ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 11, Issue, 04, pp.3327-3332, April, 2019

DOI: https://doi.org/10.24941/ijcr.34369.04.2019

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

EFFECT OF THRESHOLD INSPIRATORY MUSCLE TRAINING VERSUS INCENTIVE SPIROMETRY IN UPPER ABDOMINAL SURGERIES – A COMPARATIVE STUDY

[1]Dr. Karuna Gautam Kamble and [2,*]Dr. Vishnu Vardhan G.D.

[1]MPT in Cardio-Respiratory Physiotherapy, Dr. A. P. J. Abdul Kalam College of Physiotherapy, PIMS Loni
[2]Associate Professor of Cardiorespiratory Department, Dr. A.P.J. Abdul Kalam College of Physiotherapy, PIMS Loni

ARTICLE INFO

Article History:
Received 20th January, 2019
Received in revised form
16th February, 2019
Accepted 24th March, 2019
Published online 30th April, 2019

Key Words:

Threshold Inspiratory Muscle Training (IMT), Incentive SPIROMETRY, Pimax, Upper Abdominal Surgeries.

**Corresponding author:*
Dr. Vishnu Vardhan G.D.,

ABSTRACT

Background and Objective: Surgical care has a role in treating a broad spectrum of diseases in the alleviation of human suffering. Upper abdominal surgery included gastrectomy, pancreatectomy, hepatic resection, cholecystectomy and splenectomy. Maximal inspiratory pressure (Pimax) is an important indicator for assessing the strength of inspiratory muscles. Respiratory muscle training devices enhance respiratory muscle strength, endurance and exercise capacity. Pressure Threshold IMT devices are usually handheld devices with a spring load that is impeded with different intensities. Incentive Spiro meter is a form of ventilatory training that emphasis sustained maximum inspiration. Therefore, the present study aims to assess the effect of Threshold Inspiratory Muscle Training versus Incentive spirometry in participants with upper abdominal surgeries. **Materials and Methods:** A prospective cross-sectional comparative study was done with 30 participants with upper abdominal surgeries in the age group of 20 to 65.On Day 1 and after 2 weeks the maximal inspiratory pressure was measured using Hand Held Pressure Manometer Device (Pimax). Group Aparticipants received Threshold Inspiratory Muscle Training (IMT) and Group B participants received Incentive spirometry. The intervention was given for 5 days in a week for 2 weeks. The duration for each session was of 15-30 minutes which also includes rest periods. Data was analyzed using student Paired 't' testand Unpaired't' test. **Result:** There was extremely significant difference ($p<0.0001$) in Maximal Inspiratory Pressure (Pimax) in both the groups but Group A showed slightly more improvement were Threshold Inspiratory Muscle Training (IMT) was given as an intervention after 2 weeks. **Conclusion:** The study shows extremely significant improvement in Maximal Inspiratory Pressure (PI_{max}) in both the groups. This study concluded that Threshold IMT has more effect than Incentive Spirometry in participants with upper abdominal surgeries.

***Citation: Dr. Karuna Gautam Kamble and Dr. Vishnu Vardhan G.D.*, 2019.** "Effect of Threshold Inspiratory Muscle Training versus Incentive Spirometry in Upper Abdominal Surgeries – A Comparative Study", *International Journal of Current Research*, 11, (04), 3327-3332.

INTRODUCTION

Surgical care has a role in treating a wide range of diseases in the improvement of human suffering. Surgical necessity differs between regions of the world according to disease prevalence. According to WHO, at least 321·5 million surgical procedures would be needed to address the burden of diseasefor a global population of 6·9 billion. A large volume of surgical need, estimates one procedure per 21 people alive today, with a global rate of surgery of 4664 per 100, 000 (Rose *et al.,* 2015). Upper abdominal surgery included gastrectomy, pancreatectomy, hepatic resection, cholecystectomy and splenectomy (Kim, 2016). Upper abdominal surgery initiates a cascade of pathophysiological responses, potentially causing postoperative pulmonary complications (PPCs) (Patman, 2017). Postoperative pulmonary complications (PPCs) present high rates of morbidity, mortality, increased hospital costs and prolonged hospital stay predominantly in abdominal surgery.Surgery and general anaesthesia directly affect the respiratory system.

