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Effect of preoperative respiratory muscles training on pulmonary function test and respiratory muscle strength after abdominal surgery: Randomised controlled trial

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Abstract
Background & objectives: Abdominal surgeries are the most common operative procedures including a wide range of both emergency and elective surgical interventions. Postoperative Pulmonary complications following upper abdominal surgery are the most common surgical complications. The combined effect of surgical trauma and anaesthesia results in reduced lung volumes and respiratory muscle dysfunction. The aim of this study was to assess the effect of pre-operative respiratory muscle training on pulmonary function test (PFT) and Respiratory muscle strength after abdominal surgery.
Methodology: Total number of 104 participants of both the gender with age group between 30 to 70 years, who were planning for major abdominal surgery were to be divided in to two groups i.e. experimental group (Group- A) and control group (Group- B). The experimental group was to undergo a pre-operative respiratory muscle training and post operatively both groups were to receive conventional physiotherapy treatment. All the participants were assessed for pulmonary function test and respiratory muscle strength at the baseline, before surgery, at 3rd day, 7th day and 21st day post operatively.
Results: There were statistically significant differences ($p<0.01$) found in all the outcome measures in both groups. Further, comparison was done between the groups. It was found that the experimental and control groups were not different statistically. But on 3rd day and 7th day in pulmonary function test parameters (FVC, FEV_1, MVV) and respiratory muscle strength parameters (MIP and MEP) there was significantly difference ($p<0.01$) in the experimental group compare to control group.
Conclusion: The pulmonary function test and respiratory muscle strength values were measured on 3rd day of surgery, 7th day of surgery and 21st day of surgery. When compare to baseline values, there was significant improvement within the group. There was no significant difference on 21st day post operatively when compare to baseline values between the group. Result of the study shows that pulmonary function test values and respiratory muscle strength values on 3rd and 7th day postoperative are more significant in experimental group than control group. It is concluded that preoperative respiratory muscle training help and preserve pulmonary function and respiratory muscle strength in initial period post operatively.

Keywords: Respiratory muscle training, abdominal surgery, pulmonary function test, respiratory muscle strength

Introduction

Surgery is the science and art of treating illnesses, wounds, and physical abnormalities through incision or manipulation, often with equipment. The most common type of surgery covers a wide range of both emergency and non-emergency treatments [1]. Estimates for people over the age of 60 place the overall rate of abdominal surgeries at 43.8% [2]. According to estimates, from roughly 7,436,000 procedures in 2010 to 8,109,000 surgeries in 2020, the number of abdominal surgeries is anticipated to change dramatically [3].

A primary contributor to postoperative pulmonary issues is insufficient inspiratory effort, which results in insufficient sputum expectoration. Additionally, a high respiratory demand results in the fatigue of the inspiratory muscles, which leads to alveolar collapse. Postoperative pulmonary complications after abdominal surgery are reported to occur at a rate of 6-76 percent, with upper abdominal procedures having a higher incidence of 60-75 percent. After elective non-thoracic 63 surgery, patients who develop postoperative pulmonary issues stay in the hospital for additional days. After upper abdomen surgery, 17 percent to 88 percent of patients reported having pulmonary problems [4–11].

Pulmonary problems are a leading source of morbidity and mortality following surgery. The reported incidence of postoperative pulmonary complications (POPC) has ranged between 5 and 70% in studies conducted over the last 60 years. Upper abdominal and thoracic operations had the highest rates of pulmonary complications. Despite considerable advances in medical and surgical practise during the last 35 years, the incidence of POPC has remained relatively constant [12].

Movements of the thorax and abdominal wall are used for respiration. The division of abdominal muscles after abdominal surgery causes pain and movement restriction. Changes in diaphragmatic function and lung atelectasis are also due to this [13, 14]. Recent research has found that oxygen tension has decreased without a significant change in carbon dioxide tension. In open procedures, these alterations are common [15, 16]. Patchy atelectasis can be caused by an inability to cough due to wound pain, diaphragm elevation, and secretion retention. Atelectasis, hypoxemia, and pneumonia are the most prevalent consequences as a result of these alterations, which result in longer hospital stays, higher treatment expenses, and greater morbidity and death [17, 18].

