EXERCISE CAPACITY IN PULMONARY TUBERCULOSIS

HALL M, BSc (Physiotherapy) (WITS)[1]; DE CHARMOY S, BSc (Physiotherapy) (UCT), MSc (Physiotherapy) (Wits)[2]

[1] MSc (Physiotherapy) student at Wits.
[2] Physiotherapy Department, Ibn Al-Nafees Hospital, Manama, Bahrain

ABSTRACT: ***Aims:*** *To determine the exercise capacity of patients suffering from pulmonary tuberculosis infection and then compare this value to the normal. To determine if the regression equation for TB is comparable to that of patients with chronic obstructive pulmonary disease (COPD). To provide guidelines for clinical practice of physiotherapy should exercise capacity be found to be reduced.*

Methods: *Thirteen black, male subjects between the ages of 19 and 35 years were included in the study. Each subject completed the shuttle walking test in order to determine his VO_2peak. This was then compared to historical data for VO_2peak. A subgroup of five subjects took part in a treadmill test to calculate a regression equation for VO_2peak for TB patients.*

Results: *Exercise capacity, measured as VO_2peak, is reduced by an average of 57% when compared to the normal. The mean (SD) VO_2peak for this group of thirteen patients is 19.09 (8.19)ml/kg/min. The shuttle walking test is a valid and reliable test to determine the VO_2peak of patients with pulmonary tuberculosis. Although a trend is evident the regression equation for pulmonary TB is based on a small sample size.*

Conclusion: *Although the exercise capacity of patients with PTB is markedly reduced it does not seem to impact on their function. Based on the above results, a preliminary recommendation is that a pulmonary rehabilitation program is not necessary for patients with pulmonary tuberculosis. Although not originally an aim of the study it is also evident that the role of the physiotherapist with respect to pulmonary tuberculosis may be one of education.*

KEY WORDS: PULMONARY TUBERCULOSIS, EXERCISE CAPACITY, SHUTTLE WALKING TEST, VO_2PEAK, BORG DYSPNOEA SCALE

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INTRODUCTION

Pulmonary tuberculosis (PTB) is an infection, which causes widespread pulmonary fibrosis and cavitation, and often leaves the patient with a chronic respiratory deficit as a result. This disease often makes the largest impact on the poorest communities where poor sanitation, overcrowding and inadequate access to health care is commonplace. The spread and effects of pulmonary TB are further worsened by the rampant spread of the human immunodeficiency virus (HIV). HIV suppresses the immune system and makes its host more susceptible to opportunistic infections, of which PTB is the most common and most infectious complication (Raviglione et al, 1992; Eriki et al, 1991).

It is estimated that between the years 2000 and 2020 nearly one billion people will be newly infected and 35 million people will die unless the fight against TB is strengthened (WHO online-tuberculosis fact sheet). Statistics from the South African Department of Health report the incidence of pulmonary tuberculosis at 275/100 000 for the year 2000 for South Africa. It is further estimated that at least 50% of these cases are HIV positive (South African Department of Health 2002).

Pulmonary tuberculosis leaves the patient with a chronic respiratory limitation, which often presents as an obstructive lung dysfunction. However in some individuals, there appears to be a mixture of both an obstructive and restrictive component to the respiratory insufficiency (Hnizdo et al 2000; Willcox and Ferguson, 1989). In respiratory conditions, for example Chronic Obstructive Pulmonary Disease (COPD), patients are left with a poor exercise capacity, as measured by maximal/peak oxygen uptake (VO_2peak) (Dyer et al, 2002; Singh et al, 1994 and 1992). This poor exercise capacity, and in some instances the inability to perform simple activities of daily living, may have a profound impact on the quality of life of these patients.

The aims of this study are to determine the exercise capacity of patients with pulmonary tuberculosis and compare this to the normal value, to determine a regression equation for

CORRESPONDENCE TO:
M Hall
210 Linksview Court
15 Corlett Drive
Illovo 2196
Tel: (011) 803-2227 (w)
(011) 788-7949 (h)

exercise capacity and compare this to that of COPD. Should exercise capacity is found to be altered, to suggest guidelines for clinical practice for physiotherapy in the treatment of PTB.

