

The Effect of Drinking Four Glasses of Warm Water a Day and Walking 1,000 Meters on Lung Function in Patients with Tuberculosis and Diabetes Mellitus at Hospitals in Medan City

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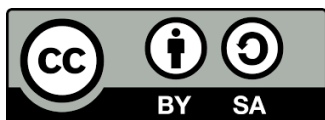
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Keywords:

Tuberculosis; Diabetes Mellitus; Warm Water; Walking; Lung Function FEV₁, FVC.

Abstract

The coexistence of tuberculosis (TB) and diabetes mellitus (DM) represents a comorbid condition in which the two diseases can adversely affect each other, potentially contributing to impaired lung function. Nonpharmacological interventions, such as drinking warm water and engaging in light physical activity, may help improve lung function in patients with TB and DM. This study aimed to determine the effects of drinking four glasses of warm water daily and walking 1,000 meters on lung function in patients with TB and DM. A pre-experimental study with a one-group pretest–posttest design was conducted involving 31 patients with TB and DM at a hospital in Medan City. The intervention consisted of drinking four glasses of warm water and walking 1,000 meters daily for two months. Lung function was assessed using spirometry to measure forced vital capacity (FVC), forced expiratory volume in one second (FEV₁), and the FEV₁/FVC ratio. Data were analyzed using a paired-samples t-test. The results showed significant increases in FVC from 72.32 ± 14.07 to 78.09 ± 13.13 ($\Delta = 5.77$, $p = 0.001$) and FEV₁ from 78.58 ± 12.85 to 84.03 ± 10.35 ($\Delta = 5.45$, $p = 0.001$). However, the FEV₁/FVC ratio increased only slightly, from 85.51 ± 12.10 to 85.97 ± 11.49 ($\Delta = 0.46$), with no statistically significant difference ($p = 0.74$). These findings suggest that drinking four glasses of warm water and walking 1,000 meters daily for two months were associated with significant improvements in FVC and FEV₁ among patients with TB and DM, although no significant change was observed in the FEV₁/FVC ratio.



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INTRODUCTION

(Belyaeva, 2022) Communicable diseases are among the leading causes of morbidity and mortality worldwide. These diseases are caused by infectious agents, including viruses, bacteria, and parasites (Anidi et al., 2023). According to the 2018 Indonesian Basic Health Research (Riset Kesehatan Dasar [Riskesdas]), the burden of communicable diseases in Indonesia remains relatively high, particularly tuberculosis, hepatitis, and diarrhea. One factor contributing to susceptibility to infectious diseases is impaired host immune function (Lee, 2021). Immune dysfunction may occur in individuals who smoke, people living with HIV/AIDS, and patients with diabetes mellitus (DM) (Ruslami et al., 2021; Hussain et al., 2024).

According to the International Diabetes Federation (2019), Indonesia ranked seventh globally in terms of the number of adults living with diabetes, with approximately 10.7 million cases, following China, India, the United States, Brazil, Mexico, and Pakistan (Byrne, 2022). Based on the 2018 Riskesdas survey, the prevalence of diabetes mellitus in Central Java Province increased between 2013 and 2018, with reported figures of 1.6% and 91.16%,

respectively. (Torres Herrera, M.T., Fabián-San-Miguel, G, 2019) Elevated blood glucose levels in patients with diabetes mellitus are considered an important factor contributing to susceptibility to *Mycobacterium tuberculosis* infection because hyperglycemia can impair both innate and adaptive immune responses (Lim, 2020). Under normal physiological conditions, an effective immune response helps control *M. tuberculosis* infection and limits disease progression. Following pathogen recognition, monocytes and macrophages are rapidly activated as part of the innate immune response. Macrophages and dendritic cells phagocytose the bacteria, while dendritic cells migrate to regional lymph nodes, where they present antigens to naïve T cells, thereby initiating an adaptive cellular immune response (Torres Herrera, M.T., Fabián-San-Miguel, G, 2019).

The association between tuberculosis (TB) and diabetes mellitus (DM) has long been recognized, as the coexistence of these conditions can increase the risk of adverse clinical outcomes and mortality. According to the World Health Organization (2018), tuberculosis was among the 10 leading causes of death worldwide (Maison, 2022; Marshall, 2021; Balakrishnan et al, 2023). In 2017, approximately 10 million people developed TB, and 1.6 million died from the disease. Meanwhile, the global burden of diabetes mellitus continues to increase. World Health Organization data (2016) indicate that diabetes was responsible for approximately 1.6 million deaths in 2016, highlighting its substantial contribution to global mortality and premature death.

