Original Article
http://mjiri.iums.ac.ir

Medical Journal of the Islamic Republic of Iran (MJIRI)
Iran University of Medical Sciences

The effect of green tea extract supplementation on sputum smear conversion and weight changes in pulmonary TB patients: A randomized controlled trial

Mohammad Reza Honarvar[1], Shahryar Eghtesadi*[2], Pooria Gill[3], Shima Jazayeri[4]
Mohammad Ali Vakili[5], Mohammad Reza Shamsardekani[6], Abdollah Abbasi[7]

Received: 20 August 2015 Accepted: 21 February 2016 Published: 1 June 2016

Abstract

Background: Acceleration in sputum smear conversion helps faster improvement and decreased probability of the transfer of TB. In this study, we aimed to investigate the effect of green tea extract supplementation on sputum smear conversion and weight changes in smear positive pulmonary TB patients in Iran.

Methods: In this double blind clinical study, TB patients were divided into intervention, (n=43) receiving 500 mg green tea extract (GTE), and control groups (n=40) receiving placebo for two months, using balanced randomization. Random allocation and allocation concealment were observed. Height and weight were measured at the beginning, and two and six months post-treatment. Evaluations were performed on three slides, using the ZiehlNeelsen method. Independent and paired t test, McNemar's, Wilcoxon, Kaplan-Meier, Cox regression model and Log-Rank test were utilized. Statistical significance was set at $p<0.05$. This trial was registered under IRCT201212232602N11.

Results: The interventional changes and the interactive effect of intervention on weight were not significant ($p>0.05$). In terms of shortening the duration of conversion, the case to control proportion showed a significant difference ($p=0.032$). Based on the Cox regression model, the hazard ratio of the relative risk of delay in sputum smear conversion was 3.7 ($p=0.002$) in the higher microbial load group compared to the placebo group and 0.54 (95% CI: 0.31-0.94) in the intervention compared to the placebo group.

Conclusion: GTE decreases the risk of delay in sputum smear conversion, but has no effect on weight gain. Moreover, it may be used as an adjuvant therapy for faster rehabilitation for pulmonary TB patients.

Keywords: Body Weight, Dietary Supplements, Humans, Sputum, Tea, Tuberculosis, Pulmonary.

Cite this article as: Honarvar MR, Eghtesadi Sh, Gill P, Jazayeri Sh, Vakili MA, Shamsardekani MR, Abbasi A. The effect of green tea extract supplementation on sputum smear conversion and weight changes in pulmonary TB patients: A randomized controlled trial. *Med J Islam Repub Iran* 2016 (1 June). Vol. 30:381.

Introduction

The Golestan Province of Iran has a high rank of the incidence and prevalence of tuberculosis (1). The patients often suffer from weight loss and malnutrition, mainly due to the high level of oxidative stress because of the disease and decreased food intake. Numerous investigations have been conducted on the effect of nutrition or supplementation of the improvement course of TB (2–5). Supplementation with macro or micronutrients (like vitamin D or arginine) is effective during anti-bacterial therapy and results in the improvement of

[1]. PhD Candidate, Department of Nutrition, School of Public Health, Iran University of Medical Sciences, Tehran, Iran. honarvar@goums.ac.ir
[2]. (**Corresponding author**) Professor, Department of Nutrition, School of Public Health, Iran University of Medical Sciences, Tehran, Iran. segtesadi@gmail.com
[3]. Assistant Professor, Departments of PhysioPharmacology & NanoBioMedicine, Research Center for Immunogenetics, Faculty of Medicine, Mazandaran University of Medical Sciences, Sari, Iran. pooriagill@yahoo.com
[4]. Associate Professor, Research Center for Prevention of Cardiovascular Disease, Department of Nutrition, School of Public Health, Iran University of Medical Sciences, Tehran, Iran. sh_jaz@yahoo.com.
[5]. Associate Professor, Health Management and Social Development Research Center, Department of Health and Community Medicine, Faculty of Medicine, Golestan University of Medical Sciences, Gorgan, Iran. vakili@goums.ac.ir
[6]. Professor, Department of Pharmacognosy, Faculty of Pharmacy and Medicinal Plants Research Center, Tehran University of Medical Sciences, Tehran, Iran. ardekani@sina.tums.ac.ir .
[7]. Assistant Professor, Department of Infection, Faculty of Medicine, Golestan University of Medical Sciences, Gorgan, Iran. abdolbas@yahoo.com

[Downloaded from mjiri.iums.ac.ir on 2026-11-20]

the general conditions of the patients and accelerates recovery from TB according to different studies (6–11). Nutraceuticals, like green tea polyphenols, have shown acceptable properties as adjuvant treatment of different diseases. Because of its active polyphenol compounds, Green tea (GT) has a scavenging effect on free radicals and exhibits anti-oxidant properties (12,13). Polyphenols fight inflammation through inhibition of the synthesis and function of inflammatory mediators like eicosanoids and cytokines (14). The increase in the level of inflammatory cytokines of the plasma may be associated with malnutrition in active pulmonary TB (15). Oxidative stress may suppress the immune system. In patients with TB, consumption of antioxidant supplements may tackle oxidative stress. Green tea can protect the immune system against oxidant compounds and free radicals through controlling oxidative stress and boost its function as well (16,17). Green tea may help to accelerate the process of recovery and weight gain in TB patients through decreasing oxidative stress.