The pulmonary system is significantly influenced by the abdominal muscles, which perform about 20% of the work involved in breathing. The anterior abdominal muscles have two distinct effects on the respiratory system. In addition to increasing intra-abdominal pressure, they also pull on the rib borders. Lung capacity decreases as a result of abdominal muscle contractions that lower transpulmonary pressure and thoracic volume. They are important in the process of inspiration, as well. By providing anterior stability to the abdomen, which enables it to act as a fulcrum for diaphragm action and maintain a zone of apposition, the abdomen helps the lateral chest wall expand during inspiration [19].

Progressive respiratory muscle weakening may be a factor in the dyspnea and decreased exercise capacity. Therefore, in these patients, respiratory muscle training is crucial to enhance exercise tolerance, pulmonary function, and possibly even lessen the intensity of dyspnea [20]. Additionally, the patient with a history of dyspnea will have a greater capacity for functional exercise as a result of the inspiratory muscle training. Studies that were conducted with the proper selection of criteria for post-IMT changes in exercise tolerance revealed a considerable improvement in exercise tolerance [21-23]. IMT showed a beneficial effect for reduction of breathlessness where 5 to 30 minute daily sessions of IMT were given and weekly training load increased by -2 to -4 cmH2O for six weeks and patients were trained at loads of > 30% of baseline maximal inspiratory pressure. It was concluded that this improves the inspiratory muscle strength and decreases dyspnea level [24, 25].

Respiration is the process through which oxygen and carbon dioxide are transferred from the air to the tissues. Both neurological variables and the activity of the respiratory muscles control it [26, 27]. The diaphragm, one of the respiratory muscles, is a crucial component of the respiratory pump. Additionally, it affects respiratory function by modifying breathing and posture [28, 29]. Diaphragmatic respiration is the act of breathing through a contracted diaphragm. Diaphragmatic breathing has been used in a spectrum of roles, including Pilates, yoga [30], and core-strengthening exercises, according to numerous studies [31]. One technique that can help to increase trunk stability and lung capacity is diaphragmatic breathing [32]. It is thought that respiratory function can be enhanced by enhancing the strength and endurance of the respiratory muscles through various forms of exercise [33].

The incentive spirometer has been shown to improve sputum expectoration, maintain or expand inhaled lung volume, and prevent lung infection after surgery. Although there is mixed information regarding the effectiveness of incentive spirometry in the treatment of chronic illnesses, strengthening the inspiratory muscle is essential for reducing or removing postoperative pulmonary complications. After surgery, employing an incentive spirometer can help keep the airways free and maintain the structural integrity of the lungs. Deep breathing promotes the circulation of secretions and helps to open up any blocked pulmonary airways. In particular, inspiratory muscle exercise stretches and trains the lungs, keeping them functioning while the patient is recovering from surgery [34, 35].

Over the past 20 years, significant advancements in risk factor identification and mitigation, patient education, surgical and anaesthetics procedures, pain control, and postoperative rehabilitation have decreased PPCs after major surgery and increased hospital discharge [36].

PPCs can be prevented and treated with a variety of methods and tools, including incentive spirometry, continuous positive airway pressure, positive expiratory pressure, intrapulmonary percussive ventilation, and respiratory muscle training using a pressure threshold device that targets the muscles of inspiration [37, 38].

The objective of this study was to investigate the changes in pulmonary function tests and respiratory muscle strength after the application of preoperative respiratory muscle training for patients undergoing abdominal surgery."

Patients and methods

Setting and patients

All the participants were assessed for different factors thoroughly with assessment format. Ethics committee approval was granted by Parul university institutional Ethics Committee for human research (PU-IECHR) with reference number PUIECHR/PIMSR/00/081734/2607. The participants were taken for the study by using Convenient sampling and allocation of group by randomization of participants. Total number of participants was 104 of both the gender with age group between 30 to 70 years.

All the participants received an explanation of the study's methodology and purpose. Written informed permission forms were signed by the participants and/or their relatives before to their inclusion in the study. A preliminary selection of the participants was made based on inclusion and exclusion criteria.

Patients were included if they were: 1. Age group between 30 to 70 years 2. Pre-operative patients planning to undergo abdominal surgery 3. First time undergoing abdominal surgery. Patients were excluded if they were: 1. Participants with known neurological deficits such as spinal cord injury, amyotrophic lateral sclerosis, poliomyelitis, guillain- barre syndrome, myasthenia gravis, muscular dystrophy. 2. Participants with unstable cardio respiratory disease. 3. Participants with unstable medical condition and high diabetes. 4. Participants not willing to participate / Uncooperative participants. 5. Orthopaedic anomalies such as kyphoscoliosis, ankylosing spondylosis, fracture of thoracic cage. 6. Participants with any acute respiratory infection.

