Utility of Incentive Spirometer and Peak Flow meter used as assessment as well as therapeutic tool to improve the respiratory muscle strength in wheelchair bound Paraplegics in community

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Aims & Objectives: to find out whether Intensive Spirometer and Peak Flow meter can be used as a treatment tool to improve the Respiratory muscle strength in wheelchair bound paraplegic in community & whether Incentive Spirometer and Peak Flow meter can be used as an outcome measure to assess the Respiratory muscle strength in wheelchair bound paraplegics in community. Method: This study was conducted with the sample size of 30 based on the inclusion criteria i.e. the male wheelchair bound paraplegic subjects with the level of lesion [T6-T12] between the age group of 25-40 years. The respiratory muscle strength of all the subjects was assessed using the Incentive Spirometer and Peak Flow meter. A ventilatory training program was given to all the subjects 3 times/week for a period of 4 weeks. The treatment duration was of 20 min. for each patient. After completion of the program, the outcome measures of Respiratory muscle strength were reassessed by using Incentive Spirometer and Peak Flow meter. Result: There was highly significant improvement in Respiratory muscle strength by using Incentive Spirometer and Peak Flow meter in wheelchair bound paraplegics in community. Conclusion: Both the devices significantly improved Respiratory muscle strength in wheelchair bound paraplegics in community & also they are cheap and easily available and used as an outcome measure to assess respiratory muscle strength by means of measuring maximum breathing capacity (MBC) and Peak expiratory flow rate (PEFR) scores in wheelchair bound paraplegics in community.

KEYWORDS: Incentive Spirometer, Peak Flow Meter, respiratory muscles, spinal cord injury (SCI), wheelchair bound paraplegics.

INTRODUCTION

Spinal cord injury (SCI) is a low incidence high-cost disability requiring tremendous changes in an individual’s lifestyle37. It is estimated that approximately 11,000 new cases of SCI occur in the United States annually. A gross estimate indicates that there are between 225,000 and 28,000 individuals with SCI currently living in the United States7.

Spinal cord injuries may be traumatic or non-traumatic. Traumas are by far the most frequent cause of injury in adult rehabilitation populations. They result from damage caused by a traumatic events such as motor vehicle accidents, fall or gunshot wound37.
Statistics from National Spinal Cord Injury Database (NSCID) indicate that accidents involving motor vehicles are the most frequent case of traumatic SCI [45.6%], followed by falls [19.6%), acts of violence [17.8%], recreational sports injuries [10.7%] and other etiologies [6.3%]37.

Because of improvement in Medical care and survival, the prevalence of people living with SCI has increased and it is predicted that there will be greater and greater number of older patients with SCI7.

Currently, the average age of injury is 36.6 years and 80% of those affected are male. According to NSCID, 81% where men, representing a slightly higher than 4:1 ratio of men to women.37 Patients injured after 1990 had an average age at time of injury of 34.8 years, 56% of SCI’s occur among persons in the 16-30 years of age group. Types of injuries are Tetraplegia [51.9%] and Paraplegia [46.27%]. T12 is most common level of injury for paraplegia6.

In India, ratio of men to women who sustained spinal injuries is 3.6:1. The maximum numbers of patients are in the age range of 20-39 years. The different levels of spine that sustained injuries are Cervical Spine [36.2%], Thoracic Spine [34.3%] and Lumber Spine [29.5%]. Mechanism of injury recorded are fall from height [58.9%], fall of weight [7.2%], motor vehicle accidents [21.3%]39.

Respiratory dysfunction is a major cause of morbidity and mortality in SCI, which causes impairment of respiratory muscles, reduced vital capacity, and ineffective cough, reduction in lung and chest wall compliance and excess oxygen cost of breathing due to distortion of the respiratory system7.

If thoracic segments are injured muscles of expiration is affected49. Following spinal cord injury above T12, the impulses traveling down the cord to stimulate the abdominal muscles is interrupted. Associated factors such as decreased volume of air able to flow in and out of the lungs, also affect the ability to expel Sputum (or cough). The inability to effectively cough allows secretions, with trapped microbes, to remain in the lungs. This increases the risk of respiratory tract infections87.

Diminished pulmonary function, due to paralysis of the expiratory muscles, depending on the level of lesion. Persons with paraplegia lack abdominal muscle function and also lesion dependent intercostal muscle function. Persons with tetraplegia lack most of the expiratory and even some of the auxiliary inspiratory muscle. This may lead to more rapid fatigue of the respiratory pump in subjects with SCI during physical activity, as well as to a restricted pulmonary capacity1.

