EFFECT OF INSPIRATORY MUSCLE STRENGTH TRAINING ON VENTILATOR WEANING

-An Experimental Study

Dissertation submitted to The Tamil Nadu Dr. M.G.R. Medical University towards partial fulfilment of the requirements of **Master of Physiotherapy [Advanced PT in Cardio-Pulmonary Diseases] Degree Programme.**

KMCH COLLEGE OF PHYSIOTHERAPY

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CERTIFICATE

This is to certify that research work entitled **"EFFECT OF INSPIRATORY MUSCLE STRENGTH TRAINING ON VENTILATOR WEANING" –An Experimental study** was carried out by the candidate bearing the Register No: **27091615**, KMCH College of Physiotherapy towards partial fulfilment of the requirements of the **Master of Physiotherapy (Advanced PT in Cardio-Pulmonary Diseases)** of The Tamil Nadu Dr. M.G.R. Medical University, Chennai-32.

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INTERNAL EXAMINER **EXTERNAL EXAMINER**

Dissertation Evaluated on:

Acknowledgement

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CONTENTS

ABSTRACT

Study Objectives:

To analyze the effect of Inspiratory Muscle Strength Training, to improve respiratory muscle strength & pulmonary function and thereby prolonging spontaneous breathing periods to facilitate ventilator weaning.

Study Design:

Pre-test & Post-test experimental study

Methodology:

30 mechanically ventilated patients were assigned into two groups with 15 patients each. One control group underwent Standard weaning technique along with diaphragmatic breathing exercise and another experimental group underwent Standard weaning technique along with Inspiratory Muscle Strength Training [IMST].

IMST consist of 3 to 5 sets of 6 repetitions breathing for 4 sessions per day. The training was conducted for one day and the arterial blood gas [ABG] before and after training was noted. Also spontaneous breathing period of the training day and next day was noted.

Results:

The data were analyzed using paired and independent‘t’ test. There is significant improvement in P_{O2} and Spontaneous breathing period [SBP] in experimental group. Also there is significant difference in P_{O2} and SBP between two groups at 5% level of significance. There is no significant difference in P_H between groups and no significant improvement in P_{CO2} in experimental group.

Conclusion

Inspiratory Muscle Strength Training can be incorporated with Standard weaning technique to facilitate ventilator weaning.

1. INTRODUCTION

Mechanical ventilation is indicated in conditions requiring adequate oxygenation and carbon-di-oxide elimination like impending respiratory failure, acute respiratory failure/arrest and post-operative patients. Also prolonged mechanical ventilation causes detrimental effect on pulmonary function, high risk of lung complication and respiratory muscle fatigue. These all probably develops a condition leading to persistent ventilator dependency[33].

Since mechanical ventilation is associated with potential complications like respiratory muscle weakness, atelectasis, barotraumas etc., and some adverse physiological effects, weaning off ventilation is instituted when the patient has recovered sufficiently to breathe spontaneously[27, 58].

Weaning is the process of discontinuing ventilator support regardless of time frame[14] involved and refers to reduction in Fractional inspired oxygen concentration [FiO_2], Positive end-expiratory pressure [PEEP] and Continuous positive airway pressure [CPAP] [19].

Weaning is also done on the basis of traditional weaning indices, conventional weaning criteria which involve mechanical, integrated factors & patient assessment-dyspnea, accessory muscle use, abdominal paradox, agitation/anxiety/tachycardia. Standard weaning criteria involves variables like mechanics (RR, TV, VC & MIF), oxygenation (PaO_2, PAO_2-PaO_2) and ventilation (MV, $PaCO_2$, V_d: Vt) [19].

There are four basic methods of discontinuing ventilator support: First method is by increasing the periods of spontaneous breathing alternating with T-tube trails or CPAP; Second method is by Intermittent mandatory ventilation; Third method is by using Positive support ventilation and Forth method is the single daily SBT [Spontaneous breathing trials][19].

CPAP has the advantage of maintaining lung volume during the weaning phase and thus of improving the patient's oxygenation status. Minimal levels of CPAP may be useful in reducing work of breathing and compensating for auto-PEEP, particularly in patients with obstructive lung disease. Along with this pressure support PEEP is gradually reduced. This standard weaning protocol is not successful in a number of patients.

As mechanical ventilation itself cause respiratory muscles weakness mainly diaphragm muscle, it leads to ventilator dependence[6].The major contributing factor for prolonged mechanical ventilation is decreased inspiratory muscle strength. Hence strength of the inspiratory muscles is an important factor in the success of weaning.

In traditional protocol the inspiratory muscles are trained by manipulating the ventilator sensitivity and mode of ventilation, still the muscle function might not improve sufficiently to sustain independent and spontaneous breathing. Consequently, specific inspiratory muscle training is indicated in patients with mechanical ventilation[33].

Inspiratory muscle strength training has been shown to improve respiratory muscle strength and exercise performance in individuals with inspiratory muscle weakness and poor exercise tolerance[15].

Thus, the purpose of this study is to find the effect of inspiratory muscle strength training on pulmonary function and to facilitate the weaning process.

1.1 NEED FOR STUDY

Mechanical ventilation is commenced for one of two reasons: failure to oxygenate and failure to ventilate[62].The patients receiving mechanical ventilation have an increased risk of, respiratory muscle weakness, sputum retention, atelectasis, infection, airway trauma and, sedation and relaxant needs making ventilator weaning more difficult and resulting in excess morbidity and mortality.

Also, the cost of maintaining patients on prolonged ventilation in the Intensive Care Unit’s of acute care hospitals is high. In order to keep the weaning time to a minimum, effort should be made to determine which patients can be rapidly extubated.

2. REVIEW OF LITERATURE

Mechanical ventilation refers to any method of breathing in which a mechanical apparatus is used to augment or satisfy entirely the bulk flow requirements of a patient's breathing[30].

Patients recovering from rapidly reversing ventilatory insufficiency or failure can be discontinued promptly from the ventilator. In contrast, weaning often is performed in patients with slowly resolving lung processes in the hope that if the patient performs some comfortable level of ventilatory work, it will accelerate muscle recovery, avoid un-necessary ventilator pressures, and require less sedation for ventilator-patient synchrony[42].

2.1. NEED FOR MECHANICAL VENTILATOR

Rold D. Hubmayr and Richard S. Irwin indicated mechanical ventilation when the patient's spontaneous ventilation was not adequate to sustain life or when it was necessary to take control of the patient ventilation to prevent impending collapse of other organ functions.

Also patients with lung failure i.e., gas exchange failure manifested by HYPOXEMIA and ventilator failure manifested by HYPERCAPNIA require mechanical ventilator support[30].

The classical indication for mechanical ventilation based on the clinical situation and respiratory variables in other conditions was explained by **T.E. Oh**[58].

Indications for intubation and ventilation were also described by **Maire P. Shelly and Peter Nightingale.**

2.2. COMPLICATIONS

As mechanical ventilation is associated with potential complications and some adverse physiological effect, hence weaning off was instituted by **Hillman DR and Lin ES**[27].

