Research Article

Diets High in Energy, Protein, Zinc, Iron and Vitamin A and Their Effects on Body Weight in Patients with Tuberculosis

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Abstract | Patients with pulmonary tuberculosis (pTB) often suffer from malnutrition, hence this issue has to be taken into account while designing a treatment plan. Patients with pulmonary tuberculosis (pTB) seeking treatment at the TB Centre in Baghdada, Pakistan, were surveyed to determine their body weight before and after receiving dietary counseling. A total of 150 patients were enlisted for this prospective analytic case-control (case-cohort) double-blind, randomized feeding experiment, with each group receiving 15 participants on average. Nutritional counseling sessions were provided to patients in the nutrition therapy groups in order to urge them to follow one of nine pre-tailored diets designed to meet the nutrient needs of the group. They were also given food that contained the targeted nutrient(s). Control patients did not participate in these sessions and did not get food rations. Weight fluctuations were among the results of the study. Weight was recorded at baseline, 3 months PI, and 6 months PI. The average weight gain in the nutrient supplementation groups was 2.04 kg. Compared to the pTB patients in the 'combined dietary' and 'combined supplements' groups, the pTB patients in the 'caloric protein' group represented the highest mean weight increase, at 2.9 Kg, increasing from 53.46 to 54.71 Kg in 3-months PI and from 54.71 to 56.33 Kg in 6-months PI, respectively. Weight gains in the nutrition therapy group were statistically significant at both 3 and 6 months PI. Patients in the control group either maintained or lost weight, with an average loss of 3.29 kilograms (7.1 pounds). In conclusion, pTB patients benefited from organized nutrition counselling sessions and the supply of extra food packs, which led to an increase in weight and an improvement in their nutritional condition.

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1. Introduction

Patients infected with the pulmonary tuberculosis bacillus (pTB) are prone to malnutrition. Serum concentrations of essential vitamins and minerals often drop drastically, as do anthropometric indices, in individuals with pTB (Van Lettow *et al.*, 2003). In particular, pTB causes excessive weight loss, which in

turn causes a low body mass index (BMI), a low lean body mass, a shortage in micro- and macronutrients, a lack of appetite, a drop in food intake, a sluggish metabolism, and an increase in protein and energy needs. A review of the literature (Macallan, 1999). Patients with pTB have been shown to have decreased levels of serum albumin, hemoglobin, skin fold thicknesses, fat percentage, plasma zinc, and plasma retinol compared to a healthy control group (Irfan *et al.*, 2011).

Low weight and BMI have been linked to higher incidences of tuberculosis (TB), pulmonary infection, and death in previous research (Lonnroth *et al.*, 2010). An accelerated rate of protein catabolism causes malabsorption, nitrogen loss, muscle atrophy, diarrhea, electrolyte losses, depletion of fluid and nutritional reserves, and perhaps mortality (Wellness, 2007).

Patients with pTB often seem listless, feeble, and weak due to their poor nutritional status and underweight circumstances, and they also exhibit less interest in daily life and physical exercise (Paton *et al.*, 2004). Because cell-mediated immunity is the first line of defense against tuberculosis infection, a low body mass index and certain micro- and macronutrient deficits weaken its capabilities (Cegielski and Mc-Marray, 2004). Patients with pTB are more slower to recover because their immune systems are suppressed by the poor nutrition and reduced food intake they experience during tuberculosis infection (Chandra *et al.*, 2004). Counseling patients on proper nutrition is an efficient method of altering their eating routines. Our goal in conducting this research was to quantify and compare the favorable effects of dietary counseling on the weight status of pTB patients. The study is anticipated to provide useful data on the nutritional condition of pTB patients, especially in regards to weight maintenance and recovery from infection. Researchers will benefit from a deeper understanding of pTB so that they may create more impactful work and interact more effectively with policymakers, practitioners, and intermediaries (Darnton-Hill *et al.*, 2022). It has been estimated that as many as 1.7 billion individuals, or one-fourth of the global population, are carrying pTB in its latent form. With such a large number, pTB has risen to become the tenth biggest killer globally. When it comes to the incidence of pTB, WHO ranks Pakistan as fifth worldwide in 2021. In Pakistan, there were around 570,000 incidents in 2019. In addition, 328,312 notified patients who started treatment for pTB were documented. There were as many as 241,688 instances of pTB that went undiagnosed. There has never been a more urgent time for health research to inform policy. There is an equally pressing need to investigate the underlying processes. Studies of this nature will aid in better policy making for pTB prevention and eradication, which is especially important as health policy making in Pakistan has just begun, especially after the decentralization and devolution of power to provinces in 2010.

