

Efficacy Of Pulmonary Rehabilitation Program In Patients With Treated Pulmonary Tuberculosis

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ABSTRACT

The prevalence of tuberculosis (TB) in developing countries is high. Patients with Pulmonary Tuberculosis (PTB) often have impaired pulmonary function because of the anatomical changes resulting from the disease in addition to substantial adverse impacts on the patient's quality of life. Pulmonary rehabilitation (PR) has arisen as a proposed standard of care for the management of PTB patients. Objective was to evaluate PR efficacy on health-related quality of Life (HRQoL), lung function, and exercise capacity among patients with treated PTB. PATIENTS AND METHODS: 60 patients with cured pulmonary TB were enrolled in this prospective intervention study. They were categorized into two groups; a study group and a control group. The study group underwent a PR program consisted of supervised exercise training for upper and lower limbs, inspiratory muscle training, and educational sessions three times weekly for 12 weeks. Outcome measures were exercise capacity measured by six minutes walking distance (6MWT), pulmonary functions measured via spirometry, and HRQoL measured by St. George respiratory questionnaire (SGRQ). All these measures were evaluated before and after 12 weeks in both groups. RESULTS: Scores of 6MWT, PFTs and SGRQ improved by the end of the treatment within each group. Comparison of post-treatment results for the two groups showed statistically significant differences ($p < 0.05$) in favor of the study group. In Conclusion, PR combined with lower and upper extremity exercises as well as inspiratory muscle training were correlated with a significant clinical improvement in terms of exercise capacity, lung function and HRQoL in PTB treated patients.

Keywords: pulmonary tuberculosis, pulmonary rehabilitation, 6MWT, HRQoL

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INTRODUCTION

The prevalence of PTB in developing countries is remarkably high, indicating high rates of mortality as well as morbidity among patients with chronic infections globally, resulting in poor health and poor quality of life [1-2]. Since 1993, the world health organization (WHO) has announced TB as a fatal uncontrolled contagious epidemic and global health emergency. Each year the number of new cases is estimated of 10.0 million, which is one of the top ten reasons of death worldwide [3]. The TB prevalence in developing countries is still high and fatal [4]. Egypt lately reported a total number of 12,000 TB cases [3]. PTB results in deficient ventilation with improper gas exchange as well as decrease in functional status [5]; In addition, it leads to muscle atrophy and impaired exercise capacity, thus reduced exercise capacity, reduce daily life activities and poor health related quality of life [6,7].

Pulmonary TB constitutes a global healthcare burden with substantial negative effect on QoL of patients. Pulmonary rehabilitation which is an evidence-based multidisciplinary comprehensive non-pharmacological intervention has been recognized as a recommended standard therapy and core component for the management of patients who have

chronic respiratory diseases [8]. There has been growing proof and literature that supports the value of PR in patients suffering from chronic lung impairment after treated from PTB [9,10]. Nevertheless, the role of PR in improving post-TB sequelae in low- and middle-income countries has not been rigorously tested. A suitable PR program for treating pulmonary TB is not available in Egypt, which was a motivation to conduct the current study. Hence, the main goal of current research was to assess PR effectiveness on lung function, exercise capacity as well as quality of life among treated pulmonary TB patients.

MATERIALS AND METHODS

Design and setting:

A prospective comparative interventional study was conducted at Abbassia chest hospital between June 2015 and Feb 2017.

Subjects:

60 clinically stable and mentally fit patients with cured pulmonary TB between the ages of 40-60 years of both genders, were involved in this study. All patients included were previously diagnosed with PTB and treated with a full course of anti-TB therapy over the last 6 months and they

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were sputum smear as well as culture negative. Exclusion criteria included patients with Multi-drug resistance TB, life-threatening disorders, mentally inadequate as well as orthopedic problems that could interfere with the rehabilitation program. Patients were divided into study and control equal groups (each thirty patients); the study group received a PR program in the form of guided exercise training for upper limbs as well as lower limbs together for 12 weeks, threshold inspiratory muscle training (IMT) besides education sessions that focus on energy conservation, breathing exercises, stress management, and lung health. Whereas the control group received education sessions with basic breathing exercises.