Rolf D. Hubmayr divided the hazards associated with mechanical ventilation into five major categories, complication attributed to Intubation & extubation, Endotracheal or Tracheostomy tubes, Ventilator operation, Medical complication and Psychological effect[30].

The complication of early extubation was described by **Mark W Sebastian**[38]**.**

Staci Revas suggested that though PEEP increase arterial oxygenation, pulmonary compliance and functional residual capacity by expanding collapsed alveoli; it has its own hazards like decreased cardiac output, barotraumas and other hazards[58].

Basil J. Petrof has described about major complications such as infection, barotraumas, cardiovascular compromise, tracheal injuries, oxygen toxicity, and ventilator-induced lung injury[59].

2.3. RESPIRATORY MUSCLE WEAKNESS DUE TO MECHANICAL VENTILATION

Eleven days of mechanical ventilation and neuromuscular blockade resulted in significant impairment in diaphragmatic endurance and strength were seen by **Anzueto and Peters**[6]**.**

Theodoros Vassilakopoulos through a perspective study concluded that mechanical ventilation lead to wasting and damage of respiratory muscles and ventilator induced diaphragmatic dysfunction[59].

A number of studies performed by **Cohen CA & Brochard L** have showed development of respiratory muscle fatigue during unsuccessful weaning and it leads to persistent ventilator dependency[8, 12].

Greet Hermans and Anouk Agten et.al have concluded that duration of mechanical ventilation is associated with a logarithmic decline in diaphragmatic force, which is compatible with the concept of VIDD. Sedatives/analgesics, sepsis and other factors also potentially contributes for the observed decline[26].

Martin J. Tobin has done a research in animals which has shown that diaphragmatic inactivity produces severe injury and atrophy of muscle fibers[39].

2.4. WEANING

Neil R.MacIntyre, MD has told that when a patient's underlying respiratory disease begins to stabilize and reverse, consideration for ventilator discontinuation should begin[42].

According to **Richard S. Irwin** weaning is a process by which a patient is removed from a treatment modality on which he or she has become dependent[30].

T.E. Oh has insisted that weaning process should end in successful extubation of the endotracheal tube[58].

Scott K. Epstein explained discontinuation process as two components: Weaning (assessing the need for ventilatory support) and Extubation (assessing the need for an airway) [51].

Brochard L classified patients according to the weaning process as simple, difficult and prolonged weaning[8].

2.5. WEANING CRITERIA

Sahn SA, Lakshminarayan MB have predicted the bedside criteria for the discontinuation of mechanical ventilation under three variables[47].

Hodgkin JE and Bowser MA conducted some tests indicative of adequate mechanical capability to allow weaning which include: VC, FEV_1, PIP, Minute Ventilation & Oxygenation status[28].

Ely et.al and Tonnelier et.al have showed that daily screening checklist of easily measured parameters, and demonstration of tolerance of spontaneous independent breathing was highly predictive of extubation success[22].

Hemant H.R et.al has given the current evidence for criteria to be used to consider a patient for weaning[17].

2.6. STANDARD WEANING TECHNIQUE

T.E. Oh has explained precisely different modes of mechanical ventilation used in weaning.

Basically, there are four ventilator modes commonly used for weaning: T-piece breathing, Intermittent Mandatory Ventilation [IMV], Pressure Support Ventilation [PSV] and Continuous Positive Airway Pressure [CPAP] [58].

Downs JB and Perkins HM also described that IMV allows spontaneous breathing between the mandatory ventilator-delivered breaths. Its advantages include better venous return via the thoracic pump mechanism and an ability to exercise respiratory muscles[16].

CPAP has the beneficial effects in increasing functional residual capacity and increasing compliance, which potentially improves gas exchange and decrease work of breathing and this, was clinically supported by **Kirby RR and Schlobohm RM**[36, 50].

CPAP of 5-15cm water is applied to wean patients after having successfully tolerated IMV or PSV. CPAP is gradually decreased to 2cm water, which approximates to ‘auto PEEP’ or the self-generated positive airway pressure[58].

Annest SJ and Quan SF proposed that patients should be extubated from low level of CPAP, because a loss of lung volumes and decrease in PaO_2 may result from leaving an endotracheal tube in place without any end-expiratory pressure[5, 46].

Rolf D. Hubmayr and Richard S. Irwin has told that irrespective of underlying disease process, it was physiologically sound to undertake spontaneous breathing weaning in conjunction with CPAP[30].

Guniz Meyanci Koksal has investigated in sixty patients and concluded that weaning via T-piece caused a greater stress response than the pressure support & CPAP modes.

Butler R & Keenan SP could not identify a superior weaning technique among the three most popular modes, T-piece, pressure support ventilation, or synchronized intermittent mandatory ventilation[9].

According to **B.R.H. Doran** a full alarm system, controlled oxygen and humidity, and controlled PEEP is available throughout the weaning process, including total spontaneous ventilation is usually called continuous positive airways pressure[CPAP].

2.7. WEANING FAILURE

Samuel S. Sprague and Phillip D. Hopkins in their inspiratory strength training to six ventilator dependent patients study have concluded that decreased inspiratory muscle strength was often cited as a major factor contributing to weaning failure and prolonged mechanical ventilation[49].

A. Daniel Martin & E. Harman have concluded that respiratory muscle weakness was often implicated as a contributor to weaning failure[15].

2.8 PHYSIOTHERAPY-INSPIRATORY MUSCLE STRENGTH TRAINING

2.8.1. IMST in ventilated patient

Paul D. Davenport and Amy C. Franceschi study results indicated that inspiratory muscle strength training has been shown to improve respiratory muscle strength in individuals with inspiratory muscle weakness and poor exercise tolerance[15].

Aldrich TK, Karpel JP used Inspiratory resistive training [IRT] in 27 patients with respiratory failure and concluded that IRT improves respiratory muscle strength and endurance in patients with respiratory failure and allows them to be weaned from mechanical ventilation[1].

Samuel S Sprague and Phillip D Hopkins explained the benefit of inspiratory strength training based on their inspiratory strength training to wean six ventilator-dependent patients[49].

Belman MJ used inspiratory muscle training by means of repeated runs of isocapnic hyperpnoea in COPD patients and the training was associated with successful weaning from mechanical ventilation[7].

Eastwood RR, Jenkins SC and Cecins NM recommended that initial training loads equivalent to atleast 30% of a person's maximum inspiratory pressure [PI_{max}] are required for all people undertaking Inspiratory muscle training[34, 35].

PH Johnson, AJ Cowley and WJ Kinnear describes the threshold inspiratory muscle trainer as an inexpensive device of consistent quality. Patients were more satisfied with the inspiratory muscle training in the clinical setting[45].

Hospital de Clinicas de Porto Alegre conducted a randomized interventional study “Is threshold IMT accelerate weaning?” and have concluded that patients under threshold IMT showed better conditions to weaning from mechanical ventilation[29].