2. Materials and Methods

As part of the first author's doctoral dissertation entitled "Effect of diet high in energy, protein, iron, zinc and vitamin a on body weight and nutritional status in patients with tuberculosis" included this research. In order to evaluate the impact of various diets and nutritional supplements on the nutritional and health status of pTB patients, this research was carried out.

2.1 Location of the study

The city of Mardan in Khyber Pakhtunkhwa Province, Pakistan, was the site of the research. There are 12 TB treatment and control units in the Mardan district. Patients are routinely checked first at several health centers in the Mardan area. Baghdada, Mardan's TB facility is where they should go for further examination and treatment.

2.2 Study design and timeline

This research's approach to study protocols was a prospective analytic case-control (case-cohort) feeding experiment with double-blind randomization. After that, we went back to square one for a week. During this week of eating normally, we were able to collect all of the baseline data needed for the intervention. The six-month intervention followed the baseline period. During the direction meeting, concentrate on necessities were investigated and members were acquainted with concentrate on methodology. The usual diet was evaluated, energy requirements were estimated, and anthropometric and biochemical measurements were taken during the baseline and pre-intervention period. When the mediation time frame began, the convention was rehashed following 3-months and following a half year. Task to the dietary intercession was arbitrary.

2.3 Recruitment of pTB patients and their screening for eligibility

Using the resources of a locally based, government-recognized organization called Nutrition Education, Awareness, and Training (NEAT), we recruited participants by posting fliers at local clinics and corresponding with them directly. NEAT is active in the field of nutrition education, and it has finished numerous nutrition projects with great success (Alam *et al.*, 2019; Almajwal *et al.*, 2020; Abid *et al.*, 2022). A sample of all successive recently determined pneumonic tuberculosis patients to have no less than 2 months of the antituberculosis treatment staying on the speculative date of beginning of wholesome supplementation, were drawn nearer and were evaluated for qualification till the example size was accomplished. Once they passed the first round of screening, males (n= 150) aged 20-50 were included in the 6-month intervention experiment (Figure 1).

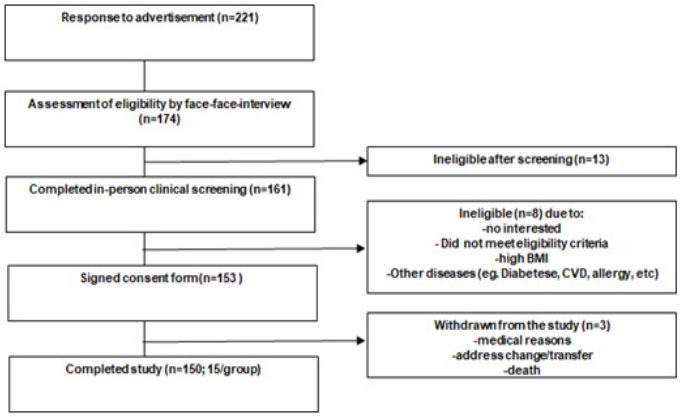

Figure 1: Patients who participated in the trial, provided informed consent, and underwent screening are shown in the CONSORT diagram. ITT (Intent-to-treat, from the Consolidated Standards of Reporting Trials, or CONSORT).

2.4 Study population and sample size

The sample size was calculated with the help of EPI-data adaption 6.04, with a population of 400 people in mind (all of whom were 'newly diagnosed' at the TB Center in Baghdada). A sample size of 92 was determined, with a target accuracy (worst acceptable) of 95% and a confidence level of 5%, based on an anticipated prevalence of previous consultation with other healthcare practitioners of 80%.