It is common practice that exercise prescription forms the basis of a management programme for patients with chronic respiratory disease (Dyer et al, 2002). Should exercise capacity be found to be reduced in patients with pulmonary tuberculosis the results of this study would imply that new treatment options might need to be considered, such as the inclusion of the patient in a pulmonary rehabilitation program.

The shuttle walking test (SWT) has been proven to be a safe, reliable and easy to administer field exercise test which allows for the calculation of a predicted maximal/peak oxygen uptake (VO_2peak). It is an incremental, progressive test which stresses the individual to a symptom limited maximal performance (Singh et al, 1992), and it has been proven effective as an exercise test for a variety of conditions such as COPD and cardiac failure. Results from the shuttle walking test have also been found comparable with those of a maximal treadmill test (Singh et al, 1994).

METHODOLOGY

Ethical clearance for this study was granted by the Committee for Research on Human Subjects (Medical) of the University of the Witwatersrand.

The study involved a single investigation of a group of adult patients with a history of pulmonary tuberculosis. The study comprised two parts, firstly a group of thirteen patients completed two separate tests of the shuttle walking test. The second experiment involved a subgroup of five of the patients already tested on the shuttle walking test who completed a symptom limited exercise test on a treadmill in order to establish their VO_2peak. The results of distance and VO_2peak for both the treadmill and shuttle walking tests for the subgroup were compared and a regression equation was calculated. This regression enabled a calculated, predicted value for VO_2peak to be obtained for the remaining eight patients. This value was then compared to normative data for VO_2peak of black, South African males (Wyndham et al, 1966), and from these values the extent to which exercise capacity is reduced in patients with PTB was determined.

All black, male patients with pulmonary tuberculosis (diagnosed by two sputum samples and chest X-ray analysis) between the ages of 19 and 35 years who gave informed consent were included in the study. Patients were receiving treatment either at Charles Hurwitz (Santa) TB hospital in Soweto or at the Community health centre (CHC) in Hillbrow. Patients had been on treatment for a minimum of two weeks and were considered stable by medical staff at the institutions. Patients with a temperature greater than 38ºC, multi-drug resistant TB, or any other condition that may influence exercise capacity were excluded from the study.

Optimally a control group should be used in a study of this nature, however due to the prevalence of HIV a normal control group, non-HIV infected, could not be guaranteed. There were also numerous ethical issues involved in obtaining HIV tests for patients comprising the normal group. For these reasons a normal group was not tested and rather historical normative data was used

TESTING PROCEDURE

Experiment 1.

Prior to testing, each patient was interviewed and a brief medical and surgical history taken as well as consultation with their medical records. Thereafter each patient was weighed (kg) and their height (m) was recorded before baseline data for heart rate (HR) (Polar heart rate monitor), blood pressure (BP) (Critikon Dynamap 8100), arterial oxygen saturation (SpO_2) (Nellcor pulse oximeter N200E), Borg rating of breathlessness (Burdon et al, 1982) was taken in sitting. Heart rate was taken three times over the course of one minute and the mean value obtained. A lung function test (using a Schiller Spirovit SP-1 pulmonary function workstation) was performed on each patient in a seated position before and 5 minutes after the initial shuttle walking test in order to determine FEV_1, FVC and PEFR. Lung function tests were performed according to American Thoracic Society (ATS) standards and the best of three tests was used.

The shuttle walking test was carried out as per the guidelines set out in the test manual (Singh et al, 1994). Each patient was required to walk up and down a ten meter course in time with an audio signal on a cassette. The number of shuttles that the subject needed to complete in each minute was set by the cassette and increased by one shuttle each minute. If the subject finished a shuttle before the audio beep was heard he was instructed to wait for the signal before setting out on the next shuttle. Should the subject not complete a shuttle in time he was instructed to speed up. If he did not complete the shuttle in time twice inn a row, the test was terminated. All shuttle walking tests were carried out by the researcher and the same procedure was followed each time.

Immediately after testing data for HR, BP, Borg rating of breathlessness and SpO_2 were recorded. Also noted was the time taken for dyspnoea and heart rate to return to baseline levels (recovery time). Five minutes after cessation of the shuttle walking test, post-exercise lung function values were obtained, using the same procedures as before.

Experiment 2

A subset of five patients volunteered to participate in the treadmill test. The volunteers were tested between one and twelve days after having performed the shuttle walking test. The symptom-limited treadmill test was explained in detail to each patient prior to commencement of the test. The subjects were asked to walk on the treadmill (Powerjog EG10, England) until the point of maximal exertion. The subjects, already familiar with the Borg dyspnoea index, were asked to give values for breathlessness at the end of each minute.