Stephanie Enright, Dennis J. Shale have stated that High-intensity IMT resulted in increased inspiratory muscle function and thickness of diaphragm and improved lung volumes[57].

Chang A.T. and Boots R.J. have indicated further research to investigate the effect of inspiratory muscle training on respiratory function, exercise tolerance and functional performance, for the possible inclusion of inspiratory muscle training into the physiotherapy management of patients following prolonged mechanical ventilation[11].

Joanne Watchie has insisted that exercise training of both the respiratory and peripheral muscles prevents deconditioning and the adverse effects of medications and also increases muscle strength and ventilator-free time and thus improves functional outcomes[31].

2.8.2. IMST in other conditions

Improved pulmonary function with Inspiratory muscle conditioning in children with Cystic Fibrosis was experimented & proved by **EH Sawyer**

and TL Clanton. The study also indicated significantly increased inspiratory muscle strength[20].

In seven normal subjects the sensation of respiratory muscle force was compared by **S. Redline and S.B. Gottfried.** They have suggested that the sensation of respiratory muscle force reflected the proportion of the maximum force utilized in breathing and may be based on the level of respiratory motor command signals[55].

Amy E. Downey et.al have proved that inspiratory muscle training significantly improves structural and functional physiological measures in hypoxic exercise[4].

Eliane R. Winkelmann et.al in their randomized trial of addition of inspiratory muscle training with aerobic exercise training in chronic heart failure and inspiratory muscle weakness patients have significant improvement in cardio-respiratory responses[21].

Josiane A. Caldiera et.al evaluated the effect of Inspiratory Muscle Trainer in respiratory muscle function and function capacity in elderly. Their result showed significant increase in inspiratory muscle strength and functional capacity[32].

Shu-Fang Hsiao et.al have compared the effectiveness of pressure threshold and targeted resistive device for inspiratory muscle training in COPD patients[54].

Paulo Eduardo Gomes Ferreira have studied thirty volunteers waiting for myocardial revascularization and cardiac valve surgery, and concluded that domiciliary program of inspiratory muscle training was safe and improved forced vital capacity & maximum voluntary ventilation[44].

A double-blind randomized controlled trial in high intensity inspiratory muscle training in 35 COPD subjects was performed by **K. Hill and D.L. Philippe et.al** and the results yielded a meaningful reduction in dyspnea and fatigue, also improvement in respiratory muscle function[34].

Shane Keene has proved that Inspiratory Muscle Training in obstructive lung patients offers improved lung function who trained appropriately[53].

According to **Weiner**, it is hypothesized that increasing the respiratory muscle strength and endurance with specific inspiratory muscle training would produce a reduction of symptoms in patients with asthma[61].

In patients with myasthenia gravis improvements in respiratory muscle strength, chest wall mobility, respiratory pattern, and respiratory endurance were observed by **Vanessa Regiane and Jesus Pradas**[25].

Alison K McConnell and Lomax M used Inspiratory Muscle Training as an ergogenic aid in alleviating the role of respiratory muscle work in limiting exercise tolerance[3].

2.9. SUMMARY:

Weaning from mechanical ventilation is an important phase in ventilated patients. As this weaning is delayed due to respiratory muscle weakness, specific inspiratory muscle strength should be incorporated along with standard weaning technique. Many studies have done using inspiratory muscle strength training in improving pulmonary function in other conditions as mentioned above. Only limited studies are there in studying the effect of inspiratory muscle strength training in mechanically ventilated patients. Hence this study was designed to analyze the effect of inspiratory muscle strength training on pulmonary function in ventilator weaning.

3. AIM & OBJECTIVES

3.1. AIM:

To study the effect of Inspiratory muscle strength training on pulmonary function to facilitate ventilator weaning.

3.2. OBJECTIVES:

- To analyze the effect of Inspiratory Muscle Strength Training.
- To improve respiratory muscle strength.
- To improve pulmonary function.
- To prolong spontaneous breathing periods.
- To facilitate ventilator weaning.

4. MATERIALS AND METHODOLOGY

4.1. RESEARCH DESIGN

Pre-test & Post-test Experimental study design.

4.2. STUDY SETTING

Medical Intensive care unit and Surgical Intensive care unit,

Kovai Medical Centre and Hospital,

Coimbatore.

4.3. SAMPLE SIZE

30 Intubated patients

4.4. SAMPLING TECHNIQUE

Purposive sampling

This included 2 groups of 15 subjects each. They are

- Group A-This group underwent standard weaning technique.
- Group B-This group underwent standard weaning technique along with Inspiratory Muscle Strength Training protocol.

4.5. CRITERIA FOR SELECTION

4.5.1. INCLUSION CRITERIA

- Age-20 to 70 years.
- Sex-both male & female.
- Conscious, oriented and co-operative patients.
- Intubated and Tracheostomy patients on mechanical ventilation.
- FiO_2 – 40%
- Hemodynamically stable patients.

4.5.2. EXCLUSION CRITERIA

- Hypotensive patients
- Severe intracranial disease
- Barotraumas
- Neuromuscular disease
- Use of vasoactive drugs or sedatives
- Poisoning
- Renal problems

4.6. HYPOTHESIS

4.6.1. NULL HYPOTHESIS:

H_{01}- There is no significant effect of standard weaning technique on ventilator weaning.

H_{02}- There is no significant effect of standard weaning technique along with inspiratory muscle strength training on ventilator weaning.

H_{03}- There is no significant difference between standard weaning technique alone and standard weaning technique along with inspiratory muscle strength training on ventilator weaning.

4.6.2. ALTERNATE HYPOTHESIS:

H_{A1}- There is significant effect of standard weaning technique on ventilator weaning.

H_{A2}- There is significant effect of standard weaning technique along with inspiratory muscle strength training on ventilator weaning.

H_{A3}- There is significant difference between standard weaning technique alone and standard weaning technique along with inspiratory muscle strength training on ventilator weaning.

4.7. PROCEDURE

4.7.1. Standard Weaning Technique

Weaning a patient from mechanical ventilation under standard weaning technique usually involves spontaneous breathing with little or no ventilator assistance ,for example, t-piece trial or using either 1-5cm H_2O continuous positive airway pressure(CPAP) or 0-12 cm H_2O of pressure support from the ventilator.

The patients are trained with diaphragmatic breathing exercise along with standard weaning technique. Sessions: 4 sessions per day, Single session: 3 to 5 sets of 6 repetitions. Spontaneous breathing period is increased along with the training.

4.7.2. Inspiratory Muscle Strength Training

Along with standard weaning technique Inspiratory muscle strength training will be initiated when the patient is medically stable, conscious, alert and co-operative.

Threshold Inspiratory Muscle Trainer [IMT] is a commercially marketed Inspiratory muscle trainer which provides consistent and specific pressure for Inspiratory muscle strength and endurance training, regardless of how quickly or slowly patients breathe. To ensure consistent resistance this device incorporates a flow-independent one-way valve to ensure consistent resistance and features an adjustable specific pressure setting [in cm H_2o] [62].