Ethical approval:

The protocol of the present study was reviewed and received the approval of ethical committee of faculty of physical therapy, Cairo University (No: P.T.REC/012/00296)

Assessment and outcome:

All patients underwent a baseline evaluation and after 12 weeks. lung function was measured by spirometry. The six-minute walk test (6MWT) was utilized to evaluate the capacity of exercise and evaluation of HRQoL was performed via St. George's Respiratory Questionnaire (SGRQ).

Exercise Capacity: The 6MWT was utilized to measure exercise capacity and it was conducted according to American Thoracic Society guidelines ^[11] in a hospital corridor 30 meters long, with line signs for every meter. Patients were given instructions for walking from one end (point) to the other and covering as much of the ground within 6 min. The test was self-controlled, and patients could have a break if they asked. It can be stopped, if symptoms of significant distress appear, such as dizziness, chest pain, as well as leg cramps. Nonetheless, they were advised to continue walking as long as they can. After completion of 6 min, the distance traveled in meters was documented.

Pulmonary function tests: Pulmonary function tests (PFTs) were performed according to American Thoracic Society/European Respiratory Society guidelines ^[12,13] using Spirobank II (MIR Medical International Research, Italy). PFTs were conducted via a trained investigator with the patient in a seated position. A nose clip was used in order to avoid air leakage. All patients were instructed not to use any bronchodilator on the night before and the day of the procedure.

Three tests with values within 5% were identified as being acceptable, and the best of three values were used to categorize pulmonary function. Forced Vital Capacity (FVC), Forced Expiratory Volume in 1s (FEV1), as well as FEV1/FVC ratios, were measured and recorded as proportion of predicted.

Health-related quality of life (HRQoL): HRQoL was evaluated via STGRQ Questionnaire ^[14]. The SGRQ was validated before to ascertain health quality in patients with treated PTB ^[15]. The Arabic version of SGRQ was used in this study and was validated by Metwally, 2004 ^[16]. Scores are calculated for three components of the SGRQ: The Symptoms score that relates to the impact of respiratory symptoms, their severity as well as frequency, activity score related to activities that result in or restricted by shortness of breath, and finally impact scores that covers multiple aspects related to social performance as well as

psychological disturbances, resulted from respiratory disease. The total score was computed as well, summarizing the effect of the disease on general health status. The scores were expressed in the form of percentages of total impairment; with 100 being the worst possible health condition while 0 means the best possible health condition. There was an Excel spreadsheet for this questionnaire named 'SGRQ Calculator', that was used to calculate the three SGRQ component scores as well as total scores. The items of this questionnaire were explained to the patients and they have to complete the test honestly and explaining to the patients that there are no right or wrong answers: The questionnaire was self-administered in a quiet hospital room under the supervision of a therapist, moreover, patients were not allowed to complete the questionnaire at home. The questionnaire was used to measure HRQoL at baseline and in week twelve.

Intervention:

