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# Influence of Abdominal Muscle Strength on Pulmonary Function in Post Upper Abdominal Surgery Subjects

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## Abstract

*To find out the relation between abdominal muscle strength and pulmonary function in post upper abdominal surgery subjects. Physiotherapy protocols concentrate on inspiratory muscles and airway clearance techniques. Very few studies were done to find out the relationship between expiratory muscles and pulmonary function. Hence, the need of the study was to find out the relationship between abdominal muscle strength and pulmonary function and its influence on pulmonary complications after upper abdominal surgery the objective of the study is to evaluate the abdominal muscle strength, $FEV_1$/FVC ratio, chest excursion in pre and post upper abdominal surgery subjects. And to find out the correlation between abdominal muscle strength and $FEV_1$/FVC ratio and also the correlation between abdominal muscle strength and chest excursion.30 subjects who met inclusive criteria with age of 35-50 years and who has abdominal muscle power grade 3 were selected for this study. Abdominal muscle strength was measured by surface EMG biofeedback, $FEV_1$/FVC was measured with portable electronic spirometer and chest excursion was measured with measuring tape. These parameters were assessed preoperatively and on the seventh day postoperatively and checked for their correlation. This study shows that good pulmonary function can be maintained by good abdominal muscle strength hence, strengthening the abdominal muscles preoperatively along with diaphragmatic breathing exercises is necessary in order to reduce the incidence of postoperative pulmonary complications after upper abdominal surgery.*

**Keywords:** Abdominal muscle strength, $FEV_1$/FVC ratio, chest excursion, EMG biofeedback, electronic spirometer.

## Introduction

The term abdominal surgery refers to "any operation that involves an incision into the abdomen"[1]. Common upper abdominal surgery procedures performed are cholecystectomy, duodenoplasty, gastrectomy etc.[2,3]. The function of respiratory system is invariably affected during and after the abdominal surgery. The closer the operation is to the diaphragm as in upper abdominal surgeries the more likely is the chance of developing postoperative pulmonary complications[4]. Based on many studies performed over a 40 year period the reported incidence of postoperative pulmonary complications varies from 6% to 76%[5]. The most common postoperative pulmonary complications seen are atelectasis, pneumonia, infections, diaphragmatic dysfunction, reduced FRC, VC and lung compliance[6]. The risk factors like age, smoking, obesity, physical inactivity, sputum production, history of chronic lung disease, abdominal muscle weakness enhances the development of pulmonary complications after upper abdominal surgery. Very few studies were done on obesity, physical inactivity and abdominal muscle weakness which enhance the development of pulmonary complications after abdominal surgery.

The role of abdominal muscles on pulmonary function is that it contributes about 20% of work of breathing. The anterior abdominal muscles have two distinct respiratory effects firstly they pull on the rib margins and second they increase the intra-abdominal pressure. The effect of abdominal muscle contraction is that it decreases thoracic volume and transpulmonary pressure and then the lung volume is reduced. They also have a significant role to play in inspiration as well. During inspiration the abdomen assists with lateral chest wall expansion by providing anterior stability to abdomen so it may act as fulcrum for the diaphragm action there by maintaining zone of apposition[7].

Conventional chest physiotherapy after upper abdominal surgery concentrates on techniques to increase ventilation and oxygenation like breathing exercises and airway clearance techniques. Very few studies were done to find out the relationship between expiratory muscles and pulmonary function. Hence, the need of the study was to find out the relationship between abdominal muscle strength and pulmonary function and its influence on pulmonary complications after upper abdominal surgery.