2.5 Study groups

Ten distinct patient groups were generated by the randomization process (Figure 2). One group served as a control, while the remaining nine received various food and nutritional supplement treatments. Patients were all similar in age, gender, marital status, education level, and occupation. Patients were randomly assigned to one of the four groups stated above to ensure that all groups had the same demographic make-up as defined by the inclusion/exclusion criteria. The 15 patients were split evenly between the two groups. Distribution of the groupings is shown in Figure 1.

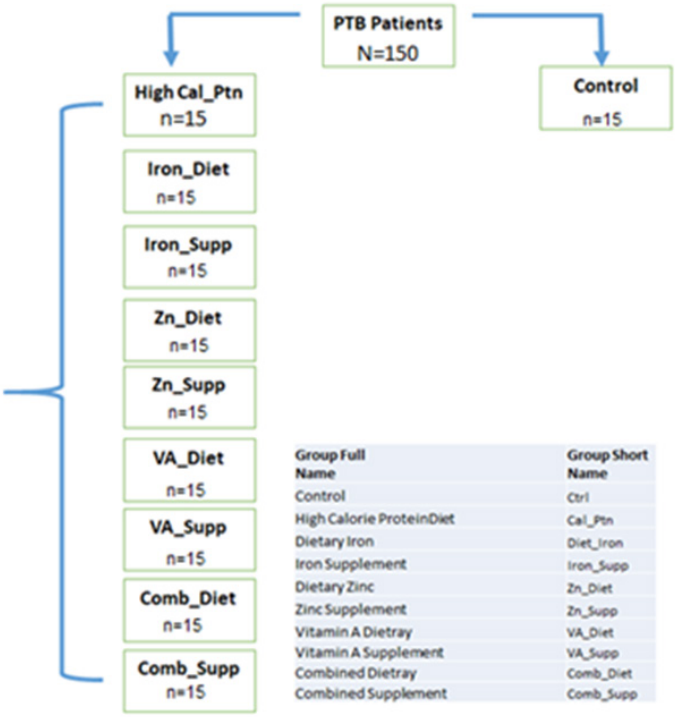

Figure 2: Schematic representation of patient classification.

2.6 Intervention protocol

The intervention was charitable food baskets and dietary counseling delivered by a local group to the patients.

2.7 Counseling session

Patients were educated on the link between good diet and speedier healing throughout these sessions of nutritional therapy. The following is a list of the topics discussed at these meetings: (1) nourishment and diet; (2) nutritional medicine; (3) TB-related weight loss; (4) Maintaining a healthy weight via food and exercise; (5) Concerns about the nutritional quality of food; (6) nutritional and food safety concerns; (7) Gaining or losing weight; (8) weight significance.

Bathroom scales were also given out to patients as a means of encouraging them to bulk up. They were instructed to keep a weight log at least three times each week. They were also given a weight-

tracking hand journal. Each patient also received a handbook written in the regional tongue (Pashto). (Supplementary File 1).

2.8 Food parcels

Patients in the nutritional therapy group were given food packages for two reasons: (1) to serve as an incentive, so maintaining the participants interest and participation in the research; (2) to encourage patients to stick to their diets by providing them with these specialized food boxes designed to boost their intake of specific nutrients. Composition information of these formulations is provided in Supplementary File 2.

2.9 Outcome measures

The primary outcome of the study was body weight, which was measured on a monthly basis and repeatedly measured in kilograms (kg) from the beginning of treatment (baseline). Information on real weight and change in weight at three time focuses, i.e., at pattern, 90 days post-mediation and a half year PI. For this review, information from the benchmark till month 6 were utilized for investigation. The baseline weight is the weight that was recorded at the start of therapy or before. The monthly weight was determined by a measurement taken in the last week of the treatment month or, if that was not possible, the first week of the following month.

