ORIGINAL ARTICLE

The Effect of Treadmill Aerobic Exercise on Walking Distance, Lung Function and Quality of Life in Tuberculosis Patients

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ABSTRACT

Objective: To observe the effect of treadmill aerobic exercise on walking distance, lung function and QoL in lung tuberculosis patients.

Methods: It was an interventional study using controlled random sampling with pre- and post- intervention observation. The study took place at Hasan Sadikin Hospital, Bandung. Subjects were post-category II-medication pulmonary TB patients with negative AFB conversion, males and females aged 18-60 years, normal BMI (according to Indonesian Ministry of Health 2003), able to comprehend spoken, written and signed instructions (mini mental state examination - MMSE 22-30), able to undergo a six-minutes walking test (6MWT), cooperative and willing to participate in the study. This study analyzed data from 30 subjects divided into two groups (interventional vs control group, each 15 subjects). Control group was given educational program, breathing techniques and chest- expansion exercises to do at home for 6 weeks (3 times a week), whereas the study group received additional aerobic exercise for 6 weeks (walking on a treadmill, 3 times a week, 30-60 minutes per session) with the intensity of 80% of the speed determined from the result of the 6MWT. Pre- and post- six weeks, walking distance (6MWT), lung function and St. George's Respiratory Questionnaire (SGRQ) evaluation were obtained from subjects.

Results: Walking distance of interventional group (mean 75.53 m, $p<0.05$) increased significantly after 6 weeks. There were also significant difference between two groups in the SGRQ components except for symptoms. Lung functions as shown on FVC and FEV1 increased significantly in interventional group. However, this increase was not confirmed by the change of breathing impairment pattern.

Conclusion: The significant difference between the study and the control groups showed that aerobic exercise using treadmill gives better improvement on the quality of life. This fact demonstrates that exercise program in pulmonary rehabilitation remains the core program to increase functional capacity and quality of life.

Keywords: *lung tuberculosis, aerobic exercise, treadmill, walking distance, quality of life, SGRQ*

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INTRODUCTION

Indonesia is currently ranked fifth worldwide among nations with the highest level of tuberculosis incidence. All cases of pulmonary TB is estimated at 660.000 and the incidence is estimated at 430.000 new cases per year. Despite

the high level of pulmonary TB burden, Indonesia is the first to be recognized as the country that has reached the global target of pulmonary TB case detection and successful medication in 2006, amongst other High Burden Country (HBC) in WHO South-East Asia region. Record shows that in 2009, 294,732 cases of pulmonary TB were detected and succesfully treated, with more than 169,213 cases Acid-Fast Bacillus (AFB) positive. The average accomplishment of treatment success rate in the last 4 years reaches 90% and from a cohort study in 2008 it reaches 91%. Attaining this global target becomes the main pillar of accomplishment for the national pulmonary TB control program.[1]

Pulmonary TB is a chronic Mycobacterium Tuberculosis infectious disease that damages the lung parenchyma causes local and systemic symptoms. Management of this disease is conducted for a long period of time with combination of drugs.[2] Chung et al. (2010) showed that there were histopathologic changes after fibrosis, bronchiectasis and bronchial stenosis treatment which tend to deteriorate lung function.[3] Another research by Pasipanodya et al. (2007) found that changes of lung function post pulmonary TB treatment consisted of 24% restriction, 23% obstruction and 19% of mixed disorder.[4] Several earlier studies also presented lung function changes before, during, and post treatment, with 48.7-76% of patients retaining abnormality in lung function at the end of medication regiment. This abnormality is presumed to be caused by the chronic process in the lungs and is indicated as chronic breathing disorder which lessen patient's quality of life.[3,4] Furthermore, this breathing disorder may also decrease exercise tolerance or exercise capacity as in the case of Chronic Obstructive Pulmonary Disease (COPD).[5]

According to the American Thoracic Society (ATS, 1999) and European Respiratory Society (ERS, 1997), pulmonary rehabilitation has accumulated many evidences to support success in treating chronic pulmonary disease by reducing shortness of breath, increasing exercise tolerance and health-related Quality of Life (QoL). At the moment, COPD is the main contributor to the number of patients managed with pulmonary rehabilitation. Hence, pulmonary rehabilitation can be applied to all patients with respiratory disorders who suffer from decreased functional capacity or QoL.[6]