Pulmonary rehabilitation program: The PR program consisted of three 60-minute sessions every week and lasted for 12 weeks. The study group received pulmonary rehabilitation program in the form of endurance training for lower limbs, strengthening exercises for upper limbs, as well as inspiratory muscle training and education, whereas the control group received basic breathing exercises and education. The exercise program followed international guidelines for pulmonary rehabilitation ^[17]. The typical exercise session consisted of; endurance training that included walking on a treadmill for 30 minutes at an intensity of 80% of the initial 6MWT results ^[18]. Resistance training for the upper limbs using free weights and the 10-repetition maximum (RM) test was used to decide the appropriate load used for upper limb exercises. For upper limb training, progressive load was used for 3 sets of 10-RM test. The first set was determined at 50% of the 10 RM obtained in the initial assessment, followed by the second set at 75% of 10 RM, while the third set at 100% of 10 RM. The relaxation time between sets, and the interval between exercises, were identified as 1 min and 30s in duration ^[19]. The IMT was performed by using a threshold inspiratory muscle trainer (Ultrabreath, Angle sales company, USA). The initial training resistance (load) was attempted at the minimal loading that patients accepted. The IMT session was five times per week twice a day and every session lasted for 10 - 15 min. The patients had to inhale slowly with an increased tidal volume, and after 10 inspirations, they can take a break by breathing at rest for one minute. Patients were instructed to perform 3 sets of 10 to 12 repetitions as suggested by Huang et al. ^[20], and the perceived inspiratory effort rates on the modified CR10 Borg Scale (4-6 of 10, moderate level), was utilized to support decisions regarding increasing training load ^[21]. The intensity of the exercise program during every session was gradually increased and graded according to symptom tolerance. The exercise was followed by an educational session.

Statistical analysis:

All the statistical analysis was carried out with Stata 14.0 ^[22]. The analysis of data for the current study was done using descriptive statistics and results were described as mean values±standard deviations. The differences in demographic characteristics between both groups were

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assessed using unpaired t-tests and Chi-square test. The 2×2 mixed model ANOVA with two independent groups (study vs. control) as the between-subjects' factor and two times for measuring the dependent variables (comparing values attained at baseline, as well as three months later) as the within-subjects' factor. The significance level was determined at P<0.05. Prior to data analysis, Levene's test and Shapiro-Wilk test were used to test the equality of variances and the normality of the data, respectively.

RESULTS

Sixty patients completed the study (thirty patients in each group), and the baseline characteristics of participants from the two groups are displayed in Table 1. The two groups were well-matched in terms of age, weight, height, and BMI. The baseline characteristics in both groups showed a non-significant difference, with respect to spirometric measures, 6MWT and health-related QOL scores (p> 0.05) (Table 1).

Table (1): Comparison of demographic and baseline characteristics of patients in both groups

	Study Group (n=30) mean±SD	Control Group (n=30) mean±SD	P-value
Age (years)	52.4 ± 5.61	51.13 ± 5.75	0.39
Weight (Kg)	62.43 ± 7.22	62.53 ± 6.46	0.95
Height (m)	1.69 ± 0.05	1.67 ± 0.04	0.15
BMI (kg/m ²)	21.79 ± 2.07	22.32 ± 1.95	0.3
FVC (% predicted)	85.99 ± 8.67	84.58 ± 10.01	0.56
FEV1 (%predicted)	68.43 ± 13.93	67.25 ± 14.8	0.75
FEV1/FVC (%predicted)	79.5 ± 13.35	79.13 ± 12.43	0.91
6MWT (m)	411.16 ± 134.49	409.8 ± 143.69	0.97
SGRQ Results			
SGRQ Symptoms score	27.8 ± 10.67	28.93 ± 11.92	0.7
SGRQ Activity score	28.6 ± 9.05	29.33 ± 11.13	0.78
SGRQ Impact score	24.63 ± 10.77	25.73 ± 11.41	0.7
SGRQ Total scores	27.23 ± 11.87	28.13 ± 13.12	0.78

S.D: standard deviation; BMI: body mass index; 6MWT: 6-min walking test, SGRQ: St George respiratory questionnaire; FVC: forced vital capacity; FEV1: forced expiratory volume in 1s; FEV1/FVC: ratio of FEV1 to FVC. Comparison of mean values of all outcome measures after 12 weeks of patients' recruitment into the study, showed significant improvement in the HRQOL, as well as exercise capacity variables for both study and control groups with the study group, showed a further prominent significant change than the control group. The percentage of change was (45.9%, 7.78%) in 6MWT in the study and control group, respectively. In addition, all sections of the SGRQ questionnaire were significantly increased. The percentage of increase in symptom score was (39.2%, 6.2%), activity score (45.1%, 5.8%), impact score (41.9%, 8.8%), and total

score (42.4, 4.3%) for the study and control group, respectively. (Table 2)

The study group also demonstrated a further clinically and statistically significant improvement in lung function in comparison to control group. With respect to lung function, a weak significant change in pulmonary function tests existed in the control group. The percentage of increase was (27.03%, 3.88%) in FEV1, (9.21%, 1.32%) in FVC, and (16.37%, 2.6%) in FEV1/FVC in the study and control group, respectively (Table 2).