Following Spinal Cord Injury, muscles below the level of injury develop variable degrees of disuse atrophy. Muscle mass of all muscles innervated by spinal cord segment below the lesion decreased compared with control values. Mass of the external oblique, internal oblique and transverse abdominis muscles decreased significantly. Mass of internal and external intercostals muscles are also significantly reduced20.

Individuals with spinal cord injury (SCI) exhibit reduced lung volumes and flow rates as a result of respiratory muscle weakness. FVC, FEV1 and IC increased with descending SCI level down to T10 below which they tended to level off. In supine position, values of FVC and FEV1 tended to be larger compared with the seated posture down to injury level T1. There is a sharp increased in FVC and IC at lower thoracic injury levels. The higher values of IC are related to the decrease in ERV between injury levels T12 and L2 in the absence of a proportional falling FVC. If the quadratus
lumborum is selectively paralyzed, as in T11-T12 injuries, the diaphragm should be displaced more cephalad, resulting in decrease in ERV and increase in IC.

Spinal cord injury causes physiological and functional disorders. These disorders have an impact on the everyday life of paraplegics and often lead to a physiological deconditioning. The limited activity often negatively affects the health of these people and leads to a debilitative cycle. A reduction in aerobic capacity and other cardiovascular consequences are linked with the lower metabolic rate of these patients. In fact, the limited life-style may lead to a physiological deconditioning.

Paralysis of lower limbs altered autonomic control and inactivity to compromise physical capacity in paraplegia. Physical capacity can be described as the capacity of cardiovascular system, muscle groups and the respiratory system, to provide a level of physical activity. It is reduced in persons with a Spinal Cord Injury by the direct loss of motor control and sympathetic influence below the level of lesion. Additionally, the majority of persons with an SCI will be wheelchair users dependent on arm work for mobility and activities of daily living. Subsequently, an inactive lifestyle may further reduce physical capacity.

A low level of physical capacity is associated with a decreased in activity, functional status and participation. This may result in vicious circle of decreased physical capacity leading to decreased activity and participation, which further reduces physical capacity.

Fitness is often poor in disabled and everyday wheelchair propulsion does not seem to provide a sufficient stimulus for Cardio-respiratory adaptation. Spinal cord injury often leads to an impairment of the respiratory system. A greater loss of respiratory function is observed in patients with a longer duration of injury, dependent of age in paraplegia.

It is often assumed that the prevalence of breathlessness due to specific task is greater at higher levels of SCI. Overall dyspnoea during activities of daily living is most common, among motorized wheel-chair users. In them dyspnoea noted while talking for more than a few minute while hand-held propelled wheel-chair users more commonly experienced dyspnoea while dressing and undressing. In motorized wheel-chair user, the relatively high rate of breathlessness during talking may be related to difficulty interrupting breathing to manipulate phrasing and speech loudness because their breathing is already greatly impaired.

Wein, M.F., E. Garshick et al suggested that after SCI, breathlessness during daily activities is common.

Zwieren LD, Bar- oR O et al suggest marked decrement in Cardio-pulmonary functions, related to the oxygen transport system, in men whose lower limbs have been immobilized for years.

Many wheel-chair users are less fit than they could be and that this lack has an adverse influence on their adaptation to their disabilities. Individuals who use wheel-chairs vary widely in their level of Cardiovascular fitness, some being seriously unfit and others achieving levels that compare closely with those of fit able-bodied athletes. Most commonly the fitness, as measured by maximum oxygen intake, of persons in wheel-chair users is low. This is often due, in part to unnecessary restrictions on their physical activity because of a lack of opportunity or awareness.
In fact that patient with SCI activate their respiratory muscles in daily life less than able-bodied persons due to the lack of whole-body physical activity may also explain the weakened respiratory system. Therefore special attention should be given to the functioning and improvement of their respiratory pump. Regular physical activity may be a decisive factor for the well-being of paraplegics and rehabilitation program improves the Cardio-respiratory functioning.

Loss of respiratory muscle strength, with ensuing ineffective cough and decreased ventilation, leads to pneumonia, atelectasis and respiratory insufficiency in sleep and while awake. These complications are generally preventable with careful serial assessment of respiratory function.