2.10 Statistical analysis

Double data entry was used to enter the data into a database using Microsoft Excel. For statistical analysis, the data were transferred to Statistica 11.0 for Windows (Stata Corp, College Station, TX, USA). The Shapiro-Wilk test was used to verify that the data were normal. For use in subsequent analysis, the non-normal data were transformed into log or cube root. Before being used in parametric tests, the normality of the transformed data was verified. The Leading Body of Study, Branch of Human nourishment, Horticulture College Peshawar supported the exploration proposition and gave the moral endorsement to the review. Additionally, the study received ethical approval from NEAT's IRB. Additionally, administrative authorization was obtained from the Mardan-based Baghdada TB Center. Before collecting the data, written informed consent was obtained from the patients. Further, the review convention was enrolled (umin.ac.jp: The study protocol (number UMIN000049569) can be accessed online.

3. Results and Discussion

3.1 The baseline properties

Table 1 shows some of the patients' baseline characteristics. We include the baseline characteristics of patients in both the control and intervention groups together since there was no statistically significant difference between them at baseline (p, for all trends>0.05). The average age of the participants was just 36.9 (12.8) years old, indicating that they were quite young. The mean (SD) initial patient weight was 53.28 (9.8 Kg). Patients were often underweight, with a mean body mass index of 18.13 (SD: 3.2) Kg/m^2. Baseline biochemical and nutritional data indicate that patients nutritional status was subpar.

Table 1: Baseline characteristics of patients.

Parameters	Mean (SD)	Maximum	Minimum
Continuous variables			
Age (years)	36.9 (12.8)	24	40
Weight (Kgs)	53.28 (9.8)	45.9	55.8
BMI (Kg/m2)	18.13(3.2)	17.4	18.2
MUAC (cm)	23.16(5.3)	18.6	24.9
TSF (mm)	7.03 (3.1)	6.5	7.4
Nutritional intake			
Energy intake (Kcal)	1578(322.6)	1456	1644
Protein (g)	50.74 (23.9)	43.2	54.7
Fats (g)	76.2 (23.9)	67.4	79
Iron (mg)	7.99 (3.8)	5.9	9.1
Zinc (mg)	10.9 (2.8)	7.2	12.9
Vitamin A (IU)	806.4 (223.9)	765	865
Biochemistry			
Serum Albumin	3.18 (1.8)	3	3.2
Hemoglobin	11.7 (2.7)	10.1	11.9
SerumZinc	61.6 (21.9)	51.8	62.9
Serum Retinol	26.6 (2.9)	23.2	27.4
Categorical variables			
Parameters		N (%)	
Highest academic qualification			
-Illiterate		60 (40.0)	
-matric		52 (34.7)	
-12 grades (FA/FSc)		18 (12.0)	
-Bachelor and above		20 (13.3)	
Marital status			
-Married		108 (72.0)	
-Unmarried		42 (28.0)	

3.2 Effect of the intervention

Patients with pTB had their health and nutritional condition evaluated after being exposed to various diets and nutritional supplements. One hundred and fifty (150) patients with pTB were randomly assigned to one of ten groups: one control group and nine nutritional/supplement intervention (therapy) groups. High caloric protein, iron diet, iron supplements, zinc diet, zinc supplements, vitamin A diet, vitamin A supplements, combination diet, and combined supplements made comprised the nine nutritional/supplement (treatment) groups. There were 15 pTB patients in each of the two groups. Patients in the nutritional therapy groups were counseled on how to make adjustments to their diets that would result in at least a 25% increase in nutrient intake, whether via new meals or supplements taken in addition to their regular prescriptions. The 'control' group patients did not get any dietary advice or recommendations. However, as per the predetermined daily pattern, they may eat anything they wanted. Anthropometrics, a 24-hour food recall, and biochemical analyses were used to evaluate the nutritional health of pTB patients.

3.3 Weight

The major variable of interest in this analysis was body weight. Therefore, patients' weight was tracked at regular monthly intervals during the study's 6-month duration. We offer information on starting weight, average weight change, and average weight at 3 and 6 months PI.

