Original article:

Effects of Diaphragmatic weight training versus Incentive spirometry in patients weaned from Mechanical Ventilation.-A pilot study

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Abstract:

Introduction: The patients requiring support of mechanical ventilation to improve their pulmonary status often compromise with respiratory muscle strength; primarily diaphragm. Effects of Incentive spirometry (IS) in ventilatory muscle training for improvement of pulmonary functions have already been proved. To achieve same improvement; another technique called 'Diaphragmatic weight training' can be used, which is cost effective and easy to perform. But there is less evidence available for this technique. So the present pilot study aims to compare effects of diaphragmatic weight training versus Incentive spirometry in patients weaned from mechanical ventilation.

Methodology: A pilot study conducted on 10 patients who were weaned from mechanical ventilation. Group A patients were trained for Diaphragmatic weight training and Group B were given Incentive spirometry. Outcome measures were pulmonary function tests (FVC, SVC and MVV) and ATS Dyspnoea scale.

Result: The study reported no statistically significant difference in values of FVC, SVC and ATS dyspnoea scale between group A and group B. But statistical difference in values of maximal voluntary ventilation (MVV) in group A and B is significant.

Conclusion: The study concludes that the diaphragmatic weight training and Incentive spirometry were equally effective in improving FVC, SVC and dyspnoea in patients after weaning from mechanical ventilation. But Incentive spirometry was more effective to advance MVV in these patients.

Key words: Diaphragmatic weight training, Incentive spirometry, ACBT

Introduction

Mechanical ventilation is a technique through which gas is moved towards and from the lungs through an external device connected directly to patient.[1] Incidence of need of invasive mechanical ventilation in patients with exacerbations of COPD has varied 9.8% to 67.6% in north India[3]. In the study involving medical- surgical intensive care units in North America, South America, Spain and Portugal, 1,638 patients were studied who were receiving mechanical ventilation. Indications for mechanical ventilation were acute respiratory failure (66%), acute exacerbations of COPD (14%), coma (10%) and neuromuscular disorders (10%).[2]

The study conducted on effects of mechanical ventilation on activity of diaphragm, proved that

mechanical ventilation in combination with 18-69 hours of complete diaphragmatic inactivity results in striking atrophy of human diaphragm myofibrils, which in turn causes its weakness[3]. During mechanical ventilation there is decrease in PaO_2 and increase in $PaCO_2$ in earlier phase, which leads to tachypnoea[4]. Tachypnoea causes increase in workload of diaphragm, which leads to intense diaphragmatic contraction. Now there is also increase in the energy demand, leading to depletion of energy stores in diaphragm. At the same time blood supply to the diaphragm is reduced due to low cardiac output status. Increased demand exceeds the ability of producing work. Such disparity occurs with increased airway resistance and results in reduced pulmonary compliance[5]. Diaphragm can lose 5% of its strength per day during mechanical ventilation[6].

To strengthen weakened diaphragm, therapist can use 'Diaphragmatic weight training'. It consists of use of small weights, such as sandbag to strengthen or to improve endurance of diaphragm. Therapist first observes normal excursion of diaphragm when patient is at rest. Then small weights are kept on the epigastric area of patient and patient is asked to perform deep breathing exercise keeping upper chest as quiet as possible. Patient should be able to breathe comfortably without using accessory muscles. A session should consist of 2-3 sets of 10 repetitions once or twice a day[6, 7].Incentive Spirometry is a form of ventilator muscle training that emphasizes 'sustained maximum inspiration'[7]. The use of Incentive spirometry as a therapy was first documented in 1972. A visual feedback device was developed in 1973. A slow deep inhalation is followed by 5-10 seconds breath hold[8]. Incorporating techniques that are cost effective, comfortable and can be independently performed by the participants without much assistance or help from the therapist & also these techniques will motivate the participants to participate actively in their own health care program. As there is less evidence of diaphragmatic weight training technique, present study aims to evaluate effects of Diaphragmatic weight training versus Incentive spirometry on pulmonary functions in patients weaned from mechanical ventilation.