Hydrotherapy, or water therapy, refers to the therapeutic use of water to support health and manage certain medical conditions. According to Daniels and Popkin (2010), water consumption may contribute to weight management, particularly when water replaces calorie-containing beverages. Adequate fluid intake is essential for maintaining hydration, supporting normal physiological functions, and facilitating renal excretion of metabolic waste products. Drinking sufficient water is an accessible and inexpensive health-promoting practice, although individual fluid requirements vary according to age, body weight, physical activity, environmental conditions, and health status. Hydrotherapy has historically involved both external and internal applications of water for therapeutic purposes. However, the effectiveness of drinking water as a treatment for specific diseases, including diabetes mellitus and tuberculosis, requires rigorous clinical evidence and should not be equated with established medical treatments.

(Romanovsky, 2019) In the present study, water therapy refers specifically to an internal hydration intervention involving the consumption of four glasses of warm drinking water every morning immediately after waking. Zeuthen (2010) discussed physiological mechanisms associated with water transport and osmotic regulation. Water plays an essential role in maintaining fluid balance, regulating body temperature, facilitating nutrient transport, and supporting metabolic processes (Orooj, 2019; (Kim H, 2020). Adequate hydration also contributes to normal kidney function and the excretion of metabolic waste products. However, drinking warm water does not directly eliminate excess blood glucose or independently normalize plasma glucose concentrations. Therefore, its potential benefits for patients with diabetes mellitus should be interpreted primarily in relation to hydration and physiological homeostasis rather than as a direct glucose-lowering treatment.

According to Lumbanraja (2006), drinking adequate amounts of water, engaging in regular physical activity, and controlling food portions are recommended lifestyle practices for individuals with type 2 diabetes mellitus. Adequate hydration supports kidney function and urinary excretion, while regular exercise and appropriate dietary management contribute to improved glycemic control. Nevertheless, the claim that warm water accelerates glucose elimination through perspiration and urination has not been conclusively established. Similarly, warm water should not be characterized as a direct source of energy because water contains no calories. Claims that drinking cold water damages the stomach, small intestine, gallbladder, or pancreas, or directly causes diabetes mellitus, are not supported by established medical evidence. Although traditional water-based therapies have been associated with the management of various conditions, including constipation, tuberculosis, diabetes mellitus, gout, hypertension, and cancer, there is insufficient scientific evidence to support claims that drinking warm water can cure these diseases within specific periods. Consequently, warm water consumption should be considered a supportive hydration practice rather than a substitute for appropriate pharmacological treatment and medical care.

In addition to maintaining adequate hydration, regular physical activity can improve glycemic control, enhance insulin sensitivity, reduce cardiovascular risk, and contribute to the prevention and management of obesity, dyslipidemia, hypertension, and other metabolic complications. Furthermore, weight loss of approximately 5–10%, combined with regular physical activity and dietary modification, may substantially reduce the risk of developing type 2 diabetes mellitus in individuals at increased risk. Experimental studies involving Zucker rats, an animal model exhibiting metabolic abnormalities associated with insulin resistance and type 2 diabetes, have demonstrated that treadmill exercise may attenuate insulin resistance, glucose intolerance, hyperlipidemia, and obesity. Walking interventions have also been investigated in individuals with type 1 and type 2 diabetes mellitus (Walker et al., 1999). Additionally, a study involving women with type 2 diabetes reported that a 12-week exercise program involving a 1,000-meter running distance was associated with significant reductions in fasting blood glucose, glycated hemoglobin (HbA1c), total cholesterol, and low-density lipoprotein (LDL) cholesterol levels. Beyond these metabolic benefits, regular aerobic exercise, including walking, may improve exercise tolerance, respiratory muscle performance, and overall functional capacity (Ilham M Santoso P, 2015). Such adaptations may contribute to improved pulmonary function in certain populations, although changes in forced vital capacity (FVC) and forced expiratory volume in one second (FEV₁) depend on the underlying respiratory condition, exercise intensity, and intervention duration.

