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ORIGINAL ARTICLE

THE EFFECTIVENESS OF POST ISOMETRIC RELAXATION TECHNIQUE IN RELATION WITH PULMONARY FUNCTION AND THE CHEST EXPANSION OF POST THORACIC SURGERY PATIENTS

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Abstract

Back ground and objectives: Post-thoracic surgery sessions are common among the patients and develops pulmonary complications such as atelectasis, retention of sputum, infections, pleural effusion, and most likely respiratory failure. After Post-thoracic surgery the patients may present with marked reduction in the chest expansion, and it may leads to reduction in the pulmonary function. This study aims to improve the chest expansion and pulmonary function by an intervention using selected physical exercise programme for thorax. **Methods:** 30 post-thoracic surgery patients selected for this study. The subjects in both groups received informative leaflet reinforcing the educational program. The experimental group had performed selected physical exercise program for thorax for 6 days after thoracic surgery with duration of 30 minutes ,twice a day along with breathing exercises. The control group had performed breathing exercise for 30 minutes and session for 6 days after thoracic surgery. The pre and post test assessment, which included chest expansion measurement and pulmonary function test values were noted. **Results:** Both groups have shown improvement after treatment .But when the score of the both groups compared to find out the effectiveness of experimental groups ,there was significant change in the group of additional of post Isometric relaxation technique over the control group on improving chest expansion and pulmonary functions. **Conclusion:** The study findings indicated that additional Post Isometric Relaxation technique to the patients helped to improve the chest expansion & pulmonary function. However before implementing on to clinical practice ,this results needs to be reviewed with few more detailed clinical trial.

Key Words: Post Isometric Relaxation, Chest Expansion Measurement, Forced Vital Capacity, Forced Expiratory Volume in 1 second.

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INTRODUCTION

Thoracic surgeries are opening the chest wall in order to access and repair the lungs, pleura, trachea, oesophagus, aorta, diaphragm and heartland it performed to diagnose or treat various of condition¹.

Post-operative pulmonary complications were identified by early as 1910 by Paster .Who thought it was due to the failure of respiratory power. But in 1914 Elliot and Dinger propose that post-operative lung collapse was the result of occlusion of the airway by mucus. Notwithstanding the subsequent advances in surgery and supportive medications. The morbidity resulting from post-operative pulmonary abnormalities remains as a significant problem².

Chest physiotherapy has a vital role in prevention as well as the treatment of post operative complications³⁸. Post-operative physiotherapeutic sessions aim to minimize the risk of infectious and non-infectious pulmonary complications the most common being atelectasis and pneumonia³.

Post-thoracic surgery patients, post operative incisional pain will affect the thoracic cage movements and rib cage movements, there will be a marked reduction in the shoulder girdle movements and this will affect the normal breathing pattern of the patient, the patient may present marked reduction in the chest expansion⁴.

In early studies, efficacy of manual therapy in reduction of pain in postero-lateral thoracotomy prove to be effective, and in other studies addition of manual therapy is rehabilitation program is recommended early Coronary Artery Bypass surgery^{5,6}.

Objectives

- To find out the effect of Post Isometric

Relaxation technique in pulmonary function and chest expansion.

- To find out the effect of breathing exercise techniques in chest expansion and pulmonary function.

- Compare the effect of Post Isometric Relaxation technique over breathing exercise in pulmonary function and chest expansion

Hyphothesis

Null hypothesis: There may be no significant improvement in chest expansion and pulmonary function of post-thoracic surgery patients following the application of post-isometric relaxation techniques.

METHODOLOGY

Population: Populations for the study were chosen from the patients referred to the researcher who were undergoing thoracic surgery, at the department of Cardio-thoracic surgery, Amala hospital, Thrissur.

Sample: Sample size was 30 and samples were selected by using simple random sampling.

The samples were post-thoracic surgery subjects with age group between 45-60 years.

Sampling: Sampling method chosen for this study was simple random sampling method. Those subjects who have fulfilled the inclusion criteria were equally divided for control and experimental group. Here 30 subjects were selected and 15 subjects each were equally allotted to experimental group and control group.

Research Design: Comparative in design with pre & post test for both control and experimental group.

Study setting: The study was conducted in the department of thoracic-surgery and in the department of pulmonology, Amala Hospital,

Thrissur, Kerala. After obtaining ethical clearance from the ethical committee.