Methodology:

Source of Data: The source of the data was Pravara Rural Hospital, Indoor- patient medicine ward, referred to Dept of Cardio respiratory physiotherapy, Loni, Tal- Rahata, Dist- Ahmednagar, Maharashtra, India. The present work was approved by Institutional ethical committee from our university.

The subjects were selected on the basis of inclusive and exclusive criteria. The study population included 10 individuals

Inclusion criteria:

1. Patients weaned from mechanical ventilation
2. Duration of mechanical ventilation >48 hours and <69 hours
3. Patients having stable cardiovascular function Heart rate <140 /min

Blood pressure (Systolic <180 mm of Hg)

Respiratory rate <35/min

4. Conscious, cooperative

Exclusion criteria:

1. Patients who had undergone abdominal or gynaecological surgery.
2. Patients with major musculoskeletal or neurological disorders.

Sample size was determined by using previous references[9].

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Procedure:

All the participants referred from IPD medicine department for physiotherapy were screened based on inclusion and exclusion criteria. Participants were briefed about nature of the study and effect of the intervention in the language best understood by them and the treatment was demonstrated to them. Written informed consent was obtained and they were divided into groups A and B.

All the participants were assessed for pulmonary functions with Computerized Spirometer (i.e. FVC, SVC and MVV) and ATS Dyspnoea scale.

Group A: Study participants received ACBT and Diaphragmatic weight training.

Group B: Study participants received ACBT and Incentive Spirometer.

The measurements were done on the 1th and last day of four weeks to give values pre and post training for each participant. The intervention duration for group A and B will be one session a day for 30 minutes for four weeks (6 days a week).

Group A (Diaphragmatic weight training): Participants were in supine lying position. A small weight (3-5 lbs) was kept over the epigastric region of the patient's abdomen.

Then participant was asked to breathe in deeply while trying to keep upper chest quiet. The resistance was kept such that it should not interfere with normal rise of abdomen during deep breathing. Slowly, patient was asked to increase the time that he/she breathe against resistance of weight. It was given for 10-15 minutes[10, 11].

Group B (Incentive Spirometry): Participants were in sitting or semi-fowler's position. Patient was instructed to inspire slowly and deeply through Incentive spirometer. Then participants were asked to sustain maximal inhalation effort for 5-10 seconds. A normal exhalation should follow the breath hold and patient was given opportunity to rest as long as needed, before next maneuver. It was given for 10-15 minutes[12].

Active cycle of breathing technique (ACBT) involves 3 phases repeated in cycles; breathing control, thoracic expansion and the forced expiratory technique (FET). Participants will be in an upright sitting position. The technique is performed in 3 phases: In first phase the participants are instructed to breathe in a relaxed manner. Instruction should be given to keep upper chest, shoulder relaxed and lower chest, abdomen active. Usually done for 5 to 10 seconds. In second phase participant is asked to perform deep and full inhalation. Exhalation should be relaxed and passive. Again first and second phases are repeated. In third phase patient is asked to perform 1-2 huffs either after medium sized breath or deep breath to clear secretions. When huff from medium sized breath is non productive and dry sounding is present for two cycles in raw, the treatment is concluded[2, 8].

Statistical analysis:

All values obtained were expressed as Mean ± Standard Deviation. Unpaired student t- test was performed and a 'p' value <0.05 was considered as statistically significant

Results

In group A Before and after mean FVC values were 0.982 ± 0.28 and 1.604 ± 0.36 respectively, (P=0.017). The pre and post mean SVC values were 0.93 ± 0.28 and 1.6 ± 0.34 respectively (P=0.009).Mean values of MVV were 34.4 ± 9.45 before training and 66.4 ± 14.6 after training (P=0.003).This indicates statistically significant increase in FVC, SVC and MVV in group A after 4 weeks of diaphragmatic weight training. The mean

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pre and post ATS dyspnoea grades were 2.6 ± 0.54 and 1.4 ± 0.54 respectively (P=0.02), which indicates statistical significant improvement in dyspnoea symptoms in group A.