The treadmill tests were carried out by the researcher and a nursing sister (in the department of Physiology of the University of the Witwatersrand) usually responsible for exercise testing. The protocol followed was the same as that for patients with chronic fatigue syndrome used by the exercise laboratory of the Department of Physiology, University of the Witwatersrand. The protocol is outlined on the next page.

Chronic Fatigue Syndrome protocol

No.	Time (minutes)	Speed (Km/h)	Gradient (%)
1	0-2	3.2	0
2	2-4	3.2	3
3	4-6	3.2	6
4	6-8	3.2	9
5	8-10	3.2	12
6	10-12	3.2	15
7	12-14	3.2	18
8	14-16	3.2	21
9	16-18	4.8	21
10	18-20	6.4	21
11	20-22	8.0	21

(Km/h - Kilometres per hour)

Table 1: Mean (SD) lung function parameters: FVC, FEV_1, FEV_1/FVC and PEFR with predicted values for all thirteen subjects.

	Pre	Post	Predicted value	p
FVC (l)	3.33(0.96)	3.37(0.89)	4.43	0.62
FEV_1 (l)	2.85(0.89)	2.92(0.84)	3.68	0.46
FEV_1/FVC(%)	85.9(10.2)	86.5(8.5)	>80	0.88
PEFR (l/sec)	7.15(2.91)	7.26(2.83)	9.28	0.68

(Pre- pre-exercise measurement; Post-post-exercise measurement)

Table 2: Values for subset for distance and VO_2 peak.

	N	Mean and SD	Min	Max
Distance (m)	5	622.00 +/- 47.11	540.00	660.00
VO_2 peak (ml/kg/min)	5	24.64 +/- 3.90	19.20	28.90

The oxygen consumption was directly determined using the Oxycon OX-4 (Mijnhardt, Holland) and readings for amongst others, minute ventilation (V_E), VO_2 and respiratory quotient were recorded every 30 seconds and printed out.

STATISTICAL ANALYSIS

Through consultation with the statistician from the Medical Research Council, and the use of the Statgraphics computer program a sample size of four patients was required to show a statistically significant difference in exercise capacity. This was done using a 95% confidence interval and a 90% power.

Results were statistically analysed using the Statistix package for Windows. As there was a small sample size with non-parametric data, the Wilcoxon signed rank - and the Pearson correlation tests were used to compare the results.

A simple linear regression was used to calculate an equation for the relationship between distance and VO_2peak.

Results were deemed significant if the "p-value" was less than 0.05, and correlations were deemed strong if the "r-value" was greater than 0.80. An "r-value" of greater than 0.70 was considered to be moderately strong.

RESULTS

Physical Characteristics

Eighteen subjects volunteered to participate in this study however five were excluded due to age(1), language difficulties(1) and an HIV-related polyneuropathy(3). Thirteen black, male subjects the youngest of whom was 21 years and the eldest 35 years (mean 28.77 +/- 4.71 years) were included in the study and all thirteen completed the shuttle walking test (SWT). The mean (SD) time, in weeks, from diagnosis and commencement of treatment till the time of the test was 9.96 (8.26) weeks. The mean (SD) height, weight and body mass index are as follows: 58.09 (8.18)kg, 1.72 (0.07)m and 19.57 (1.94) kg/m2.

A subset of five patients who completed the SWT also completed an incremental treadmill test. Mean (SD) values for the physical characteristics of these five men with respect to age, weight, height and BMI were 30.20 (3.19) years, 60.40 (10.53)kg, 1.71 (0.09)m and 20.50 (1.96)kg/m^2 respectively.

Lung Function

Lung function tests were performed on each patient before and after the first SWT. Measurements for FVC, FEV_1 and PEFR were recorded and the mean (SD) for each variable before and after the SWT are shown in table 1.

Relationship between distance walked in the shuttle walking test and directly measured VO_2peak for the subset of five subjects.

Table 2 shows values obtained for distance completed during the shuttle walking test and directly measured VO_2peak on the treadmill test for the subset of five patients.

The relationship between distance walked on the SWT and the treadmill test was moderately strong when using the Pearson correlation test (r=0.77 and p=0.06).