## Material and Methods

To record abdominal muscle strength EMG biofeedback machine, MYOMED 932 is used. To record the $FEV_1$/FVC ratio

portable electronic spirometer, BIONET, CARDIOTOUCH 3000 is used. To measure the chest excursion measuring tape is used. Inclusive criteria Age between 35-50 years both male and female, upper abdominal surgeries, haemodynamically stable subjects, subjects with abdominal muscle power three, subjects who are able to understand local languages (Telugu, English). Exclusive criteria Emergency upper abdominal surgeries. Neuromuscular diseases, Patients on ventilator support. Systemic disorders. History of smoking, Past history of pulmonary disorders and surgeries. 30 subjects selected in gastroenterology ward in Sri Venkateswara Institute Of Medical Sciences, Tirupati, Andhra Pradesh were taken up for the study. Three months of study period from November to January 2010-2011.

Convenient sampling of 30 patients who met inclusive criteria with abdominal muscle power three was included in the study and informed consent was taken from all the patients. Preoperatively the values of abdominal muscle strength, $FEV_1$/FVC ratio and chest excursion were taken and postoperatively assessment was done again on the seventh day for exclusion of the ventilator patients. Outcome measure was used in this study is Abdominal muscle strength measured through EMG biofeedback, FEV1/FVC ratio measured by portable electronic spirometer and Chest excursion measured by measuring tape. Written informed consent was obtained from all the patients included in the study. Preoperatively patients were screened for inclusion and exclusion criteria and they are assessed for abdominal muscle strength, $FEV_1$/FVC ratio and chest excursion. Postoperatively patient was again screened for exclusion criteria, and then again assessed for the parameters. Surface EMG biofeedback was used to quantify rectus abdominals and external oblique muscular activity. Disposable surface electrodes with interelectrode distance of 2 cm were used. Threshold EMG of 400 microvolt's, filter-average, sound-above threshold and a graph showing the threshold was set in the machine. Subject preparation was done by cleaning the surface of skin before electrode placement. To record rectus abdominis activity a pair of electrodes are placed on both the left and right aspects of umbilicus and oriented parallel with muscle fibers. To record left and right external obliques, pair of electrodes are placed above the anterior superior iliac spine, halfway between the iliac crest and ribs at a slightly oblique angle. A ground electrode was placed on the tibial tuberosity. Electrode placement was verified by inspection of the signal during voluntary contraction. Testing was done by maximum voluntary isometric contractions (MVICs) of each muscle were collected to allow normalization of the EMG data. Maximum rectus abdominis activation was obtained with the subject supine in a bent-knee sit-up posture with knees at 90 degrees (crook lying) and arms placed across the chest. For the external oblique MVIC, the subject lay on his side with the knees bent and the thighs secured to the table with a strap. The trunk was rotated so the shoulders were facing upward and the arms were placed across the chest. This was repeated for both right and left external oblique muscles. Three five second trials of all MVICs were repeated and best of the three trials was recorded[8].

Pulmonary function test was performed by using a portable electronic spirometer to assess $FEV_1$/FVC ratio. Initially name, age, height and weight of the patient were entered into the data of the machine in order to get the percentage predicted values. The patient is placed in a comfortable high sitting position and was instructed to put the mouth piece of the spirometer into the mouth and inhale as much as possible and then exhale rapidly and forcefully for as long as flow can be maintained. This was repeated until the largest value of $FEV_1$/FVC ratio is less than one liter. The value of $FEV_1$/FVC ratio was given out automatically by spirometer on a graph paper with a flow-volume chart[9].

Chest excursion of the patient was assessed by positioning the patient in a supine position on the bed, without a pillow, with arms extended along the sides of the trunk and chest uncovered. Then chest circumference was measured by using a measuring tape at 3 levels: axillary,nipple and xiphisternum levels, where the respective landmarks used are the anterior axillary line, nipple area and tip of the xiphoid process. The standardized procedure was used for making the measurements by keeping the zero point of the tape fixed on the midline of the body, aligned horizontally with the landmarks, while the other end of the tape was kept mobile to allow tape displacement and furthermore the tape was held snuggly but not tightly, where soft tissue contours remained unchanged. First, the patients were asked to perform maximum inspiration, followed by maximal expiration for training up the patient and at each level evaluated the patients were asked to perform maximal inspiration and expiration again. The measurements were made twice at each level during separate breaths at the end of the maximal inspiration and expiration, where they are asked to maintain maximal inspiration and expiration for at least two seconds in order to gather data. Then the chest excursion values were calculated as the difference between the inspiratory measurement and the expiratory measurement for each of the three levels and were recorded on the paper[10].