In group B Before and after mean FVC values were 0.85 ± 0.16 and 1.72 ± 0.41 respectively, (P=0.002). The pre and post mean SVC values were 0.81 ± 0.16 and 1.68 ± 0.36 respectively (P=0.001). Mean values of MVV were 33.6 ± 6.5 before training and 88.2 ± 13.12 after training (P< 0.0001). The mean pre and post ATS dyspnoea grades were 2.8 ± 0.44 and 1.2 ± 0.44 respectively (P=0.0005). This shows statistically significant increase in FVC and SVC in group B after 4 weeks of Incentive spirometry training. Also indicates highly significant improvement in MVV and ATS dyspnoea scale.

Parameters	Group A (Mean difference ± SD)	Group B (Mean difference ± SD)	t-value	P-value
FVC L/min	0.62±0.20	0.87±0.26	1.64	0.139 NOT SIGNIFICANT
SVC L/min	0.67±0.14	0.87±0.22	1.71	0.12 NOT SIGNIFICANT
MVV L/min	2±9.5	54.6±12.36	3.24	0.011 SIGNIFICANT
ATS dyspnoea scale	1.2±0.44	1.6±0.54	1.26	0.24 NOT SIGNIFICANT

Table: Mean, SD, P values, t-values of parameters among Group A and B before and after Diaphragmatic weight training and Incentive spirometry.

The table represents values of pulmonary function tests and ATS dyspnoea scale after 4 weeks of diaphragmatic weight training and Incentive spirometry in group A and group B respectively. The mean FVC values of group A is 0.62 ± 0.2 and of group B is 0.87 ± 0.26 (P=0.1392). The mean SVC values of group A is 0.67 ± 0.14 and group B is 0.87 ±0.26 (P=0.12). The mean MVV values of group A is 32 ± 9.5 and group B is 54.6 ± 12.34 (P=0.011). The mean ATS dyspnoea scale values of group A is 1.2 ± 0.44 and group B is 1.6 ± 0.54 (P=0.24)

Results showed no significant statistical difference in improvement of FVC, SVC and ATS dyspnoea scale values between group A and B. But there is statistical significant enhancement in MVV in group B than group A.

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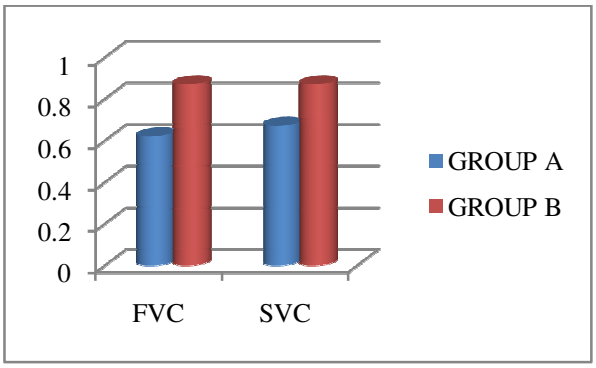