Robert Brown MD, Anthony F Dimarco MD et al measured spirometry and maximum inspiratory and expiratory pressure to assess breathlessness in SCI patient. Dr. Norma M. T Braun studied that respiratory muscle weakness can be determined from reduction of maximum respiratory muscle pressures, either measured at the mouth (maximum inspiratory and expiratory pressures) or across the diaphragm.

Imle, Cristina P. recorded maximal inhalation volume without weight by using Incentive Spirometer. Dr. Sullivan C. recommended Incentive spirometer (e.g.: Tri-flow type) for home respiratory monitoring by patient.

LeBlanc C., et al measured Peak Cough Flow (PCF) by using a peak flow meter. This measurement can be expressed in L/min or L/sec (L/min divided by 60). Diminished respiratory function as measured by forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1), or peak expiratory flow (PEF).

Patients with neuromuscular disorders, where respiratory muscle training led to increased MIP and stabilization or improvement of FVC. Patients with chronic cervical spinal cord injury showed both a strong increase in MIP and FVC following respiratory muscle training.

Leith and brandy showed that respiratory muscle strength and endurance can be specifically increased by appropriate muscle training in able-bodied subjects. So far, studies showing an improvement of respiratory muscle function in patient with SCI focused on respiratory resistance or resistance endurance training.

Several research methods have been utilized to design on exercise protocol for spinal cord injury patients [paraplegics and tetraplegics] to improve the Respiratory muscle strength. It has been noted that most of the studies had utilized Spirometry as a single outcome measures to assess the pulmonary status following intervention.

So far there is no such simplest tool to measure the Respiratory muscle strength at the community level of rural India.

The purpose of this study is to find out whether the Incentive Spirometer and Peak Flow meter can be used both as ventilatory muscle trainer as well as outcome measure to assess the Respiratory muscle strength in wheelchair bound paraplegics in the community.

In keeping with the concept that exercise test is preferable to measurements done at rest in assessing perception of dyspnoea and that a test that is cheap and easy to perform has many advantages. The dyspnoea can be assessed by scoring the maximum breathing capacity [MBC] by incentive spirometry.
A variability of peak expiratory flow [PEF] is now commonly used in the diagnosis and management of asthma. Peak flow meters generally are inexpensive devices that can be provided for personal use, for every individual patient. Patient home monitoring of peak expiratory flow [PEF] with a peak flow meter [PFM] is increasingly advocated as an aid to better management of diseases.

MATERIAL AND METHODS

Study Design: The study is a pre-post test, Single Group Experimental Design in nature.

Study Setting: The participants were collected from the community center, AVBRH, Sawangi (M), Wardha, RNPC, Sawangi (M), Wardha and from nearby rural areas.

Sample Size and Sampling Technique:
30 Wheelchair bound traumatic paraplegic patients between the ages 25-40 years were selected for the study from the above mentioned sources by the means of purposive sampling. The entire subjects participated in this study voluntarily, after signing a written consent form. The purpose of this study was explained to all the subjects.

Inclusion Criteria:
a) Subjects of wheelchair bound traumatic paraplegics.
b) Subjects diagnosed as traumatic paraplegia with the level of lesion [T6-T12] for more than 6 months.
c) Males only.
d) Age: 25-40 years.

Exclusion Criteria:
a) Subjects other than spinal cord injury.
b) Subjects of traumatic paraplegia with the level of lesion <T6 and >T12.
c) Subjects with Orthopedic (like rib fracture, PIVD etc), Cardio-respiratory (like Hypertension, active pulmonary infections, pre-injury history of pulmonary diseases or respiratory symptoms, Hypoxemia secondary to interruption of prescribed oxygen therapy etc) disorders.
d) Female subjects.

e) Age: Below 25 years and above 40 years.

Duration of the study:
Study was carried out on 4 weeks for each individual with the total duration of 1 year i.e. from Aug. 2007 to Aug. 2008.

Outcome Measures:
1) Maximum breathing capacity (MBC) by Incentive Spirometer.
2) Peak expiatory flow Rate (PEFR) by Peak Flow meter.

Material used:
1) Incentive Spirometer
2) Peak Flow meter.

Method:
This study was conducted with the sample size of 30 based on the inclusion criteria i.e. the male wheelchair bound paraplegic subjects with the level of lesion [ T6-T12 ] between the age group of 25-40 years. The selected subjects were with the informed consent at their door steps. The respiratory muscle strength of all the subjects was assessed using the Incentive Spirometer and Peak Flow meter. A ventilatory training...
program was given to all the subjects 3 times/ week for a period of 4 weeks. The treatment duration was of 20 min. for each patient. After completion of the program, the outcome measures of Respiratory muscle strength were reassessed by using Incentive Spirometer and Peak Flow meter.