When patients inhale through threshold IMT, the resistance is provided by a spring-loaded valve that exercises Inspiratory muscles through conditioning. The patients exhale through the low-resistance, one-way, silicone rubber diaphragm[15].

The training is given in following steps:

1. Patient is explained about the training before incorporating the device.
2. Patient is positioned in approximately 30^o head-up tilt position.
3. Threshold IMT is connected to the endotracheal tube or tracheostomy tube with suitable adapters.
4. Patient is instructed to inhale through threshold IMT and exhale through the same device.
5. Initially the resistance pressure given is 9cm H_2O, on progression it is increased according to patient tolerance.
6. Session: 4 sessions per day.

   Single session: 3 to 5 sets of 6 repetitions of breath.

The training is conducted for one day and during the training sessions; the spontaneous breathing period is prolonged and noted. Also the arterial blood gas values of P_H, P_{CO2} and P_{O2} are noted before and after the training to study the improvement of pulmonary functions.

Based on patient tolerance, duration of Spontaneous breathing periods and arterial blood gas (P_H, P_{CO2} & P_{O2}) - the efficiency of Inspiratory Muscle Strength Training on ventilator weaning is analyzed and studied.

4.8. OUTCOME MEASURES

- Arterial blood gas (P_{H}, P_{CO2} & P_{O2}) - before and after the training sessions.
- Spontaneous breathing period –duration of patient on CPAP mode [day of training and next day of training].

4.9. STATISTICAL TOOL

Pre-test and Post-test values of the study will be collected and assessed for variation in improvement & their results will be analyzed using Independent `t' test and Paired `t' test.

INDEPENDENT 't'TEST: (between groups)

$$t = \frac{\overline{X1} - \overline{X2}}{S}\sqrt{\frac{n_1 n_2}{(n_1 + n_2)}}$$

Where,

$$S = \sqrt{\frac{\sum d_1^2 + \sum d_2^2}{n_1 + n_{2-}2}}$$

PAIRED `t'TEST: (within groups)

$$t = \frac{\bar{d}\sqrt{n}}{S}$$

Where,

$$\mathbf{S} = \sqrt{\frac{\sum \boldsymbol{d^2} - [\boldsymbol{\bar{d}}]^2 \times \boldsymbol{n}}{\boldsymbol{n-1}}}$$

S=combined standard deviation

d_1&d_2 =difference between initial & final readings in group A &group B respectively.

n_1&n_2=number of patients in group A & group B respectively.

$\overline{X_1}$&$\overline{X_2}$ =Mean of group A & group B respectively.

Level of Significance = 5%

5. DATA PRESENTATION

5.1. TABULAR PRESENTAION-

PARIED'‘t’ TEST:

Table I:- P_H of Group A [Control group]

PARAMETER		P_H
MEAN VALUES	Pre-test	7.425
	Post-test	7.451
STANDARD DEVIATION		0.069
CALCULATED ‘t’ VALUE		1.458
p VALUE and LEVEL OF SIGNIFICANCE		p > 0.05 and not significant

Table II:- P_{CO2} of Group A [Control group]

PARAMETER		P_{CO2}
MEAN VALUES (mmHg)	Pre-test	33.28
	Post-test	31.8
STANDARD DEVIATION		4.81
CALCULATED ‘t’ VALUE		1.195
p VALUE and LEVEL OF SIGNIFICANCE		p > 0.05 and not significant

Table III:- P_{O2} of Group A [Control group]

PARAMETER		P_{O2}
MEAN VALUES (mmHg)	Pre-test	141.23
	Post-test	257.21
STANDARD DEVIATION		51.53
CALCULATED 't' VALUE		0.097
p VALUE and LEVEL OF SIGNIFICANCE		p > 0.05 and not significant

Table IV:- Spontaneous Breathing Period of Group A [Control group]

PARAMETER		SBP
MEAN VALUES (hrs)	Pre-test	9.57
	Post-test	8.64
STANDARD DEVIATION		2.94
CALCULATED 't' VALUE		0.5002
p VALUE and LEVEL OF SIGNIFICANCE		p > 0.05 and not significant

Table V:- P_H of Group B [Experimental group]

PARAMETER		P_H
MEAN VALUES	Pre-test	7.432
	Post-test	7.455
STANDARD DEVIATION		0.0561
CALCULATED ‘t’ VALUE		1.863
p VALUE and LEVEL OF SIGNIFICANCE		$p < 0.05$ and significant

Table VI:- P_{CO2} of Group B [Experimental group]

PARAMETER		P_{CO2}
MEAN VALUES (mmHg)	Pre-test	36.48
	Post-test	36.9
STANDARD DEVIATION		3.405
CALCULATED ‘t’ VALUE		0.443
p VALUE and LEVEL OF SIGNIFICANCE		$p > 0.05$ and not significant

Table VII: - P_{O2} of Group B [Experimental group]

PARAMETER		P_{O2}
MEAN VALUES (mmHg)	Pre-test	120.27
	Post-test	137.98
STANDARD DEVIATION		35.275
CALCULATED 't' VALUE		1.944
p VALUE and LEVEL OF SIGNIFICANCE		$p < 0.05$ and significant

Table VIII:- Spontaneous Breathing Period of Group B [Experimental group]

PARAMETER		SBP
MEAN VALUES (hrs)	Pre-test	10.28
	Post-test	6.53
STANDARD DEVIATION		3.561
CALCULATED 't' VALUE		4.559
p VALUE and LEVEL OF SIGNIFICANCE		$p < 0.05$ and significant

INDEPENDENT‘t’ TEST:

Table I :- Pre-test P_H

PARAMETER		P_H
MEAN VALUES	Group A	7.425
	Group B	7.432
STANDARD DEVIATION		0.0613
CALCULATED ‘t’ VALUE		0.3117
p VALUE and LEVEL OF SIGNIFICANCE		$p > 0.05$ and not significant

Table II:- Pre-test P_{CO2}

PARAMETER		P_{CO2}
MEAN VALUES (mmHg)	Group A	33.28
	Group B	36.48
STANDARD DEVIATION		6.575
CALCULATED ‘t’ VALUE		1.328
p VALUE and LEVEL OF SIGNIFICANCE		$p > 0.05$ and not significant

Table III:- Pre-test P_{O2}

PARAMETER		P_{O2}
MEAN VALUES (mmHg)	Group A	141.23
	Group B	120.27
STANDARD DEVIATION		40.584
CALCULATED 't' VALUE		1.409
p VALUE and LEVEL OF SIGNIFICANCE		$p > 0.05$ and not significant

Table IV:- Pre-test Spontaneous Breathing Period

PARAMETER		SBP
MEAN VALUES (hrs)	Group A	9.57
	Group B	10.28
STANDARD DEVIATION		2.667
CALCULATED 't' VALUE		0.6779
p VALUE and LEVEL OF SIGNIFICANCE		$p > 0.05$ and not significant