Upper abdominal surgery alters postoperative pulmonary function, as observed by impairment of lung volumes such as total lung capacity, vital capacity and tidal volume (Carvalho *et al.,* 2011). There may be some benefits of pre-operative incentive spirometry, deep breathing exercises and chest physiotherapy in reducing postoperative pulmonary complications following major abdominal surgery (Kulkarni *et al.,* 2010). Surgical procedures can affect the respiratory muscles by a number of mechanisms including thoracoabdominal mechanics, reflexes, neuromechanical coupling and loss of muscular integrity. Impairment of respiratory muscle function after surgery may lead to postoperative complications such as hypoventilation, hypoxia, atelectasis and infections that may be life threatening. Respiratory muscles are affected during and after abdominal surgery. The most important factors of affecting the respiratory muscles are the side of the operation and type of operation.

This is because the diaphragm is the muscle that is mainly affected during upper abdominal surgery (Siafakas *et al.,* 1999). Muscle fatigue has a major role in affecting exercise tolerance among healthy individuals. Therefore, muscle training devices play a great role in improving muscle activities. Maximal Inspiratory Pressure (MIP) and Maximal Expiratory Pressure (MEP) are measures of maximal strength of respiratory muscles. They are correspondingly the greater pressure which may be produced during maximal inspiration and expiration against an occluded airway (Gil Obando, 2012). Maximal Inspiratory Pressure (MIP) is the most widely used measure of respiratory muscle strength. It is determined by measuring upper airway pressure (mouth for patients) during a maximal voluntary inspiratory effort. The measured pressure is a composite of the pressure generated by the inspiratory muscles and the elastic recoil pressure of the lungs and chest wall (Caruso *et al.,* 2015).

Black and Hyatt introduceasimple way to measure maximal respiratory pressure with a hand-held mouth pressure meter in cm H2O. This is a way to quantitatively measure the function and respiratory muscle strength; this is indicative of the strength of inspiratory and expiratory muscle groups (Gil Obando *et al.,* 2012). The inspiratory muscles, including the diaphragm, are morphologically and functionally skeletal muscles, therefore should respond to training in the same way as would any locomotor muscle if asuitable physiological load is applied. It has been documented that the diaphragm increases its thickness when resistance is applied during weight training (Enright, 2006). Respiratory muscle training devices improve respiratory muscle strength, endurance and exercise capacity. These training devices divided into two main categories, namely Inspiratory Muscle Training devices (IMT) and Expiratory Muscle Training devices (EMT). Inspiratory Muscle Training devices improve both inspiratory and expiratory muscle strength. In contrast, EMT devices improve only the strength of the expiratory muscle (Nora *et al.,* 2018). Inspiratory muscle training (lMT) is currently used in pulmonary rehabilitation to increase the strength and endurance of the inspiratory muscles. Resistive inspiratory muscle training is divided into two types: Pressure resistive IMT devices (PR-IMT) and flow resistive devices. Pressure resistive IMT devices are usually handheld devices with a spring load that is impeded with different intensities. These intensities can be adjusted by the resistive load knob (varying from low to high). In addition, the normal mechanism of PR-IMT devices requires the initiation of a negative pressure (breath) done by the subjects to overcome the load resistance. The effectiveness of these devices has been proved, which stated that the PR-IMT devices work on improving the maximal inspiratory pressure (MIP) (Nora *et al.,* 2016).

Usually, the patient begins training at a low load, equal to about one third of the Pimax and progresses slowly in small increments adjusting a screw to alter the tension until the training load reaches 60% of the current Pimax. The threshold device delivers a reliable tension because the poppet valve at the end of the device will not open and allow inspiration unless the patient generates the designated negative pressure. Both types of devices are hand held and portable and are easily used and maintained by patients (Donna Frownfelter). The purpose of Incentive Spirometer (IS) is to coach the patient to take a sustained maximal inspiratory (SMI) effort resulting in a decrease in PPCs and maintaining the patency of airways at risk for closure (Robert).

The equipment needed for SMI is typically simple, portable, and inexpensive. Incentive Spiro meter devices can commonly be categorized as volume-oriented or flow-oriented. True volume-oriented devices measure and visually indicate the volume achieved during an SMI. The most popular true volume-oriented IS devices employ a bellows that rises according to the inhaled volume. When the patient reaches a target inspiratory volume, a controlled leak in the device allows the patient to sustain the inspiratory effort for a short period (usually 5 to 10 seconds). Because the bellows types of IS devices are bulky and large, smaller devices that indirectly indicate volume based on flow through a fixed orifice have been developed. These devices sacrifice accurate measurement ofthe inhaled volume to achieve portability and smaller size.[13] Therefore the present study has been taken up to evaluate the effect of Threshold Inspiratory Muscle Training versus Incentive Spirometer in upper abdominal surgeries.