Conversion of the sputum smear is an important indicator of treatment after two months of intensive antibiotic therapy in sputum smear positive patients (18). Acceleration in sputum smear conversion helps faster improvement and decreased probability of the transfer of TB in smear-positive patients with tuberculosis. Green tea catechin is an important potential immunotherapeutic agent against respiratory infections and negatively affects the survival of M. tuberculosis through inhibition of the NF-κB pathway in vitro (13,19). Therefore, consumption of green tea or supplementation with concentrated polyphenols derived from green tea can be regarded as an adjuvant therapy in patients receiving antibiotics (13).

Considering the lack of such studies in Iran, we aimed to perform this study to evaluate the effect of green tea as an adjuvant therapy on shortening the sputum smear conversion time and weight in patients with smear positive pulmonary tuberculosis. The primary outcome of this study was the sputum smear conversion time and the secondary outcome was changes in weight and BMI within the two months.

Methods

Data and Design

This double blind clinical trial, with a randomized design, included patients with smear positive pulmonary TB, who were diagnosed with TB based on clinical manifestations and sputum smear positivity according to the guidelines of the Iranian Ministry of Health. The patients received Isoniazid, Rifampin, Pyrazinamide, and Ethambutol according to the DOTS (Directly Observed Treatment, Short course) strategy. All participants were selected from governmental health centers of Golestan Province in Iran. This study was conducted from September 2012 to December 2013.

Inclusion criteria were as follows: Definite diagnosis of the disease according to the guidelines of the Ministry of Health (a positive sputum smear along with clinical and radiologic manifestations); living in the Province of Golestan; receiving treatment in a DOTS program, age 15 years and older; willingness to participate in the study; Non drug-resistant TB; BMI more than 14, and 7); no history of diseases affecting the course of TB including autoimmune diseases like SLE and RA, type 1 diabetes mellitus, thalassemia, hemochromatosis, pregnancy, lactation, and renal failure. The exclusion criteria were as follows: Development of the signs and symptoms of sensitivity to green tea or the complications of its use; severe changes in the liver function tests following the administration of anti TB drugs; and development of severe complications of anti TB medicines.

To achieve an adequate number of patients in the two study groups, we divided the patients who met the inclusion criteria into the two arms of treatment and

[Downloaded from mjiri.iums.ac.ir on 2026-11-20]

placebo, using block randomization (block size = 2, treatment to placebo proportion= 1:1).

The sample size was calculated to be 40 persons according to a study by Nursyam (20) based on the estimation of 100% sputum conversion in the intervention group and 67.6% in the placebo group, level of significance (α=0.05), test power 90%, and 10% attrition of the samples. With respect to allocation concealment, every new patient was allocated to either group A or B introduced by the health centers of the cities of the province. The name of the groups was placed in a closed envelop with a non- see through covering. For blinding, similar boxes were provided for the green tea or placebo capsules, and the packages were coded as A or B. The boxes containing the capsules were similar with no nametags. An expert who was not involved in the treatment process or supervision delivered the drugs to the DOTS staff based on the designated codes. The treatment staff and patients were unaware of the allocated treatment.

Green tea capsules were purchased from Vitacost Company, USA, with the following specifications:

Green Tea Extract 500mg (Camellia Sinensis) standardized to 98% polyphenols, 80% catechins, 50% EGCG (leaves).

The placebo capsules containing green tea powder without catechin were provided from a local pharmaceutical company.

The dose of 500 mg catechin was selected based on the studies conducted on the effect of green tea on infections, particularly tuberculosis (21).

The intervention group received green tea supplementation and the control group received supplementation with placebo for two months. Both groups received anti TB therapy according to the DOTS protocol under the supervision of a coordinating physician. In this protocol, the patients take their anti TB drugs daily under the direct supervision of a health worker during an intensive phase. The patients receive a 4-drug regimen at the first 2 months, with a two-drug regimen in the following four months of the treatment. Sputum smear evaluation was performed at two and six months post-treatment to assess improvement.

The weight and height of the patients were measured at the beginning of the treatment and after two and six months. Weight was measured, using a Seca Scale (Seca, Hamburg, Germany) with a precision of 0.1kg; and height was measured, using a stadiometer to the nearest of 0.1cm. Body Mass Index (BMI) was calculated using the following formula: Weight (kg)/height(kg)^2. Physical examinations were performed to evaluate the improvement course and weight at 0, 2, and 6 months. From day 20 onward, sputum smears were obtained from the patients every 10 days until they turned negative and sent to the laboratory for evaluation of the microbial load. Trained assistants performed direct smear evaluations on three slides, using the ZiehlNeelsen method, and sputum smear conversion was defined as two negative slides for M. tuberculosis. All the slides were sent to the Central Laboratory of Golestan province for controlling purposes. To ensure compliance, health workers in charge of the DOTS protocol supervised the daily consumption of the supplements.