When comparing outcome measures between the two groups at the end of the study, a strong statistically significant difference was observed in all measured variables (p< 0.05), in favor of the study group (table 2).

Table 2. Comparison of outcomes for study and control groups

	Study Group (n=30)		Control Group (n=30)		Post-treatment mean difference between the two groups	P-value
	At Baseline Mean±S.D	After 12 weeks Mean±S.D	At Baseline Mean±S.D	After 12 weeks Mean±S.D		
FVC%	85.99±8.67	93.92± 4.82	84.58±10.01	85.71±9.82	8.2	0.0001
FEV1%	68.43±13.93	86.93± 7.62	67.25±14.8	69.86± 14.43	17.07	0.0001
FEV1/FVC	79.5± 13.35	92.52± 6.04	79.13±12.43	81.2± 12.03	11.32	0.0001
6MWT (m)	411.16±134.49	600.3± 168.9	409.8±143.69	441.7±151.25	158.6	0.0001
SGRQ Symptom score	27.8±10.67	16.9± 7.96	28.93±11.92	27.13±11.59	10.23	0.0001
SGRQ Activity score	28.6±9.05	15.7± 5.59	29.33±11.13	27.6± 10.93	11.9	0.0001

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SGRQ Impact score	24.63± 10.77	14.3± 7.75	25.73±11.41	24.46± 11.44	10.16	0.0001
SGRQ Total score	27.23±11.87	15.66±8.18	28.13± 13.12	26.93±13.12	11.26	0.0001

S.D: standard deviation; BMI: body mass index; 6MWT: 6-min walking test SGRQ: St George respiratory questionnaire; FVC: forced vital capacity; FEV1: forced expiratory volume in 1s; FEV1/FVC: ratio of FEV1 to FVC

DISCUSSION

Pulmonary Tuberculosis (PTB) is considered a long-term disability that has a general adverse impact on the social as well as physical aspects of patients diagnosed with PTB [7]. Pulmonary rehabilitation (PR) is a comprehensive evidence-based, multidisciplinary program for patients diagnosed with chronic respiratory diseases [17]. There is growing evidence that shows the values of PR in patients with PTB [9,10,23,24], however, there is still no PR guideline for the management of pulmonary impairment that may occur in PTB patients after microbiological cure. Therefore, the current study is designed to investigate whether a detailed comprehensive pulmonary rehabilitation program would help to improve exercise capacity, pulmonary function, and HRQoL in patients with PTB who completed their pharmacotherapy.

The results revealed a strong significant difference in lung function parameters, SGRQ scores, and 6MWT after completion of the pulmonary rehabilitation program. The results demonstrated that both the study and the control groups showed improvement in the assessed parameters; however, the improvement was more prominent and statistically significant in the study group, compared to control group. The PR applied to study group was effective for improving exercise capacity, HRQoL, and lung function for patients with PTS characterized by both restrictive and obstructive ventilatory defect. The reason for this improvement can be attributed to the physiological effect, i.e. a decrease in the demand for ventilation and the decrease in the level of lactic acid in the blood, resulting in improved aerobic metabolism in muscles, thus relieving muscle fatigue [25]. Furthermore, there were effects where patients were more motivated to exercise, less depressed, and less fear of dyspnea, besides they reported fewer episodes of severe breathlessness, and this was reflected in the significant improvement in SGRQ scores after the intervention [26].