MATERIALS AND METHODS

Participants: Total thirty participants both male and female with upper abdominal surgeries were included in the study. Participants were screened according to the inclusion and exclusion criteria. Participants with age group of between 20-65, with upper abdominal surgeries and willing to participate were selected for the study. Participants who were heamodynamically unstable and chronic debilitating conditions were excluded from the study. The study received approval from Institutional Ethical Committee of Dr. APJ Abdul Kalam College of Physiotherapy, Pravara Institute of Medical Sciences, Loni. Written informed consent was taken from all the participants selected for the study.

Procedure: The study received approval from Institutional Ethical Committee Ref.no. PIMS/CPT/IEC/2018/208 of Dr. A.P.J. Abdul Kalam College of Physiotherapy, Pravara Institute of Medical Sciences, Loni. Total thirty participants (n=30) were selected and screened according to inclusion and exclusion criteria. The details about the study and intervention were explained to the participants and informed written consent form was obtained. Demographic details of the participants were noted including name, age, gender. Participants were divided into 2 groups, Group A; included 15 participants and Group B; included 15 participants. Before starting the intervention, participants were assessed for Pimax (Maximum Inspiratory Pressure) using Hand Held Pressure Manometer device. The intervention was given for the period of 2 weeks, twice a day. After 2 weeks participant were reassessed with same outcome measure, for the effects of training due to the intervention.

Group A: The participants in this group received threshold inspiratory muscle training. Treatment session lasted for 15-30 minutes. This intervention was given for 2 weeks.

Group B: The participants in this group received incentive spirometry. Incentive spirometry was given for 10repetitions every two hourly. This intervention was given for 2 weeks.

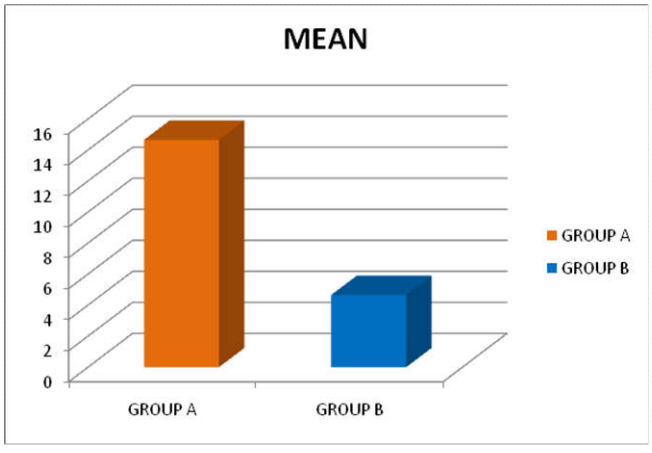
Outcome measures: Hand held pressure manometer device (Pimax - Maximum Inspiratory Pressure) Maximal Inspiratory Pressure (MIP) is the most widely used measure of respiratory muscle strength. MIP is measured from Residual Volume (RV).

DATA ANALYSIS AND RESULTS

The objective of the study was to find the effect of Threshold Inspiratory Muscle Training versus Incentive Spirometry on Pimax in participants with abdominal surgeries. The data was collected and used to analyze the results. The result for the study was obtained from the Pimax. All 30 participants completed 2 weeks of intervention. All the patients were screened and evaluated for baseline measurements of dependent variable and all the values were recorded. Participants were evaluated and data was recorded after 2 weeks. Statistical analysis was carried out utilizing the trial version of Graph Pad Instat software. The data was entered into an excel spread sheet, tabulated and subjected to statistical analysis. Various statistical measures such as mean, standard deviation (S.D.) and test of significance such as Paired 't' test and Unpaired 't' test were utilized to analyzed the data. The results were concluded to be statistically significant with $p<0.0001$ extremely significant. Paired't' test was used to compare the difference between the pre-intervention and post-intervention values within the group and Unpaired 't' test was used to compare the difference between the post intervention values between the groups. The differences in the baseline parameter for Pimax perceived by participants in both the groups were extremely significant ($p<0.0001$, $t=7.276$ with $df=28$). Pimax perception was more decreased in Group B as compared to Group A. Students Unpaired 't' was used which revealed that there is extremely significant difference between both the groups. The mean difference Pimax in group A and group B is 14.66±4.419 and 4.66±2.968 ($p=0.0001$, $t=7.276$ with $df=28$).