Table V:- Post-test P_H

PARAMETER		P_H
MEAN VALUES	Group A	7.451
	Group B	7.455
STANDARD DEVIATION		0.0585
CALCULATED 't' VALUE		0.186
p VALUE and LEVEL OF SIGNIFICANCE		$p > 0.05$ and not significant

Table VI:- Post-test P_{CO2}

PARAMETER		P_{CO2}
MEAN VALUES (mmHg)	Group A	31.8
	Group B	36.9
STANDARD DEVIATION		7.491
CALCULATED 't' VALUE		1.858
p VALUE and LEVEL OF SIGNIFICANCE		$p < 0.05$ and significant

Table VII:- Post-test P_{O2}

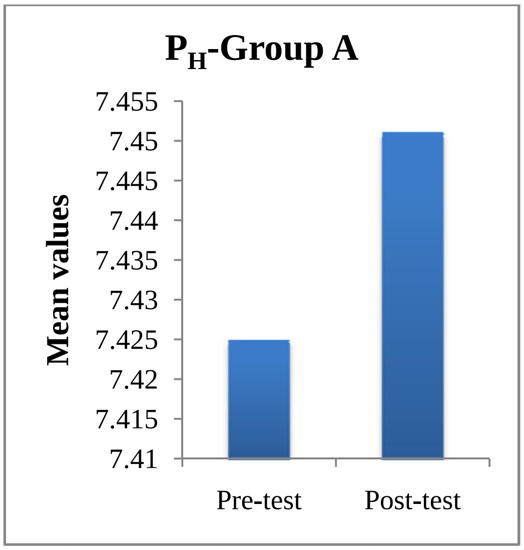
PARAMETER		P_{O2}
MEAN VALUES (mmHg)	Group A	257.21
	Group B	137.98
STANDARD DEVIATION		100
CALCULATED 't' VALUE		3.254
p VALUE and LEVEL OF SIGNIFICANCE		$p < 0.05$ and significant

Table VIII:- Post-test Spontaneous Breathing Period

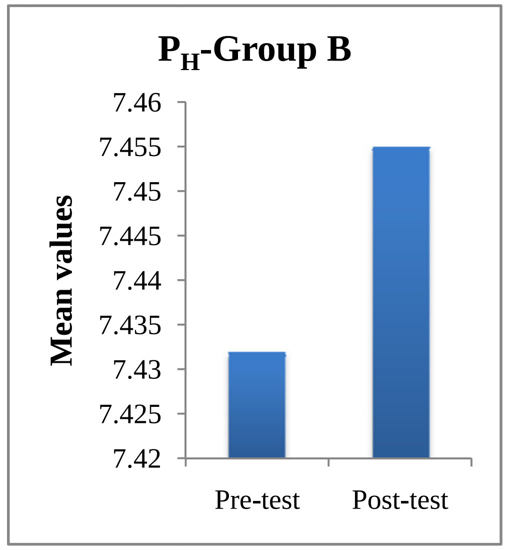
PARAMETER		SBP
MEAN VALUES (hrs)	Group A	8.64
	Group B	6.53
STANDARD DEVIATION		3.36
CALCULATED 't' VALUE		1.714
p VALUE and LEVEK OF SIGNIFICANCE		$p < 0.05$ and significant

5.2. GRAPHICAL PRESENTATION

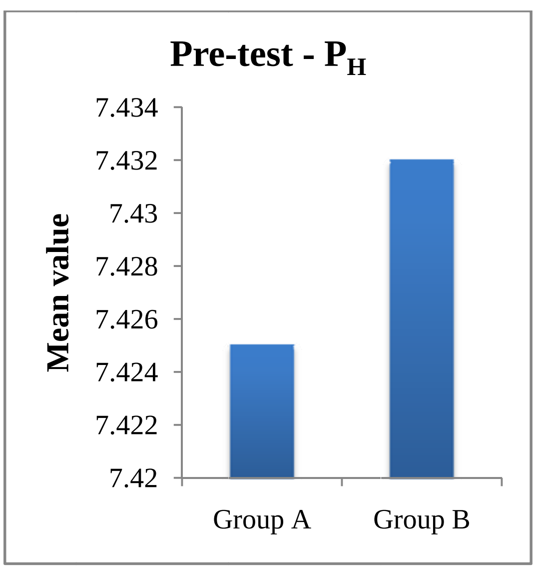
➩ **P_H**



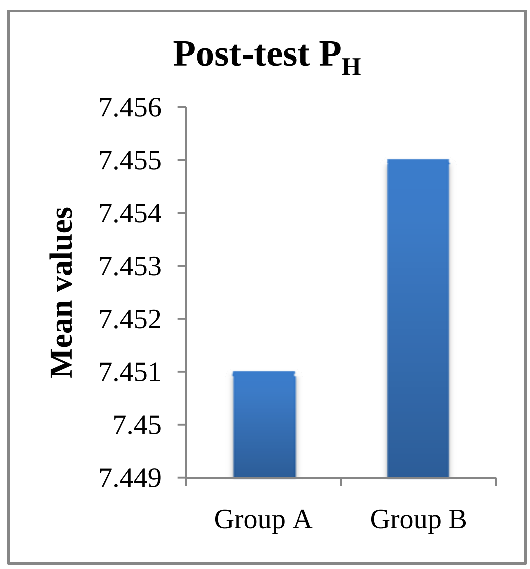
Control Group



Experimental Group

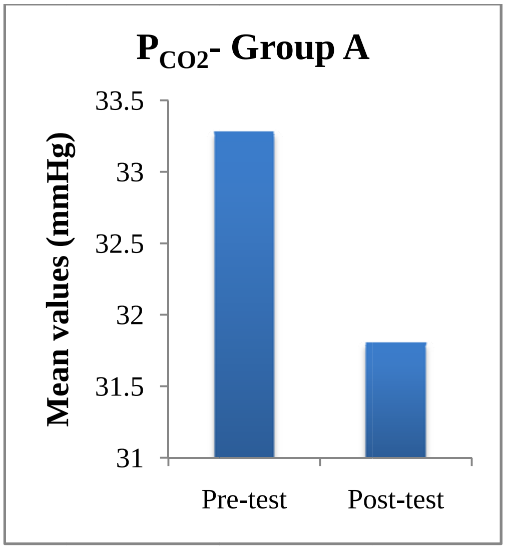


Pre-test [between groups]

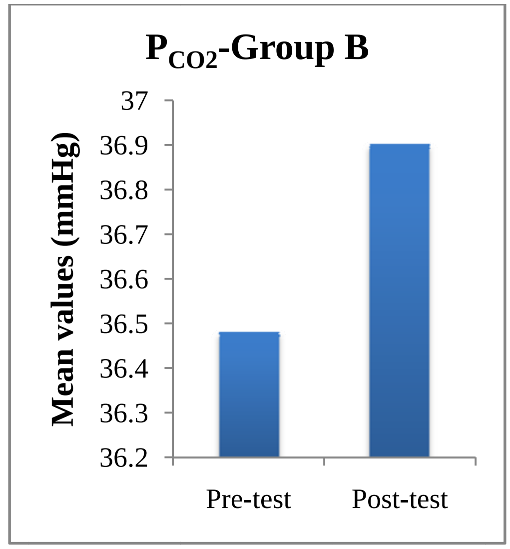


Post-test [between groups]