Intervention

The participants who were planning for major abdominal surgery and eligibility criteria were divided into two groups, i.e., group- A (experimental group) and group- B (control group). The experimental group was to undergo pre-operative respiratory muscle training, which included Inspiratory muscle training, Breathing exercises (Diaphragmatic and segmental breathing exercises), and incentive spirometry. Exercises were to be started four days prior, and 20 to 30 repetitions of each exercise were to be given three times a day. Each session was 20 to 30 minutes' duration. Postoperatively, participants were to receive conventional exercises.

In the control group, post-operatively, all participants were to receive conventional physiotherapy treatment. Exercises included limb physiotherapy, bronchial hygiene technique, chest physiotherapy, cuffing and huffing, and sustained maximum inspiration exercise.

Outcomes measurement

Outcomes parameters i.e., FEV_1, FVC, PEFR, MVV, MIP, and MEP were measured on baseline (before intervention), Before surgery, 3rd day of post-surgery, 7th day of post-surgery and 21st day of post-surgery for both groups. The control group had not received any intervention before surgery. Pulmonary function test values and respiratory muscle strength were recorded in the sitting position by a flow based Spirotech computerised spirometer and a Micro RPM device.

Results

Table 1: Represents descriptive statistics of age for total 104 participants (i.e. Group A: 52 subjects, Group B: 52 subjects) in both the groups.

Group	No. of sample	Mean ± SD
Group A	52	49.98± 5.73
Group B	52	50.03± 5.86

Repeated measure multivariate ANOVA for within-group and between – group comparison result with interaction of various outcomes for the experimental and control group.

a. **FVC**
The within-group repeated measure multivariate ANOVA with Greenhouse-Geisser correction (GGC) showed the significant statistical difference with F= 2578.987, p<0.001. A repeated measure multivariate ANOVA with (GGC) between-group analysis showed that the experimental and control groups were not different statistically with F 0.817, p<0.368.

b. **FEV_1**
The within-group repeated measure multivariate ANOVA with Greenhouse-Geisser correction (GGC) showed the significant statistical difference with F= 1066.324, p<0.001. A repeated measure multivariate ANOVA with (GGC) between-group analysis showed that the experimental and control groups were not different statistically with F = 0.869, p<0.354.

c. **PEFR**
The within-group repeated measure multivariate ANOVA with Greenhouse-Geisser correction (GGC) showed the significant statistical difference with F= 2281.492, p<0.001. A repeated measure multivariate ANOVA with (GGC) between-group analysis showed that the experimental and control groups were not different statistically with F = 0.101, p<0.752.

d. **MVV**
The within-group repeated measure multivariate ANOVA with Greenhouse-Geisser correction (GGC) showed the significant statistical difference with F= 1738.487, p<0.001. A repeated measure multivariate ANOVA with (GGC) between-group analysis showed that the experimental and control groups were not different statistically with F = 1.303, p<0.256.

e. **MIP**
The within-group repeated measure multivariate ANOVA with Greenhouse-Geisser correction (GGC) showed the significant statistical difference with F= 2160.504, p<0.001. A repeated measure multivariate ANOVA with (GGC) between-group analysis showed that the experimental and control groups were not different statistically with F = 3.205, p<0.076.

f. **MEP**
The within-group repeated measure multivariate ANOVA with Greenhouse-Geisser correction (GGC) showed the significant statistical difference with F= 2244.625, p<0.001. A repeated measure multivariate ANOVA with (GGC) between-group analysis showed that the experimental and control groups were not different statistically with F = 0.890, p<0.348.

Table 2: Shows the FVC time parameter estimates result of between group.

Parameter	Period	Group	Mean	t	p
FVC	Baseline	Group -A	2.89 ±0.44	-1.852	0.067
		Group-B	3.07±0.49		
	Before surgery	Group -A	2.98±0.45	-0.837	0.405
		Group-B	3.06 ±0.50		
	3RD Day	Group -A	2.02 ±0.29	3.788	0.000
		Group-B	1.80 ±0.28		
	7TH Day	Group -A	2.31 ±0.34	5.385	0.000
		Group-B	1.97 ±0.30		
	21ST Day	Group -A	2.97 ±0.45	0.552	0.582
		Group-B	2.92 ±0.47		

Table 3: Shows the FEV_1 time parameter estimates result of between group.