Table 1.1. Represents the Mean Difference in Pimax of Group A and Group B

	GROUP A	GROUP B	t-value	p-value
Mean	14.66	4.66	7.276	<0.0001 Extremely significant
SD	4.419	2.968		



Graph 1.1. Represents the Mean Difference of Pimax of Group A and Group B

DISCUSSION

The present study "Effect of Threshold Inspiratory Muscle Training versus Incentive Spirometry inparticipants with Upper Abdominal Surgeries – A Comparative Studywas carried out In-patient Surgery Department referred to Department of Cardio-Respiratory Physiotherapy, Pravara Rural Hospital. Loni (Bk), Taluka- Rahata, Dist- Ahmednagar, Maharashtra, India. 413736. In both the groups, Pimax was evaluated pre and post intervention as outcome measure in abdominal surgeries. The main purpose of this study was to determine the effect of Threshold Inspiratory Muscle Training versus Incentive Spirometry in participants with upper abdominal surgeries. Many studies support the use of IMT in preoperative conditions for prevention of post-operative complications. Most of the studies have focused on the use of Threshold IMT and Incentive Spirometry in respiratory conditions but there is very few literature available on the use of this device in abdominal surgeries. In the present study inspiratory muscle training was given for 2 weeks (5times per week) after abdominal surgery using a Threshold Inspiratory Muscle Training Device in group A. By using students paired't' test within the group there was extremely significant difference ($p< 0.0001$, 't'=12.856 with df=14) which states that there is increase in Pimax in Group A as compared to the other group. Post-operative drugs such as anaesthetics and analgesic also affect upper airway and accessory muscle function, increasing the risk of Post-operative Pulmonary Complications (PPC).

As the site of surgery has a potent influence upon the development of PPC, thoracic and abdominal surgeries are also associated with the high risk of PPC[15] and give rise to post-operative respiratory muscle dysfunction. The origin of the resulting muscle dysfunction is complex, but includes factors such as changes in thoracoabdominal mechanics and loss of muscular integrity (Siafakas, 1999). In addition; post-operative pain can limit respiratory movements, which can also be impaired by reflex inhibition of respiratory muscle activity, especially the diaphragm (Sharma, 1999). Primary Inspiratory muscle is diaphragm, which generates negative intra thoracic pressure and enlarges the thoracic cavity during inspiration. Other inspiratory muscles include the external intercostal muscles; essential for rib cage flexibility, while scalene and sternocleidomastoid muscles elevates the rib cage during inspiration. The diaphragm and intercostal muscles are naturally slow to fatigue due to their high content of oxidative type I and type IIA muscle fibres. Moderate-to-high intensity IMT (~60% of maximal inspiratory pressure) will increase muscle strength, maximal shortening velocity and maximal power ofthe inspiratory muscles.

In addition, inspiratory muscle strength training will also improve muscle endurance and delay diaphragm fatigue, thus increasing exercise tolerance and performance (McConnell, 2013). Inspiratory pressure threshold loading requires individuals to produce a negative pressure sufficient to overcome a threshold load and thereby initiates inspiration. Threshold loading permits variables loading at a quantifiable intensity by providing flow independent resistance to inspiration. This type of loading has been achieved with a spring loaded poppet valve and constant negative pressure system. Training with Inspiratory pressure threshold loading increases the maximal force production, the maximal velocity, the maximal rate of shortening, the maximal power output and the endurance of the inspiratory muscles. A study was done by Tzelepis et al, Tzelepis et al, Romer& McConnell, found that, when IMT was undertaken using moderate loads (~60% of MIP) allowed rapid muscle shortening and improvement in muscle strength in healthy people by increasing maximal shortening velocity (peak inspiratory flow rate) and maximal power (Tzelepis, 1994; Tzelepis *et al.,* 1999; Romer, 2003). Inspiratory muscle training has been conducted pre-operatively & post-operatively.