Exercise is the basic of pulmonary rehabilitation and the best modality in increasing muscle function in COPD and other lung diseases.[6,7] Meanwhile, reports are scarce regarding the effects of exercise on lung function of pulmonary TB patients.[8] Pasipanodya et al. (2007) studied the effects of pulmonary rehabilitation on pulmonary TB patients who had completed their TB-treatment, and found increased exercise capacity and QoL. Nonetheless, a consensus for pulmonary rehabilitation for TB cases has not yet been established.[4,9]

Exercise in pulmonary rehabilitation is genuinely aerobic, and the most common method used is walking on a treadmill. Walking exercise is preferred because it resembles daily activities which patients generally find easy to do.[10]

The use of 6MWT in pulmonary TB has been observed in several studies such as by Adedoyin et al. and Ando et al. showing that the 6MWT could be used as an indicator for the development of functional capacity.[5] Most daily activities are considered sub-maximal activities, which makes the 6MWT a better option among other tests, especially since it has been proven a reliable, objective, cost-effective and easely executed test.[10-13]

The influence of respiratory diseases on QoL is related to health and well-being can be measured using the St George's Respiratory Questionnaire (SGRQ). It has been confirmed to be valid and responsive in measuring QoL of pulmonary TB patients as shown in a study by Pasipanodya.[9,10,14] Aerobic treadmill exercise is used in this study to evaluate any changes on walking distance, lung function and QoL in pulmonary TB patients.

METHODS

This interventional study used controlled random sampling and pre- and post- intervention observation. This study was conducted in Hasan Sadikin Hospital, Bandung, Indonesia, in October 2012 until January 2013. Subjects are post-category II-medication pulmonary TB patients with negative AFB conversion,

male and female aged 18-60 years, normal BMI (according to Indonesian Ministry of Health 2003), able to comprehend spoken, written and signed instructions (mini mental state examination - MMSE 22-30), able to undergo a 6MWT, are cooperative and willing to participate in the study, as shown by signing the informed consent.

Exclusion criteria were history of diabetes mellitus, heart failure, less than 90% oxygen saturation, haemoptysis with hemodynamic disorder or neuromusculoskeletal disorder that restricts patients from doing the exercise procedures.

All pulmonary TB patients who fulfilled inclusion and exclusion criteria, and who underwent physical examination were informed and asked to sign the informed consent. Subjects were randomly divided into two groups; study and control groups. All subjects were required to fill out the SGRQ QoL form and perform the 6MWT for the distance score. Pulmonary function was measured using a spirometer operated by a trained handler. Statistical calculation indicated a minimum sample of 15 subjects in each group.

Control group is rolled on educational program, breathing techniques and chest-expansion exercises to do at home for 6 weeks (3 times a week), whereas the study group received an additional aerobic exercise for 6 weeks (walking on a treadmill, 3 times a week, 30-60 minutes per session) with the intensity of 80% of the speed determined from the result of the 6MWT. Before and after each session, subjects' vital signs, oxygen saturation and perceived exertion with the Borg scale were measured and recorded. Subjects did stretching exercises before and after exercies on treadmill. After the six-week (18 sessions) exercise program, every subject was reevaluated to obtain their QoL score using the SGRQ, their walking distance using the 6MWT, and their pulmonary function using spirometer. Finally, the scores before and after the program were compared and analysed.

Data was analyzed using SPSS program, with Shapiro-Wilk distribution test involving paired t-test for subjects with normal distribution data (compared to its average differences), or the Wilcoxon test for subjects with abnormal distribution data.

This study obtained ethical clearance from the Medical Research Ethical Committee of Hasan Sadikin Hospital, Bandung, Indonesia.

RESULTS

Characteristics of the subjects were homogenous (Table 1) except in FEV1/FVC ratio and Dist.1.