Diagram1: Mean FVC and SVC values of group A and B

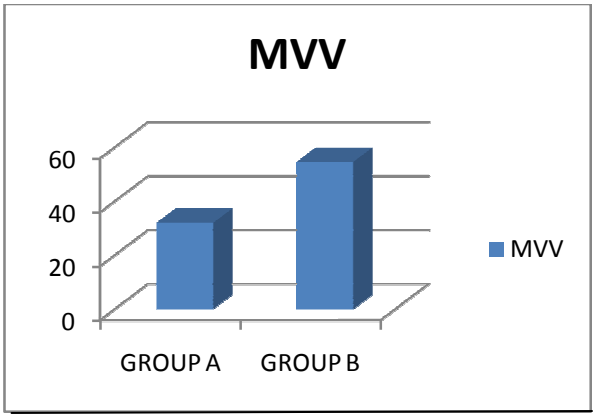

Diagram2: Mean difference of MVV in group A & B

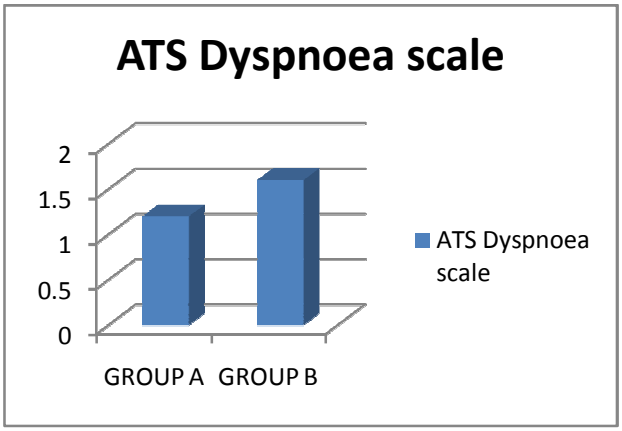

Diagram3: Mean difference of ATS dyspnoea scale in group A and B

Discussion

Patients on mechanical ventilatory support develop respiratory muscles weakness altering their normal pulmonary functions. Increased respiratory workload causes diaphragm dysfunction. To retrain these weakened respiratory muscles, primarily diaphragm which undergoes disuse atrophy as a consequence of the mechanical ventilation, a physical training program must be devised. Respiratory resistance training can be given to the patients having weakness and atrophy of inspiratory muscles. Improvement in respiratory functions can be achieved by strengthening diaphragm. In order to train diaphragm, Incentive spirometry and diaphragmatic weight training can be used. A training effect can be achieved only if sufficient load in terms of intensity, duration and frequency is applied to respiratory muscles[7].

The effect of diaphragmatic weight training in improving pulmonary functions is still questionable. But Incentive spirometry can be used for training of inspiratory muscles[12]. So the effects of these two techniques are compared in this study. A prospective case study was conducted by Winser SJ. Et.al. on a tetraplegic patient with the aim of studying long term effects of abdominal weight training as a part of respiratory rehabilitation. They found out the abdominal weight training can be used as an effective adjunct to pulmonary rehabilitation in maintaining or improving efficiency of diaphragm and reducing the risks associated with pulmonary complications.[13]

A study was conducted on group of 30 ICU patients on mechanical ventilation to compare effects of proprioceptive neuromuscular facilitation (PNF) versus resistance training of respiratory muscles on respiratory rate during weaning off period. They found out that there was decrease in respiratory rate of the patients who were treated with PNF and there was no change in the patients who were treated with diaphragmatic weight training[9].

Leith and Bradley showed endurance trainers increased their ability to sustain hyperpnea from

81% to 96% of their pretraining MVV while increasing their MVV by 14%[14].Effects of diaphragmatic weight training in improving competence of diaphragm and reducing the risks associated with pulmonary complications had been reported[13].We found diaphragmatic weight training as effective in improving FVC, SVC and dyspnoea as Incentive spirometer. Weights applied directly on epigastric area are useful in strengthening weakened diaphragm [11]. Gain in strength of diaphragm would have caused better performance in pulmonary functions and dyspnoea.

A Study conducted on effects of Incentive spirometer in ventilatory muscle training has proved improvement in pulmonary functions [11]Incentive spirometry has been advocated primarily to prevent alveolar collapse and atelectasis, as it increases the volume of air inspired and assists in chest wall expansion. It is also useful in strengthening weak inspiratory muscles[7]. Incentive spirometer helps the ability of the patient to maintain a sustained maximal inspiration, thereby improving lung expansion [15], which might have contributed in improvement in MVV than diaphragmatic weight training.

Conclusion

We may conclude that Diaphragmatic weight training and Incentive spirometry are effectual in improving pulmonary functions and dyspnoea. But when compared; improvement in MVV was better after training with Incentive spirometry than diaphragmatic weight training. Both techniques were equally helpful in advancing FVC, SVC and improving dyspnoea in patients weaned from mechanical ventilation.

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Abbreviations:

IS: Incentive spirometry
FVC: Forced vital capacity
SVC: Slow vital capacity
MVV: Maximal voluntary ventilation
COPD: Chronic obstructive pulmonary diseases
ACBT: Active cycle of breathing technique

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