Graph 1 shows the regression equation obtained from the directly measured VO_2peak and distance achieved in the shuttle walking test.
(See graph 1 on the next page)

Using the regression plot from Graph 1 above an indirect VO_2peak can be calculated for the remaining eight

Graph 1. Simple regression plot with 95% confidence intervals for directly measured VO_2 peak (ml/kg/min) and distance (m) achieved in the shuttle walking test.

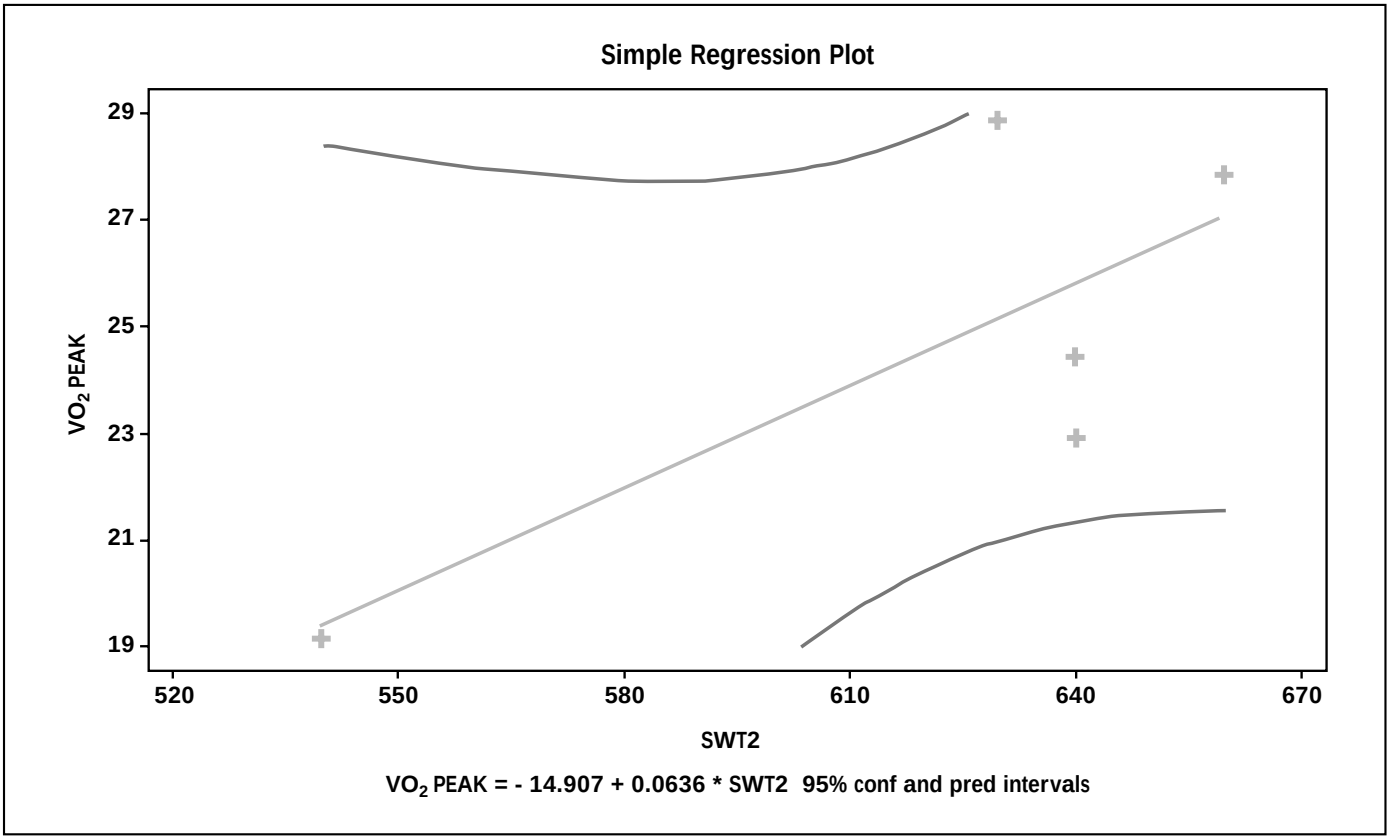

Table 3: Mean, SD, minimum value and maximum value for distance and VO_2 peak for all subjects.

