnaire was used. Each participant provided informed consent prior to the study.

The Institutional Ethics Committee provided ethical approval for the study (Ref No. MDC/JNM CIEC/77). Statistical Package for the Social Sciences software version 25 was used for data analysis. Data were assessed for normality and continuous data between two outcome groups are assessed using the Welch's t-test and within two outcome group's data are assessed using the repeated measure ANOVA test. Post hoc analysis between two outcome groups was done using pair wise t test and within two outcome groups it was

done using one-way repeated measures of ANOVA test. Categorical data are assessed using Chi-square test and multiple logistic regression analysis was also done. Significance was set at $p < 0.05$.

Results

Demographic profile of the study participants

In our study, 180 (68.96%) literates and 10 (3.83%) illiterates had successful treatment outcome. Significant association was found between literacy and TB treatment outcome ($p < 0.05$). Overcrowding was present in 80 (30.65%) houses and absent in 105 (40.22%) houses in the successful treatment group. This association was found to be significant ($p < 0.05$). One hundred and seventy-five (67.05%) patients had pulmonary smear positive TB and 82 (31.41%) had extra pulmonary TB.

Body weight

In the present study, mean weight in the successful outcome group at baseline, 2 months completion and 6 months completion was 43.55 ± 7.09 , 44.49 ± 6.89 and 46.04 ± 6.91 respectively. The mean weight of the unsuccessful outcome group at baseline, 2 months completion and 6 months completion was 40.12 ± 4.45 , 37.73 ± 2.77 and 36.59 ± 3.0 respectively. There was a statistically significant difference in the mean weights at baseline, 2 months completion and 6 months completion between two outcome groups of TB ($p < 0.001$) (Table 1). In present study, within the successful outcome group, mean body weight increased at 2 months completion in comparison to baseline body weight. Mean body weight also increased at 6 months completion when compared to 2 months. It was found that there was a statistically significant difference in the weight change over time during follow-up within the successful result group ($p < 0.001$). Within

unsuccessful outcome group the mean body weight decreased at 2 months completion when compared to baseline body weight. The mean body weight also decreased at the completion of 6 months when compared to 2 months. This difference in weight change over time throughout follow-up within the TB unsuccessful outcome group was not statistically significant ($p=0.21$).

Body mass index

In our present study, the mean BMI of the successful outcome group at baseline, completion of 2 months and completion of 6 months was 16.81 ± 2.75 , 17.19 ± 2.73 and 17.8 ± 2.78 respectively. The mean BMI of the unsuccessful outcome group at baseline, completion of 2 months and completion of 6 months was 15.8 ± 2.02 , 15.22 ± 1.47 and 14.77 ± 1.64 respectively. There was a statistically significant difference in the mean BMI at baseline, completion of 2 months and 6 months between participants with successful and unsuccessful outcome ($p < 0.001$) (Table 1). In our present study, within the successful outcome group the mean BMI increased at the completion of 2 months when compared to baseline. The mean BMI also increased at the completion of 6 months. This difference in change of BMI over time was noted to be statistically significant ($p < 0.001$).

Within unsuccessful outcome group the mean BMI decreased at the completion of 2 months when compared to baseline BMI. The mean BMI also decreased at the completion of 6 months when compared to 2 months, this was noted to be not statistically significant ($p=0.21$) (Table 1).

In our present study from post hoc analysis, it was observed that, there was difference in the mean

weight over time point (Baseline v/s completion of 2 months, completion of 2 months v/s completion of 6 months and baseline v/s completion of 6 months) in both outcome groups ($p < 0.001$). (i.e., mean weight had increased over time point in successful group and decreased over time in unsuccessful group which was found to be statistically significant (Table 2). In the present study from post hoc analysis, it was observed that mean BMI increased over time point (Baseline v/s completion of 2 months, completion of 2 months v/s completion of 6 months and baseline v/s completion of 6 months) in successful group, this was noted to be statistically significant ($p < 0.001$) (Table 3). In our study logistic regression analysis showed that factors associated with weight were age, gender, occupation and socio economic status. Patients between 41-60 years were 0.35 times more likely to have normal weight than other age groups [UOR: 0.35; 95% CI (0.24-0.52)]. Females were 1.91 times more likely to have a normal weight than males [UOR: 1.91; 95% CI (1.28-2.86)]. Unemployed had a 0.65 times risk of being under weight compared to employed [UOR: 0.65; 95% CI (0.43-0.98)]. Those under socio-economic status 3 were 1.13 times more likely to have normal weight compared to others [UOR: 1.13; 95% CI (0.49-2.57)] (Table 4). Patients with diabetes were 0.68 times more likely to be under weight compared to those with no diabetes [AOR: 0.683; 95% CI (0.087-5.380)]. Patients with support of supervisor were 0.89 times less likely to be under weight compared to others [AOR: 0.896; 95% CI (0.564-1.424)] (Table 5).