Pre-operative IMT has been undertaken prior to coronary artery by-pass graft surgery (CABG) (Weiner, 1998; Hulzebos *et al.,* 2006; Hulzebos *et al.,* 2006), abdominal surgery (Dronkers, 2008; Dronkers *et al.,* 2010), oesophagectomy (Dettling *et al.,* 2013), open bariatric surgery (Barbalho-Moulim, 2011), and thoracic orthopaedic surgery (Takaso *et al.,* 2010). Post-operative treatment has followed open bariatric surgery (Casali, 2011) and cardiac surgery (Kodric *et al.,* 2013), whereas pre- and post-operative treatment has been undertaken in patients undergoing CABG surgery (Savci, 2011) and pneumonectomy (Weiner, 1997). The respiratory muscles are unique among skeletal muscles because of their continuous activity throughout life. There are three training principles that are well established for skeletal muscles namely 'overload', 'specificity' and 'reversibility' (Pardy, 1995). Romer& McConnell studied on specificity and reversibility of inspiratory muscle training which stated that respiratory muscles respond to these principles in the same manner as other muscles (McConnell, 2013). Therefore there is possibility that the present study shows improvement in MIP in Group A when treated with Threshold IMT considering the above studies. Hence the present study suggests that increase in MIP increases the strength of the respiratory muscles. Nora SulaimanAlwohayeb, et al; carried out a studyon Threshold IMT and POWERbreath plus training devices and found that both the devices were effective and well tolerated by the normal Subjects who were included in the study. Threshold group revealed improvement in Maximal inspiratory pressure (MIP), Maximal expiratory pressure (MEP), and Mandatory Voluntary Ventilation (MVV) whereas there was no improvement seen in the peak expiratory flow rate Peak Expiratory Flow Rate (PEFR)as well as there was significant improvement in MIP, PEFR and MVV in POWERbreath plus group. The study postulated that Threshold device is superior to POWER breath plus device in improving the MIP parameters, while the MVV did not show any difference between the two devices (Tzelepis, 1999). The above study can be related to the present study which shows improvement in respiratory muscle strength as there was increase in the MIP treated with Threshold IMT (Nora, 2018). These findings are consistent with studies of IMT performed on athletes[34] and patients with COPD[35] that showed improvement in inspiratory muscle strength, exercise tolerance and quality of life was improved after Threshold IMT training.

Preoperative IMT programs are used to increase respiratory muscle strength and endurance and several studies have demonstrated their benefits (Dronkers, 2008; Agrelli, 2012). Riganas et al reported a 28% increase of inspiratory muscle strength after 6 weeks of IMT, and Stein et al demonstrated a 37% increase of MIP after 4 weeks of ambulatory IMT post-operative Esophagectomy patients. Other studies found a significant increase of inspiratory muscle strength between the second and fourth week of preoperative IMT (Agrelli, 2012).
Participants in group B were given Incentive spirometry for 5 days/week for 2 weeks. By using students paired't' test within the group there was extremely significant difference ($p<0.0001$, $t=6.089$ with $df=14$) which states that there is improvement in group B but there is more improvement seen in group A in which threshold IMT was given. The therapeutic efficacy of incentive spirometry is controversially discussed in the literature (Weindler, 2001). Schwieger et al demonstrated the lack of benefit of postoperative incentive spirometry in patients with an American Society of Anesthesiology physical status of I or II undergoing elective cholecystectomy.

Hall and colleagues compared incentive spirometry and chest physiotherapy for the prevention of pulmonary complications after upper abdominal surgery and found them to be equivalent (Hall, 1991). Christensen et al compared the efficacy of chest physiotherapy with both positive expiratory pressure and inspiratory resistance after upper-abdominal surgery. There were no statistically significant differences in the incidence of PPCs (Tomich *et al.,* 2007). Respiratory impairment includes a reduction in both chest wall volume and bronchial capacity, which may result in respiratory infection. Incentive spirometry can be used to encourage deeper breaths and provide increased respiratory capacity, thus reversing alveolar collapse and improving oxygenation. Incentive spirometer has been used for the prophylaxis and treatment of pulmonary complications during abdominal (Carvalho, 2011; Restrepo, 2011), cardiac, and thoracic surgeries (Agostini, 2008; Paisani, 2012). Denise de MoraesPaisani PhD, Adriana Claudia Lunardi PhD et al; conducted study which states that Volume oriented Incentive Spirometry (VIS) and Flow oriented Incentive Spirometry (FIS) increased pulmonary volumes in healthy adults; however VIS induced a greater total chest wall volume, especially in the abdominal compartment, and lower respiratory muscle activity, compared to FIS (Paisani, 2012). Parreira et al and Tomich et al showed that VIS induced a higher pulmonary volume than FIS, although both devices induced similar displacement of the abdominal and thoracic compartments. In addition, they showed that FIS induced a higher breathing frequency and accessory respiratory muscle activity than did VIS (Parreira, 2005; Tomich, 2007). Incentive spirometers differ considerably in their additional Wbimp with a potential impact on the efficacy of postoperative incentive spirometry performance. PImax might be an easy clinical estimate for the WBimp during incentive spirometry. Incentive spirometers with low WBimp permit increased maximal sustained inspiration and thus, enhanced incentive spirometry performance and therefore it might be more suitable for use in postoperative respiratory care (Weindler, 2001).