	N	Mean and SD	Min	Max
Distance (m)	13	534.62 +/-126.86	260.00	660.00
VO_2 peak (ml/kg/min)	13	19.09 +/- 8.19	1.64	28.9

subjects who completed the SWT only. Table 3 shows values obtained for VO_2peak and distance for all 13 subjects. Values for mean, SD, minimum value and maximum value are also shown.

Comparison of calculated predicted VO_2peak to normal data

Values obtained from the regression equation for VO_2max were compared to the normal values (Wyndham et al, 1966) for VO_2peak using a one sample T-test. The normal value for VO_2peak is given as 44.6ml/kg/min with upper and lower 95% confidence intervals of 45.5 and 43.7ml/kg/min respectively. As reported earlier mean VO_2peak for this study is given as 19.1ml/kg/min. When compared with the norm, the result was highly significant with $p < 0.01$. Upper and lower 95% confidence intervals were given as -18.96 and -28.86ml/kg/min respectively.

Reproducibility of the shuttle walking test.

The distance walked during both the first and second shuttle walking test ranged from 250m to 660m. There was no significant difference between SWT1 and SWT2 ($p < 0.01$) and the relationship between the two trials was strong ($r = 0.96$). This therefore shows, that the shuttle walking test is a reproducible test.

Relationship between pulmonary function and performance on the shuttle walking test.

A Pearson correlation test showed that pulmonary function, taken as FEV1, and distance completed in the SWT (Singh et al, 1994), was not significantly related ($r = 0.45$, $p<0.01$).

DISCUSSION

The aim of this study was to determine the exercise capacity of patients currently on treatment for pulmonary tuberculosis, using the shuttle walking test. From these results recommendations can be made with regard the treatment and if necessary pulmonary rehabilitation of patients with pulmonary tuberculosis.

Maximal/peak oxygen uptake (VO_2peak) is considered to be the reference measurement of exercise capacity (Singh et al, 1994). The results of this study show that as a result of pulmonary tuberculosis the exercise capacity of these subjects is reduced. When compared to the normal value for VO_2peak, the results from this study are markedly reduced, by an average of 26ml/kg/min. Statistically, this reduction in exercise capacity is highly significant ($p< 0.01$) however, is this reduction clinically significant?

When one considers exercise capacity and VO_2peak, one would expect that at a maximum oxygen uptake the subject would be out of breath. This was not the case with the shuttle walking test. The majority of the subjects in this

study stopped the SWT because they were unable to maintain the speed necessary to continue the test. At this stage most of the subjects were not out of breath at all and a large number had a score of less than six on the Borg dyspnoea scale. This is comparable to the study of Singh et al (1992) where patients with COPD were tested using the shuttle walking test. This study found that the subjects with COPD were not out of breath on cessation of the shuttle walking test (Singh et al, 1992).

The mean VO_2peak for this study is 19.09ml/kg/min (range 1.64-28.90ml/kg/min). This mean value is only 43% of the given normal value (Wyndham et al, 1966). This value is comparable to the values achieved for the shuttle walking test used in other studies (Singh et al, 1992 and 1994). The study by Singh et al (1994), investigating patients with chronic obstructive pulmonary disease (COPD) found a mean VO_2peak of 10.1ml/kg/min for patients who completed the shuttle walking test. However this value is for patients with a mean (SD) age of 61(7) years with physical characteristics different to the characteristic of the patients who completed this study.

The distance covered on completion of the shuttle walking test appears to have a strong correlation with the directly measured VO_2max from the treadmill test (r=0.77). This finding is consistent with other studies in which the distance covered on the shuttle walking test has been compared to treadmill VO_2max tests. Singh et al (1994), in a study on patients with COPD, found a strong correlation between the SWT and the treadmill test (r = 0.88).

On comparison of the regression equation for this study (VO_2peak= 0.0636(distance) - 14.907) with that of the study by Singh et al, (1994) (VO_2peak= 0.025(distance) + 4.19), it is evident that although the equations appear different the values obtained for exercise capacity are not. When the distance completed in the shuttle walking test was substituted into each equation the values obtained for exercise capacity were not significantly different .