Overall, 17 patients were excluded from the analyses according to the exclusion criteria (eight patients were lost to follow-up, nine had illegible data, and three migrated).

Statistical Analysis

The results were presented as mean ± SD, median and range (Table 3). Comparison between the two groups was performed using χ 2 and t-test. Repeated measures of ANOVA accounting for three time measurement of weight, group (Green Tea and Placebo) and interaction of time and group were used to assess the differences between the three times for each group and compare the differences between the two groups. Box's test was used for equality of

[Downloaded from mjiri.iums.ac.ir on 2026-11-20]

covariance matrices, Mauchly's test was conducted for sphericity, and Bonferuni as a post hoc test to determin the changes in the three stages. The normality assumption for variables was tested by both the Kolmogorov–Smirnov test and Shapiro-Wilk test. Considering the two-month follow-up, the Kaplan-Meier test was used to calculate the duration of treatment, Cox regression model was utilized to assess the effect of smear rank on survival adjusted for treatment of other prognostic variables, and Log-Rank test was employed to compare the duration of treatment between the two groups. Data were analyzed using SPSS16. To assess the assumption of the appropriateness of risks, a cumulative logarithmic graph was used for all the independent variables in the model, and the results indicated observance of the assumption of appropriateness of risk over time.

Survival time (in months) was calculated from the date of diagnosis to the date of death or last follow-up. Failure was defined as death by any cause during the follow-up period; and the sputum smear conversion time of more than two months was censored in the patients.

The duration of intervention was considered from the commencement of the therapy to the date of sputum conversion in the second month of the treatment. For simpler calculation, we merged the scanty and +1 groups.

Results

Forty-one patients (51%) in the green tea group and 39 patients (49%) in the placebo group completed the study (Fig. 1). To explore the relationship between ethnic groups, intervention type and use of chi-square test, data of ethnic groups were considered in three subgroups including Sistani, Turkmen and other (Fars and Afghan). Moreover, to investigate marital status, widowed and divorced were merged; in brief, to conduct the chi-square