Experimental research involving Zucker rats, which exhibit metabolic characteristics resembling those of type 2 diabetes mellitus, has further demonstrated the potential benefits of treadmill exercise in preventing or attenuating insulin resistance, glucose intolerance, hyperlipidemia, and obesity (Stuck, 2019; Huang et al, 2021). Similar investigations have examined the effects of structured walking programs in individuals with type 1 and type 2 diabetes mellitus, emphasizing the role of physical activity in metabolic regulation and diabetes management (Dobler, 2021; Miller, 2019).

Furthermore, a study involving women with type 2 diabetes mellitus reported that participation in a 12-week exercise program involving a 1,000-meter running distance

significantly reduced fasting blood glucose, HbA1c, total cholesterol, and LDL cholesterol levels. These findings suggest that structured physical activity may improve glycemic control and cardiovascular risk profiles in individuals with diabetes mellitus. However, the extent to which walking interventions improve pulmonary function in patients with concurrent tuberculosis and diabetes mellitus remains uncertain and warrants further investigation (Chan, 2023).

METHOD

Type of Study

This study employed a pre-experimental, one-group pretest–posttest design to assess the effects of drinking four glasses of warm water daily and walking 1,000 meters per day on pulmonary function in patients with pulmonary tuberculosis and diabetes mellitus (TB-DM). Pulmonary function was measured before and after the intervention to evaluate changes in respiratory parameters. No control group was included in the study.

The study design is illustrated as follows:

Table 1. Type of Research

O1	X	O2
<i>Pre-test</i>	<i>Experiment</i>	<i>Post-test</i>

Where:

1. O₁ = Pretest observation (initial pulmonary function test)
2. X = Intervention (drinking warm water and walking 1,000 meters daily)
3. O₂ = Posttest observation (final pulmonary function test)

In this design, there is no comparison (control) group; however, two observations are conducted: the first (pretest) and the second (posttest), which allow the researcher to assess the benefits occurring after the intervention. The intervention consists of providing warm water (38–40°C) at a quantity of 4 glasses per day and walking 1,000 meters.

RESULTS AND DISCUSSION

Description of Research Subjects

In this study, 31 participants met the criteria to be included as research subjects. The table below presents a descriptive overview of the study participants.

Table 2. Characteristic of Research Subjects

Characteristics	Number (n=31)
Age Mean ± SD / Median (IQR)	52.81 ± 12.84 / 55 (19)
Gender (Male), n %	19 people, 61.29%
Gender (Female), n %	11 people, 38.70%
FVC_pre ± SD % / Median (IQR)	72.32 ± 14.07 / 67 (29)
FEV1_pre ± SD % / Median (IQR)	78.58 ± 12.85 / 78 (18)
FEV1/FVC1_pre ± SD % / Median (IQR)	85.51 ± 12.10 / 85.92 (22)

In this study, among the 31 collected samples, the average age of the study participants was 52.81 years with a median of 55. The mean Forced Vital Capacity (FVC) was 72.32 with a median of 67, the mean Forced Expiratory Volume in one second (FEV1) was 78.58 with a median of 78, and the mean FEV1/FVC ratio was 85.51 with a median of 85.92.

Analysis of Research Results

Based on the analysis of the research results, after the intervention of drinking 4 glasses of warm water daily for 2 months, the data were analyzed using a paired *t*-test. The analysis of the intervention's effect can be observed in Tables 4, 5, 6.

Table 3. The Effect of Intervention on FVC Value

Parameter	FVC pre	FVC post	Δ FVC	p value*
Mean $\pm$ SD (percentage)	72.32 $\pm$ 14.07	78.09 $\pm$ 13.13	5.77%	0.001

*Paired T-test

In this study, the average FVC increased by 5.77% after the intervention of drinking four glasses of warm water daily for two months. The analysis showed a *p*-value of <0.05 , indicating statistical significance.

Table 4. The Effect of Intervention on FEV1 Value

Parameter	FEV1 pre	FEV1 post	Δ FEV1	p value*
Mean $\pm$ SD (percentage)	78.58 $\pm$ 12.85	84.03 $\pm$ 10.35	5.45%	0.001

*Paired T-test

In this study, the average FEV1 increased by 5.45% after the intervention of drinking four glasses of warm water daily for two months. The analysis showed a *p*-value of <0.05 , indicating statistical significance.