The average weight of pTB patients in the 'control' group and the 9 nutrition intervention groups at baseline, 3 months PI, and 6 months PI are shown in Figure 3. Compared to the pTB patients in the 'combined dietary' and 'combined supplements' groups, the pTB patients in the 'caloric protein' group represented the highest mean weight increase, at 2.9 Kg, increasing from 53.46 to 54.71 and from 54.71 to 56.33 Kg in 3 months PI and 6 months PI, respectively. The average patient weight in the "combined dietary" group rose from 53.21 to 54.38 kilograms at three months PI and from 54.38 to 55.92 kilograms at six months PI, while the average patient weight in the "combined supplement" group rose from 53.13 to 54.29 kilograms at three months PI and from 54.29 to 55.79 kilograms at six months PI.

A spider graph displaying the mean weight at baseline (blue), the PI at three months, and the PI at six months. Groups names shortened as: cal-ptn= caloric protein; Ctrl=control; iron_diet= iron dietary; Iron_Supp = Iron Supplement; Zn_Supp= Zinc Supplement; Zn_Diet= Zinc Dietary; VA_Diet= Vitamin A dietar; Comb_Diet=Combined dietray; VA_Supp = Vitamin A Supplement; Comb_Suppl = Combined Supplementary. PI=PI

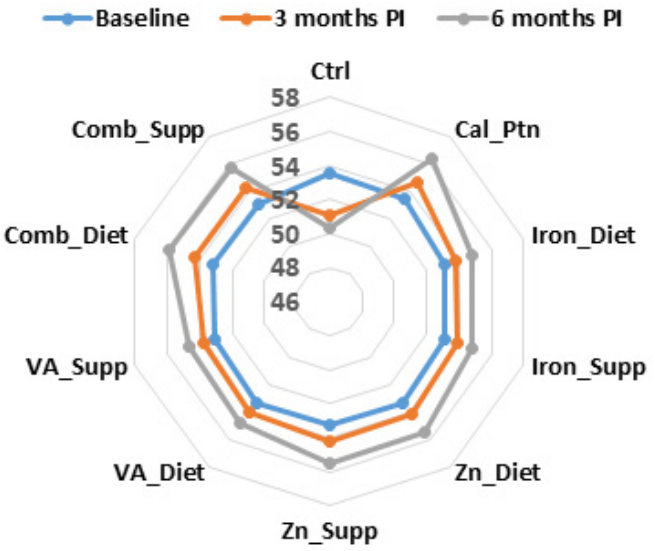

Figure 3: Average patient weight among the 9 nutrition intervention groups and the control group.

Similar increases in mean weight were seen between the 'zinc supplement' and 'zinc dietary' groups, with the former seeing a gain of 2.17 Kg (from 53.29 Kg to 54.17 Kg) and the latter seeing an increase from 54.21 Kg (from 53.38 Kg to 54.21 Kg) and a gain of 2.16 Kg (from 53.38 Kg to 55.54 Kg) at 3 months PI and 6 months PI, respectively. The mean weight of patients in the 'control' group declined from 53.58 Kg to 51.08 Kg after 3 months PI and from 51.08 Kg to 50.29 Kg after 6 months PI, with a final mean weight of 51.65±1.71 Kg.

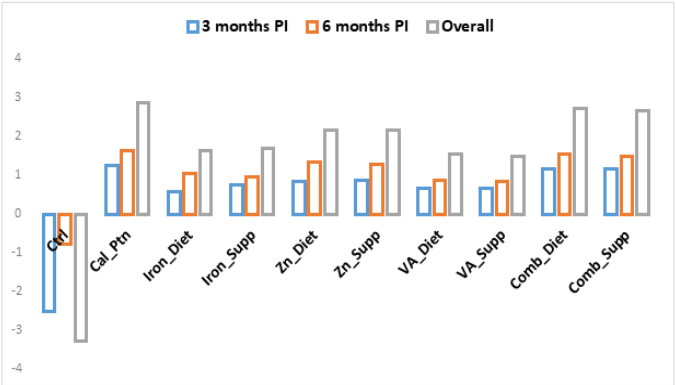

Figure 4: Progress images showing weight changes at 3, 6, and 12 months PI.

