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EFFECT OF INSPIRATORY MUSCLE TRAINING VERSUS RESPIRATORY PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION ON PULMONARY FUNCTION AND CHEST EXPANSION IN SUBJECTS WITH QUADRIPLEGIA: AN EXPERIMENTAL STUDY

Physiotherapy

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ABSTRACT

Background: The International Headache Society [1] classified 2 basic categories of headaches, primary and secondary. A cervicogenic headache is a common cause of a chronic headache that is often misdiagnosed. It is Secondary type of Headache. Cervical and thoracic mobilization and manipulation are frequently used to treat patients diagnosed with cervicogenic headache (CEH); however, there is conflicting evidence on the efficacy of these manual therapy techniques. Some researches shown beneficial effects of these 2 techniques. Present study is done to compare efficacy of two different treatment techniques in patients with cervicogenic headache. **Methodology:** This study included 30 subjects with Quadriplegia and divided into 2 groups. Group A received Respiratory Proprioceptive Neuromuscular Facilitation and Group B received Inspiratory Muscle Training. Both groups received conservative management. Outcome measures were Chest Expansion and Pulmonary Function Tessting. **Result:** Result of this study shown that there is significant statistical difference within group results and slightly more improvement in Group B when compared with group A in Between group Analysis. **Conclusions:** Results of present study confirms that Inspiratory Muscle Training is more effective than Respiratory PNF in improving Chest Expansion and Pulmonary Function in Quadriplegia.

KEYWORDS

Quadriplegia, Chest Expansion, Pulmonary Function Testing

INTRODUCTION

The spinal cord is part of the central nervous system and consists of a tightly packed column of nerve tissue that extends downwards from the brainstem through the central column of the spine. Even though it is a relatively small bundle of tissue, weighing a mere 35g and just about 1cm in diameter, the spinal cord plays a crucial role in facilitating our daily activities. It carries nerve signals from the brain to other parts of the body, commanding the muscles we use to move. It also receives sensory input from the body, partially processes it, and transmits that information to the brain.[1]

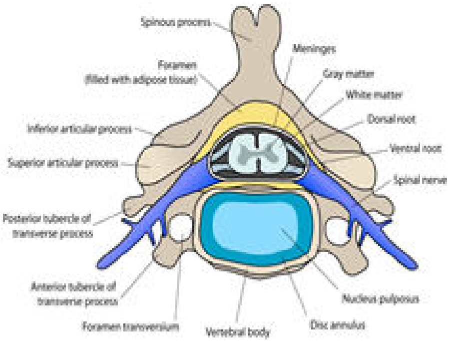

Figure 1: Spinal Cord Anatomy

As well as carrying motor and sensory signals between the brain and periphery, the spinal cord provides separate neural circuits for many of our reflexes - automatic, involuntary responses to sensory inputs. Some reflexes, such as the knee-jerk and the withdrawal reflex (for example, when touching something hot), are built into the nervous system and bypass the brain, while others can be learned over time[2]

Externally, the spinal cord is protected by 26 bones called vertebrae, which are sandwiched between cartilage discs to cushion the cord from any inappropriate movement caused by body. Just like the brain itself, the spinal cord is also protected by three layers of meninges (membranes). Inside, the spinal cord consists of grey matter and white matter. If you look at a cross-section, the grey matter takes on the shape of a butterfly, with four 'wings' called horns. The horns in the front contain motor neurons, which carry information from the brain and spinal cord to the body's muscles, stimulating their movement. The horns in the back contain sensory neurons which carry sensory information – like, touch, pressure or pain – from the body back to the spinal cord and the brain[2]

The spinal cord grey matter is enveloped in a column of white matter, which contains axons that allow different parts of the spinal cord to communicate smoothly. These axons travel in both directions - some carry signals from the body to the brain, while others deliver signals from the brain to neurons located elsewhere in the body. [3]

Spinal cord injury (SCI) is an insult to the spinal cord resulting in a change, either temporary or permanent in its normal motor, sensory or autonomic function. Spinal cord injury (SCI) often leads to an impairment of the respiratory system. The more rostral the level of injury, the more likely the injury will affect ventilation. More than one half of all SCIs (56.4%) occur at the cervical level [1] Cervical SCI often leads to an interruption of the descending bulbospinal respiratory pathways, resulting in respiratory muscle paresis and/or paralysis; the more rostral the level of the injury, the greater the likelihood that a major respiratory impairment will occur[3]