Data Collection: 30 subjects undergone thoracic surgery were selected for the study. Those subjects were with the age group between 45 and 60 years. They were selected by simple random sampling method and divided into experimental and control group.

The data were collected before and after the treatment for both the groups. The pre score was obtained before the intervention applied to both the groups. The post score was obtained from the subject after the treatment sessions.

It was seen in the present study that of the 30 subjects studies were 15 (50.00%) in the experimental group and 15 (50.00%) in the control group. Of the 15 in the experimental group age (Mean 55.00 ± 4.39) and 15 in the control group age (Mean 53.16 ± 4.17).

Sex-wise distribution of present study is that, in 15 subjects in the control group is 12 male (80%) and 3 female (20%) and in the experimental group is 9 male (60%) and 6 female (40%) is distributed.

Inclusion Criteria

- subjects with Postero-lateral thoracotomy.
- Thoracotomy for all types of intra-thoracic lesions, except resection of lungs.
- Patients of both gender.
- Age group of 45 to 60.
- Consent subjects with their volunteered participation.
- Patient who are stable on the 4th day of surgery.

Exclusion Criteria

- Subjects with antero-lateral thoracotomy.
- Video assisted thoracoscopy (VATS).
- Unstable patients.
- Trauma to thorax including rib fracture.
- Chest wall surgery for chest wall deformity.

- Lung resection surgery including lobectomy.

Selected Measurement tool

Spirometry⁷.

Thoracic expansion measurement⁸.

Materials Used

Inch tape, Pulmonary function test (Spirometry), Stethoscope, Paper, Pencil, Couch, Pillow, Towel.

Out come Measurement

Chest expansion measurement.

Forced Vital Capacity (FVC).

Forced Expiratory volume in 1 sec (FEV1).

Procedure:

Data Collection Procedure

Referred Patients who were undergone thorocotomy were divided into 2 groups i.e. Group A (Control Group) & Group B (Experimental Group).The purpose and procedure of the study were explained to the patients family. Patient's assessment was taken by using cardio-pulmonary rehabilitation assessment (Appendix I) Each subject was asked to read and sign the consent form (Appendix II). Data needed for the study was taken in the 4th day of surgery and on the completion of the treatment session i.e. on the 9th day. The outcome measurements were taken as per the following procedure.

Assessment procedure

Chest Expansion: Inch tape was used for measuring the chest expansion and the recordings were taken in the centimetres (cm). During the Post-thoracic surgery sessions, on the 4th day chest expansion is measured and recorded for all the patients.

Patients were asked to sit on the couch. They were asked to have gentle breath to get relaxed and then to go for a complete exhalation and the diameter of the chest is measured.

By keeping the inch tape at the axillary level, the patient are asked to go for a deep inhalation, the value is noted. Both the values of exhalation and inhalation values are recorded. Continue the same procedure for measuring chest expansion at the level of nipple and xiphoid level.

After the treatment session on the 9th day the same protocol is repeated and the difference of exhalation and inhalation value are recorded. Differences in the chest expansion are statistically analyzed.

Pulmonary functions: The forced vital capacity(FVC) and forced Expiratory Volume at 1 second(FEV1)of the patients both group are taken on the 4th day then repeated on the 9th day, at the end of the treatment session. The result recordings are then statistically analyzed.

Control Group (Group A)

After thoracic surgery from 4th to 9th day the patient received diaphragmatic breathing exercise and pursed lip breathing exercise with coughing and lower Rom exercise. The exercise and self assisted breathing technique were demonstrated before administration.

Diaphragmatic Breathing: The subjects started the exercise in half-lying position and were asked to keep hand, over the abdomen below the anterior costal margin. The hand should rise during inspiration and fall during expiration. During inspiration the breathing was done slowly, Keeping the shoulder and upper chest relaxed allowing the abdomen to rise. The breathing out was by pursing the lips and let all the air let out slowly.

Pursed lip Breathing: The subjects were taught the self-assisted technique in half-lying position. they were asked to placed their hand over the abdomen below the anterior margin. During the inspiration ,breathing was done slowly, keeping the shoulders and upper chest relaxed allowing the abdomen to rise. The hand placed should rise during inspiration and fall during expiration. The breathing out was by pursing the lips and letting all air out slowly.