Parameter	Period	Group	Mean	t	p
FEV_1	Baseline	Group -A	2.58 ±0.43	-1.211	0.229
		Group-B	2.69 ±0.43		
	Before surgery	Group -A	2.63 ±0.43	-0.540	0.590
		Group-B	2.68 ±0.43		
	3RD Day	Group -A	1.82 ±0.28	3.898	0.000
		Group-B	1.63 ±0.20		
	7TH Day	Group -A	2.10 ±0.33	3.655	0.000
		Group-B	1.88 ±0.29		
	21ST Day	Group -A	2.63 ±0.43	0.741	0.460
		Group-B	2.57 ±0.42		

Table 4: Shows the PEFR time parameter estimates result of between group**.**

Parameter	Period	Group	Mean	t	p
PEFR	Baseline	Group -A	5.24 ±1.10	-0.458	0.648
		group-B	5.34 ±1.10		
	Before surgery	Group -A	5.38 ±1.10	0.209	0.835
		Group-B	5.33 ±1.10		
	3RD Day	Group -A	3.67 ±0.77	1.451	0.150
		Group-B	3.46 ±0.68		
	7TH Day	Group -A	3.95 ±0.90	-0.239	0.811
		Group-B	3.99 ±0.87		
	21ST Day	Group -A	5.27 ±1.04	0.915	0.362
		Group-B	5.08 ±1.09		

Table 5: Shows the MVV time parameter estimates result of between group

Parameter	Period	Group	Mean	T	p
MVV	Baseline	Group -A	88.14 ±14.94	-0.569	0.571
		Group-B	89.82 ±15.13		
	Before Surgery	Group -A	88.90 ±14.99	-0.224	0.823
		Group-B	89.56 ±15.02		
	3RD Day	Group -A	61.67 ±10.53	3.536	0.001
		Group-B	55.68 ±7.80		
	7TH Day	Group -A	75.15 ±12.87	3.061	0.003
		Group-B	67.80 ±11.61		
	21ST Day	Group -A	88.22 ±14.57	1.127	0.262
		Group-B	85.06 ±14.06		

Table 6: Shows the MIP time parameter estimates result of between group.

Parameter	Period	Group	Mean	T	P
MIP	Baseline	Group -A	91.72 ±15.18	-0.506	0.614
		Group-B	93.18 ±14.16		
	Before surgery	Group -A	93.27 ±15.18	0.077	0.938
		Group-B	93.05 ±14.18		
	3RD Day	Group -A	66.77 ±10.70	4.735	0.000
		Group-B	57.76 ±8.32		
	7TH Day	Group -A	79.42 ±13.37	4.513	0.000
		Group-B	69.01 ±9.89		
	21ST Day	Group -A	92.61 ±14.48	1.579	0.117
		Group-B	88.30 ±13.31		

Table 7: Shows the MEP time parameter estimates result of between group.

Parameter	Period	Group	Mean	t	p
MEP	Baseline	Group -A	85.85 ±14.73	-0.593	0.554
		Group-B	87.61 ±15.56		
	Before surgery	Group -A	86.38 ±14.64	-0.384	0.702
		Group-B	87.51 ±15.49		
	3RD Day	Group -A	59.93 ±11.57	3.075	0.003
		Group-B	53.74 ±8.78		
	7TH Day	Group -A	71.60 ±13.22	2.454	0.016
		Group-B	65.55 ±11.91		
	21ST Day	Group -A	86.12 ±14.48	1.067	0.289
		Group-B	83.02 ±15.17		

Discussion

The main goal of this study was to evaluate the effect of preoperative respiratory muscle training on pulmonary function and respiratory muscle strength after abdominal surgery. Each group consisted of 52 participants who were to undergo abdominal surgery and were randomly divided into the group A (experimental) and group B(control).

In this study, the group A which is the experimental group, was to undergo a pre-operative respiratory muscle training, which included breathing exercises, inspiratory muscle training and incentive spirometry. Post-operative all participants received conventional exercises. The control group, no preoperative therapy was given and post-operative all participants received conventional physiotherapy treatment. Exercises included bronchial hygiene technique, limb physiotherapy, chest physiotherapy, huffing and coughing, sustain maximum inspiratory exercises.