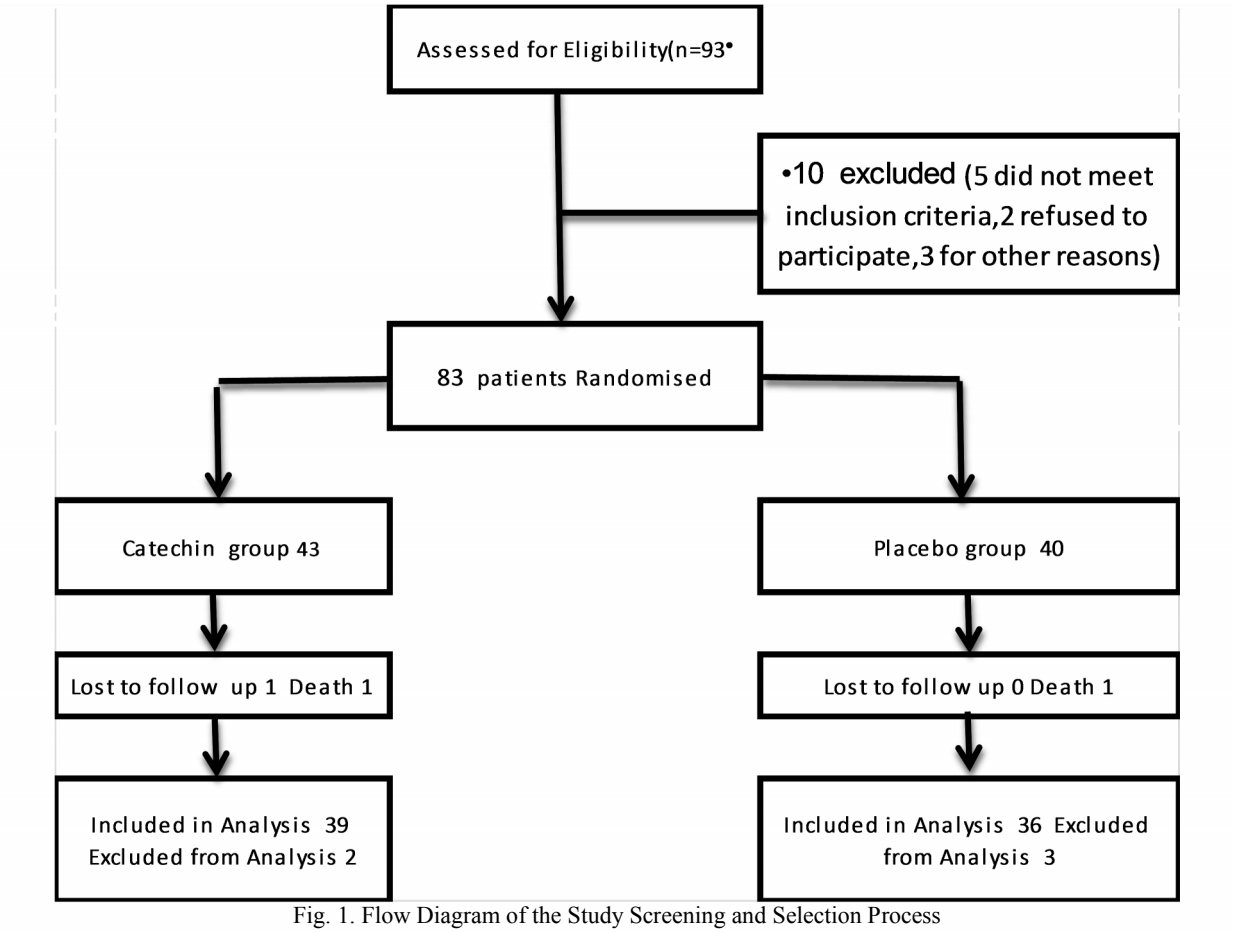


Fig. 1. Flow Diagram of the Study Screening and Selection Process

[Downloaded from mjiri.iums.ac.ir on 2026-11-20]

Table 1. Characteristics of the Patients

Variable	Catechin group	Placebo group	p
Sex, n (%)	41 (%51)	39 (%49)	0.805
Male	19 (% 24)	17(%22)	
Female	22(% 27)	22(%27)	
Age in years, (Mean±SD)			0.634
Male	45.8±19.4	41.5±16.7	
Female	43.5±20.2	43.3±18.4	
Marital Status, n (%)			0.248
Married	31(%39)	30(% 39)	
Single	4(% 5)	7 (% 8)	
Divorced	2(% 2)	2(% 2)	
DeadWife	4(% 5)	0	
Literacy, n (%)			0.481
Illiterate	18(% 23)	16(%21)	
Primary school	14(% 18)	10(%12)	
Near Diploma	8(% 10)	10(% 12)	
Graduated	1(% 1)	3(% 4)	
Current Smoking, n (%)	10(% 12)	9(% 11)	0.69
Ethnicity, n (%)			0.686
Afghan	2(% 2)	2(% 2)	
Sistani &Baluch	28(% 35)	23(% 29)	
Fars	3(% 4)	4(% 5)	
Turkmen	8(% 10)	10(%12)	
Occupation, n (%)			0.628
Housekeeper	14(% 18)	14(%18)	
Unemployed	11(% 14)	9(%11)	
Labor	11(% 14)	10(%12)	
Employed	5(% 6)	6(% 7)	

test, high school diploma and academic education were integrated. No significant difference was found between the two groups in the distribution of age, sex and clinical status at the beginning of the treatment (Table 1). In the placebo group, the mean±SD weight of the patients was 53.4±10.4kg at the beginning of the treatment, 54.2±9.97kg at the end of the second month, and 56.1±11.26kg at the end of the six month. On average, the patients gained 0.9±1.95kg at the end of the second month and 2.6±2.52 kg at the end of the sixth month (t=-3.36, p=0.004).

In the green tea (GT) group, the mean±SD weight of the patients was 55.7 ±12.38kg at the beginning of the treatment, 56.9±12.16kg at the end of the second month, and 58.6±11.9kg at the end of six month. On average, the patients gained 1.25±1.48kg at the end of the second month and 2.97±2.6 kg at the end of the sixth month (t=-4.46, p<0.001). Weight gain at the end of the second and sixth months was significant in both groups. The results of ANOVA repeated measure revealed that weight gain was different in the control and intervention groups by the time trend, while it was not significantly different between the two groups after two and six months (Table 2).

Sputum samples of 36 patients in the placebo group and 39 patients in the GT group were examined at the beginning and during the treatment (Table 3). The sputum samples of four patients in the GT group and four in the placebo group were excluded from the analysis due to the laboratory or delivery with a delay of more than 30 days. The conversion time was more than 60 days in 16 patients in the placebo and in 12 patients in the GT group;

Table 2. Repeated Measures of ANOVA Comparing Patients' Weight within and between Groups

Source	Type III sum of squares	df	Mean square	F	p
Time	302.49	1.67	181.3	62.63	<0.001
Group	318.15	1	318.15	0.82	0.37
Time*Group	1.73	1.67	1.04	0.36	0.66

[Downloaded from mjiri.iums.ac.ir on 2026-11-20]

Table 3. Sputum Smear and Conversion Time of Patients with Pulmonary Tuberculosis from Beginning of the Treatment

Sputum smear grade	intervention group (n=39)		Placebo group (n=36)		p
	N (%)	Mean±SD	N (%)	Mean±SD	
Scanty& 1+	19 (52.8%)	32.9±16.42	19 (48.7%)	45.1±19.59	0.69*
2+	8 (20.5%)	37.4±24.13	9 (25%)	46.0±26.14	
3+	12 (30.8%)	62.1±22.82	8 (22.2%)	77.6±19.93	

*Not significant

and therefore, they were removed from analysis. The mean±SD sputum conversion time (days) was 52.5±24.5 days (median: 53 days) in the placebo group and 40.6±22.5 days (median: 29 days) in the GT group. As demonstrated in Figure 2, the proportion of the patients in the GT group to patients in the placebo group was significantly high in terms of sputum conversion time (Log Rank (Mantel-cox)= 4.61 (p=0.032)).