Table 1: Association of weight and Body Mass Index (BMI) change over time during follow up between and within two outcome groups of tuberculosis

		Successful outcome	Unsuccessful outcome	<i>t</i>	<i>p</i>
Weight (Kg)	Baseline	43.55 ± 7.09	40.12 ± 4.45	4.6227	< 0.001* ^{Wt}
	2 month	44.49 ± 6.89	37.73 ± 2.77	10.04	< 0.001* ^{Wt}
	6 month	46.04 ± 6.91	36.59 ± 3.0	13.466	< 0.001* ^{Wt}
	F	1221.4	46.902	-	-
	p	< 0.001* ^{RMA}	< 0.001* ^{RMA}	-	-
Body Mass Index (Kg/m²)	Baseline	16.81 ± 2.75	15.8 ± 2.02	3.1959	< 0.001* ^{Wt}
	2 month	17.19 ± 2.73	15.22 ± 1.47	6.3213	< 0.001* ^{Wt}
	6 month	17.8 ± 2.78	14.77 ± 1.64	9.0094	< 0.001* ^{Wt}
	F	566.87	1.5942	-	-
	p	< 0.001* ^{RMA}	0.21 ^{RMA}	-	-

Wt: Welch's t-test; RMA: One way repeated measures of ANOVA

Table 2: Post hoc analysis for weights over different time points for both groups

	Successful outcome			Unsuccessful outcome		
	Baseline	2 month	6 month	Baseline	2 month	6 month
Baseline	-	< 0.001*	< 0.001*	-	< 0.001*	< 0.001*
2 month	< 0.001*	-	< 0.001*	< 0.001*	-	< 0.001*
6 month	< 0.001*	< 0.001*	-	< 0.001*	< 0.001*	-

* Post hoc analysis for one-way repeated measures of ANOVA test, * Pair wise t test is used for post hoc analysis

Table 3: Post-hoc analysis for BMI over different time points for successful group

	Successful outcome		
	Baseline	2 month	6 month
Baseline	-	< 0.001*	< 0.001*
2 month	< 0.001*	-	< 0.001*
6 month	< 0.001*	< 0.001*	-

* Post hoc analysis for one-way repeated measures of ANOVA test

* Pair wise t test is used for post hoc analysis.

Table 4: Factors associated with sociodemographic characteristics and weight (n=261)

Variable	Weight		χ^2	<i>p</i>	UOR (95% CI)	<i>p</i>	AOR (95%CI)
	Normal weight (%)	Underweight (%)					
Age (years)							
≤20	29 (11.11)	7 (2.68)	39.13		Reference		Reference
21-40	88 (33.71)	25 (9.57)		0.929	1.03 (0.56-1.90)	0.374	1.400 (0.667-2.938)
41-60	56 (21.47)	21 (8.04)		0.001	0.35 (0.24-0.52)	0.742	1.095 (0.638-1.879)
> 60	22 (8.44)	13 (4.98)		0.065	1.86 (0.96-3.59)	0.649	1.144 (0.641-2.041)
Gender							
Male	70 (26.81)	15 (5.77)	10.11		Reference		Reference
Female	116 (44.44)	60 (22.98)		0.001	1.91 (1.28-2.86)	0.001	1.094 (0.719-1.667)
Educational status							
Illiterate	20 (7.66)	40 (15.32)	10.15		Reference		
literate	133 (50.95)	68 (26.07)		0.2	0.66 (0.44-0.99)		

Continued...

Occupation							
Employed	80 (30.65)	24 (9.20)	4.2		Reference		
Unemployed	111 (42.52)	46 (17.63)		0.03	0.65 (0.43-0.98)		
Socio economic status							
I	25 (9.57)	11 (4.21)	27.81		Reference		Reference
II	24 (9.19)	12 (4.59)		0.9	0.98 (0.37-2.57)	0.107	0.513 (0.228- 1.154)
III	125 (47.89)	55 (21.07)		0.001	1.13 (0.49-2.57)	0.001	0.934 (0.530-1.647)
IV	5 (1.91)	4 (1.57)		0.7	1.17 (0.49-2.85)	0.988	0.994 (0.444-2.226)

Data shown are frequencies (n) of subjects and proportions (%). χ^2 : Pearson's chi-square. In the multivariable models, only variables with a significance level of $p < 0.05$ were included. AOR: adjusted odds ratio; CI: confidence interval

Table 5: Factors associated with clinical profile of patient and weight (n=261)

Variable	Weight		χ^2	p	UOR (95% CI)	p	AOR (95%CI)
	Normal weight (%)	Under weight (%)					
Overcrowding							
Yes	120 (45.97)	62 (23.75)	0.16		Reference		
No	36 (13.79)	43 (16.49)		0.68	0.9 (0.53-1.93)		
Cough							
No	70 (26.82)	15 (5.75)	0.006		Reference		
Yes	126 (48.28)	50 (19.16)		0.93	1.02 (0.68-1.51)		
Diabetes							
No	30 (11.50)	40 (15.33)	27.34		Reference		Reference
Yes	78 (29.89)	113 (43.30)		0.001	0.71 (0.48-1.07)	0.001	0.683 (0.087-5.380)

Continued...