Table 1. Characteristics of Subjects

Variables	A (n=15)		B (n=15)		p value
	Mean (SD)	Median	Mean (SD)	Median	
Age (y.o)	37.20 (8.87)	(25-58)	36.07 (11.02)	(23-50)	0.66**
BMI	18.69 (0.88)	(17.6-20.7)	19.36 (2.27)	(17.6-27)	0.41**
Duration of Med	6.93 (1.16)	(5-9)	7.53 (1.06)	(6-9)	0.19**
FEV 1	66.06 (18.72)	(24-81)	66.85 (17.92)	(32-93)	0.98**
FVC	59.13 (15.72)	(24-75)	61.28 (16.55)	(28-89)	0.72*
FEV1/ FVC	83.37 (6.90)	(66.2-94.7)	90.67 (5.73)	(84.3-99.3)	0.00†
Dist 1	335.86 (45.03)		411.26 (45.64)		0.00†
Total 1	1428.32 (442.96)	(728.9-2059.1)	1475.35 (49.10)	(740-2552.4)	0.78*
Symp. 1	275.76 (80.82)	(134.5-410.3)	266.40 (152.18)	(29.3-522.4)	0.83*
Act. 1	491.49 (206.30)	(281.7-1056.5)	531.69 (214.36)	(206.2-819.3)	0.60*
Imp. 1	661.12 (287.47)	(300.1-1159.9)	677.27 (252.14)	(237.4-1273.6)	0.87*

Note: BMI:body mass index; FEV 1: forced expiratory volume in one second; FVC: forced vital capacity; Dist.1: pre intervention distance from 6MWT; Total 1: pre-score of total component of SGRQ; Symp.1: pre-score of symptoms component of SGRQ; Act.1: pre-score of activity component of SGRQ; Imp.1: pre-score of impact component of SGRQ; Independent t-test; ** Mann-Whitney; †significant ($p \leq 0.05$)

After 6 weeks of intervention, 6MWT distances were found to have significantly increase in group B (p 0.00, p < 0.05) (Table 2).

Table 2. Differences of Pre and Post Intervention 6MWT Distance

Variables	A	B	p value
	Rerata (SD)	Rerata (SD)	
Dist 1	335.86 (45.03)	411.27 (45.64)	0.00*†
Dist 1	358.66 (45.68)	486.8 (41.98)	0.00*†
Distance Diff.	22.8	75.53	0.00**†

Note: Dist.2: post intervention distance from 6MWT, Diff: differences; *Independendent t-test; ** Mann-Whitney; † significant (p≤0.05)

Other variables from SGRQ also resulted in significant differences (Table 3) throughout all of the components in group B.

Table 3. Differences in Pre and Post Intervention in Quality of Life (SGRQ)

Variables	A			B (n=15)		
	Mean (SD)	Range	p value	Mean (SD)	Range	p value
Total 1	1428.33 (442.33)	728.9 - 2059.1		1475.35 (499.11)	740 - 2552.4	
Total 2	1224.85 (408.68)	457 - 1765.7	0.01†	876.81 (394.66)	268.9 - 1941.5	0.00†
Symp. 1	275.76 (80.83)	134.5 - 410.3		266.41 (152.19)	29.3 - 522.4	
Symp. 2	249.83 (130.25)	29.3 - 584.6	0.24	157.81 (126.29)	15.4 - 405.3	0.00†
Act. 1	491.49 (206.3)	281.7 - 1056.5		531.69 (214.37)	206.2 - 819.3	
Act. 2	420.71 (171.27)	210.2 - 718.9	0.03†	311.75 (201.78)	0 - 879.5	0.00†
Imp. 1	661.13 (287.47)	300.1 - 1159.9		677.27 (252.14)	237.4 - 1273.6	
Imp. 1	560.97 (259.72)	217 - 983.1	0.01†	407.5 (155)	84 - 717.5	0.00†

Note: Total 2: post intervention score of total component of SGRQ; Act.2: post score of activity component of SGRQ; Imp.2: post score of impact component of SGR

Activity and components' effects showed significant differences in group A. Comparison between group A and B in SGRQ results showed significancy in total sum, activity and effects, but not in symptoms (p 0.15) (Table 4).