Experimental Group (Group B)

The experimental group, group B received all the post thoracic surgery physiotherapeutic management along with 4th day onwards, they were receiving post-isometric relaxation techniques.

The post operative physiotherapeutic management included breathing exercises and coughing techniques, general ROM exercises.

As they reached the 4th day of surgery they were trained with post-isometric relaxation technique of trained with post-isometric relaxation techniques of muscle energy technique. Along with all the general physiotherapeutic management, the patients were administered to post-isometric relaxation techniques for pectoralis major and pectoralis minor.

Dosage: All the patients of control group or group A were received diaphragmatic and pursed lip breathing exercise. The exercise was performed for 15 minutes each session for 6 days (4th to 9th day) which consist of 12 sessions. The group was advised to the exercise in 2 sessions. The whole 30 minutes of exercise were divided in to 15 minutes during the morning and 15 minutes in the evening. The session was divided in to 2, so as to avoid fatigue and hyperventilation of the subjects.

Post Isometric Relaxation Method ⁹.

1.The muscle is taken, without a force or bounce, to a length just short of pain, or to the point where resistance is first noted.

2.The patient gently contracts the affected muscle away from the barrier for between 5-10 seconds.

3.This resistance involves the operator holding the contracting muscle in a direction which would stretch it, where resistance not being affected.

4.The degree of effect in lewit's method is minimal. The patient may be instructed to think in terms of using only 10 -20% of his available strength, so that the maneuver is never allowed to develop into a contest of strength between the operator and the patients.

5.After the effect, the patient is asked to exhale and to let go completely and only when this is achieved is the muscle taken to a new barrier with no stretch to extend that the relaxation of the muscle will now allow.

6.Starting from this new barrier the procedure is repeated 2 or 3 times.

7.In order to facilitate the process, the patient to assist by looking with his eye in the direction of contraction, during contracting phase and the direction of stretch during the stretching phase of procedure.

Post isometric relaxation of pectoralis major:

The patients in supine lying with the head in neutral position. The patients are asked to abduct their arm to the maximum pain free range and as they reach the painful range, they were asked to contract the arm to adduction and resistance of equal force is applied to adduction and resistance of equal force is applied to the patients arm while

adduction, for 7 to 10 second. During this contraction phase, tell the patient to go for inhalation.

After the use of Isometric contraction for 7 -10 seconds, tell the patient to relax and to exhale. After 15 -30 seconds of latency period, the muscle can be taken to new resting length or stretched more to abduction, easily than would have been the case before contraction¹⁰.

The protocol was repeated according to the co-operation of the patient. (A minimum of 3-5 sessions twice a day).



Figure1 Post isometric relaxation of pectoralis major

Post isometric relaxation of pectoralis minor

Patients were in supine lying and they were asked to flex the arm in a preferably pain free range. As they reached the painful range, the patient were asked to contract their arm in such a way that their elbow should reach the sternum along with inhalation and the equal counter force is applied as the resistance for 7 – 10 seconds. After the contraction phase the patient is asked to relax himself and after 15-30 seconds again the contraction phase is repeated. The procedure is repeated according to the co-operation of the patient (A minimum 3-5 session twice a day).

Dosage: The patient of experimental group or Group B received physiotherapeutic

rehabilitation protocol twice a day. From 4th to 9th day, they were received post-isometric relaxation for pectoralis major and pectoralis minor twice a day



Figure 2 Post isometric relaxation of pectoralis minor.

Statistical Methods: The data collected in this study was analyzed statistically using version SPSS 11.0. The descriptive statistics viz., mean, SD, percentage have been computed. To arrive at the statistical inference the paired

t-test was used to examine the difference between the experimental and control group in case of age, sex, all the three CEM parameters, FVC and FEV1.

RESULTS

Demographical presentation of Age: The break up of samples in group A and B based on age distribution is given in Table 1.

Group	N	Mean	SD
A	15	53.16	4.17
B	15	55.00	4.39

Table 1 Age distribution in group A and B.

Demographical presentation of sex: The break up of samples based on sex distribution in group A and Group B is given in the table 2.

Group	Male	Female	% of Male	% of Female
A	12	3	80	20
B	9	6	60	40

Table 2 Age distribution in group A and B.