The current study demonstrated significant changes in lung functions by the end of the PR program in study group. Such improvement can be attributed to the strength/conditioning of the respiratory muscle after training with the threshold IMT device. This is supported by other studies that investigated the impact of IMT on improving strength and endurance of inspiratory muscle, functional exercise capacity as well as quality of life [27-28].

An important finding of the current study showed a significant improvement in exercise capacity as evidenced by increased the distance walked in 6MWT by end of the 12 weeks of treatment, (45.99% increase) in study group. The current findings are consistent with Miyahara and coworkers who demonstrated an improvement in 6MWT as an indication of improving the functional exercise capacity following 6 weeks of PR in TB patients [24]. The improvement in exercise capacity, as well as tolerance, may

be due to increased motivation, improved aerobic capacity of the muscles, and desensitization to dyspnea sensation [25]. The present study showed a significant improvement in HRQoL as evaluated by the mean percentage of change in total SGRQ by end of 12 weeks (from 27.23 to 15.66), compared to baseline, compared to baseline in the study group. Reduced dyspnea, as well as other symptoms, for instance, efficient breathing patterns, and improved ability to fulfill daily activities can be a reason for the noticed improvement in HRQoL. Dyspnea upon exertion was reduced, as manifested by the SGRQ results. Due to the major effect of dyspnea on health status, the improved HRQoL of PTB patients can be indicative of a decrease in symptoms like dyspnea. Reduction in dyspnea could be due to multiple factors, such as improve breathing patterns, reduced ventilatory demand, improved ventilatory muscle performance characteristics in addition to psychological factors [25,29].

Pulmonary TB induced muscle wasting and fatigue due to the combination of decreased appetite and changed metabolism related to the inflammatory processes as well as immune responses, in addition to losing both fat and lean tissue [30]. Therefore, improvement in the exercise capacity and the different components of the SRGQ, especially the observed improvement in the activity component, could be explained by the increase in muscle mass following pulmonary rehabilitation program and the decrease of muscle wasting and fatigue. The results of the current study also revealed a minor improvement in exercise capacity as well as HRQoL in control group. There are several possible reasons for this improvement. First, it may be related to the instruction and basic breathing exercises received by the control group. Second, the improvement reported in the control group may be attributed to the natural recovery after completion of the TB treatment and the patients' return to their normal life activities.

Similar findings were reported by other studies; Rivera Motta et al. [10], Jones et al. [18], demonstrated that PR was feasible and correlated with marked clinical improvements in respiratory outcomes, HRQoL, as well as exercise capacity in PTB patients. Other studies have reported different findings, such as Yoshida et al. [31] who examined the effect of exercise training in the form of non-treadmill walking on improving exercise performance in patients with PTB sequelae and the reported findings indicated absence of significant change in PFT (FEV1/FVC); however, there was an improvement of peak VO₂ existed following two weeks of daily walking exercises. Another study illustrated that it appears unnecessary to subject patients with PTB to pulmonary rehabilitation [32]. The differences can be attributed to multiple aspects such as the difference in age, sex, and demographic parameters, of examined populations, as well as the variation in the applied pulmonary rehabilitation regimen.

LIMITATIONS

The current study has its own limitations which may influence the validity of the study results. This study sample size could restrict generalizability of results and results

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cannot be extrapolated to all PTB patients in Egypt. The current research only examined the short-term effect of pulmonary rehabilitation, and further investigation is needed to evaluate the long-term effect.

CONCLUSION

The study results demonstrated that a comprehensive PR program in the form of inspiratory muscle training, aerobic training, as well as resistance exercise had a significant improvement in exercise capacity, pulmonary function, and HRQoL in PTB patients. The study results provide motivation to consider the implementation of a pulmonary rehabilitation program after PTB treatment to reduce the pulmonary impairment the patient may suffer after microbiological cure and to alleviate the long-term disability that contributes to the overall detrimental effects on the physical and social aspects of PTB patients. Since no adverse effects or complications were observed during the intervention period, further research involving a larger sample size at multiple research sites and testing further the hypothesis that PTB patients would benefit from pulmonary rehabilitation is recommended. In addition, the authors need to emphasize that the current training method is not necessarily the most appropriate for improving exercise capacity for patients with PTB. Further research is required to compare different training methods.