When compared to preoperative values on the third postoperative day in both groups (Group-A and Group-B) of our study, pulmonary function (FVC, FEV_1, PEFR, and MVV) and respiratory muscle strength showed a decrease, with an average decrease of 36% in forced vital capacity, 34% in forced expiratory volume in one second, 33% in peak expiratory flow rate, 33% in maximum voluntary ventilation, and 33% in maximum inspiratory pressure. The findings from the current study, which show a decrease in

pulmonary function throughout the postoperative day, are similar to those from a previous study [39-42].

Our results are consistent with those of Schauer *et al*. who reported that laparoscopic cholecystectomy resulted in a 30 to 38 percent decline in postoperative pulmonary function (FVC, FEV_1, FEF25 percent to 75 percent) [43]. After a laparoscopic cholecystectomy, 22 percent of FVC and 19 percent of FEV_1 were reduced, according to Karayiannakis *et al*. In laparoscopic cholecystectomy, Ramos *et al*. discovered a 20–30% decline in postoperative pulmonary function (FVC, FEV_1) [44]. Laparoscopic cholecystectomy patients' postoperative day pulmonary function measures (FVC, FEV_1, FEF25 percent to 75 percent) decreased by 21 to 31 percent, according to Ravimohan *et al* [45].

Our results are in accordance with those of Ford *et al*., who discovered that the main cause of poor pulmonary function was decreased inspiratory muscle activity, particularly at the diaphragm. Diaphragm dysfunction may result from reflex inhibition of efferent phrenic activity [46]. Laparoscopic abdominal surgery causes phrenic nerve reflex suppression, which may lead to short breaths and reduced pulmonary ventilation, according to a number of studies. reduction of pulmonary ventilation [47], is mostly due to decreased inspiratory muscle activity, according to Erice *et al* [48] Patients who underwent laparoscopic abdominal surgery exhibited a 27 percent reduction in respiratory muscle activity, according to Adriana *et al* [49].

In our study Within the group, there was significant improvement. This was reflected in the 3rd day of surgery to 7th day of surgery and 7th day of surgery to 21st day follow up in the measurement of pulmonary function test and respiratory muscle strength. Between the groups, there was no significant improvement but the preoperative respiratory muscle training proved to be effective on 3rd day and 7th day post operatively. The percentage across 3rd day and 7th day showed a significant improvement statistically ($p< 0$.

Patients who are constrained by weak or reduced inspiratory muscles should engage in inspiratory muscle training. Dysfunction of the respiratory muscles has also been noted in various restrictive lung diseases, chronic heart failure, and after abdominal surgery. The strength and stamina of the inspiratory and expiratory muscles can be improved by the performance of specific exercise training. Resistance training is beneficial for respiratory muscles that are weak. Patients who have respiratory muscle weakness may breathe with large lung volumes. The hyperinflation, which depresses the diaphragm's dome, shortens its fibres, and forces it to function on an ineffective portion of its length, results in a mechanical disadvantage as a result of this weakness. Therefore, a decrease in inspiratory capacity results from the development of expiratory flow restrictions [50].

In order to improve respiratory muscle performance and perhaps lessen the intensity of dyspnoea, inspiratory muscle exercise is considered to be advantageous. IMT is a type of resistance exercise that strengthens the breathing muscles. These muscles adapt and start getting stronger and being able to work for extended periods of time after receiving consistent strengthening for a few days.

There is strong evidence that a preoperative physiotherapy programme can decrease the amount of post-pulmonary problems following abdominal surgery. The goal of the current study is to assess the potential advantages of preoperative respiratory muscle training in helping patients recover from abdominal surgery. Acceptable markers of pulmonary function and respiratory muscle strength include FVC, FEV_1, PEFR, MVV, MIP, and MEP. The study's findings indicate that the experimental group's pulmonary function test results and respiratory muscle strength results on the third and seventh postoperative days are more significant than those of the control group.

Conclusion

The pulmonary function test and respiratory muscle strength values were measured on 3rd day of surgery, 7th day of surgery and 21st day of surgery. When compare to baseline values, there was significant improvement within the group. There was no significant difference on 21st day post operatively when compare to baseline values between the group.

Result of the study shows that pulmonary function test values and respiratory muscle strength values on 3rd and 7th day postoperative are more significant in experimental group than control group.

From the results obtained it is concluded that preoperative respiratory muscle training help and preserve pulmonary function and respiratory muscle strength in initial period post operatively.

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