Considering the status of the sputum microbial load, the time of sputum smear conversion was expected to be shorter in the scanty and +1 group versus the +3 group. The two groups of GT and placebo were compared to sputum smear conversion for days considering the

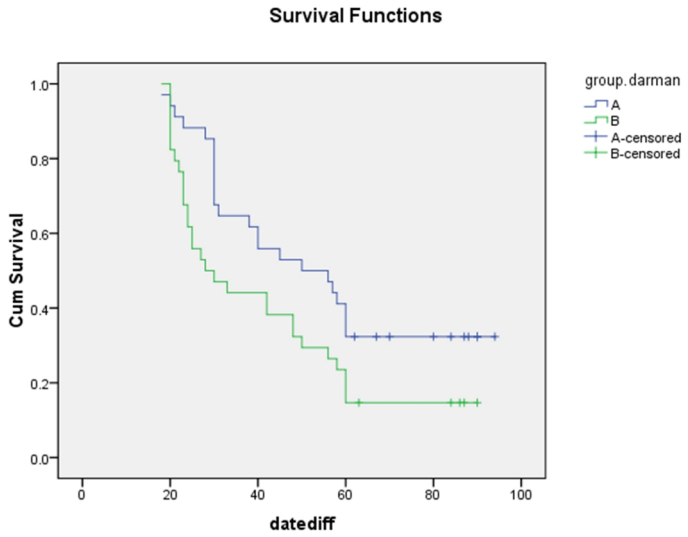


Fig. 2. Sputum Smear Conversion of the Patients (A = placebo group. B = Catechin group)

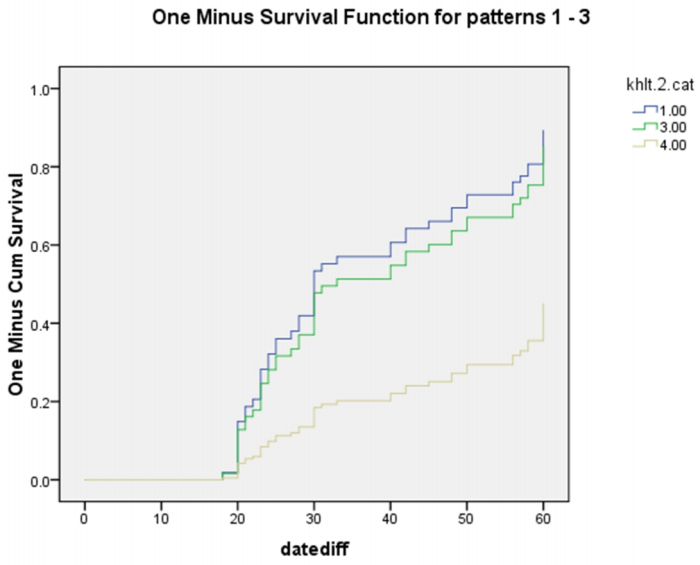


Fig. 3. Sputum Smear Conversion of the Patients according to Smear Grading
(1= Scanty and Grade 1. 3 = Grade 2. 4 = Grade 3)

[Downloaded from mjiri.iums.ac.ir on 2026-11-20]

microbial load of the sputum in the beginning of the study. It was found that the sputum smear conversion time was significantly shorter in the GT group than the placebo group (p=0.031) (Fig. 3).

Based on the Cox regression model for considering the simultaneous effect of the microbial load and type of treatment, the hazard ratio of the risk of delay in smear conversion was 3.7 (95% CI: 1.7-8.6, p=0.002) in group 2 vs. group 1; 3.2 (CI 1.2-8.2, p=0.016) in group 3 vs. group 1; and 0.54 (95% CI: 0.31-0.94, p=0.031) in the GT group vs. the placebo group. Therefore, the risk of delay in sputum conversion augmented with the increase in the microbial load and decreased with the consumption of green tea.

Discussion

Our study well documented the effect of catechin on sputum smear conversion. The microbial load of the sputum decreased faster in patients who received catechin compared to the control group.

Range and et al. found no significant difference in the culture conversion rate between patients who received micro-nutrient supplements and those who received placebo (89.5% versus 86.2%, p=0.29) and reported that zinc had no effect on the culture conversion rate (10). A study by Martins et al. on sputum smear positive TB patients revealed that the proportion of the sputum smear clearance one month after the start of treatment was higher but non-significant in patients receiving food package (85%, n=40) compared to the control group (67%, n=37) (22). In the study by Karyadi, supplements resulted in faster clearance of the sputum smears (15). Nursyam presented that Vit D3 supplementation significantly increased the sputum smear conversion at the end of the sixth week compared to the control group (% 100 compared to % 76.7) (20).