Table 4. Differences of SGRQ Components After 6 Weeks

Variables	A		B		p value
	Mean	SD	Mean	SD	
Total Diff	203.48	292.36	598.54	402.52	0.00†
Symp. Diff	0.13	0.35	0	0	0.15
Act. Diff	70.78	119.55	219.94	165.18	0.00†
Imp. Diff	100.16	142.45	269.77	198.14	0.00†

Note: Symp: symptoms component; Act: Activity component; Inpact component; † significant (p≤0.05)

In both groups, spirometry results of pulmonary function after 6 weeks were found to be significant only in FVC and FEV1 values (Table 5). These spirometry results were then classified into types of lungs disorders.

Table 5. Lung Function Differences Before and After 6 Weeks

Variables	A		B	
	Mean (SD)	p value	Mean (SD)	p value
FVC pre	59.13 (15.73)		61.28 (16.56)	
FVC post	59.93 (16.04)	0.00* †	62.43 (16.89)	0.00* †
FEV1/ FVC pre	83.37 (6.91)		90.68 (5.73)	
FEV1/ FVC post	83.15 (7.88)	0.74*	90.81 (5.72)	0.09*
FEV1 pre	66.07 (18.72)		66.86 (17.92)	
FEV1 post	66.73 (18.58)	0.00**†	68.57 (18.54)	0.02**†

Note: • T-test; ** Wilcoxon Matched Pair Test; † significant ($p \leq 0.05$)

From Table 6, 93.33% of subjects in group A were included as restrictive type and 6.67% were mixed type. All subjects in group B were restrictive type.

Table 6. Lung Fuction Disorder Classification Before and After 6 Weeks

Lung Fuction Disorder Type	A (n=15)		B (n=14)	
	Before (%)	After 6 Weeks (%)	Before (%)	After 6 Weeks (%)
Restrictive	93.33	93.33	100	100
Obstructive	0	0	0	0
Mixed	6.67	6.67	0	0

DISCUSSION

Subjects in this study are patients with pulmonary TB under category II treatment who are already tested for AFB negative, which means they are no longer infectious after an average treatment duration of 6.93 months for the control group and 7.53 months for the study group. This study is different from previous studies which involved subjects who had finished receiving treatment. Involving patients in the middle of their treatment also ensures their adherence to finish their exercise sessions.

With the age parameter of 18 to 60 years, the average age of both groups stands around 36-37 years old. The IMT of the two groups averaged at 18-19. With these statistics, subjects are characterized as homogenous thus indicating that there are no significant differences between the two groups, except for the 6MWT distance prior to the exercises. The average of 6MWT distance score of the control group was 335.87 metres whereas the study group was 411.27 metres. This difference is believed due to subject variations, which is minimized by using simple random sampling into two groups. Statistically, there was no significant dissimilarity, but because of the contrasting 6MWT scores the researcher decided not to compare the start and end values of both groups, but the difference between the distance score prior and after the programmed six weeks was assessed.

The average distance on both groups was 373.57 metres in the early sessions, and is found to be shorter than the study by Adedoyin (491.88 metres) and by Di Naso (484.21

metres).[2,5] The last two studies were descriptive research without any evaluation on differences on walking distance.

Another research by Ando (2003) recorded an initial average walking distance of 342 metres based on 6MWT, with an average increase of 42 metres after treatment program. Yoshida (2006) recorded the average of initial walking distance was 399 metres and increased by 68 metres after the program. The outcome of this study showed longer distances both in the study group, increased by 75.53 metres, and 22.8 metres in the control group although the applied intensity was less than other previous studies. The author assumes that this result is influenced by higher frequency and duration of the study, and the researcher's direct supervision during the 18 sessions of exercise which ensured accuracy of the exercise.[7,8] The endurance exercise was delivered with a higher intensity, where subjects were given 80% of the maximum work load for 3 times a week as recommended by the American College of Sport Medicine (ACSM).[12]

In this study, both groups show a significant increase on the average walking distance. However, the study group showed significantly longer than the control group. As noted, aerobic exercise induces several physiologic responses in the cardiovascular and pulmonary systems, as well as the peripheral muscles. Aerobic exercise enhances the ability of peripheral muscles to take up and use oxygen which causes improvement in exercise tolerance, as is seen through the significant increase of walking distance after six weeks of aerobic exercise.