Conclusion

The present study shows extremely significant improvement in PI_{max} in both the groups. This study concluded that Threshold IMT has more effect than Incentive Spirometry in the upper abdominal surgeries. Thus the result rejects the null hypothesis and accepts the alternate hypothesis which states that, there was significant difference in the Pimax of 30 participants with upper abdominal surgeries when treated with Threshold Inspiratory Muscle Training (IMT) and Incentive Spirometer (IS) for the period of 2 weeks.

Limitation of Study:

- At times, it was difficult to perform Threshold IMT because of the wound and stitches pain.
- It was difficult to explain the procedure
- Un co-opertive participants

Suggestion for future research: Future research should be done with more sample size and more focus Threshold IMT on upper and lower abdominal surgeries.

Acknowledgements: Authors are thankful to the Almighty, the College Principal, Staff for the continuous support and encouragement and all the participants who very well co-operated for the study. Special thanks to those who directly and indirectly helped us for the study.

Ethical Approval Ref. no.: PIMS/CPT/IEC/2018/208
Conflict of Interest: None
Funding: None

REFERENCES

Agostini P., Calvert R., Subramanian H., Naidu B. 2008. Is incentive spirometry effective following thoracic surgery?. *Interactive cardiovascular and thoracic surgery*. Apr 1; 7(2):297-300.

Agrelli TF., de Carvalho Ramos M., Guglielminetti R., Silva AA., Crema E. 2012. Preoperative ambulatory inspiratory muscle training in patients undergoing esophagectomy. A pilot study. *International surgery*. Oct; 97(3):198-202.

Barbalho-Moulim MC., Miguel GP., Forti EM., Campos FD., Costa, D. 2011. Effects of preoperative inspiratory muscle training in obese women undergoing open bariatric surgery: respiratory muscle strength, lung volumes, and diaphragmatic excursion. Clinics., 66(10):1721-7.

Canet J., Mazo V. 2010. Postoperative pulmonary complications. *Minerva Anestesiol.,* 76: 138-43.

Caruso P., Albuquerque AL., Santana PV., Cardenas LZ., Ferreira JG., Prina E., Trevizan PF., Pereira MC., Iamonti V., Pletsch R., Macchione MC. 2015. Diagnostic methods to assess inspiratory and expiratory muscle strength. *Jornal Brasileiro de Pneumologia*. Apr;41(2):110-23.

Carvalho CR., Paisani DM., Lunardi AC. 2011. Incentive spirometry in major surgeries: a systematic review. *Brazilian Journal of Physical Therapy*. Oct; 15(5):343-50.

Casali CC., Pereira AP., Martinez JA., de Souza HC., Gastaldi AC. 2011. Effects of inspiratory muscle training on muscular and pulmonary function after bariatric surgery in obese patients. *Obesity surgery*. Sep 1;21(9):1389-94.

Dettling DS., van der Schaaf M., Blom RL., Nollet F., Busch OR., van Berge Henegouwen MI. 2013. Feasibility and effectiveness of pre-operative inspiratory muscle training in patients undergoing oesophagectomy: a pilot study. *Physiotherapy Research International*. Mar;18(1):16-26.

Donna Frownfelter, Elizabeth Dean. Principles and practice of cardiopulmonary physical therapy. Edition- 3, chapter-25, page no- 448-450.

Dronkers J., Veldman A., Hoberg E., Van Der Waal C., Van Meeteren N. 2008. Prevention of pulmonary complications after upper abdominal surgery by preoperative intensive inspiratory muscle training: a randomized controlled pilot study. *Clinical rehabilitation.,* 22(2):134-42.