DISCLAIMER

We, the authors, hereby affirm that the views stated in the submitted article are our own and not an official opinion of the organization. Besides, we declare that there is no conflict of interest.

REFERENCES

1. Di Naso FC, Pereira JS, Schuh SJ, Unis G. Functional evaluation in patients with pulmonary tuberculosis sequelae. *Rev Port Pneumol* 2011; 17:216-221.
2. Ramos LM, Sulmonett N, Ferreira CS, Henriques JF, de Miranda SS. Functional profile of patients with tuberculosis sequelae in a university hospital. *J Bras Pneumol* 2006; 32:43-47.
3. Global tuberculosis report 2020. Geneva: World Health Organization; 2020. Licence: CC BY-NC-SA 3.0 IGO.
4. Haradhan Kumar Mohajan: Tuberculosis is a Fatal Disease among Some Developing Countries of the World, *American Journal of Infectious Diseases and Microbiology*, 2015, Vol. 3, No. 1, 18-31
5. Pasipanodya JG, Miller TL, Vecino M, Munguia G, Garmon R, Bae S, et al. Pulmonary impairment after tuberculosis. *Chest* 2007;131(June (6)):1817–24.
6. Sivaranjini S, Vanamail P, Eason J. Six minute walk test in people with tuberculosis sequelae. *Cardiopulm Phys Ther J* 2010; 21:5-10.
7. Maguire GP, Anstey NM, Ardian M, Waramori G, Tjitra E, Kenangalem E, Handoyo T, Kelly PM. Pulmonary tuberculosis, impaired lung function, disability and quality of life in a high-burden setting. *Int J Tuberc Lung Dis* 2009;13:1500-1506
8. Croitoru A, Bogdan MA. Evidences related to pulmonary rehabilitation in the respiratory pathology. *Pneumologia* 2014; 63:88-90, 92-95.
9. Ando M, Mori A, Esaki H, Shiraki T, Uemura H, Okazawa M, Sakakibara H: The effect of pulmonary rehabilitation in patients with post-tuberculosis lung disorder. *Chest*. 2003, 123:1988-1995. 10.1378/chest.123.6.1988
10. Rivera Motta J, Wilches E, Mosquera R: Pulmonary rehabilitation on aerobic capacity and health-related quality of life in patients with sequelae of pulmonary TB. *Am J Respir Crit Care Med*. 2016, 193:A2321
11. Holland AE, Spruit MA, Troosters T., Puhan MA, Pepin V., Saey D., et al; An official European Respiratory Society/American Thoracic Society technical standard: field walking tests in chronic respiratory disease *Eur Respir J* 2014; 44: 1428–1446
12. Miller MR, Hankinson J, Brusasco V, Burgos F, Casaburi R, Coates A, et al.; ATS/ERS Task Force. Standardization of spirometry *Respir J* 2005;26:319–338.
13. Graham BL, Steenbruggen I, Miller MR, Barjaktarevic IZ, Cooper BG et al; Standardization of Spirometry 2019 Update An Official American Thoracic Society and European Respiratory Society Technical Statement. *American Journal of Respiratory and Critical Care Medicine* Volume 200 Number 8|October 15 2019
14. Jones P., Quirk F., Baveystock C. (2008): A self-completed measure for chronic airflow limitation: The St. George's Respiratory Questionnaire. *Am Rev Respir Dis.* ;145(6):1321-7.
15. Pasipanodya JG, Miller TL, Vecino M, et al. Using the St. George respiratory questionnaire to ascertain health quality in persons with treated pulmonary tuberculosis. *Chest* 2007;132(5):1591-8.
16. Metwally M. M., (2004): "Validity and reliability of the first Arabic version of St. George's respiratory questionnaire after adaptation to a completely different language and culture". *Eur Respir J*, 24:Suppl. 48,142s.
17. Spruit M, Singh S, Garvey C, et al; ATS/ERS Task Force on Pulmonary Rehabilitation. ATS/ERS task force on pulmonary rehabilitation. An official American Thoracic Society/European Respiratory Society statement: key concepts and advances in pulmonary rehabilitation. *Am J Respir Crit Care Med*. 2013;188(8):e13–e64
18. Jones R, Kirenga BJ, Katagira W, Singh SJ, Pooler J, Okwera A, Kasiita R, Enki DG, Creanor S, Barton A. A pre-post intervention study of pulmonary rehabilitation for adults with post-tuberculosis lung disease in Uganda. *Int J Chron Obstruct Pulmon Dis*. 2017;12:3533-3539
19. Marrara KT, Marino DM, De Held PA, et al; Different physical therapy interventions on daily physical activities in chronic obstructive pulmonary disease. *Respiratory Medicine* (2008)102, 505–511.
20. Huang C, Yang G, Wu Y, et al. Comparison of inspiratory muscle strength training effects between older subjects with and without chronic obstructive pulmonary disease. *J Formos Med Assoc*. 2011;110(8):518–26.
21. Charususin N, Gosselink R, Decramer M, McConnell A, et al. Inspiratory muscle training protocol for patients with chronic obstructive pulmonary disease (IMTCO study): a multicenter randomized controlled trial. *BMJ Open Access* 2013; 3 (8): e003101.
22. StataCorp. 2014. Stata Statistical Software: Release 14. College Station, TX: StataCorp LP.