Procedure:
I) Three minute respiratory exerciser test (3 MRET) by Incentive Spirometer: This test scored a maximum breathing capacity of (MBC) by repetitive inspiratory effects within three minutes based on incentive spirometry, (Tryflow type) that was routinely used in our hospital for the purpose of Chest Physiotherapy and scored the maximum breathing capacity (MBC), at the end of this three minute period. By repeated inspiratory effort, patients were asked to get as many balls as possible to reach the top of each of the three columns (A, B and C) within three minutes, column A, B and C required to flow rates of 600 cc/min, 900cc/min and 1200 cc/min respectively to bring the balls to reach the top, and as such, required the generation of sufficient inspiratory effort on the part of the subject to achieve this. When all three balls reached their column top, it indicated that the subject was able to generate inspiratory airflow of 1200 cc/min. When only two balls reached their column tops, it indicated that the subject generate 900 cc/min. When only one ball reached their column tops, it indicated that the subject could only generate 600 cc/min. The cumulative times of three balls, two balls or one ball reaching the column top became an index of maximal breathing capacity (MBC score) and the formula used was as follows:

\[
MBC \text{ scores} = (\text{no. of times that all three balls reached the top of column}) \times 2 + (\text{no. of times that two balls reached the top of column}) \times 1.5 + (\text{no. of times only one ball reached the column top}) \times 1.
\]

The MBC score were compared with the mean MBC scores, mild 168 (145-192); moderate: 153 (136-169); severe 125 (109-142)\(^3\).

II) Peak expiratory flow Rate (PEFR) by Peak Flow meter: Peak flow meter was used to measure the peak expiratory flow by asking the patient to achieve maximum inspiration first, and then forcibly exhale all of the air in to a measuring device\(^3\) i.e. Peak flow meter, as hard as possible, then the readings of the Peak flow meter were noted. Steps\(^2\) are as follows:

a) First the pointer placed at zero.
b) Asked the patient to sit in a comfortable, upright position on wheel-chair.
c) Asked the patient to hold the peak flow meter level (horizontally) and keep your fingers away from the pointer.
d) Asked to take a deep breath and close your lips firmly around the mouthpiece.
e) Then blow as hard as you can - as if you were blowing out candles on a birthday cake - remember it is the speed of your blow that is being measured.
f) Looked at the pointer and reading had been checked and then reset the pointer back to zero.
g) Same procedure repeated for three times and the highest reading recorded in assessment chart.

The data of the Pre-post test scores of all the subjects were collected and computed for data analysis with the help of paired t-test\(^8\).
Statistical Analysis: Descriptive statistics were used to study the pre-post clinical variables for assessing respiratory muscle strength by using Incentive Spirometer and Peak Flow meter in wheelchair bound traumatic paraplegic subjects. The values were expressed in Mean, Standard deviation, Standard error mean and 95% confidence interval. Differences in means of percentages of variables between pre and post test scores were assessed using students paired t-test. MBC scores and PEF score were expressed as means and 95% confidence interval and their difference between pre-post test scores were assessed by using Students paired t-test. The required level of significant for test was set at p<0.0001

RESULTS
Table I represents the mean, standard deviation, standard error mean and 95% Confidence interval for the reproducibility of the pre and post test Maximum breathing capacity [MBC] scores used in the study. Data describing the comparison between pre and post test MBC scores.

Table II represents the mean, standard deviation, standard error mean and 95% Confidence interval for the reproducibility of the pre and post test Peak Expiratory Flow Rate [PEFR] scores used in the study. Data describing the comparison between pre and post test PEFR scores.

The data of Table I showed that the mean MBC scores were progressively lower with increasing disease severity, i.e. pre test scores was 118.28±12.05 cc/min and post test score was 153.45±22.76 cc/min. Statistically highly significant difference were observed between pre-post test MBC scores in wheelchair bound paraplegic patients [Mean difference: -100±73.10, p<0.0001 and 95% Confidence interval: Lower= -127.29±73.10, p<0.0001; Upper= -72.70±73.10, p<0.0001; t=7.49, p<0.0001 pre-post test] respectively.