Jahnavi reported a higher sputum conversion rate (p=0.039) in patients receiving supplements (9). Coussens and et al. found that supplementation with vitamin D accelerated sputum smear conversion. They attributed this finding to the role of vitamin D in decreasing inflammatory responses during TB treatment (23). However, in Martineau et al. study, vitamin D supplementation as 2.5mg did not significantly reduce time to sputum culture conversion in the intervention group compared to the control group (24). In a study by Visser and et al. no significant difference was found in the smear or culture conversion time between the recipients of vitamin A and zinc, using the Kaplan-Meier method (p=0.15 and p=0.38, respectively, log-rank test) (11).

Researchers believed that many factors affect sputum smear conversion. Jayakody and et al. reported that a high grade of smear positivity was associated with failure in sputum smear conversion, whose beliefs were due to the higher initial bacterial load that required a longer time for clearance in the early stages of treatment (25).

Lawson et al. study showed that using Zinc and Retinol as supplementation in patients with pulmonary tuberculosis did not result in improved outcome of disease compared to the placebo. They believed that sputum smear grade is one of the most effective factors on time of sputum conversion (26). Ponnuraja showed that patients with cavitary disease, high sputum smear grade before treatment, or a past history of TB were more likely to experience a delay in sputum smear conversion ($p<0.05$) (27). In our study, a higher microbial load was correlated with a delay in sputum smear conversion.

The patients in our study were generally underweight at the beginning of the study (39%), but gained weight significantly two months after the commencement of the therapy. Schwenk and et al. noted a weight gain of 8.9%±9.5% in 40 TB patients following six months of standard anti TB treatment in England (28). HOW, S.H reported that 14.7% of patients with pulmonary tuberculosis were yet positive smear after one month (18). Krapp, F and et al. reported an increase in median weight

[Downloaded from mjiri.iums.ac.ir on 2026-11-20]

gain in TB patients at the end of the first month as 2.6 kg, at the end of initial phase as 4.8 kg, and at the end of treatment as 8.2 kg in cured patients (29).

Pharmacotherapy with anti-tuberculosis drugs results in nutrition improvement and weight gain. We reckoned that supplementation with green tea accelerated weight gain in patients since the combination of TB pharmacotherapy and anti-inflammatory compounds accelerate recovery from TB (30), but the results of our intervention indicated a slight increase in weight gain.

Different studies have evaluated different compounds as adjuvant therapy to anti TB treatment. Some of these compounds have shown positive effects on weight gain, while some did not have any effects compared to the control group. A study by Range in Tanzania on multi-micronutrient therapy and zinc supplementation in 530 pulmonary TB patients showed that patients who received supplementation with multi-micronutrients and zinc, weighed 2.4 kg more on average. The mean of total weight gain was 6.88 kg in that study (95% CI 0.1-0.8; RR 0.29) (10). Schön T and et al. in a study conducted on 180 Ethiopian patients with tuberculosis found that food enrichment with arginine had no effect on weight gain in the intervention group compared to the control group (3). In a study implemented by Ralph AP and et al. adjunctive Therapy with L-arginine (six grams daily for 8 weeks) and vitamin D (50.000 IU daily for 4 weeks) for 200 patients with tuberculosis had no effects on weight gain in the intervention group compared to the control group (31).

Previous studies found no difference in weight gain between their intervention and control groups, and this could be due to the sample size or the effect of other factors such as nutrition. These studies mostly used a nutrient (macronutrient or micronutrient), while we used the nutraceutical supplement of green tea. It seems that the contribution of green tea to decrease the inflammatory status of the patients has a little effect on improving the nutritional status of the patients compared to the effect of antibacterial therapy.

Other studies evaluated the status of the inflammatory indices. For example, Kim et al. reported that the levels of TNF-α and IL-6 were higher in malnourished TB patients than the control group and well-nourished TB patients (31). Furthermore, they found that the level of C-reactive protein (CRP) and the proportion of CRP to albumin was lower in patients not afflicted with TB than TB patients 30 and 60 days after treatment (32).

Numerous studies have highlighted the role of green tea, particularly its catechins in regulating inflammatory reactions (13,33-35). Green tea entraps reactive oxygen species (ROS) and is protective against oxidative stress. Agarwal and et al. showed the effect of green tea extract on the reduction of oxidative stress in patients receiving anti TB treatment (21).

To our knowledge, our study was the first to be conducted on the use of green tea extract as a supplement in the treatment of tuberculosis in Iran. The main limitation of our study was the lack of sputum culture, which is considered the gold standard of TB diagnosis. In addition, difficulty obtaining sputum specimens during treatment, due to the clearance of the patients' lungs, was another limitation of this study. Finally, considering the DOTS protocol, few patients were asked to take a chest X-ray to follow the improvement.