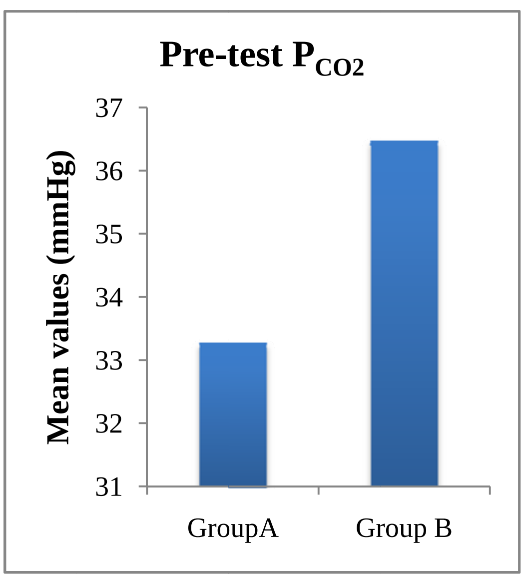
⇘ P_{CO2}



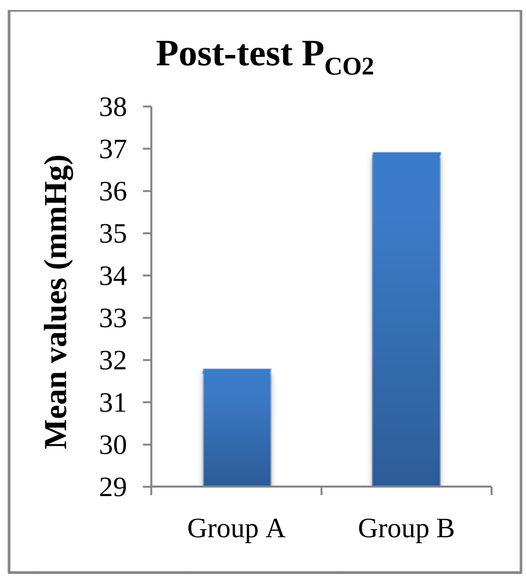
Control Group



Experimental Group

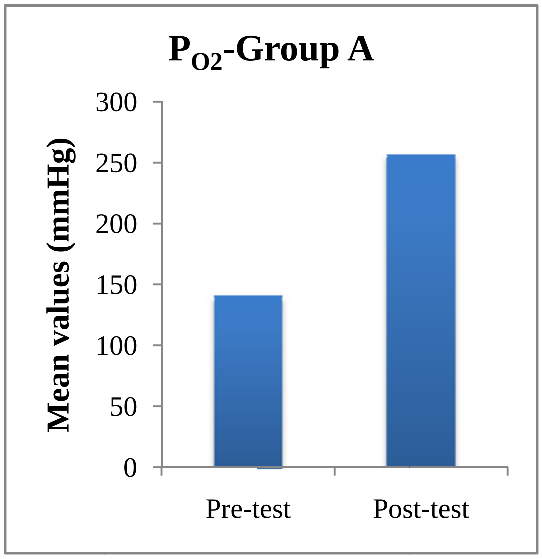


Pre-test [between groups]

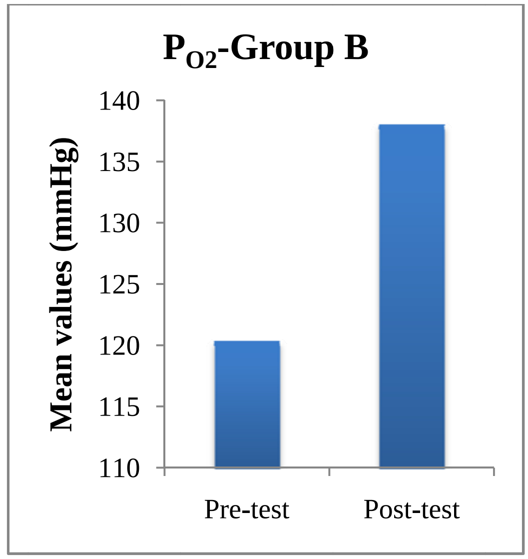


Post-test [between groups]

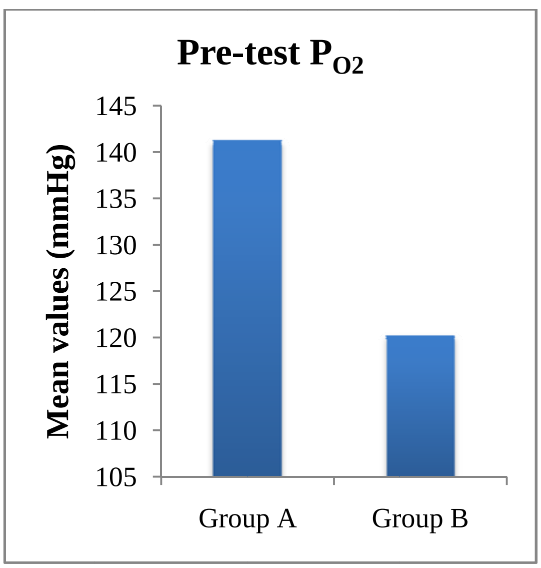
↳ P_{O2}



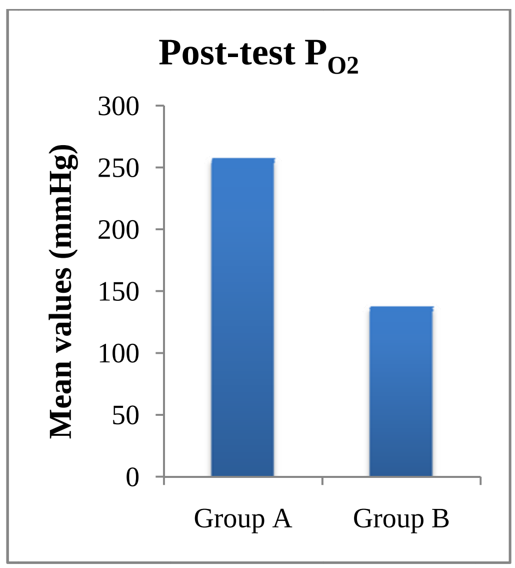
Control Group



Experimental Group

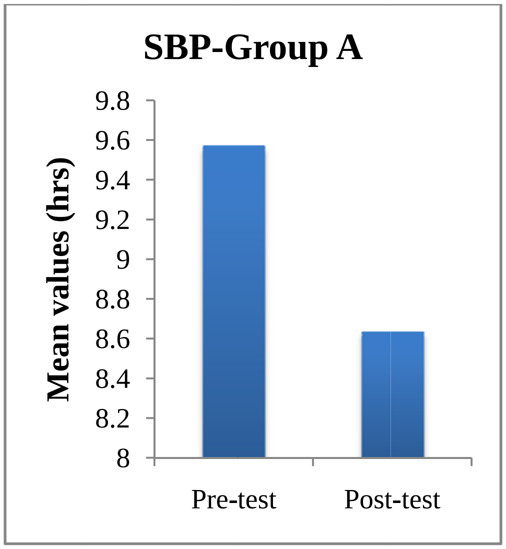


Pre-test [between groups]