The forced expiratory volume in one second (FEV_1) has been considered a measure of pulmonary function (Singh et al, 1994). The relationship between FEV_1 and the distance that a patient is able to complete in the shuttle walking test is not strong at all (r = 0.45). As indicated by the literature this finding is expected and is consistent with the SWT studies on patients with chronic obstructive pulmonary disease (Singh et al, 1994 and 1992).

The patients in this study do not appear to be inhibited by their pulmonary function, and pulmonary function does not appear to be a good prognostic indicator of how well the patient will perform during the shuttle walking test. This being the case it is doubtful as to whether these patients require any form of pulmonary or exercise rehabilitation. The resultant decrease in VO_2peak may be attributed to a deconditioning process as a result of being sick and less active than before.

When looking at pulmonary function, those subjects with an FEV_1 value of less than 80% amount to 46% of the total (6/13). However it is not known in all patients how many previous episodes of PTB each patient had experienced previously. Hnizdo et al, (2000) found an increase in the degree of airway obstruction with more than one episode of PTB infection. Hnizdo et al, (2000) concluded that PTB can cause COPD and a similar conclusion can be drawn from this study although a much larger sample size would be necessary for conclusive results.

LIMITATIONS TO THE STUDY

There are certain limitations to this study which may impact on the validity of these results. The sample size used in this study, although large enough to show a statistically significant change in exercise capacity (the primary aim of this study) is too small to show significant changes in other parameters measured.

The study may be biased to a degree in that the subjects were volunteers and this was not a randomised controlled study. Although all participants met the inclusion and exclusion criteria, it is generally believed that volunteers are more enthusiastic than randomly picked subjects and therefore may try harder. They may also not feel as sickly and therefore more willing to participate. Although this may be the case, the results for the distance achieved in the shuttle walking test are variable and have a wide range of values (250m-660m). However due to the nature of the test and the equipment used in the measurement of parameters it is believed that objectivity has been maintained.

The use of historical data for normal value comparisons instead of a matched control may have an effect on the results. Obviously a control group, matched for race, age, weight and height would be optimal, however when using a control group one would need to discount any underlying disease states. In the South African population at present one cannot discount the prevalence of HIV in the general population; although it is believed that HIV may not necessarily cause any changes in exercise capacity, there is to my knowledge, no research to support this claim and it is for these reasons that a matched control group was not used.

As this study studied a selected group of patients from two institutions from around the same area these results cannot be extrapolated to all patients with PTB. These results are only applicable to those patients attending these institutions who fulfil the same criteria as those patients who participated in this study.

RECOMMENDATIONS FOR FUTURE RESEARCH

In order to obtain more accurate and reliable results a larger multi-centre study with a larger sample size is advised. Further-more the effects on exercise capacity, if any, as a result of HIV infection needs to be determined. New data needs to be collected for normal values of VO_2max for the current population, which takes into account factors prevalent today.

It may also prove to be interesting to divide the subjects into groups according to episodes of TB infection and determine at which point a handicap develops.

A questionnaire focussing on quality of life may show if there is a lifestyle impairment as a result of PTB infection. This aspect of the disease is at present unreported.

CONCLUSION

It is evident from these results that exercise capacity, expressed as VO_2peak, is indeed markedly reduced in this group of patients with pulmonary tuberculosis. Due to the nature of this study one is unable to say that all patients with pulmonary TB will have a reduced exercise capacity however it would seem likely. However, although VO_2peak is reduced, these patients do not appear to be unduly distressed by the demands placed on them in an exercise test, which may be compared to their activities of daily living. Due to the nature of the society in South Africa a large percentage of the population travel by means of taxis and by foot. It is not uncommon for people to have to walk distances of one kilometre in order to go to the shops or reach a taxi. The majority of the patients in this study, when asked, had no difficulty in performing these tasks. For this reason it does not appear necessary for the physiotherapist to be involved in the active treatment of patients with pulmonary tuberculosis regarding pulmonary rehabilitation. However, research on a larger sample size with respect to lung function and exercise capacity may provide more conclusive results.

The shuttle walking test appears to be an easy and reliable field test for the calculation of VO_2max in patients with PTB. The test, once purchased, is a cost effective, simple and easy to use field test, which could be distributed to health care institutions around the country and could be used to determine the exercise capacity of these patients as well as a other patients within our population such as diabetes and cardiac disease. Although this study did not set out to show it, it is evident that the role of the physiotherapist in the treatment of PTB may be one of education as part of a multidisciplinary medical team.

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