Dronkers JJ., Lamberts H., Reutelingsperger IM., Naber RH., Dronkers-Landman CM., Veldman A., van Meeteren NL. 2010. Preoperative therapeutic programme for elderly patients scheduled for elective abdominal oncological surgery: a randomized controlled pilot study. *Clinical rehabilitation.,* Jul;24(7):614-22.

Duggan, M. & Kavanagh, B.P. 2010. Perioperative modifications of respiratory function. Best Pract. Res. Clin. Anaesthesiol. 24(2): 145-155.

Enright SJ., Unnithan VB., Heward C., Withnall L., Davies DH. 2006. Effect of high-intensity inspiratory muscle training on lung volumes, diaphragm thickness, and exercise capacity in subjects who are healthy. Physical therapy. Mar 1;86(3):345-54.

Gil Obando LM., LópezLópez A., Ávila CL. 2012. Normal values of the maximal respiratory pressures in healthy people older than 20 years old in the City of Manizales-Colombia. *Colombia Médica.,* Apr;43(2):119-25.

HajGhanbari B., Yamabayashi C., Buna TR., Coelho JD., Freedman KD., Morton TA., Palmer SA., Toy MA., Walsh C., Sheel AW., Reid WD. 2013. Effects of respiratory muscle training on performance in athletes: a systematic review with meta-analyses. *The Journal of Strength & Conditioning Research*. Jun 1; 27(6):1643-63.

Hall JC., Harris J., Tarala R., Tapper J., Chnstiansen K. 1991. Incentive spirometry versus routine chest physiotherapy for prevention of pulmonary complications after abdominal surgery. The lancet. Apr 20; 337(8747):953-6.

Hulzebos EH., Helders PJ., Favié NJ., De Bie RA., de la Riviere AB., Van Meeteren NL. 2006. Preoperative intensive inspiratory muscle training to prevent postoperative pulmonary complications in high-risk patients undergoing CABG surgery: a randomized clinical trial. Jama. Oct 18;296(15):1851-7.

Hulzebos EH., van Meeteren NL., van den Buijs BJ., de Bie RA., De La Riviere AB., Helders PJ. 2006. Feasibility of preoperative inspiratory muscle training in patients undergoing coronary artery bypass surgery with a high risk of postoperative pulmonary complications: a randomized controlled pilot study. *Clinical rehabilitation*. Nov;20(11):949-59.

Kim TH., Lee JS., Lee SW., Oh YM. 2016. Pulmonary complications after abdominal surgery in patients with mild-to-moderate chronic obstructive pulmonary disease. *International journal of chronic obstructive pulmonary disease.* 11:2785.

Kodric M., Trevisan R., Torregiani C., Cifaldi R., Longo C., Cantarutti F., Confalonieri M. 2013. Inspiratory muscle training for diaphragm dysfunction after cardiac surgery. *The Journal of thoracic and cardiovascular surgery*. Mar 1;145(3):819-23.

Kulkarni SR., Fletcher E., McConnell AK., Poskitt KR., Whyman MR. 2010. Pre-operative inspiratory muscle training preserves postoperative inspiratory muscle strength following major abdominal surgery–a randomised pilot study. *The Annals of The Royal College of Surgeons of England*. Jul 26;92(8):700-5.

McConnell AK. 2013. Respiratory Muscle Training: Theory and Practice. Edinburgh, Churchill Livingstone/Elsevier.

Nield MA. 1999. Inspiratory muscle training protocol using a pressure threshold device: effect on dyspnea in chronic obstructive pulmonary disease. *Archives of physical medicine and rehabilitation*. Jan 1; 80(1):100-2.

Nora SA., Bushra AA., Fay AA. and Mashail MA. 2018. A Comparison between Two Types of Resistive Inspiratory Muscle Training Devices in Normal Subjects in Regards to Pulmonary Functions. *International Journal of Physical Medicine & Rehabilitation*. 6:1.

Paisani DM., Lunardi AC., da Silva CC., Porras DC., Tanaka C., Carvalho CR. 2012. Volume rather than flow incentive spirometry is effective in improving chest wall expansion and abdominal displacement using optoelectronic plethysmography. *Respiratory Care*. Dec 11:respcare-02037.

Pardy RL., Leith DE. 1995. Ventilatory muscle training. In: Roussos C, Macklem PT, eds. The Thorax. New York, Marcel Dekker, Inc., pp. 1353–1371.