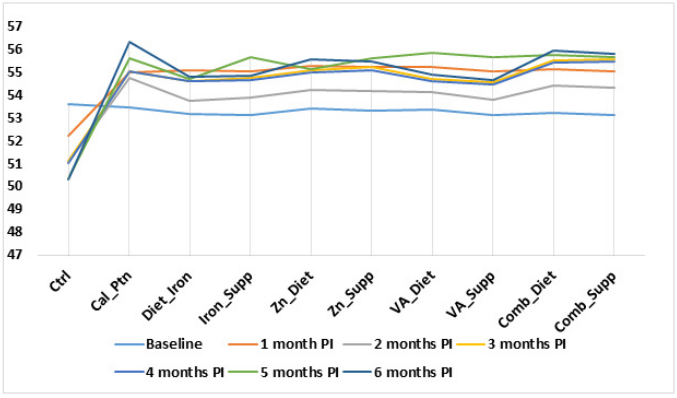

Figure 5: Monthly PTB patients' weight gain or loss.

Figures 4 and 5 show the variations in mean weight that resulted from the intervention. The average weight loss for the 'control' group was 3. 3 kg, which was statistically significant (p=0.00). However, recommending 25% higher caloric protein, iron, zinc, and vitamin-A diets and supplements along with their recommended dietary allowance (RDA) led to a 2.04 Kg increase in the mean weight of nutritional treatment groups of tuberculosis patients in 6 months (p=0.00). After 6 months of PI, PTB patients in the iron supplement, iron dietary, vitamin-A dietary, and vitamin-A supplement groups gained 1.7, 1.62, 1.55, and 1.5 Kg, respectively.

Weight changes at 3 months PI were determined by subtracting the patient's current weight from their initial starting weight; weight changes at 6 months PI were determined by subtracting the patient's current weight from their starting weight at 3 months PI. Difference between initial and 6-month PI weights was used to determine total weight changes PI=PI

The percentage monthly weight change is shown. PTB patients in the 'control' group lost weight, whereas those in the intervention groups gained weight over time. There was a more rapid rise in weight in the first PI month, a peak at the third PI month, and then a gradual increase from the third to the sixth PI month. Nutritional intervention led to a statistically significant rise across all treatment groups. cal-ptn= caloric protein; Ctrl= control; iron_supplement= iron supplement; iron_diet= iron diet; zn_diet= zinc diet; va_diet= vitamin a diet; zn_supplement= zinc supplement; comb_diet= combined dietray; va_supplement= vitamin a supplement; comb_suppl= combined supplement. PI=PI

Patients with pTB need specialized dietary therapy to protect their nutritional status and, more specifically, their body weight from the debilitating consequences of the illness (Akkerman *et al.*, 2020). The primary objectives of the current research were (1) to determine the initial body mass index (BMI) of patients with pulmonary tuberculosis and (2) to examine the impact of various dietary modification techniques introduced via nutritional counselling on the body mass index of patients with pulmonary tuberculosis. Over the course of 6 months, individuals with pTB received an intervention in the form of organized dietary counselling sessions. Sessions were led by registered dietitians and held in the facility where patients were receiving medical care. The goal of these meetings was to inspire pTB patients to alter their everyday diets in order to ingest greater quantities of a certain nutrient. Nine diet plans were created for this specific reason. Dietary patterns of pTB patients were not drastically altered by these menus; rather, those in the nutrition intervention groups were urged to eat more of certain foods and/or take in more nutrients overall without drastically altering their existing diets. Patients with pTB were kept in constant communication with one another through mobile phones, in-person interactions, and family monitoring to ensure they were following the suggested diet. All pTB patients started off with a lower body weight. All patients were underweight, as measured by a body mass index (BMI) of less than 18.5 Kg/m2.

In contrast to patients in the control group, those in the intervention group gained a substantial amount of weight. Responses to intervention in the form of weight gain varied not only across the nutrition intervention groups but also between the three- and six-months PI. Patients with pTB in the "caloric protein" group gained the most weight (2.9 Kg), followed by those in the "combined diet" group, "combined supplements" group, "zinc supplement" group, "iron supplement" group, "iron dietary," "vitamin A supplement" group, and "vitamin A dietary" group (mean weight gain, respectively, 2.71, 2.66, 2.17, 2.16, 1.7, 1.62, 1.55, and 1.5 Kg).