Conclusion

In this study, green tea had a little effect on weight gain; however, its catechins contents are natural compounds with relatively safe profiles, and the use of green tea as an adjuvant therapy in TB patients may be a new method for faster rehabilitation of these patients through shortening the time to sputum smear conversion.

Acknowledgments

The authors wish to thank the staff of the

[Downloaded from mjiri.iums.ac.ir on 2026-11-20]

Health Centers of Golestan province, research and health authorities of Golestan University of Medical Sciences and Iran University of Medical Sciences for their financial support and the managers of Giah Esans Industry & Agriculture Company for providing the placebo.

Trial Registration

This trial was registered under IRCT 201212232602N11.

References

1. Ministry of Health and Medical Education of Iran. Communicable disease control center. Department of Tuberculosis and Leprosy [Internet]. [cited 2014 Dec 11]. Available from: http://tb-lep.behdasht.gov.ir/Default.aspx

2. PrayGod G, Range N, Faurholt-Jepsen D, Jeremiah K, Faurholt-Jepsen M, Aabye MG, et al. Daily Multi-Micronutrient Supplementation during Tuberculosis Treatment Increases Weight and Grip Strength among HIV-Uninfected but Not HIV-Infected Patients in Mwanza, Tanzania. J Nutr 2011 Apr 1;141(4):685-91.

3. Schön T, Idh J, Westman A, Elias D, Abate E, Diro E, et al. Effects of a food supplement rich in arginine in patients with smear positive pulmonary tuberculosis--a randomised trial. Tuberc Edinb Scotl 2011 Sep;91(5):370-7.

4. Jordao L, Lengeling A, Bordat Y, Boudou F, Gicquel B, Neyrolles O, et al. Effects of omega-3 and -6 fatty acids on Mycobacterium tuberculosis in macrophages and in mice. Microbes Infect 2008 Oct;10(12-13):1379-86.

5. Crewe RM. HIV/AIDS, TB and Nutrition [Internet]. Academy of Science of South Africa; 2007. Available from: http://www.assaf.org.za

6. Papathakis P, Piwoz E. Nutrition and Tuberculosis: A Review of the Literature and Considerations for TB Control Programs. U S Agency Int Dev Afr Health 2010 Proj 2008;1.

7. Abba K, Sudarsanam TD, Grobler L, Volmink J. Nutritional supplements for people being treated for active tuberculosis. Cochrane Database Syst Rev Online 2008;(4):CD006086.

8. Sudarsanam TD, John J, Kang G, Mahendri V, Gerrior J, Franciosa M, et al. Pilot randomized trial of nutritional supplementation in patients with tuberculosis and HIV–tuberculosis coinfection receiving directly observed short-course chemotherapy for tuberculosis. Trop Med Int Health 2011 Jun 1; 16(6):699-706.

9. Jahnavi G, Sudha CH. Randomised controlled trial of food supplements in patients with newly diagnosed tuberculosis and wasting. Singapore Med J 2010 Dec;51(12):957-62.

10. Range N, Andersen AB, Magnussen P, Mugomela A, Friis H. The effect of micronutrient supplementation on treatment outcome in patients with pulmonary tuberculosis: a randomized controlled trial in Mwanza, Tanzania. Trop Med Int Health TM IH 2005 Sep;10(9):826-32.

11. Visser ME, Grewal HM, Swart EC, Dhansay MA, Walzl G, Swanevelder S, et al. The effect of vitamin A and zinc supplementation on treatment outcomes in pulmonary tuberculosis: a randomized controlled trial. Am J Clin Nutr 2011 Jan 1; 93(1):93-100.

12. Hegde ML, Bharathi P, Suram A, Venugopal C, Jagannathan R, Poddar P, et al. Challenges Associated with Metal Chelation Therapy in Alzheimer's Disease. J Alzheimers Dis JAD 2009 Jul;17(3):457-68.

13. Anand PK, Kaul D, Sharma M. Green tea polyphenol inhibits Mycobacterium tuberculosis survival within human macrophages. Int J Biochem Cell Biol 2006;38(4):600-9.

14. Serafini M, Peluso I, Raguzzini A. Flavonoids as anti-inflammatory agents. Proc Nutr Soc 2010 Aug;69(03):273-8.

15. Kim JH, Lee CT, Yoon HI, Song J, Shin WG, Lee JH. Relation of ghrelin, leptin and inflammatory markers to nutritional status in active pulmonary tuberculosis. Clin Nutr Edinb Scotl 2010 Aug; 29(4):512-8.

16. Matsumoto K, Yamada H, Takuma N, Niino H, Sagesaka YM. Effects of Green Tea Catechins and Theanine on Preventing Influenza Infection among Healthcare Workers: A Randomized Controlled Trial. BMC Complement Altern Med 2011 Feb 21;11:15.

17. Neyestani T, Khalaji N. Inhibitory effects of black tea (Camellia sinensis) extracts on Streptococcus pyogenes: A comparison between black and green teas in vitro. Iran J Nutr Sci Food Technol 2007 Jun 15;2(1):41-7.