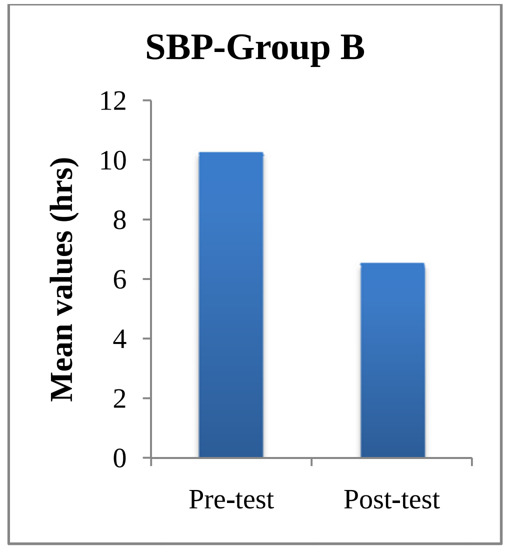


Post-test [between groups]

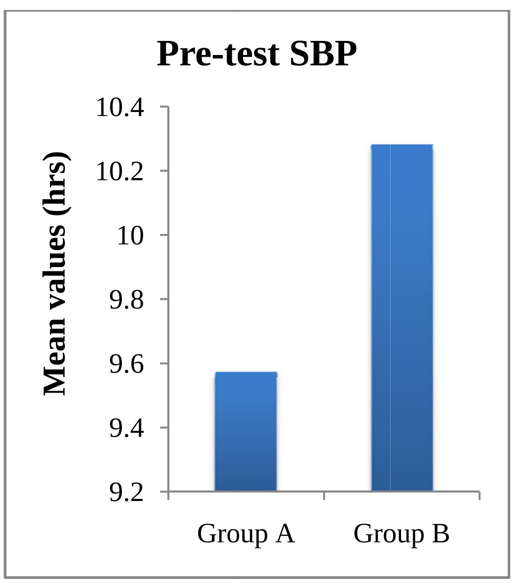
⇘ SBP



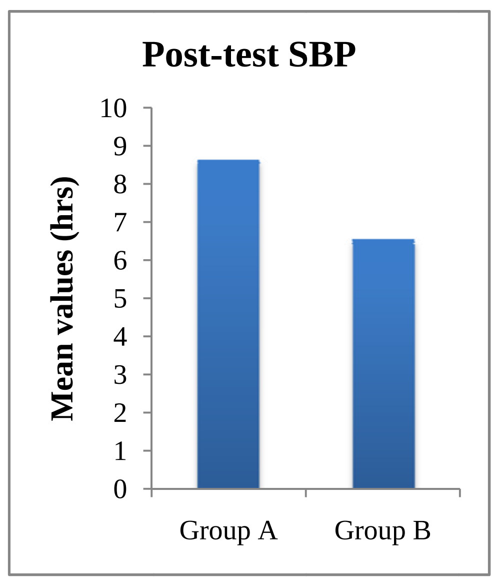
Control Group



Experimental Group



Pre-test [between groups]



Post-test [between groups]

6. DATA ANALYSIS & INTERPRETATION

The significant improvement within the control and experimental group were analyzed using paired‘t’ test. The significant difference between the groups are analyzed using independent‘t’ test.

- **P_H**
  - Pre-test

The calculated‘t’ value for pre-test P_H of group A and group B is 0.3117. The table‘t’ value is 1.701. Since the calculated‘t’ value is less than the table‘t’ value, there is no significant difference between the groups.

  - Control Group

For 14 degrees of freedom at 5% level of significance the table‘t’ value is 1.761. The calculated‘t’ value is 1.458. Since the calculated‘t’ value is less than the table‘t’ value, the null hypothesis is accepted.

  - Experimental Group

For 14 degrees of freedom at 5% level of significance the table‘t’ value is 1.761. The calculated‘t’ value is 1.863 and is greater than the table‘t’ value. Hence the null hypothesis is rejected.

- Post-test

The difference between the post-test P_H values of group A and group B is 0.186. The table‘t’ value is 1.701. The calculated‘t’ value is less than the table‘t’ value, hence there is no significant difference between the groups.

- **P_{CO2}**

- Pre-test

The calculated‘t’ value for pre-test P_{CO2} of group A and group B is 1.328. The table‘t’ value is 1.701. Since the calculated‘t’ value is less than the table‘t’ value, there is no significant difference between the groups.

- Control Group

For 14 degrees of freedom at 5% level of significance the table‘t’ value is 1.761. The calculated‘t’ value is 1.195. Since the calculated‘t’ value is less than the table‘t’ value, the null hypothesis is accepted.

- Experimental Group

For 14 degrees of freedom at 5% level of significance the table‘t’ value is 1.761. The calculated‘t’ value is 0.443 and is lesser than the table‘t’ value. Hence the null hypothesis is accepted.

- Post-test

The difference between the post-test P_{CO2} values of group A and group B is 1.858. The table‘t’ value is 1.701. The calculated‘t’ value is greater than the table‘t’ value, hence there is a significant difference between the groups.

- **P_{O2}**

  - Pre-test

The calculated‘t’ value for pre-test P_{O2} of group A and group B is 1.409. The table‘t’ value is 1.701. Since the calculated‘t’ value is less than the table‘t’ value, there is no significant difference between the groups.

  - Control Group

For 14 degrees of freedom at 5% level of significance the table‘t’ value is 1.761. The calculated‘t’ value for P_{O2} is 0.097. Since the calculated‘t’ value is less than the table‘t’ value, the null hypothesis is accepted.

  - Experimental Group

For 14 degrees of freedom at 5% level of significance the table‘t’ value is 1.761. The calculated‘t’ value is 1.944 and is greater than the table‘t’ value. Hence the null hypothesis is rejected.

- Post-test

The difference between the post-test P_{O2} values of group A and group B is 3.254. The table‘t’ value is 1.701. The calculated‘t’ value is greater than the table‘t’ value, hence there is a significant difference between the groups.

- **Spontaneous Breathing Periods**
  - Pre-test

The difference between the pre-test SBP values of group A and group B is 0.677. The table‘t’ value is 1.701. The calculated‘t’ value is lesser than the table‘t’ value, hence there is no significant difference between the groups.

- Control Group

For 14 degrees of freedom at 5% level of significance the table‘t’ value is 1.761. The calculated‘t’ value for SBP is 0.5002. Since the calculated‘t’ value is less than the table‘t’ value, the null hypothesis is accepted.

- Experimental Group

For 14 degrees of freedom at 5% level of significance the table‘t’ value is 1.761. The calculated‘t’ value is 4.559 and is greater than the table‘t’ value. Hence the null hypothesis is rejected.