Past history of tuberculosis							
No	150 (57.48)	48 (18.40)	1.75		Reference		
Yes	42 (16.10)	21 (8.02)		0.18	1.31 (0.88-1.96)		
Family support							
No	30 (11.50)	41(15.70)	32.67		Reference		Reference
Yes	160 (61.30)	30(11.50)		0.001	3.19 (2.13-4.77)	0.891	0.965 (0.580-1.605)
Supervision by family							
No	20 (7.66)	24 (9.19)	0.62		Reference		
Yes	173 (66.28)	44 (16.87)		0.43	0.85 (0.56-1.28)		
Support of supervisor							
No	50 (19.15)	35 (13.43)	24.33		Reference		Reference
Yes	145 (55.55)	31 (11.87)		0.001	2.9 (1.89-4.46)	0.001	0.896 (0.564-1.424)

Data shown are frequencies (n) of subjects and proportions (%). χ^2 : Pearson's chi-square. In the multivariable models, only variables with a significance level of $p < 0.05$ were included. AOR: adjusted odds ratio; CI: confidence interval

Discussion

In the present study, the majority of patients with newly diagnosed TB were youngsters and from middle age group, which happens to be the most significant and important phase in life. Majority of the study participants were male; similar to another study done in Mumbai [14]. These may include many people who work as the family's only income earner, which might lead to a loss of livelihood and further drive the family into bankruptcy and impoverishment. It is imperative that NTEP investigate the possibility of offering a reasonable allowance for lost jobs and employment days resulting from TB. In this study, we observed that, mean weight and BMI was significantly more in successful group at the completion of 2 months and completion of 6 months compared to unsuccessful group at every time point, similar to another study done in

Bangladesh [15]. The successful outcome group's mean body weight rose from baseline to the completion of the two months of intense therapy, indicating that the group's body weight gain over the two months of intensive medication was enabled by medication in that phase. Also effective monitoring of the TB patients by the TB health visitor and treatment supervisors might have played a significant role in this. Weight gain during tuberculosis treatment can predict treatment outcome especially after 2 months of intensive treatment [16]. Similarly, a study done in Bangladesh [15] showed higher mean body weights after 2 months and 6 months of medication. Whereas another study done in Mumbai [14] showed that there was no difference in weight at baseline in both the groups ($p > 0.05$) but at first month and 4th month participants

with positive result put on an estimated almost 1kg and 3kg in contrast to their weight at the beginning ($p < 0.001$).

Patients who had poor outcomes did not have increase in weight during the intensive medication phase, which emphasizes the significance of TB patients starting treatment with a balanced diet and gaining the appropriate amount of weight as the treatment goes on. In a study done in India [16,17], there was no discernible change in BMI throughout the course of therapy ($p > 0.05$). This might be because local TB health professionals did not provide enough health education regarding the significance of eating a nutritious diet and how it affects treatment outcomes. In our study, it was seen that mean weights differed significantly from each other in follow ups at baseline, completion of 2 months and completion of 6 months indicating the body weight kept increasing during the course of treatment ($p < 0.001$). Similarly, studies done in Puducherry [18,19] and India [20,21] showed increase in weight during the course of TB treatment. The successful outcome group in this study had an increase in mean body weight and BMI from baseline to the conclusion of the two-month treatment period, indicating that the two months of intense therapy contributed significantly to the successful outcome group's increase in body weight. In comparison to the first two months, the mean body weight also rose towards the completion of the six-month period. While those who had a significant decrease in weight and BMI during the treatment phase had more unsuccessful outcomes. Weight variations during TB therapy might be used to forecast treatment results. Due to the increased risk of failure or mortality, patients who lose weight

during TB treatment—especially in the first month—should be monitored more carefully. The NTEP may be further strengthened and evaluated by tracking the weight gain and analyzing the results of TB treatment and determining the reasons linked to the failure of TB treatment.

Recommendations

Nutritional assessment at treatment initiation and monthly once thereafter should be undertaken. Peripheral health care workers at primary and secondary levels should be trained for providing nutritional counselling. Nutritional support through involvement of non-governmental organisations, and subsidised ration through government ration depots should be provided to all TB patients. Food vouchers can be distributed to those taking treatment to get nutritious eatables from nearby stores.

Limitations

Factors such as medication adherence, nutritional intake, severity of disease, drug resistance, role of inflammation and hormones can be explored in future studies. Other weight measuring indices, such as mid upper arm circumference, waist and hip circumference, waist hip ratio could have been applied. Diet history using 24 hours recall method could have been done.

Conclusion

This study showed that changes in body weight and BMI during anti-TB treatment were strongly associated with treatment outcomes. Patients with successful treatment outcomes showed a significant and sustained increase in weight and BMI from baseline to the second and sixth months of treatment, whereas those with unsuccessful outcomes experienced a decline in both parameters. These

findings suggest that serial monitoring of weight and BMI can serve as simple, inexpensive and effective indicators of treatment response.

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