Table 5. The Effect of Intervention on FEV1/FVC Values

Parameter	FEV1/FVC pre	FEV1/FVC post	Δ FEV1/FVC	p value*
Mean $\pm$ SD (percentage)	85.51 $\pm$ 12.10	85.97 $\pm$ 11.49	0.46%	0.74

*Paired T-test

In this study, the average FEV1/FVC increased by 0.46% after the intervention of drinking four glasses of warm water daily for two months. The analysis showed a *p*-value >0.05 , indicating that the change in FEV1/FVC was not statistically significant.

Table 6. FEV1 Classification after Intervention

Pre Intervention	n (%)	Post: Normal n = 22 (70.96%)	Post: Mild n = 9 (29.03%)	Post: Moderate n = 0	Post: Severe n = 0	p value*
Normal	13 (41.93%)	100%	—	—	—	
Mild	17 (54.83%)	52.94%	47.05%	—	—	0.002
Moderate	1 (3.22%)	—	100%	—	—	

Pre Intervention	n (%)	Post: Normal n = 22 (70.96%)	Post: Mild n = 9 (29.03%)	Post: Moderate n = 0	Post: Severe n = 0	p value*
Severe	0	–	–	–	–	

*Friedman test

In this study, 41.93% of the study population (n = 13) had normal FEV1 values both before and after the intervention. Additionally, 29.03% (n = 9) showed an improvement from mild impairment to normal, 25.8% (n = 8) remained in the mild category before and after the intervention, and 3.22% (n = 1) improved from moderate to mild. Analysis using the Friedman test yielded a *p*-value <0.05, indicating statistical significance.

Table 7. FVC Classification after Intervention

Pre Intervention	n (%)	Post: Normal n = 13 (41.93%)	Post: Mild n = 7 (22.5%)	Post: Moderate n = 10 (32.25%)	Post: Moderate-severe n = 1 (3.22%)	Post: Severe n = 0	p value*
Normal	9 (29.03%)	100%	–	–	–	–	
Mild	6 (19.35%)	66.66%	33.33%	–	–	–	
Moderate	10 (32.34%)	–	50%	50%	–	–	0.001
Moderate-severe	5 (16.12%)	–	–	100%	–	–	
Severe	1 (3.22%)	–	–	–	100%	–	

In this study, 29.03% of the study population (n = 9) had normal FVC values both before and after the intervention. Additionally, 12.9% (n = 4) improved from mild impairment to normal, 6.45% (n = 2) remained in the mild category, 16.12% (n = 5) improved from moderate to mild, another 16.12% (n = 5) remained in the moderate category, 16.12% (n = 5) improved from moderate-severe to moderate, and 3.22% (n = 1) improved from severe to moderate-severe. The Friedman test analysis yielded a *p*-value <0.05, indicating statistical significance.

Table 8. FEV1/FVC Classification After Intervention

Pre Intervention	n (%)	Post: Non-obstruction n = 29 (93.5%)	Post: Obstruction n = 2 (6.45%)	p value*
Non-obstruction	28 (90.32%)	100%	–	
Obstruction	3 (9.67%)	33.33%	66.66%	1.000

*Mc Nemar test

In this study, 90.32% of the study population (n = 28) had non-obstructive FEV1/FVC values both before and after the intervention. Additionally, 3.22% (n = 1) improved from obstructive to non-obstructive, and 6.45% (n = 2) remained in the obstructive category. The McNemar test analysis yielded a *p*-value >0.05, indicating that the change in FEV1/FVC was not statistically significant.

Analysis of Research Results Adjusted for Gender

After adjusting for gender, the following data were obtained (Table 8 and 9).

Table 9. After adjusting for gender, the following data were obtained

Parameter	Male Value	Male p-value	Female Value	Female p-value
Δ FVC (Mean $\pm$ SD)	5.52 $\pm$ 2.52	0.01	6.16 $\pm$ 4.64	0.01
Δ FEV1 (Mean $\pm$ SD)	5.84 $\pm$ 5.12	0.01	4.83 $\pm$ 3.73	0.01
Δ FEV1/FVC (Mean $\pm$ SD)	1.21 $\pm$ 9.02	0.56	-0.72 $\pm$ 4.94	0.62

After adjusting for gender, the analysis showed the following results. In male participants, the FVC increased by 5.52 after the intervention, with a p-value of <0.05 , indicating that the result was statistically significant. The FEV1 also increased by 5.84 with a p-value of <0.05 , which is likewise statistically significant. Although there was an increase in the FEV1/FVC ratio by 1.21, this change was not statistically significant, as the p-value was 0.56.