## Results and Discussion

Analysis was done to find out the significant relation between the parameters like abdominal muscle strength, $FEV_1$/FVC ratio and chest excursion preoperatively and on the seventh day postoperatively. Entire analysis was performed by using SPSS 16.0 version and MS-EXCEL packages.

To test the significance between preoperative and postoperative values paired t-test has been utilized. Pre and post mean values of abdominal muscle strength are 139.33 and 132.67 which shows the significant reduction in postoperative values, pre and post mean values of $FEV_1$/FVC ratio are 96.67 and 93.20 which shows the significant reduction in postoperative values and the pre and post mean values of chest excursion are 1.99 and 1.72 which shows significant reduction in postoperative values. It is observed that there is a significant reduction in the postoperative

values of abdominal muscle strength, $FEV_1$/FVC ratio and chest excursion when compared with that of preoperative values. Relation of abdominal muscle strength with $FEV_1$/FVC ratio and chest excursion was found by using Pearson's Rank Correlation test 'r'. The t-test was used to test the significance of 'r'. Finally a scatter plot was used to show the relation between each parameter. The comparison was noted to be significant at 5% level.

The correlation coefficient between Abdominal Muscle Strength and $FEV_1$ / FVC ratio was 0.89, which indicates that there is a high positive correlation between these two parameters. r = 0.89, which means that, with the increase/decrease in abdominal Muscle Strength, there was 89% of corresponding increase/decrease in FEV1/FVC ratio. Scatter plot between abdominal muscle strength and $FEV_1$ / FVC ratio.

**Table-1**
**Analysis of Preoperative and Postoperative Values of Abdominal Muscle Strength, $FEV_1$/FVC Ratio and Chest Excursion**

| Parameters | N | Mean | Standard Deviation | t-Value | df | p-Value |
|---|---|---|---|---|---|---|
| AMS (Pre) | 30 | 139.33 | 36.38 | 9.10 | 29 | 0.00* |
| AMS (Post) | 30 | 132.67 | 36.83 | | | |
| $FEV_1$/FVC (Post) | 30 | 96.67 | 5.21 | 4.44 | 29 | 0.00* |
| $FEV_1$/FVC (Pre) | 30 | 93.20 | 8.44 | | | |
| Chest Excursion (Pre) | 30 | 1.99 | 0.06 | 5.42 | 29 | 0.00* |
| Chest Excursion (Post) | 30 | 1.72 | 0.28 | | | |