18. Fatima Z, Hameed S, Islam N. Epigallocatechin-3-gallate (EGCG), a green tea polyphenol suppresses bacilli-induced augmented expression of Mycobacterium tuberculosis 85B and proinflammatory TNF-α in human monocytes. Int J Sci Res Publ 2012;90.

19. Nursyam EW, Amin Z, Rumende CM. The effect of vitamin D as supplementary treatment in patients with moderately advanced pulmonary tuberculous lesion. Hemoglobin 2006;1500:1500.

20. Agarwal A, Prasad R, Jain A. Effect of green tea extract (catechins) in reducing oxidative stress seen in patients of pulmonary tuberculosis on DOTS Cat I regimen. Phytomedicine Int J Phytother Phytopharm 2010 Jan;17(1):23-7.

21. Martins N, Morris P, Kelly PM. Food incentives to improve completion of tuberculosis treatment: randomised controlled trial in Dili, Timor-Leste. BMJ 2009;339.

[Downloaded from mjiri.iums.ac.ir on 2026-11-20]

22. Coussens AK, Wilkinson RJ, Hanifa Y, Nikolayevskyy V, Elkington PT, Islam K, et al. Vitamin D accelerates resolution of inflammatory responses during tuberculosis treatment. Proc Natl Acad Sci 2012 Sep 18;109(38):15449-54.

23. Martineau AR, Timms PM, Bothamley GH, Hanifa Y, Islam K, Claxton AP, et al. High-dose vitamin D3 during intensive-phase antimicrobial treatment of pulmonary tuberculosis: a double-blind randomised controlled trial. The Lancet 2011 Jan 21;377(9761):242-50.

24. Jayakody W, Harries AD, Malhotra S, de Alwis S, Samaraweera S, Pallewatta N. Characteristics and outcomes of tuberculosis patients who fail to smear convert at two months in Sri Lanka. Public Health Action 2013 Mar 21;3(1):26-30.

25. Maciel EL, Brioschi AP, Peres RL, Guidoni LM, Ribeiro FK, Hadad DJ, et al. Smoking and 2-month culture conversion during anti-tuberculosis treatment. Int J Tuberc Lung Dis 2013 Feb 1;17(2):225-8.

26. Ponnuraja C. Survival analysis: Kaplan-Meier and life table estimates for time to event clinical trial tuberculosis data. Concepts Pure Appl Sci 2013 Jun 25;1(1):17-21.

27. Schwenk A, Hodgson L, Wright A, Ward LC, Rayner CF, Grubnic S, et al. Nutrient partitioning during treatment of tuberculosis: gain in body fat mass but not in protein mass. Am J Clin Nutr 2004 Jun 1;79(6):1006-12.

28. How SH, Kuan YC, Ng TH, Razali MR, Fauzi AR. Monitoring treatment response in sputum smear positive pulmonary tuberculosis patients: comparison of weight gain, sputum conversion and chest radiograph. Malays J Pathol 2014;36(2):91-6.

29. Krapp F, Véliz JC, Cornejo E, Gotuzzo E, Seas C. Bodyweight gain to predict treatment outcome in patients with pulmonary tuberculosis in Peru. Int J Tuberc Lung Dis Off J Int Union Tuberc Lung Dis 2008 Oct;12(10):1153-9.

30. Sinclair D, Abba K, Grobler L, Sudarsanam TD. Nutritional supplements for people being treated for active tuberculosis. Cochrane Database Syst Rev Online 2011;(11):CD006086.

31. Ralph AP, Waramori G, Pontororing GJ, Kenangalem E, Wiguna A, Tjitra E, et al. L-arginine and vitamin D adjunctive therapies in pulmonary tuberculosis: a randomised, double-blind, placebo-controlled trial. PloS One 2013;8(8):e70032.

32. Moraes ML de, Ramalho DM de P, Delogo KN, Miranda PFC, Mesquita EDD, Oliveira HM de MG de, et al. Association of Serum Levels of Iron, Copper, and Zinc, and Inflammatory Markers with Bacteriological Sputum Conversion During Tuberculosis Treatment. Biol Trace Elem Res 2014 Aug 1; 160(2):176-84.

33. von Staszewski M, Pilosof AMR, Jagus RJ. Antioxidant and antimicrobial performance of different Argentinean green tea varieties as affected by whey proteins. Food Chem 2011 Mar 1;125(1):186-92.

34. Singh BN, Shankar S, Srivastava RK. Green tea catechin, epigallocatechin-3-gallate (EGCG): mechanisms, perspectives and clinical applications. Biochem Pharmacol 2011 Dec 15;82(12):1807-21.

35. Basu A, Betts NM, Mulugeta A, Tong C, Newman E, Lyons TJ. Green tea supplementation increases glutathione and plasma antioxidant capacity in adults with the metabolic syndrome. Nutr Res 2013 Mar;33(3):180-7.

[Downloaded from mjiri.iums.ac.ir on 2026-11-20]