The CEM score was analyzed using paired t test (Table 3). It has revealed that in the experimental group, the Mean \pm SD of axillary measurement during pre-test was 1.600 ± 0.1254 , which has got increased in post

Study variables	Pre-test		Post-test		t-value	p-value
	Mean	SD	Mean	SD		
Axillary	1.600	0.1254	2.333	0.3830	7.72	<0.001
Nipple	3.293	0.1387	4.553	0.1959	19.29	<0.001
Xiphoid	5.880	0.3707	6.933	0.3519	38.48	<0.001

Table 3 Analysis of different study variable of CEM with in the experimental group during pre and post test using paired t-test

test to 2.33 ± 0.3830 . the calculated t value was 7.723. The statistical 'p' value was <0.001,

which shows there was a significant improvement in the axillary chest

measurement of the subjects after intervention.

The Mean \pm SD of nipple chest expansion measurement during the pre-test of experimental group was 3.293 ± 0.1387 , which has been increased in post-test to 4.553 ± 0.939 . Calculated t value was 19.296. The statistical p value was, 0.001, which shows there was a significant improvement in the nipple chest expansion measurement of the subjects after intervention.

In the xiphoid chest expansion measurement of the experimental group Mean \pm SD during the pre-test was 5.88 ± 0.3707 , which has been increased in post-test to 6.933 ± 0.3519 . The calculated t value was 38.483. The statistical p value was, 0.001, which shows there was a significant improvement in the Xiphoid chest expansion measurement of the subjects after intervention.

In the control group (Table 4) ,CEM was analyzed using paired t-test. It has revealed that in the control group the Mean \pm SD of

axillary chest measurement during the pre-test was 1.55 ± 0.1464 , which has got decreased in post-test to 1.33 ± 0.1464 . The calculated t value was 4.019. The statistical p value was, 0.001. This shows there was significant decrease in axillary chest measurement after intervention.

The control group mean \pm SD of nipple chest measurement during the pre-test was 3.380 ± 0.1521 , which has got decreased in post-test to 3.227 ± 0.1280 . The calculated t value was 2.448. The statistical p value was, 0.026. This shows there was significant decrease in nipple chest measurement after intervention.

The control group the Mean \pm SD of Xiphoid chest measurement during the pre-test was 5.720 ± 0.4127 , which has got decreased in post-test to 6.107 ± 0.4383 . The calculated t value was 2.046. The statistical p value was >0.06 . This shows there was significant decrease in nipple chest measurement after intervention.

Study variables	Pre-test		Post-test		t-value	p-value
	Mean	SD	Mean	SD		
Axillary	1.500	0.1464	1.300	0.1464	4.019	>0.06
Nipple	3.380	0.1521	3.227	0.1280	2.488	<0.026
Xiphoid	5.720	0.4127	6.107	0.4383	2.046	<0.001

Table 4 Analysis of different study variable of CEM with in the control group during pre and post test using paired t-test

Paired t test is used (Table 5) to analyze the response of control group (Group A) and Experimental Group (Group B) to the given treatment session i.e. the post-test value are analyzed with pre-test value.

Unpaired t test is used to compare the post test result of experimental group with control group and to analyze the effectiveness of given treatment.

The FVC score was analyzed by using paired t test .It has revealed that in the control group, the mean of FVC during the pre-test was 1.00, which has got an increase in 1.141 in post-test value, which means there is a significant difference in FVC after intervention.

The mean of FVC during pre-test of experimental group was 0.95, which has got an increase in 1.1410 in post-test value, which shows there is a significant difference in FVC after intervention.

Comparison of post-test value of FVC of experimental and control group Mean post-test value of FVC of group A is 1.41 and group

B is 1.41. Since calculated p value is >0.001 , which shows there is no significant difference between post-test value of FVC of group A and Group B.

Percentage of difference

The percentage of improvement in FVCs from the initial value of control group is 40.85% and the experimental group is 48.39%.

While comparing the difference in percentage of difference in the improvement of FVCs between group A and group B shows there is gain of 7.54% for group B at the end of treatment.

Study variables	Pre-test	Post-test	t-value	% increase	p-value
	Mean	Mean			
Control Group A	1.00	1.41	15.19	40.85	<0.016
Experimental Group B	0.95	1.41	21.00	48.39	<0.001

Table 5 Statistical analysis of changes in forced vital capacity(FVC)

Study variables	Pre-test	Post-test	t-value	% increase	p-value
	Mean	Mean			
Control Group A	0.936	1.124	14.130	27.89	<0.016
Experimental Group B	0.840	1.075	3.134	19.57	<0.001

Table 6 Statistical analysis of changes in forced expiratory volume in one second(FEV1)

Paired t test is used (Table 6) to analyze the response of control group (group B) to the given treatment session i.e. the post-test value are analyzed with pre-test value. Unpaired t test is used to compare the post-

test result of control group (group A) and analyze the effectiveness of given treatments.

The FEV1 score was analyzed by using paired t test it has revealed that in the control group (group A) mean of FEV1 during pre-test was

0.936, which has got an increase to 1.124 in post-test value, which means that there is a significant difference in the FEV1 after intervention.

The mean of FEV1 during pre-test of experimental group was 0.8413, which has got an increase in the 1.076 in post-test value, which shows there is a significant increase in FEV1 after intervention.

Comparison of post-test value of FEV1 of experimental group and control group.

Mean post-test value of FEV1 of group A is 1.12 and Group B is 1.07. Since calculating the p value is .0.001. Which shows there is no significant difference in between the post-test value of FEV1 of group A and group B.

Percentage of difference

The percentage of improvement in FEV1, from the initial value of control group is 19.57%, and experimental group is 27.89%.

Which comparing the percentage of difference in the improvement of FEV1, between group A and group B shows gain of 8.32% of group B at the end of treatment.

DISCUSSION

Pulmonary complications such as atelectasis, retention of sputum, infections, pleural effusion and most likely respiratory failure are commonly seen after thoracic surgeries. The morbidity resulting from post-operative pulmonary abnormalities remains as a significant problem¹¹.

Normally chest expansion of a healthy individual as 3-5 cm, but in case of post-thoracic surgery patients it won't be able to achieve due to the severe incisional pain and decreased breathing ability.

Chest physiotherapy has a vital role in prevention as well as the treatment of post-

operative complications³⁸. Post-thoracic surgery patients, post-operative incisional pain will affect the thoracic cage movements and rib cage movements. There will be a marked reduction in the shoulder girdle movements and this will affect the normal breathing pattern of the patients. The patients may present marked reduction in the chest expansion, it gradually leads to stiffness of joints; it also affects the lung compliance.

Thus this study selected post isometric relaxation technique for pectoralis major and pectoralis minor and common physiotherapy modalities administered to the post-thoracic surgery patients and evaluate the improvement on chest expansion and pulmonary function outcome.

The objective of the study was to find out the individual effect of PIR exercise programme for thorax and to compare the effectiveness between the breathing exercise on chest expansion and pulmonary function.

In the intra group analysis of chest expansion measurement, which was taken in axillary, nipple, and xiphoid level, in experimental group, showed significant improvement in post score ('p' ,0.001). So statistically, it has proved that the selected physical exercise programme for the thorax was found to be significant improvement in the chest expansion of post-thoracic surgery subjects.

This improvement may have been due to changes in ventilatory capacity, increased thoracic expansion and improved respiratory patterns. The improved respiratory pattern may have been achieved by improved diaphragm excursion. This improved diaphragm excursion may be due to improved thoracic expansion. The same result was brought about by E laine paulin et al⁶. they had shown that increased in the thoracic expansion was effective to diaphragm excursion.

In the intra group analysis of chest expansion measurement which was taken in axillary, nipple, and xiphoid level. In control group showed significant decrease at axillary level in post score ($p < 0.001$) and nipple ($p < 0.026$) in post score. In xiphoid level there was no significant improvement after intervention. ($p < 0.05$). So statistically it has proved that the breathing exercise was found to be no significant improvement in chest expansion at three level in post thoracic surgery subjects.

The p value for the post-test in the inter group analysis of experimental and control group at axillary level was, 0.001, which showed that there was a significant improvement. There for it proved that experimental group showed more significance than the control group in improving chest expansion measurement.

The p value for the post-test in the inter group analysis of experimental and control group at nipple level was, 0.001, which shows that there was a significant improvement. It proved that experimental group showed more significant than control group in improving chest expansion measurement.

The p value for the post-test in the inter group analysis of experimental and control group at xiphoid level was < 0.001 , which showed there was significant improvement. It proved that experimental group showed more significant than control group in improving chest expansion measurement.

Therefore, statistically it was proved that the chest expansion, which was measured at three levels, was to be significant in experimental group.

Kakizaki et al showed that FVC is increased following by stretching respiratory muscle. Since the selected physical exercise for thorax has effect of stretching of respiratory muscle,

which could have attributed to the improvement in functional activities¹².

Ruiz de ona Lacasta JM et al had supported the type of intense training given in this study. He concluded that intense training produces changes in breathing pattern of the patient with respiratory problem. This also possible reason for the change in ventilator capacity and breathing pattern, which have attributed to the improvement of the patients¹³.

In our study, the increase in thoracic expansion was noted which suggested that there may be subsequent improvement in diaphragm excursion. Kakizaki³⁹ et al showed that the patients presented increased expansion in apical thoracic region. A possible explanation for this difference may be the kind of exercise used in their study, since the present study shows the improvement in the entire three regions (Apical, nipple and xiphoid).

The intra group analysis of pre and post test in FVC, of the experimental group shows that the post-test of the experimental group shows significant improvement in FVC. Therefore statistically it was proved that the FVC in post thoracic surgery patients have improved after post Isometric Relaxation exercise.

In the intra group analysis of pre and post test in FVC, of the control group shows that the post test of the control group shows improvement in FVC, there for statistically it was proved that the FVC in post-thoracic surgery patients have improved after intervention. In the comparison of FVC value between experimental and controlled group during pre and post test was analyzed by 't' test. The p value of the post test in inter group analysis of experimental and control group were < 0.001 , which shows that there was significant improvement. It proved experimental group showed more significance than the control group.

The 'p' value for the post-test in inter group analysis of experimental and control group were <0.001 , shows that there was significant improvement. It proves that the experimental group shows more significance than control group. It suggested that selected exercise program has shown significant improvement in FVC values.

The intra group analysis of pre and post test in FEV1 of the experimental group shows that the post-test of the experimental group showed significant improvement in FEV1. there for statistically it was proved that the FEV1, in the post thoracic surgery patients have improved after Post Isometric Relaxation exercise.

In the intra group analysis of pre and post test in FEV1, of the control group shows that the post test of the control group shows the improvement in FEV1, there for statistically proved that the FEV1 in the post thoracic surgery patients have improved after intervention.

In the comparison of FEV1, value between experimental and control group during pre and post test was analysed by 't' test. The 'p' value for the post test in inter group analysis of experimental group and control group were <0.001 , which shows that there was significant improvement. It proves experimental group showed more significance than control group. It proves that the experimental group shows more significance than the control group. It suggested that selected exercise programme has shown significant improvement in FEV1 values.

The average increase in the chest expansion was about 1cm indicates improvement in ventilator capacities, consequently have improve mobility in the patients as proved by Viitanen JV, et al. This further substantiate the results have been obtained in this present study. The present study was conducted for 6

days, patients become stable after post thoracic surgery. So more duration of the same intervention used in this study may even produces a better and long term effect¹⁴.

CONCLUSION

The morbidity resulting from post-operative pulmonary complications remains as a significant problem. Pharmacological and medical management has shown to help to overcome these complications. Pulmonary rehabilitation has also proved to be effective in this condition.

In this study post-isometric relaxation technique were given to the post thoracic surgery patients. Study was conducted to asses the improvement in chest expansion and pulmonary function of the post-thoracic surgery subjects.

30 subjects participated in this study. All the subjects were divided into two groups namely experimental group and control group. They underwent treatment for 30 minutes twice a day, each session for 6 consecutive days, from 4th post-operative day, which consist of total 12 sessions of treatment.

The subjects underwent pre and post test to find the efficiency of post-isometric relaxation exercise for improving chest expansion and pulmonary function of the subjects. The pre and post analysis of test result was done by using paired 't' test for both measurements.

When comparing the post test of experimental and control group, there was significant improvement in the experimental group, there by revealing that selected physical exercise program for thorax were useful in improving chest expansion and pulmonary function.

Statistically the results had proved that selected physical exercise program for thorax was more effective when compared to

breathing exercise to improve chest expansion and pulmonary function. Thus the alternative hypothesis is accepted and null hypothesis rejected.

In conclusion, the selected physical exercises for thorax are effective intervention for the treatment of post-operative thoracic subjects.

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