This study suggests that the category II pulmonary TB patients have lower pulmonary dysfunction, with their average VEP1, KVP, and KVP/VEP1 were 66.48%, 60.172%, and 86.9%. These scores are notably lower than scores recorded by Pasipanodya (2007) on subjects who finished their treatment in 20 weeks at the minimum, with the average VEP1, KVP, and KVP/VEP1 were 77.77%, 82.77%, and 76.07%. In a study conducted by Chung, post-treatment VEP1 and KVP scores in average were 77.5% and 87.94%, which are higher than, and 70.35% of VEP1/KVP which is lower than the scores of this current study. Whereas a study by Ando (2003) demonstrated lower average VEP1 and VEP1/KVP at 39.5% and 66.5% respectively.[3,7,9]

Study by Di Naso (2011) classified subjects into two groups: group 1 with standard amount of medication, and group 2 with higher amount of medication. Group 1 had higher KVP (72.06%) and VEP1/KVP (77.1%) than the author's study, while its VEP1 was slightly lower at 66.13%. Whilst group 2 of Di Naso study showed lower VEP1, KVP and VEP1/KVP at 33.08%, 43.58% and 61.75% respectively.[2]

The result of this study shows significant increases of VEP1 and KVP in both groups. There were no other studies evaluating the changes of lung function in pulmonary TB patients during treatment, therefore no comparation could be made. Al-Hajjaj (2002) states several factors affecting lung function in TB patients including the duration after completing medication. The longer the period of time after medication the better outcome is. It is because lungs parenchyme improves during medication and even after medication. Al-Hajjaj differs from Chung (2011) where the latter says that the function of lungs continue to deteriorate gradually up to 18 months after treatment, in which throughout the study, subjects were given only standard medication stated as less effective compared to the current standard medication consisting of 4 drugs. Chung additionally says that other factors also influence the deterioration of lung functions, such as AFB results, massive involvement of lung tissue, no improvement on radiologic morphology, prolonged medication period and a change of medication regiments. Furthermore, comorbid factors such as other chronic lung diseases, heart failure, auto-immune diseases and Human Immunocompromising Virus (HIV) can also contribute to the risk of deteriorating function of lungs. Whereas according to Pasipanodya (2007), lung function in pulmonary TB patient might get worse or better.[3,4,9,14]

The differences found between the author's study and Chung's are caused by plenty of factors affecting lung functions, which may result in varieties of changes in function of lungs. Several sources show that aerobic exercise has the ability to improve ventilation muscles thus modify lung function in a normal person.[3,13] The authors found a statistically significant increase

in lung function, which did not alter the pattern of respiratory disorder of the subject.

In pulmonary TB, changes in lung parenchyme will result in decreased lung function with varying mild to severe degree. This decrement affects daily activities and QoL, which are measured using the SGRQ. The SGRQ is a specific measurement tool made to evaluate the QoL of patients suffering from chronic lung disease, and to measure the level of disability of each individual. Pasipanodya (2007) has validated the SGRQ through its use on pulmonary TB patients, and has showed that it is a valid and reliable measurement tool. Pasipanodya also reported that cured patients suffer from a deteriorating QoL, which impacts the global health.[9] Troosters (2010) asserts that pulmonary rehabilitation using aerobic exercise as the core to increase exercise tolerance, skeletal muscle function, and functional capacity. Pulmonary rehabilitation increases health-related QoL, improves psychological state, decreases events of exacerbation and increases participation in daily activities.[15]

The QoL of control group measured through the SGRQ before and after 6 weeks in this study shows a significant increase in total, activity and impact components with 95% reliability, except in the component of symptoms. This improvement is assumed to have been due to the education and chest physiotherapy given even without aerobic exercises. This was also confirmed by Casciari who states breathing exercises and chest physiotherapy are important in increasing functional capacity.[16]

CONCLUSION

The significant difference between the study and control group shows that aerobic exercise using the treadmill gives better QoL improvement. This fact is used to demonstrate that the exercise program in pulmonary rehabilitation still takes place as the core program to increase functional capacity and QoL, as is concluded in this study.

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