In female participants, FVC increased by 6.16 after the intervention, with a p-value of <0.05 , showing statistical significance. FEV1 also increased by 4.83 with a p-value of <0.05 , which is statistically significant. However, the FEV1/FVC ratio decreased by 0.72, and the p-value was 0.62, indicating that the decline was not statistically significant.

Based on the data analysis, it was found that both FVC and FEV1 improved significantly in the overall population and after adjustment by sex following the intervention of drinking four glasses of warm water per day for two months. These findings are consistent with a study by, which found that hydration improves maximal oxygen uptake (VO_2 max) and FEV1 after exercise. This may be due to the role of hydration in stabilizing the airways, where adequate hydration helps protect against airway damage.

Water is an essential component of the pulmonary system, where sufficient airway hydration is key to maintaining proper lung function. On average, around 700 ml of water is lost from the lungs every day. In dehydration, at the airway surface level (ASL), epithelial injury and impaired mucociliary clearance may occur. Dehydration can also impair thermoregulation, cardiovascular function, and cerebrovascular function. Water passes through the bronchial epithelium based on osmotic concentration. Under dehydrated conditions, bronchial blood flow and its composition change, potentially impairing airway hydration. In such states, the airway surface may undergo changes in surface tension, composition, and/or rheology, which can lead to airway instability. Dehydration causes airways to close more rapidly compared to a well-hydrated body.

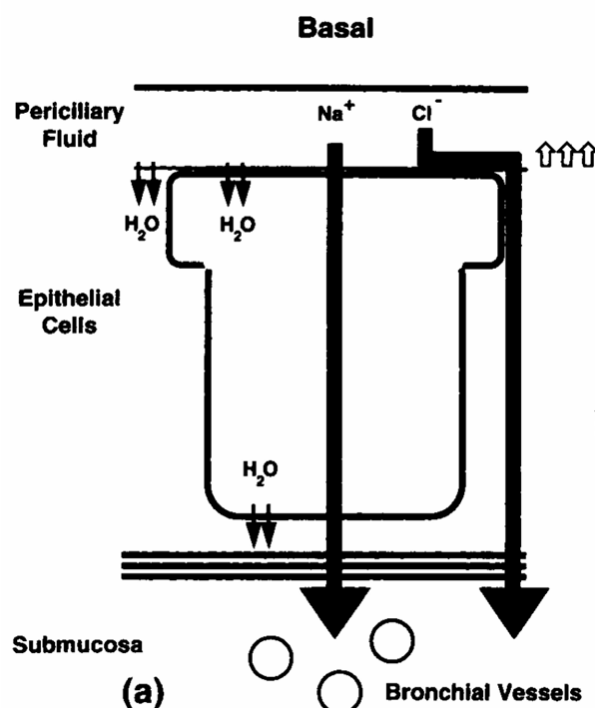


Figure 1. Mechanism of Ion Transport and Its Effects on Epithelium and Water Movement under Basal Conditions.

Hydration of the ASL is largely influenced by ion channels. These ion channels also play a role in maintaining water and salt balance on the airway surface. The airway epithelium is highly permeable to water and can both absorb and secrete fluid. Through modulation of apical ion channels, optimal ASL hydration can be maintained. One example of how this ion channel regulation works is when the epithelium detects high salt levels in the ASL—it will automatically allow water to enter to maintain isotonic conditions. In addition, chloride ion channels mediated by the cystic fibrosis transmembrane conductance regulator (CFTR) also play a role in fluid secretion into the airway. CFTR regulates both sodium and chloride ion absorption and secretion. A decrease in chloride ion secretion will lead to increased sodium ion absorption.

When the body is well-hydrated, body temperature and blood volume remain controlled. Proper thermoregulation will help maintain an individual's VO_2 max, and adequate blood volume supports efficient oxygen utilization and delivery. Maintaining adequate hydration status also helps regulate heart rate and cardiac output, which in turn support optimal VO_2 max.