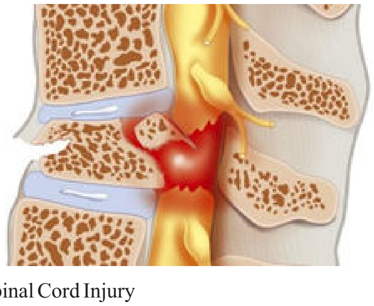

Figure 2: Spinal Cord Injury

Currently, there are no known cures for respiratory muscle paralysis. In cases in which patients are unable to maintain adequate ventilation, long-term mechanical ventilator support is indicated [2][3]. Although this

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treatment is effective, it can also lead to serious medical complications such as infection, pneumonia, atelectasis, and even death [4] In fact, the primary cause of death after SCI, regardless of the level of injury, is caused by respiratory insufficiency and complications associated with impaired respiratory function.

Inspiratory muscle training (IMT) is a therapeutic technique which involves specific training of respiratory muscles to yield improvements in inspiratory muscle strength and respiratory function.[5] Previous studies have shown positive effects of IMT on exercise capacity in able-bodied individuals[6] and other neurological conditions. [7] In spinal cord injured improvements in peak exercise responses were seen in quadriplegics [8]

Figure 3: Inspiratory Muscle Trainer

The Proprioceptive neuromuscular facilitation technique is defined as a positive functional approach to help patients achieve their highest level of function. Breathing problems can be a result from both disturbed inspiration and expiration phases. To improve breathing, the related structures involving diaphragmatic, sternal and coastal areas should be treated. The physiological mechanism that enables the initiation of inspiration is thought to be the stretch reflex. The stretch reflex resists the change in muscle length by contracting the stretched muscle fiber via its muscle spindle (proprioceptor). Appropriate resistance during applying for one of the PNF techniques strengthens the muscles and guides the chest motion.[9]

SCI that involves the innervation to the phrenic nerve and in turn the diaphragm, C2, C3, C4, and C5, C6, result in impaired inspiration and expiration. Injuries at these levels often require mechanical ventilation for at least some period and may require phrenic nerve pacing in the future to restore diaphragm function. [10]

1) In patients with cervical or high thoracic SCI, a paradoxical and inefficient mechanism of breathing develops in which the upper rib cage moves inward during inspiration due to decreased activity of the external intercostals creating decreased chest-wall compliance. Conversely, the abdominal compliance in an SCI patient is increased.

2) In patients with complete SCI, this will result in a decrease in vital capacity to 20-50% of predicted value and a weakened cough.[10]

It has been shown that both FEV1 and FVC improved in 12 patients with complete SCI over the first year following injury. In another study, vital capacity improved by 13% over a 10-month period following injury, with the most improvement in the first 3 months. However, in the long term there is a decrease in FEV1 that is related to increasing years after injury. [11]

Aim Of The Study

To find out and compare the Effect Inspiratory Muscle Training and Proprioceptive Neuromuscular Facilitation on Pulmonary function and chest expansion in subject with Quadriplegia.

Need Of Study

In acute spinal cord injury, 80 % of patients may suffer from respiratory complications. Long-term follow-up indicates that respiratory complications are the most common cause of death in these patients.[17] The most common respiratory complications are atelectasis, pneumonia and respiratory failure. So that Prevention is essential. Previous studies have shown positive effects of Inspiratory Muscle Training as well as Proprioceptive Neuromuscular Facilitation on exercise capacity in individuals but combination and comparison of its effects are unknown. So present study is conducted to find out comparative effectiveness of Inspiratory Muscle Training and Proprioceptive Neuromuscular Facilitation on Pulmonary function and chest expansion in subject with Quadriplegia.

Objective Of The Study

- To see the effect of Inspiratory Muscle Training on Pulmonary function and chest expansion in subject with Quadriplegia.
- To see the effect of Proprioceptive Neuromuscular Facilitation on Pulmonary function and chest expansion in subject with Quadriplegia.
- To compare the Effect of Inspiratory Muscle Training and Proprioceptive Neuromuscular Facilitation on Pulmonary function and chest expansion in subject with Quadriplegia.