Nutritional counseling has been shown to improve nutritional outcomes in several research trials by leading to dietary changes. A high-energy-protein diet (Chandr *et al.*, 2004), micronutrient supplements (Guo and Xu, 2011), and arginine supplementation (Martineau *et al.*, 2011) were all used as interventions.

It might be instructive to draw attention to certain tips for improving one's nutrition in this unusual Asian context: (1) low-sodium, low-saturated-fat, and micronutrient-rich whole foods; (2) frequent, short meals; and (3) fresh, locally-grown fruits, vegetables, and snacks. Patients with pTB may benefit from a culturally adapted diet counseling program that may be indicative of the local cuisine (WHO, 2013). When enrolled in care, pTB patients need access to an evaluation system. When patients first start taking their medications, they may have unpleasant side effects including nausea, vomiting, and weight loss, making it difficult to maintain meaningful interactions with loved ones who regularly visit them in the hospital. Patients with pTB, as well as their carers, might benefit from nutritional advice if they have access to funds for supplemental food purchases.

However, when comparing tuberculous and non-tuberculous persons, we may notice a substantial difference, which may be a lower value of serum albumin in infected individuals, despite the fact that the nutritional state of the investigated population seems to be normal. This shift can be related to how much fat the body has. The immune system's shift from TH1 to TH2 CD4 T-cell subsets, which is linked to cardiovascular health (Alam *et al.*, 2022), may be triggered by excess body fat, which in turn may destabilize a latent infection by Mycobacterium tuberculosis and make the individual susceptible to the disease's manifestation. Lower immunity profiles have been seen in the Pakistani population in general (Alam *et al.*, 2012, 2013, 2019; Almajwal *et al.*, 2020), which is closely related to the severity of TB illness and the rate of recovery.

The sample sizes used in each group were quite small, which is both a weakness and a strength of the research. Cultural norms discouraged women from taking part. Restrictive inclusion criteria employed to include a sample of patients from this border area that is not as typical of future nutritional treatments further limits the comparisons that can be drawn from this sample. Relapsed tuberculosis patients and those with concomitant diseases like diabetes mellitus were not included in this research since they may have been prescribed different dietary and treatment plans than those generally given to TB patients. Methodological constraints include a lack of serial meal recall surveys, potential errors in measurement and memory, and misalignment between local diet food descriptors and databases of food composition. The inclusion of more anthropometric measurements, especially those that are more sensitive in diagnosing malnutrition and take into consideration the degree of illness, may be useful in future studies. The gadgets featured have been developed after several regional health evaluations, with endorsement systems for various indigenous populations in mind.

Despite these caveats, this research is the first Pakistani attempt to compare the efficacy of different dietary patterns in pTB patients. The findings are encouraging, and they need further evaluation in future, larger studies.

Conclusions and Recommendations

The current research found that among the numerous diets examined for their efficiency, the 'caloric protein' diet had the greatest effect on weight growth in pTB patients, followed by the 'iron' diet, the 'vitamin-A enhance' diet and the 'zinc diet,'. The nutritional condition of pTB patients was shown to improve with advise on 9 various diets/supplements, and they may be prepared in 2-3 forms, making them more convenient.

During the course of anti-tuberculosis treatment, pTB patients should have their weight assessed and documented at least once or twice a month, and they should also be provided with nutritional assistance in the form of a dietary guidance.

Acknowledgements

We appreciatively recognize the organization at Baghdada TB focus Mardan and the Nourishment Schooling, Mindfulness and Preparing (Slick) at Charsadda, KPK.

Novelty Statement

This is the first study on TB patients of its type in Khyber Pakhtunkhwa which has highlighted the importance of BMI and body weight in the treatment outcomes of TB patients.

Author's Contribution

The study was designed by MAR and SK. AZ and ZD gathered the information and performed concentrate

on management. MAR and AZ looked at the data. AZ and ZI added to drafting the original copy.

Supplementary material

There is supplementary material associated with this article. Access the material online at: https://dx.doi.org/10.17582/journal.jis/2023/9.2.208.216

Conflict of interest

The authors have declared no conflict of interest.

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