* Indicates significance at 5% level

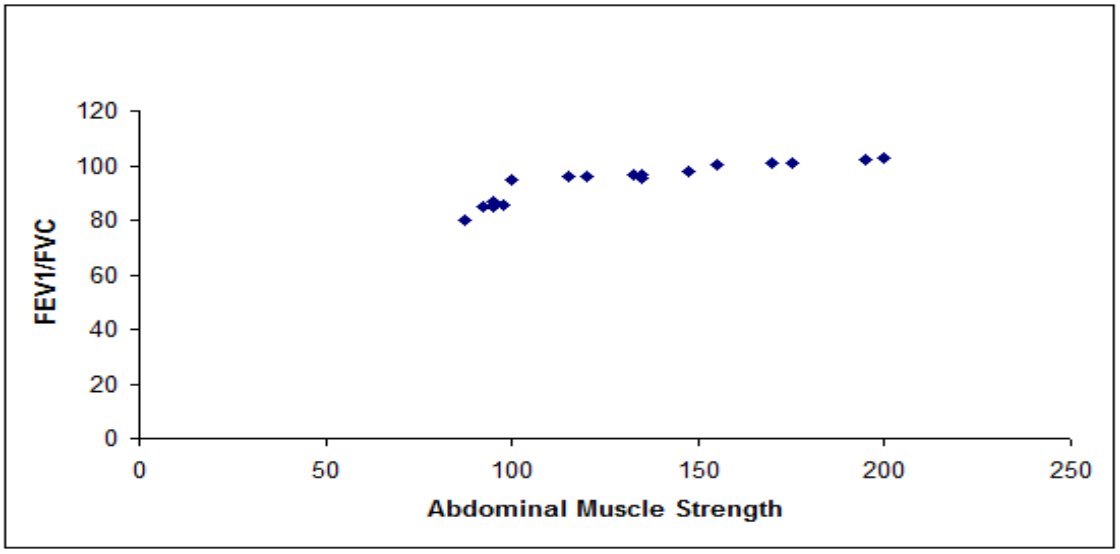


**Figure-1**
**The correlation coefficient between Abdominal Muscle Strength and $FEV_1$ / FVC**

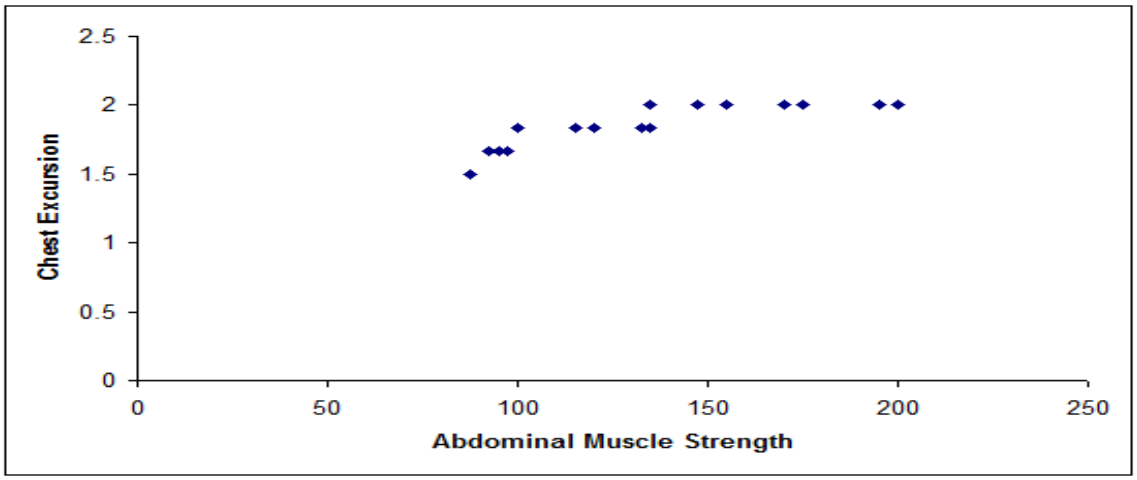


**Figure-2**
**The correlation coefficient between Abdominal Muscle Strength and Chest Excursion**

The correlation coefficient between Abdominal Muscle Strength and Chest Excursion was 0.87, which indicates there is a high positive correlation between these two parameters.

r = 0.87, which means that, with the increase/decrease in Abdominal Muscle Strength, there was 89% of corresponding increase/decrease in Chest Excursion also. Scatter plot between Abdominal Muscle Strength and Chest Excursion:

**Table-2**
**Summary of reports**

| Parameters | Correlation Coefficient | Correlation Type | Significance |
|---|---|---|---|
| Abdominal Muscle Strength – $FEV_1$ /FVC ratio | + 0.89 | Positive | 0.00* |
| Abdominal Muscle Strength – Chest Excursion | + 0.87 | Positive | 0.00* |

* Indicates significance at 5% level.

A major contributor to reduction in lung volumes after upper abdominal surgery is breathing pattern characterized by decreased tidal volume, absence of sighing, respiratory pattern and chest wall movement. As ribcage and abdomen motion reflects intercostal and diaphragm contribution to breathing, the reduction in diaphragmatic motion results in diminished ventilation and expansion of lower parts of lung after upper abdominal surgeries, hence there is a reduction in chest excursion postoperatively.