Study Design And Study Setting:

- **Study Design:** An Experimental Study
- **Study Setting:** Spinal cord injury rehabilitation centers and Neuro ICUs/ Hospitals and Clinics
- **Study Duration**: 4 weeks
- **Sampling Technique:** Simple Random Sampling
- **Sample Size:** 30 subjects, calculated from following formula.
- **Population:** Subject having quadriplegia with respiratory involvement. (Cervical and Upper thoracic traumatic Spinal Cord Injury)

Selection Criteria

A. Inclusion criteria:

- Patient willing to participate
- Age group of 20 to 60 years,
- Both male and female patients
- Subjects with Cervical & upper Thoracic traumatic spinal cord injury.

B. Exclusion criteria:

- Chest Trauma & Rib fracture,
- Non-Traumatic spinal cord injury like Spinal TB, Spinal metabolic diseases like osteoporosis
- Patient who needs ventilatory assistance on IMV, SMV, or BI-PAP
- Hemodynamically unstable patients,
- Other neurological condition,
- K/C/O Pre and Post operative Respiratory Disease

Outcome Measures:

- Chest Expansion in Centimeter (using a tape measure)
- Pulmonary Function Testing (Spirogram)

Methodology:

Figure 4: Flow Chart Of The Study Procedure

Ethical Approval Was Taken

Subjects were assessed according to inclusion and exclusion criteria After taking Written and informed consent, the subjects were randomly allocated into 2 groups by simple random Sampling.

Group A: Respiratory PNF +Conventional treatment (n=15)

Group B: IMT +Conventional treatment (n=15)

Group A: Respiratory PNF +Conventional treatment: [12]

- Intercostal stretch, Posterior basal lift, Abdominal co-contraction
- 10-12 repetitions of each tech in 1 set (1 min rest after 5-6 repetitions)
- 5 sets in one Session
- 1 session in a day
- 6 days/Week for 4 weeks in IPD (Indoor patient Department)

Group B: Group B: IMT + Conventional treatment [13]

- The mouth piece of the threshold trainer will put inside the participant's mouth and nose clip will be attached to prevent any breathing through the nose.
- The participants were instructed to breathe in a force to overcome the resistance of a spring-loaded valve and enable airflow.
- The resistance of the inspiratory muscle threshold trainer was adjusted at 40% 14 of the obtained MIP.
- The resistance was increased to the next level as the participants completed 50 breathes without any difficulty for consecutive 3 days.
- Participants repeated this maneuver for 15 minutes15 with 2–3 minutes rest periods in between.
- Intervention was given 6 days a week for four weeks.

Conventional treatment for both groups: [12]

Strengthening exercises for bilateral upper and lower extremities according to the level with the help of weight cuff. (Weight were selected according to RM result)

- Trapezius
- Latissimus dorsi
- Biceps
- Triceps
- Gluteus maximus
- Mat activities,
- Transfer training,
- Balance training,
- Gait training with appropriate assistive and ambulatory aids,
- Glossopharyngeal breathing
- Diaphragmatic breathing,
- Incentive Spirometer ,
- Chest mobility exercise (Butterfly exercises with support)

RESULT

Study variable was taken before starting sessions on both groups and at the end of the study, study variable was Chest expansion and PFT.

Age Distribution:

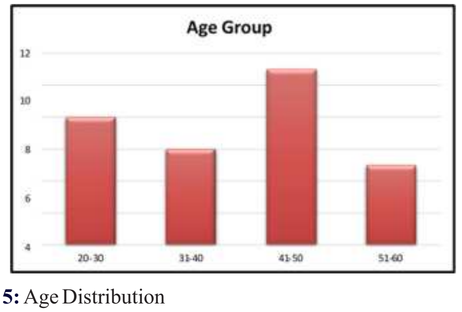

Figure 5: Age Distribution

Age group was between 20-60 years. Among a total of 30 subjects, 8 were between 20-30 years, 6 were between 31-40 years, 11 were between 41-50 years and 5 were between 51-60 years. The mean age of participants was 40±20 years.

Gender Distribution:

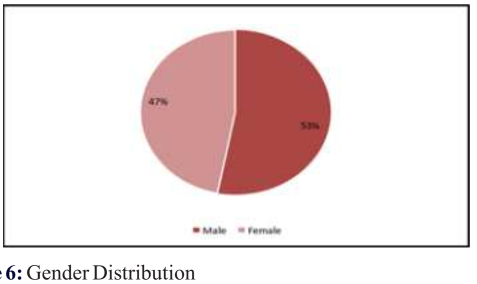

Figure 6: Gender Distribution

Among total 30 subjects with Spinal cord injury, 53% were female and 47% were male.

Data Analysis:

Statistical analysis was performed on the data obtained from 30 patients. Data was analyzed using SPSS Version 25.0. Descriptive statistics for all outcome measures were expressed as mean, standard deviations and test of significance such as paired 't' test used for comparing data within each group and independent 't' test for comparing between the groups. Data was considered statistically significant with $P<0.05$ and highly significant at $p<0.01$. Pre and post mean difference of Chest Expansion shows 1.47cm in group A and 2.03 cm in group B. Pre and post mean difference of PFT was 12.18 in group A and 14.13 in group B. As $p<0.05$ there is significant difference between two groups.

Table 1: Paired "t" test values for Chest Expansion

Group	Mean Difference (cm)	Standard Deviation	"t" Value	"p" Value
Group A	1.47	0.18	8.25	P<0.05
Group B	2.03	0.59	10.13	P<0.05

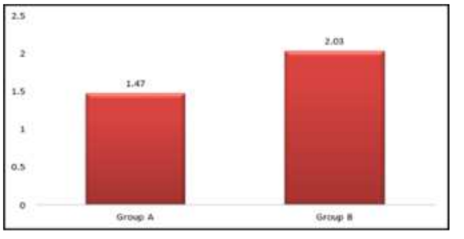

Figure 7: Mean Values of Chest expansion (cm)

Table 2: Paired "t" test values for PFT (Combined Value of FEV1+FVC)

Group	Mean Difference (Liters)	Standard Deviation	"t" Value	"p" Value
Group A	12.8	1	12.81	P<0.05
Group B	14.13	0.97	14.53	P<0.05

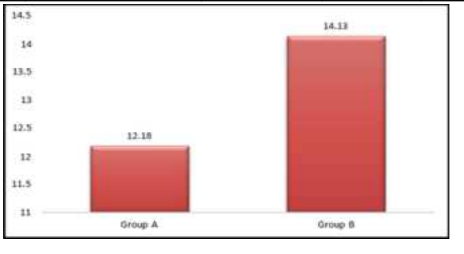

Figure 8: Mean Values of PFT (Combined Value of FEV1+FVC) (Liters)

Table 3: Independent "t" test values

Outcome Measure	"t" Value	"p" Value
Chest Expansion	-1.10	P<0.05
PFT	0.68	P<0.05

DISCUSSION

Present study compares the Effect of Respiratory Proprioceptive Neuromuscular Facilitation Versus Inspiratory Muscle Training on Pulmonary function and Chest Expansion in Quadriplegia. Total 30 patients between age of 20-40 were taken. Among them 47% were male and 53% were female.

Statistical analysis of present study confirms that there is significant within group difference in Group A as well as Group B. This suggests that both Respiratory Proprioceptive Neuromuscular Facilitation and Inspiratory Muscle Training both were effective in improving Chest Expansion and Pulmonary function in Quadriplegia. Between group analysis of this study shown significant difference in Group B when compared Respiratory Proprioceptive Neuromuscular Facilitation and Inspiratory Muscle Trainer.

Expiratory muscle function is more compromised than inspiratory muscle function among subjects with tetraplegia and high paraplegia, which can result in ineffective cough and propensity to mucus retention and atelectasis. Injury to the cervical and upper thoracic spinal cord disrupts function of inspiratory and expiratory muscles, as reflected by reduction in spirometric and lung volume parameters.[19] There was also an improvement in both Chest expansion and Pulmonary function in IMT group. Study by Liaw suggests that with increased oxygen demand during physically strenuous activities, the effort of breathing is increased. Studies have shown that IMT results in improvement of respiratory muscle strength and fatigue tolerance. Inspiratory muscle training has an indirect positive effect on FVC, FEV1, and PEF, which denote the expiratory pulmonary function. In healthy people, FVC and FEV1 are positively correlated with upper and lower chest expansion. However, in Quadriplegic patients showed no significant correlation between pulmonary function and chest expansion. Rib cage joint mobilization is designed to improve inspiration, which is a main effect of Inspiratory Muscle Trainer. This finding may be attributed to the fact that FVC, FEV1, and PEF represent expiratory pulmonary function.[20]

Recent studies further emphasize the importance of targeting both inspiratory and expiratory muscle functions to improve respiratory outcomes in individuals with spinal cord injuries (SCI). The compromised expiratory muscle function, notably in individuals with tetraplegia and high paraplegia, leads to ineffective coughing and an increased risk of mucus retention and atelectasis. This issue is compounded by the disruption of both inspiratory and expiratory muscles due to cervical and upper thoracic SCI, which is reflected in reduced spirometric and lung volume parameters. Inspiratory muscle training (IMT) has been shown to improve respiratory muscle strength and fatigue tolerance, indirectly enhancing expiratory pulmonary functions such as Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV1), and Peak Expiratory Flow (PEF). This finding is supported by studies demonstrating that IMT can lead to significant improvements in both chest expansion and pulmonary function, particularly during physically strenuous activities that increase oxygen demand.[21]

Vikram M. and Kamaria K. (June 2012) conducted study on effect of intercostal stretch on pulmonary function Parameters and they stated that the use of manual stretching procedures has become more prevalent in cardiorespiratory physiotherapy to improve pulmonary functions. In the experimental group, subjects underwent intercostal stretch for ten breaths on the inspiratory phase of the respiratory cycle with breathing control exercises in semi recumbent position, while in the control group, breathing control exercises alone were performed in the semi recumbent position. The results of the study showed, FEV1 and FVC in the experimental group significantly improved than the control group, which means intercostal stretch increased lung volume and lead to improved lung function. This study suggested the intercostal stretching with breathing control may be more effective in improving dynamic lung parameters. The intercostal may enhance the chest wall elevation and thus increase expansion to improve intra-thoracic lung volume which contributes to improvement in flow rate percentage. This may contribute to the increase in ventilatory capacity (Chang et al., 2002). The changes in ventilatory parameters may be due to the firing discharge of the muscle spindle during a passive stretch phase (Hirai et al., 1996). Intercostal stretching has activated the stretch receptors in the chest wall, thereby distending the thorax which could be neurologically linked to medulla with efferent nerve cells. It could also be argued that this altered ventilatory function may have resulted because of reflexive activation of the diaphragm by the intercostal afferents that innervate its margins (Jennifer and Pryor, 2008).[22]

Recent research supports the use of intercostal stretching and other respiratory interventions to improve pulmonary function in individuals with spinal cord injuries (SCI). For instance, a study by Dangi et al. (2017) compared intercostal stretch techniques with diaphragmatic breathing in COPD patients, demonstrating significant improvements in chest expansion, dyspnea, and functional capacity in the intercostal stretch group. These findings highlight the potential of intercostal stretching to enhance lung function by increasing chest wall mobility and lung volume, thus improving overall ventilatory capacity.[23]

Another study by Gupta et al. (2014) explored the effects of intercostal stretch and anterior basal lift techniques on respiratory parameters in ICU patients. The study found significant improvements in respiratory rate, oxygen saturation, and heart rate, suggesting that intercostal stretching can effectively enhance respiratory mechanics even in critically ill patients.[24]

Yamada et al. (1996) demonstrated that respiratory muscle stretch gymnastics, which include intercostal stretching, improved respiratory function in patients with chronic respiratory diseases. This supports the notion that stretching exercises targeting the chest muscles can be beneficial in a wide range of respiratory conditions by improving the flexibility and function of the thoracic structures.[25]

Overall, the integration of intercostal stretching techniques into respiratory rehabilitation programs for individuals with SCI and other respiratory conditions can significantly enhance pulmonary function. These interventions not only improve chest wall mobility and lung volumes but also contribute to better overall respiratory health and quality of life.

CONCLUSION

Results of present study confirms that Inspiratory Muscle Training is more effective than Respiratory PNF in improving Chest Expansion and Pulmonary Function in Quadriplegia.

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