Parreira VF., Tomich GM., Britto RR., Sampaio RF. 2005. Assessment of tidal volume and thoracoabdominal motion using volume and flow-oriented incentive spirometers in healthy subjects. *Brazilian journal of medical and biological research.* Jul; 38(7):1105-12.

Patman S., Bartley A., Ferraz A., Bunting C. 2017. Physiotherapy in upper abdominal surgery–what is current practice in Australia?. *Archives of physiotherapy*. Dec; 7(1):11.

Reeve JC., Nicol K., Stiller K., McPherson KM., Birch P., Gordon IR., Denehy L. 2010. Does physiotherapy reduce the incidence of postoperative pulmonary complications following pulmonary resection via open thoracotomy? A preliminary randomised single-blind clinical trial. *European journal of cardio-thoracic surgery*. May 1; 37(5):1158-66.

Restrepo RD., Wettstein R., Wittnebel L., Tracy M. 2011. Incentive spirometry: 2011. Respiratory care. Oct 1;56(10):1600-4.

Robert MK., James KS., Albert JH. Egan's Fundamentals of respiratory care. Edition-11, Chapter-42, page no- 940-943.

Romer LM., McConnell AK. 2003. Specificity and reversibility of inspiratory muscle training. Medicine and science in sports and exercise. Feb 1;35(2):237-44.

Rose J., Weiser TG., Hider P., Wilson L., Gruen RL., Bickler SW. 2015. Estimated need for surgery worldwide based on prevalence of diseases: a modelling strategy for the WHO Global Health Estimate. *The Lancet Global Health*. Apr 27;3:S13-20.

Savci S., Degirmenci B., Saglam M., Arikan H., Inal-Ince D., Turan HN., Demircin M. 2011. Short-term effects of inspiratory muscle training in coronary artery bypass graft surgery: a randomized controlled trial. *Scandinavian cardiovascular journal*. Oct 1;45(5):286-93.

Sharma RR., Axelsson H., Oberg A., Jansson E., Clergue F., Johansson G., Reiz S. 1999. Diaphragmatic activity after laparoscopic cholecystectomy. Anesthesiology: The Journal of the American Society of Anesthesiologists. Aug 1; 91(2):406-13.

Siafakas NM., Mitrouska I., Bouros D., Georgopoulos D. 1999. Surgery and the respiratory muscles. Thorax. May 1;54(5):458-65.

Takaso M., Nakazawa T., Imura T., Okada T., Ueno M., Saito W., Takahashi K., Yamazaki M., Ohtori S. 2010. Surgical correction of spinal deformity in patients with congenital muscular dystrophy. Journal of Orthopaedic Science. 2010 Jul 1;15(4):493-501.

Tomich GM., França DC., Diório AC., Britto RR., Sampaio RF., Parreira VF. 2007. Breathing pattern, thoracoabdominal motion and muscular activity during three breathing exercises. *Brazilian Journal of Medical and Biological Research*. Oct; 40(10):1409-17.

Tomich GM., França DC., Diório AC., Britto RR., Sampaio RF., Parreira VF. 2007. Breathing pattern, thoracoabdominal motion and muscular activity during three breathing exercises. *Brazilian Journal of Medical and Biological Research*. Oct; 40(10):1409-17.

Tzelepis GE., Kadas V., McCool FD. 1999. Inspiratory muscle adaptations following pressure or flow training in humans. European journal of applied physiology and occupational physiology. Apr 1;79(6):467-71.

Tzelepis GE., Vega DL., Cohen ME., Fulambarker AM., Patel KK., McCool FD. 1994. Pressure-flow specificity of inspiratory muscle training. *Journal of Applied Physiology*. Aug 1;77(2):795-801.

Weindler J, Kiefer RT. The efficacy of postoperative incentive spirometry is influenced by the device-specific imposed work of breathing. Chest. 2001 Jun 1;119(6):1858-64.

Weiner P., Man A., Weiner M., Rabner M., Waizman J., Magadle R., Zamir D., Greiff Y. 1997. The effect of incentive spirometry and inspiratory muscle training on pulmonary function after lung resection. *The Journal of Thoracic and Cardiovascular Surgery*. Mar 1;113(3):552-7.

Weiner P., Zeidan F., Zamir D., Pelled B., Waizman J., Beckerman M., Weiner M. 1998. Prophylactic inspiratory muscle training in patients undergoing coronary artery bypass graft. World journal of surgery. May 1;22(5):427-31.

****