The results of this study showed positive correlation coefficient. Good abdominal muscle strength maintains good pulmonary function and there by reduces the pulmonary complications after upper abdominal surgeries in individuals with good abdominal muscle strength.

The motion of the ribcage can almost be completely attributed either to the direct action of diaphragm through its insertion at the lower ribs or its indirect action on the reduction of intrathoracic pressure through the abdominal musculature. It is believed that when the ventilatory capacities of lungs are compromised, the respiratory functions are affected and the individual could utilize the abdominal muscles to effect forced expiration, thus getting room for improved inspiration action. According to Nimmo and Drummond, upper abdominal surgery alters the relative activity of respiratory muscles including the abdominal muscles leading to changes in ribcage-abdominal configuration[11.] Craig stated that patients undergoing upper abdominal surgery develop restrictive pattern of pulmonary dysfunction[12]. According to Howkins respiratory complications after abdominal surgery were related to decreased diaphragm movement and this in turn could be related to abdominal movement[13]. Simmomeau et al concluded that diaphragm movement and lung compliance are reduced after upper abdominal surgery which may account for postoperative reduction in vital capacity which inturn leads to reduction in tidal volume, total lung capacity, functional residual capacity, insufficient cough, atelectasis in basal lung segments, increased ventilation perfusion mismatch, hypoventilation and later pulmonary infections[14]. According to R.M.W. Wabha reduction in functional residual capacity and vital capacity are due to mechanical disruption of abdomen**[15].** Abdominal muscle contraction reduces the lung volumes, increases the recoil pressure of lung and the airways dilate by cholinergic mechanisms, which might be expected to offset the propensity of airways to narrow and close. The activity of abdominal muscles will result in pressure changes in the pleural space similar to those caused by ribcage inspiratory activity. These changes are mistaken for inadequate diaphragm activity.[16] Abdominal muscles also play a role in effective coughing. Individuals with weak abdominal muscles showed ineffective coughing which inturn leads to accumualtion of secretions and infections there by affecting the pulmonary function. According to Sanya A.O. and Ramuyide A.O. it is believed that the abdominal muscles could be strengthened inorder to assist the ventilator process[17].

## Conclusion

This study concludes that good pulmonary function can be maintained by good abdominal muscle strength. Hence strengthening the abdominal muscles preoperatively along with diaphragmatic breathing exercises is necessary in order to reduce the incidence of postoperative pulmonary complications after upper abdominal surgery.

## References

**1.** Mosby's medical dictionary, **(2009)**

**2.** Maingot's abdominal operations, *Michael J Zinner*, **1**, 395-425 **(1997)**

**3.** Surgery of upper gastrointestinal tract, Rob and Smith's operative surgery, 5th edition, **(1994)**

**4.** B. Celli, Respiratory mescle strength after upper abdominal surgery, *Inernational journal of Respiratory Medicine*, **48(7)**, 683-684 **(1993)**

**5.** Charles Weissman, pulmonary function during the perioperative period, *Anesthesiology*, **2**, 868-874 **(2000)**

**6.** Siaficas N.M. et al., Surgery and respiratory muscles, *Thorax* , **54**, 458-465 **(1999)**

**7.** Drummond G.B., The abdominal muscles in anesthesia and after surgery, *British Journal of Anesthesia,* **91(1)**, 73-80 **(2003)**

**8.** An electromyographic study of the abdominal muscles during postural and respiratory manoeuvre, *J Neurol Neurosurg Psychiatry*, **50(7),** 866–869 **(1987)**

**9.** Barisone G. et al., Upper abdominal Surgery: does a lung function test exist to predict early severe postoperative respiratory complications, *Eur Respir J.,* **10**, 1301-1308 **(1997)**