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23. Nogas A, Grygus I, Nagorna O. Results of the physical rehabilitation of patients with pulmonary tuberculosis. *Journal of Physical Education and Sport*, 2019;19(1), Art 98: 684–690.
24. Singh SK, Naaraayan A, Acharya P. Pulmonary rehabilitation in patients with chronic lung impairment from pulmonary tuberculosis. *Cureus*. 2018;10(11): e3664.
25. Vogiatzis I. and Zakynthinos S. The physiological basis of rehabilitation in chronic heart and lung disease. *J Appl Physiol* 115: 16–21, 2013
26. Bulent Kayahan, Hale Karapolat, Ender Atýntoprak, Alev Atasever, Özgür Öztürk, Psychological outcomes of an outpatient pulmonary rehabilitation program in patients with chronic obstructive pulmonary disease, *Respiratory Medicine*, Volume 100, Issue 6, 2006.
27. Beaumont M, Forget P, Couturaud F, Reyckler G. Effects of inspiratory muscle training in COPD patients: A systematic review and meta-analysis. *Clin Respir J*. 2018 Jul;12(7):2178-2188. doi: 10.1111/crj.12905. Epub 2018 May 23.
28. Gosselink R, De Vos J, van den Heuvel SP, Segers J, Decramer M, Kwakkel G. Impact of inspiratory muscle training in patients with COPD: what is the evidence? *Eur Respir J*. 2011 Feb;37(2):416-25.
29. Mahler B, Croitoru1 A., Pulmonary rehabilitation and tuberculosis: a new approach for an old disease. *General Review* • DOI: 10.2478/pneum-2019-0024 • 68 • 2019 • 107-113
30. Paton NI, Chua Y-K, Earnest A, Chee CB: Randomized controlled trial of nutritional supplementation in patients with newly diagnosed tuberculosis and wasting. *Am J Clin Nutr*. 2004, 80:460-465
31. Yoshida N, Yoshiyama T, Asai E, Komatsu Y, Sugiyama Y, Mineta Y: Exercise training for the improvement of exercise performance of patients with pulmonary tuberculosis sequelae. *Intern Med*. 2006, 45:399-403. 10.2169/internalmedicine.45.1505
32. Hall M, De Charmoy S. Exercise capacity in pulmonary tuberculosis. *S Afr J Physiother* 2002;58:9-14