From the data analysis, it was found that FEV_1/FVC improved after the intervention of drinking 4 glasses of warm water per day for 2 months, although this result was not statistically significant. This may be due to the relatively equal improvements in FEV_1 and FVC in this study. Overall, the increase in FEV_1 was 5.45 and in FVC was 5.77, indicating that the difference between the two was not large enough to yield statistical significance.

After adjusting for male gender, it was found that FEV_1/FVC increased after the intervention, though the increase was not statistically significant ($p = 0.566$). This can also be

attributed to the proportional improvements in both FEV₁ and FVC. The overall increase in FEV₁ was 5.84 and in FVC was 5.52. The lack of significant difference may also be explained by the tendency for android (central) obesity to be more common in males, whereas females tend to exhibit gynecoid (peripheral) obesity. It has been reported that a larger waist circumference is associated with lower FVC, which would lead to a higher FEV₁/FVC ratio.

After adjusting for female gender, FEV₁/FVC was found to decrease following the intervention, though again the reduction was not statistically significant ($p = 0.621$). In this study, the improvement in FVC (6.16) was greater than the improvement in FEV₁ (4.83). These results are consistent with a study by, which found that total body water (TBW) is negatively correlated with FEV₁/FVC. This can be explained by the more substantial improvement in FVC compared to FEV₁. Another study reported that FEV₁ has a positive correlation with TBW ($r = 0.456$) and FVC ($r = 0.537$).

In addition to the intervention of drinking 4 glasses of warm water, subjects were also instructed to walk 1000 meters. A study that examined the effects of exercise on lung function by⁵¹ found significant increases in both FVC and FEV₁ ($p < 0.05$) in the intervention group who walked on a treadmill. Conversely, while FEV₁/FVC did improve in the intervention group, the change was not statistically significant ($p > 0.05$). These findings are consistent with our study, where FVC and FEV₁ improved significantly across the population. Overall, the increase in FEV₁ was 5.45 and in FVC was 5.77 ($p < 0.05$). However, the improvement in FEV₁/FVC was only 0.46 and was not statistically significant ($p = 0.74$).

Improvement in lung function may be attributed to exercise, which is an important part of pulmonary rehabilitation and one of the best modalities for improving muscle function in patients with lung disease. The exercise prescribed in this study was aerobic in nature, such as walking. Aerobic training improves the function of respiratory muscles, thereby affecting overall lung function. Aerobic exercise is central to pulmonary rehabilitation, as it enhances exercise tolerance, skeletal muscle function, and pulmonary functional capacity by strengthening the respiratory muscles.

Walking as a form of physiological exercise has also been associated with other health benefits. It is known to slow aging, reduce resting heart rate, improve postural stability, decrease fatigue perception, increase walking speed, reduce anxiety, and improve mental health. In this study, FEV₁ and FVC increased significantly, consistent with previous findings. Maximum ventilation volume also improved significantly in groups given moderate-to-high-intensity aerobic exercise.

In this study, a decrease in FEV₁/FVC was observed in females following the intervention. This may be explained by the fact that a smaller waist circumference is associated with higher FVC. A study found that after moderate-to-high-intensity aerobic training, waist circumference significantly decreased post-intervention. Additionally, the typical fat distribution pattern in females (hip-dominant) may contribute to a lower FEV₁/FVC ratio, even if both FEV₁ and FVC improved when considered separately.

CONCLUSION

Based on the findings of this study, drinking four glasses of warm water and walking 1,000 meters daily for two months were associated with significant improvements in forced

vital capacity (FVC) and forced expiratory volume in one second (FEV₁) among patients with pulmonary tuberculosis and diabetes mellitus (TB-DM) ($p < 0.05$). These improvements remained statistically significant after accounting for sex ($p < 0.05$). Although the FEV₁/FVC ratio increased following the intervention in the overall study population and among male participants, these changes were not statistically significant ($p > 0.05$). In contrast, female participants exhibited a decrease in the FEV₁/FVC ratio after the intervention; however, this reduction was also not statistically significant ($p > 0.05$). Overall, these findings suggest that the combined intervention may be associated with improvements in selected pulmonary function parameters in patients with TB-DM, although the absence of a control group limits causal interpretation.

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