**10.** Carla Malaguti et al., Reliability of chest wall mobility and its correlation with pulmonary function in patients with chronic obstructive pulmonary disease, *Respiratory care,* **54(12**), 1703-11 **(2009)**

**11.** Nimmo A.F. and Drummond G.B., Respiratory mechanics after abdominal surgery measured with continuous analysis of pressure flow and volume signals, *BJA*, **77(3),** 317-326 **(1996)**

**12.** Dureuil B., Cantineau J.P. and Desmonts J.M., Effects of upper or lower abdominal surgery on diaphragmatic function, *British Journal of Anaesthesia,* **59**, 1230-1235 **(1987)**

**13.** Drummond G., Surgery and respiratory muscles, *Thorax,* **54,** 1140 **(1999)**

**14.** Simonneau et al., Diaphragmatic dysfunction induced by upper abdominal surgery, Role of postoperative pain .*Am Rev Respir Dis*., **112(8),** 899-903 **(1983)**

**15.** Wahba R.W.M., Perioperative functional residual capacity, *Can J Anaesthesia,* **38(3**), 384-400 **(1990)**

**16.** Gilbert R. et al., Relationship of ribcage and abdomen motion to diaphragm function during quiet breathing, *Chest* , **80(5**), 607-12 **(1981)**

**17.** Sanya A.O., Abdominal muscle strength and some respiratory function indices in subjects of varying parity status, *Journal of the Nigeria Society of Physiotherapy,* **14(2**), 35-39 **(2002)**

**18.** Effective Thermal Conductivity of Cucurbit as a Function of Temperature by Thermal Probe Method Kumar Anil, Chauhan Rekha Rani and Kumar Pradeep, *Res. J. Recent Sci.,* **1(10),** 33-36 **(2012)**

**19.** Paras Manoj Kumar and Rai Jagdish, On the Energy Estimation of Lightning Discharge, *Res.J.Recent Sci.,* **1(9),** 36-40 **(2012)**

**20.** Nimawat Dheeraj and Namdev Vishal, An Overview of Green Supply Chain Management in India, *Res. J. Recent Sci.,* **1(6),** 77-82 **(2012)**

**21.** Idris O.F. and Sabahelkhier M.K., The Effects of Induced Hyperthyroidism on Plasma FSH and LH Concentrations in Female of Wistar Rats, Idris M.A., *Res.J.Recent Sci.,* **1(6),** **(2012)**

**22.** Sharma R.L., Sharma K.K. and Sharma N., Hypervitaminosis - A causes Degenerative changes in Thyroid of Mouse, *Res.J.Recent Sci.,* **1(3),** 26-30 **(2012)**

**23.** Carlson K. and Smith M., A Cadaveric Analysis of the Vastus Medialis Longus and Obliquus and their Relationship to Patellofemoral Joint Function, *I. Res. J. Biological Sci.,* **1(5**), 70-73 **(2012)**

**24.** Hasna Abdul Salam, Rajiv P., Kamaraj M., Jagadeeswaran P., Sangeetha Gunalan and Rajeshwari Sivaraj, Plants: "Green" Route for Nanoparticle Synthesis, *I. Res. J. Biological Sci.,* **1(5),** 85-90 **(2012)**

**25.** Muthusamy P., Murugan S. and Manothi Smitha, Removal of Nickel ion from Industrial Waste Water using Maize Cob, *ISCA J. Biological Sci.,* **1(2),** 7-11 **(2012)**

**26.** Balamuralitharan S. and Rajasekaran S., Stability of the Six Equilibrium States between CN and G-CSF with Infectives Growth Rate Progression: A FFT Study, *ISCA J. Biological Sci.,* **1(2),** 55-60 **(2012)**

**27.** Jatwa Jayshree and Bhai Ismail, Studies on Human Thyroid disorders based upon assay of TSH and Thyroid Hormones in Ujjain, MP, India, *ISCA J. Biological Sci.,* **1(2),** 43-47 **(2012)**