- Post-test

The calculated‘t’ value for post-test SBP of group A and group B is 1.714. The table‘t’ value is 1.701. Since the calculated‘t’ value is greater than the table‘t’ value, there is a significant difference between the groups.

7. DISCUSSION

Invasive mechanical ventilation is always associated with complications, and its abbreviation reduces morbidity like hospital-acquired infections and mortality. Low endurance or strength may be present due to respiratory muscle atrophy and dysfunction caused by mechanical ventilation, critical illness or steroids.

This study is an experimental study in which the objective is to analyze "**Effect of Inspiratory muscle strength training on ventilator weaning".**

The study consists of 2 individual groups, one control group A and other experimental group B with the inclusion of 15 mechanically ventilated patients in each group. On the basis of treatment protocol, control group A underwent standard weaning technique along with breathing exercise and experimental group B underwent standard weaning technique along with Inspiratory muscle strength training.

The arterial blood gas parameters P_H, P_{CO2} and P_{O2} were taken before and after the Inspiratory muscle strength training. The spontaneous breathing period on the day of training and the next day of training were noted.

Analysis of standard weaning technique in control group A using paired‘t’ test showed no significant improvement in P_H, P_{CO2}, P_{O2} and spontaneous breathing periods

This may be due to inability of the lungs to carry out gas exchange effectively without the assistance of the ventilator which continue if the underlying cause of respiratory failure has not sufficiently improved. There may be profound inspiratory respiratory muscle fatigue and psychological dependency[30].

Since the training was conducted for only one day, there may be no significant improvement in control group. Other weaning criteria regarding vitals and ventilator readings showed good improvement. This may be due to diaphragmatic breathing exercise which is associated with improvement of blood gases at the expenses of a greater inspiratory muscle loading.

This was supported by BELMAN MJ and MITTMAN C - breathing retraining like diaphragmatic breathing exercises increase ventilatory efficiency and therefore increases function[7, 13]. Also COLLEEN M KIGIN have used graded resistance diaphragmatic breathing exercise to wean patients from mechanical ventilation, which resulted in a dramatic change in tidal volume and vital capacity[13].

When Inspiratory muscle strength training was administered along with standard weaning technique, there was significant improvement in P_H, P_{O2} and spontaneous breathing periods in experimental group B using paired 't' test.

This may be due to muscle strength gain which is highly specific to the training mode, speed and task. Also the subjects soon learnt that if they change their breathing patterns and inhale at low rates, inspiratory resistance and hence the perception of inspiratory difficulty decreases[15].

On statistical analysis using independent't' test between group A and group B showed significant difference in P_{CO2}, P_{O2} and spontaneous breathing periods.

This may be due to the inspiratory muscle strength training, changes in the motor program, in the excitability of the neuromuscular system, or both may have occurred. Neural adaptations that may have potentially occurred as a result of training include an improved ability to attain a maximal volitional contraction, a decreased co-activation of antagonist muscle groups, and an enhanced synchrony of motor unit firing, an increased reflex potentiation, and more efficient motor programming[15].

In experimental group, there is no significant changes in P_{CO2} using paired'tʼ test. Also, there is no significant difference in P_H between group A and group B using independent'tʼ test.

G.BOUACHOUR et.al successfully weaned patients with drop in P_H ($P_H < 7.3$) and rise in P_{CO2} ($P_{CO2} > 40$mmHg), since it occurred despite a stable arterial bicarbonate concentration[23].

Z.MOHSENIFAR et.al found that the arterial blood gas parameters P_H and P_{CO2} were affected due to gastrointestinal acidosis which was an early sign of weaning failure[64].

Though there are controversies regarding P_H and P_{CO2} as a weaning predictor, the null hypothesis is rejected with the result of significant difference of P_{O2} and spontaneous breathing periods between group A and group B. Since Inspiratory Muscle Strength Training increases threshold training pressure in combination with progressive spontaneous breathing periods[15] and improved lung volumes[57]. The P_H and P_{CO2} values difference lie under limitations of this study.

Hence these results infer that Inspiratory muscle strength training can be incorporated along with standard weaning technique on ventilator weaning.

8. SUMMARY AND CONCLUSION

This study was conducted to analyze the effectiveness of Inspiratory Muscle Strength Training on ventilator weaning. The study was conducted in 2 groups with 15 patients each. Group A received Standard weaning technique and Group B received Standard weaning technique along with 1 day Inspiratory Muscle Strength Training. Arterial Blood Gas parameters P_H, P_{CO2} & P_{O2} and Spontaneous breathing period were noted before and after training.

The statistical analysis using paired‘t’ test at 5% level of significance showed that there was significant improvement in P_{O2} and spontaneous breathing period in Group B. Also the statistical analysis using independent‘t’ test at 5% level of significance showed that there was significant difference in P_{O2} and Spontaneous breathing period. Hence it can be concluded that Inspiratory Muscle Strength Training has effect on pulmonary function to facilitate ventilator weaning.

9. LIMITATIONS AND SUGGESTIONS

Though carried out with the best of efforts, the study has the following limitations. Suggestions for modifying the study to conduct further studies are given below:

- The samples studied were small population and studies with larger population are recommended.
- The study was a short-term study and studies with long-term follow-up are suggested.
- The criterion for patient selection was much general, and both Intubated and tracheostomy patient were selected. Further studies which compare the effect of Inspiratory Muscle Strength Training in Intubated and tracheostomy patients can be conducted.
- Arterial blood gas parameters P_H, P_{CO2} and P_{O2} are indirect outcome measures for Inspiratory muscle strength training. Hence Maximum Inspiratory Pressure [PI_{max}] can be used as a direct outcome measure.
- P_H and P_{CO2} values were also affected by gastrointestinal acidosis and other metabolic factors. Therefore P_H and P_{CO2} can be analyzed separately as a weaning success or failure predictor.

- Mostly patients with neurological conditions were excluded in this study, hence studies may be conducted in patients with neuromuscular diseases and poisoning, who are ventilator dependent.

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APPENDIX-I

ASSESSMENT FORM

Patient Name:

Age/Sex:

Diagnosis:

VENTILATOR STATUS:

Mode	
FiO_2	
SaO_2	
PSV	
PEEP	

SPONTANEOUS BREATHING PERIOD:

DATE	DURATION

ARTERIAL BLOOD GAS:

ABG	Pre-test	Post-test
P_H		
P_{CO2}		
P_{O2}		

APPENDIX- II

INFORMED CONSENT TO PARTICIPATE IN THE RESEARCH STUDY

I _____________ voluntarily consent to participate in the research study, "EFFECT OF INSPIRATORY MUSCLE STRENGTH TRAINING ON VENTILATOR WEANING" – An Experimental Study.

The researcher has explained to me about the research in brief, the risk of participation and has answered the questions related to the research to my satisfaction.

Signature/Thumb print of the applicant:

Signature of the researcher:

Signature of the witness: