Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 15s (2025)
https://www.jneonatalsurg.com

OPEN ACCESS

Impact of Lung Boost Exerciser on Inspiratory Muscle Strength post Abdominal Surgeries

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Cite this paper as: Shrouk M. Mahrous Elzoghpy, Marwa M. Abdelhameed, Mohamed M. Raslan, Ghada S. Hussain, Nessrien A. Abdelrashid, (2025) Impact of Lung Boost Exerciser on Inspiratory Muscle Strength post Abdominal Surgeries. *Journal of Neonatal Surgery*, 14 (15s), 1104-1111.

ABSTRACT

Background: Abdominal surgery often leads to the occurrence of postoperative pulmonary complications (PPCs). Reduced maximum inspiratory volumes, an inability to overcome postoperative atelectasis, and a higher risk of developing a PPC result from weaker respiratory muscles' reduced capacity to produce enough effort to expand non-compliant lung tissue

Purpose: This study was done to evaluate the effect of lung boost exerciser on inspiratory muscle strength post upper abdominal surgeries

Materials and methods: sixty patients of post upper abdominal surgeries both sex patients, aged from 35-50 years old, were randomly allocated from KasrEliny Hospital, throughout the period between July and February 2024/2025, patients were randomized into two groups (Experimental group(A) and Control group(B)), the treatment lasted four weeks , the assessments were performed on the selected patients three times; pretreatment , two weeks post treatment then four weeks post treatment. Maximum inspiratory pressure (MIP)was assessed using Respiratory pressure check, measuring inspiratory muscle strength.

Result: a significant increase was noted in the maximum inspiratory pressure (MIP) of group A compared to that of group B at post I ($d = 1.03$, $p < 0.001$) and post II ($d = 1.95$, $p < 0.001$).

Conclusion: Adding lung boost exerciser to conventional chest physiotherapy has favorable outcomes for patients having upper abdominal surgeries.

Keywords: *Abdominal Surgery, Lung Boost Exerciser, Inspiratory Muscles, Maximal Inspiratory pressure*

1. INTRODUCTION

Among the main causes of postoperative morbidity and mortality following abdominal surgery is postoperative pulmonary complications (PPCs)1. Based on the abdominal regions, abdominal surgery was divided into four categories: genitourinary, colorectal, and upper abdominal surgery, among others2.Following abdominal surgery, the impairment of pulmonary function is more pronounced after abdominal or non-thoracic surgeries3.

A reduction in muscle contractility that prevents the respiratory muscles from producing appropriate pressure as well as air flow during respiration is known as respiratory muscle weakness4.

Trauma to the diaphragm, either directly or indirectly, after abdominal surgery might reduce maximum static respiratory pressures (MRPs), particularly the maximum inspiratory pressure (PIMax) in addition to the maximum expiratory pressure (PEMax), that reflect the strength of the muscles responsible for breathing. Reflex paresis can weaken diaphragm function, and the inspiratory action is reduced due to the synergistic activity of abdominal muscles5. Inspiratory Muscle Training (IMT) helps reduce dyspnea while simultaneously enhancing functional capacity, respiratory muscle strength, along with pulmonary function6.

The Lung Boost is an instrument for strengthening the muscles of respiration. Multiple studies have demonstrated that the respiratory muscles can be strengthened and endurance improved by combining the use of a Respiratory Muscle Training (RMT) device accompanied with fitness regimen such as walking. In turn, this may lead to a better quality of life, less fatigue, longer periods of walking, and an enhanced feeling of well-being3.

So that the current study aimed to investigate the impact of lung boost exerciser on inspiratory muscle strength post abdominal surgeries.

2. MATERIALS & METHODS

Study Design:

This study was designed as a Prospective, randomized controlled trial.

Ethics approval statement:

An ethics committee at Cairo University's Faculty of Physical Therapy in Egypt gave its approval to the study before it could begin (No:P.T.REC/012/005406), and also approved by the clinical trial with an identification number (PACTR202412825107761). The procedures of the present study were discussed thoroughly and all the patients were requested to sign a written informed consent.

Participants:

Sixty patientsof both sexes that underwent upper abdominal surgeries were enrolled in this study. Patients were assigned randomized into two groups Experimental group (group A) and control group (group B). The patients were employed from KasrEliny hospital, faculty of medicine, Cairo university at the time from July 2024 till February 2025.The assessments were performed on the selected patients three times; Two days pretreatment, two weeks post treatment then four weeks post treatment.

The inclusion Criteria comprised the following, patients' age ranged from 35 to 50 years old, Male and female patients participated in this study. All patients had undergone upper abdominal surgeries Group A (n= 30), Group B (n= 30). All patients had a good educational level enabled them to understand written words, numbers, and orders for procedures of assessment and treatment by the same physical therapist, prior to the study procedure began, all patients had been referred by surgeons.

A patient was not considered for inclusion if he met any of the following exclusion criteria: All patients were screened to ensure they were not hemodynamically unstable. Heart conditions having symptoms, such as a myocardial infarction, arrhythmia, or congestive heart failure, that have been diagnosed within the past three months, Acute pleuritic pain in the chest, rib fractures, and thoracic vertebral fractures in addition to chronic disabling conditions, Infectious chest diseases like tuberculosis (TB) and viral infections. Those who did not give their consents for the study, Patients suffering from psychological, cognitive, or emotional disturbance, Patients with any previous pulmonary complications, Uncooperative patients who are unable to follow the instructions for using lung boost exerciser.

Sample size calculation:

For this study, we used a 95% power and 5% types I error to determine the sample size utilizing a repeated-measures analysis of variance (F-test). According to the published research (Alande& Vardhan, 2021; Huang et al., 2022), the effect size (PIMax) was used to calculate the effect size (0.37). With a 20% increase to account for dropouts, the minimum sample size was raised to 50. At least sixty participants were needed for the study. Franz Faul of the University of Kiel in Germany provided the G* Power version 3.1.9.2 that was used for the calculations.

Intervention:

Lung Boost Exerciser (MD8000) (Made in China), UPC-A (8 46841 03014 7) The lung boost exerciser is an adaptable instrument that can be used for both low-intensity endurance aerobic training as well as high-intensity anaerobic interval training. It strengthens the inspiratory and expiratory muscles and includes different resistance levels. It has five different resistance levels, tracks your breathing at the recommended intensity, lets you mix targeted as well as resistance training in real time, and has a memory that remembers all of your training sessions so you can see how much you've come and set realistic goals for yourself.

The study implicated two equal groups of participants: Group A Included Thirty patients (14 males and 16 females) post upper abdominal surgeries and complaining from pulmonary complications who was given lung boost exerciser program for 30 minutes, six sessions per week as well as conventional chest physiotherapy (Breathing exercises such as pursed lip breathing along with diaphragmatic breathing. Each exercise was performed ten times, with a 20-second relaxation period in between from a high supine lying posture, Upper limb Exercises connected with respiration: These included two shoulder flexion-extension exercises (one synchronized with inspiratory time during the concentric process and the other with expiratory time) and two shoulder abduction-adduction exercises. Each exercise was performed ten times, with a 30-second relaxation period in between from a standing position two times daily six times per week for 4 weeks7. Regarding lung boost exerciser proper ventilation was advised that the room be ventilated for at least 15 minutes and it was instructed that the equipment be cleaned using disposable cleaning wipes and 75% alcohol for 30 seconds after each use which was sufficient to prevent cross infection between patients. Before beginning the exercise, the patients received training on the respiratory exercise protocol. While wearing a mouthpiece over his mouth, the patient examined the respiratory exercise equipment and

took a breath. The training progresses one level at a time until the target difficulty level is reached, beginning with the easiest level 1 (default). With a 1 to 3-minute pause among sets and a 15-second rest in between maneuvers, the workout lasted five to twenty minutes or three sets of fifteen deep breaths, each of which was performed five times7. Attaching a resistance cone to the unit's back made it more difficult. After attaching the resistance cone, the patient would resume level 1 training two times daily 6 sessions per week for 4 weeks3.

Group (B) included thirty patients (12 males and 18 females) post upper abdominal surgeries and complaining from pulmonary complications who received conventional chest physiotherapy program. Breathing exercises such as pursed lip breathing as well as diaphragmatic breathing. Each exercise was performed ten times, with a 20-second relaxation period in between from a high supine lying posture, Upper limb Exercises connected with respiration: These included two shoulder flexion-extension exercises (one synchronized with inspiratory time during the concentric process and the other with expiratory time) and two shoulder abduction-adduction exercises. Each exercise was performed ten times, with a 30-second relaxation period in between from a standing position two times daily 6 sessions per week for 4 weeks7.

Outcome measures:

At the beginning and after 4 weeks of intervention, we recorded outcome measurement that included Maximum inspiratory pressure (MIP).

Assessments were measured for three times, pretreatment, two weeks post treatment and four weeks post treatment. Maximum inspiratory pressure was estimated using Respiratory pressure check (MD Diagnostics Ltd, manufactured in Uk). Mouth and nose pressures (MIP, MEP, and SNIP) can be measured with the RP check, a portable meter for respiratory regulation. The RP Check is a convenient tool for testing both adults and children in a variety of settings, such as as preoperative evaluations, outpatient clinics, as well as bedside. It is lightweight, portable, and easy to transport. Parameters measured (displayed in cmH2O). Mouth pressures include MIP, MEP, Pmax-peak pressure, MIP/MEP combined single use filtered valve system with better than 99% efficacy for both bacteria and viruses, Nasal pressures include SNIP- Sniff nasal inspiratory pressure.

Procedure for evaluation:

Maximum inspiratory pressure (MIP):

In each group, MIP was measured using Respiratory pressure (RP check) at day two postoperative as a pre assessment, then after two weeks as post treatment and after four weeks as post treatment, Patients were measured while seated, with or without nose clips. The procedure was performed at least three times before the average was calculated. After participants exhaled to Residual Volume (RV), they were instructed to make a maximal inspiratory effort and hold it for 1 to 2 seconds3.

Every patient enrolled in the ongoing clinical trials had their medical history documented in a data recorder prior to the commencement of the study. The researcher personally performed all assessments. To ensure full participation from the patients, every patient in this particular experimental group was given oral instructions about the study's aims, significance, and methodology. After obtaining full details about the study's objective, procedure, potential benefits, privacy, and data utilization, all patients signed a written consent form.

1. Statistical analysis:

The subject characteristics were compared between the groups using an independent t test. We used a chi-squared test to compare the distribution of gender and surgery type among the groups. For each group, an ANOVA with repeated measurements was used to compare MIP before, during, and after treatment; for comparisons between groups, independent t test was employed. All statistical tests were set to have a significance level of $p < 0.05$. Windows version 25 of the statistical package for the social sciences (SPSS) (IBM SPSS, Chicago, IL, USA) was used for all statistical analysis.

2. Results

An initial screening was performed of seventy patients to determine their eligibility for this study. Following that scanning, 60 were accepted into the research and randomly allotted into two equivalent groups (30/group). No participants withdrew after randomization nor reported any adverse effects during or after applying Lung boost exerciser (Figure 1).

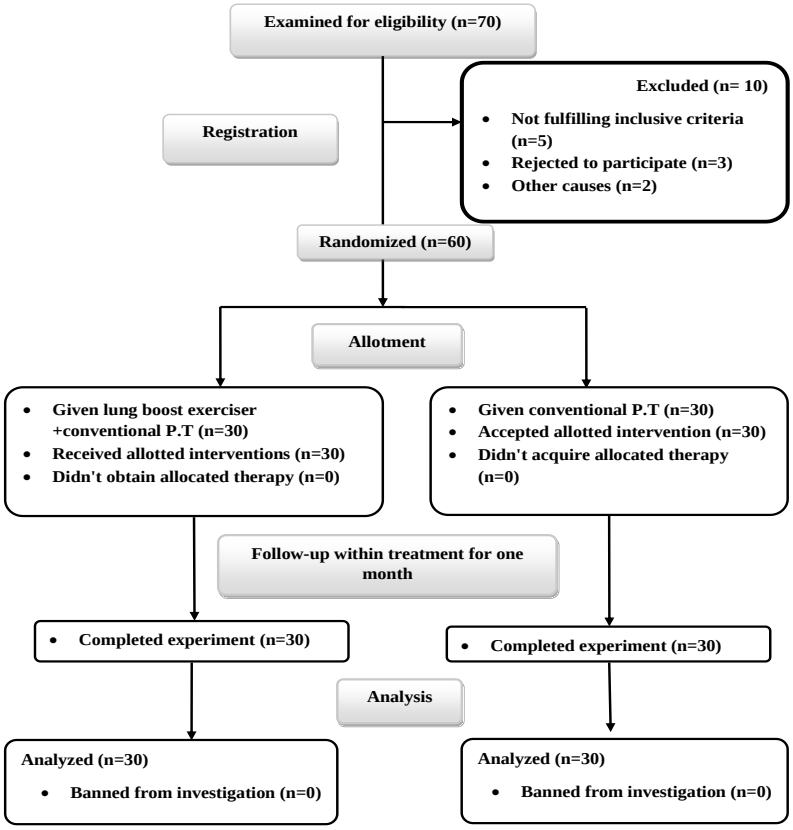

Fig.1 flow diagram of the trial

Subject characteristics:

Sixty patients who underwent abdominal surgeries took-part in this study. Group A and B's participant characteristics were displayed in Table (1). Age, weight, height, body mass index (BMI), genders, and distribution of surgical procedures did not differ significantly between groups. significance level ($p > 0.05$).

Table 1. Basic characteristics of participants.

	Group A	**Group B**			
	Mean ± SD	**Mean ± SD**	**MD**	**t-value**	**p-value**
Age (years)	41.90 ± 5.70	43.73 ± 6.22	-1.83	-1.19	0.24
Weight (kg)	78.17 ± 20.78	79.90 ± 19.86	-1.73	-0.33	0.74
Height (cm)	165.07 ± 6.59	166.57 ± 7.73	-1.5	-0.81	0.42
BMI (kg/m²)	28.77 ± 7.83	28.94 ± 7.68	-0.17	-0.09	0.93
Sex, n (%)					
Females	16 (53%)	18 (60%)	χ^2 =0.27		0.60
Males	14 (47%)	12 (40%)			
Type of surgery, n (%)					
Cholecystectomy	12 (40.0%)	10 (33.3%)	χ^2 =0.72		0.87
Gastric bypass	10 (33.3%)	9 (30.0%)			

Hernia	6 (20.0%)	8 (26.7%)
Hiatus hernia	2 (6.7%)	3 (10.0%)

SD, standard deviation; MD, mean difference; χ2, Chi squared value; p-value, level of significance

Effect of treatment on MIP:

With a p-value of 0.001 and a partial eta squared of 0.79, mixed-effects ANOVA showed that treatment and time interacted significantly. The main impact of time was statistically significant (F = 2832.74, p = 0.001, partial eta squared = 0.98). F=15.88, p = 0.001, partial eta squared = 0.22, indicating a statistically significant main impact of treatment.

Within group comparison

Groups A and B showed a statistically significant (p < 0.001) improvement in MIP between pre-treatment and post-I and post-II. Furthermore, in both groups, the MIP was significantly greater after post II compared to post I (p < 0.001). (table 2).

Between group comparison

Groups did not differ significantly before treatment (p > 0.05). Group A's MIP was significantly higher than group B's at both post-I (d = 1.03, p < 0.001) and post-II (d = 1.95, p < 0.001). Table (2), fig. (2).

Table 2. Mean MIP at pre-treatment, post I and post II of group A and B.

MIP (cmH2O)	**Pre treatment**	**Post I**	**Post II**	**p-value**		
	mean ± SD	**mean ± SD**	**mean ± SD**	**Pre vs Post I**	**Pre vs Post II**	**Post I vs Post II**
Group A	30.43 ± 10.18	51.20 ± 9.71	74.20 ± 9.10	0.001	0.001	0.001
Group B	29.87 ± 10.51	40.30 ± 11.35	54.20 ± 11.32	0.001	0.001	0.001
MD	0.56	10.9	20			
95% CI	-4.78: 5.92	5.44: 16.36	14.69: 25.31			
	P = 0.83	***P = 0.001***	***P = 0.001***			
		d = 1.03	***d = 1.95***			

SD, standard deviation; MD, mean difference; CI, Confidence interval; p-value, level of significance; d, effect size

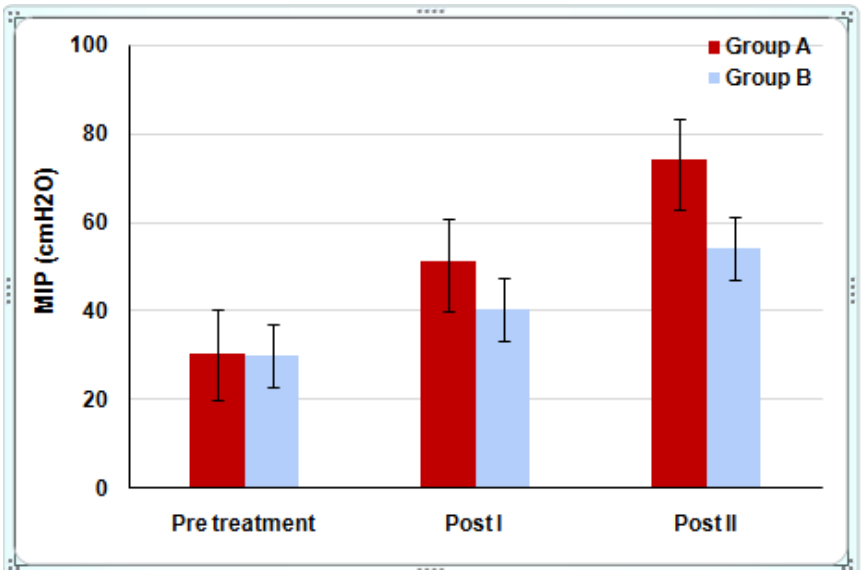

Figure 2. Mean MIP at pretreatment, post I and post II of group A and B.

3. DISCUSSION

The purpose of this study was to examine the effect of a lung boost exerciser upon inspiratory muscle strength following upper abdominal surgery.

The results of the study revealed a statistically significant increase in maximum inspiratory pressure (MIP) from pretreatment to post treatment I, II in both groups with favour improvement in group A (Experimental group).

In relation to our findings, Enright et al. (8) reported that IMT can be done independently at home and uses limited airflow breathing to activate the respiratory muscles. This causes a hypertrophic reaction similar to that observed in peripheral muscles following a strength training program.

Similarly, in line with the results of IMT in the clinic in a meta-analysis, it was found that RMT significantly improved the strength and endurance of muscles of inspiration compared to the control group. The studies included high-quality evidence from 12 (n = 736) and moderate-quality evidence from 3 (n = 384) studies, respectively, with standardized mean differences of 0.39 (n = 384) and 16.62 cmH2O [95% CI = 12.48 to 20.77] respectively. These findings are in line with those of the present study.

Additionally, it was in line with a recent meta-analysis on IMT in COPD patients that Beaumont et al. (10) carried out. The results demonstrated that IMT reduced dyspnea and improved exercise capacity, MIP, as well as quality of life.

The superiority of lung boost exerciser in the present study is matched with what was conducted by Manifield et al (11) as improvements in inspiratory muscular strength (maximal inspiratory pressure; PImax) found in this study after IMT (about 20 cmH2O) align with prior research on healthy older individuals increased inspiratory muscle strength, power output and speed of shortening and/or hypertrophy of inspiratory muscles are probably the factors underlying these gains. Additionally, this study found that, in comparison to the SHAM-IMT group, there was a substantial decrease in breathing discomfort after IMT during a bout of inspiratory muscle effort equal to 50% of PImax. A number of underlying mechanisms pertaining to structural and functional modifications of the inspiratory muscles after IMT could account for this decreased effort perception, including: 1) thicker diaphragm, 2) higher percentage of type I muscle fibers 3) enhanced oxidative capacity, 4) enhanced ability to generate force, and/or 5) desensitization of the brain to sensory input from the inspiratory muscles.

It was stated by McCool et al (12) that the diaphragm, the most significant respiratory muscle, is crucial to sustaining the respiratory system's ventilation. Diaphragmatic function can be monitored in a number of clinical ways.

Similar results were conducted by Huang et al (13) that retrospectively found that in comparison to the baseline, the CTL group's diaphragmatic excursion at the after treatment was much lower. The groups differed significantly from one another. Consequently, it is clear that the diaphragm's movement is better preserved in the IMT group, so it can be proven that the IMT program may help in the diaphragm's post-operative recovery, even though the surgery causes physical harm.

Another agreement with the role of IMT in reinforcement of diaphragm strength was stated by Liu et al(14) that Improved diaphragmatic function may increase the recovery of muscles of inspiration and expiration, it is the aim of post-operative lung muscle strength rehabilitation techniques. A previous meta-analysis of patients who received preoperative RMT before assisted thoracoscopic surgery for lung tumors demonstrated a lower rate of postoperative pulmonary complications, a faster recovery of pulmonary function, and a considerably higher MIP when compared with patients who didn't get the training.

In accordance with Menzes et al (15) indicated that fourteen respiratory training devices that were documented by published studies were on the market. However, due to a lack of information, three devices were not thoroughly described. All eleven of the assessed devices had advantages and disadvantages that needed to be considered. It is impossible to select the finest equipment depends solely on its clinical utility and technological details, even though some seem more beneficial than others. The particular health condition, the type of impairments and the training's goal must all be considered in order to choose the best one. Using a combination of low-intensity endurance aerobic training (endurance mood) as well as high-intensity anaerobic interval training (strength mood), the Lung Boost device helps its user develop their respiratory muscles during inspiration and expiration. It offers six resistance levels, each of which has five places for adjustment.

Our results are at contradiction with those of Brocki et al.(16), who conducted a randomised clinical trial on individuals undergoing high-risk lung cancer surgery and found that, when compared to standard physiotherapy alone, Up to 5 days following the treatment, additional IMT significantly increased oxygenation among those at high risk of PPC; no changes were observed between groups in terms of walked distance or respiratory muscle strength were detected as the patient in study of brocki. There was a disagreement in the outcomes since the participants in the study who underwent lung resection also had COPD, and because the elderly were a clinical indicator for poor survival.

4. STRENGTHS AND LIMITATIONS

The findings of this study contribute to fundamental knowledge and offer several advantages including the use of respiratory pressure check for objective maximum inspiratory pressure measurement. The study's design strengthens its validity through features such as randomization, participant blinding to group allocation and direct investigator oversight of the intervention.

However, we acknowledge limitation which is the relatively small number of participants who completed the study. Future research should involve larger samples.

5. CONCLUSION

Based on the obtained data, application of lung boost exerciser can be used as an effective strategy in the treatment program for improving inspiratory muscle strength as well as performance in patients with post-operative pulmonary complications (ppcs).

6. ACKNOWLEDGEMENTS

The author would like to thank the staff members for their effort and support throughout this investigation and all the participants for their cooperation.

7. CONFLICTS OF INTEREST DECLARATION

There was no disclosure of any conflicts of interest related to this research.

8. FUNDING

The study, publication, or authorship received no external financial support.

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