The data of Table II showed that the mean PEFR pre test scores was 185±67.14 L/min and post test score was 285±70.89 L/min. Statistically highly significant difference were observed between pre-post test MBC scores in wheelchair bound paraplegic patients [Mean difference: -35.16±13.01, p<0.0001 and 95% Confidence interval: Lower= -40.02±13.01, p<0.0001; Upper= -30.30±13.01, p<0.0001; t=14.79, p<0.0001 pre-post test] respectively.

The overall statistical analysis showed highly significant improvement in Respiratory muscle strength by using Incentive Spirometer and Peak Flow meter in wheelchair bound paraplegics in community.

DISCUSSION
Our study showed a highly significant improvement in respiratory muscle strength in wheelchair bound paraplegics in community by using Incentive Spirometer and Peak Flow meter as a treatment tool.

Bromley I., et al also studied that loaded expiration or incentive spirometry may be useful in increasing the strength of inspiratory muscles\textsuperscript{77}.

These two devices also used as an outcome measure to assess respiratory muscle strength.

Our study included three- minute respiratory exerciser test (3-MRET)\textsuperscript{13} by using incentive spirometer (Triflo-type) to score maximum breathing capacity (MBC) and Peak Flow meter to score peak expiratory flow rate (PEFR).
Li-Cher Loh et al used 3-MRET to score breathlessness by incentive spirometer (Triflow II)\textsuperscript{13}.

Patient requires repetitive inspiratory effort to achieve as high score as possible, from the number of balls reaching the column tops of an incentive spirometer (Triflow type) to perform 3-MRET. Incentive spirometer is cheap, easily available and reusable up to at least 50 times\textsuperscript{13}. The time limit of three minutes was arbitrarily chosen based on the observation that most normal healthy subjects experienced some degree of breathlessness after this time\textsuperscript{13}. Incentive spirometer is a safe device because no subjects were reported adverse effects like fainting from 3-MRET.

Like other Lung function test like Spirometry which was used in many studies (3, 22, 24, 51), this 3-MRET depends very much on the effort put in by the subject. Thus, this test required proper supervision and adequate motivation.

Imle, et al used incentive spirometer to measure forced maximal inhalation volume without weight\textsuperscript{56}.

Dr. Sullivan C. recommended incentive spirometer (e.g. Tri-flow type) for home respiratory monitoring by patient\textsuperscript{71}.

Our study also utilized incentive spirometer (Tri-flow type) as an outcome measure to assess respiratory muscle strength by means of scoring maximum breathing capacity (MBC).

Many studies (3, 22, 24, 51, 65) used spirometry as a outcome measure to score peak expiratory flow.

Susan B, Oo' Sullivan studied in his literature that peak expiratory flow (PEF) is measured by asking the patient to achieve maximum inspiration first, then forcibly exhale all of the air the air into a measuring device\textsuperscript{37}.

Dr. Partridge M.R. demonstrated procedures that how can Peak flow meter used\textsuperscript{72}.

LeBlanc C., et al used peak flow meter to measure peak cough flow\textsuperscript{73}.

Our study utilized peak flow meter as an outcome measure to assess respiratory muscle strength by means of measuring peak expiratory flow rate (PEFR).

Rea T. D., et al used Peak inspiratory flow meter to measure inspiratory muscle strength. They also found this device is a simple and inexpensive and easily assess respiratory muscle strength even during a short office visits\textsuperscript{51}.

Peak flow meters are cheap and easily available as Folgering H., et al also indicated in his study that this device is inexpensive that can be provided for personal use, for every individual patient\textsuperscript{18}.

Weakness of respiratory muscle after spinal cord injury may lead to dyspnoea as the diaphragm is innervated at C3 to C5 and is predominantly used for resting breathing. The intercostals (innervated T1 to T12) and abdominal wall muscle group (innervated T7 to L4) provides respiratory muscle strength for maximal inspiratory and expiratory efforts\textsuperscript{65}. The rectus abdominis, internal and external obliques, and transversus abdominis muscles are innervated sequentially from the lower six thoracic nerves (T7-T12). The quadratus lumborum, on the other hand, is innervated by the 12th thoracic and first three or four lumber spinal nerves. It contracts synergistically with the diaphragm, exerting a downward force on the 12th rib and preventing any tendency for the vertebral part of the diaphragm to pull the 12th rib upward. Thus this muscle and the vertebral part of the diaphragm may operate as a single functional unit. If the quadratus lumborum is
selectively paralyzed, as in T11-L2 injuries, the diaphragm should be displaced more cephalad, resulting in a decrease in ERV and increase in IC. With denervation of the intercostal and abdominal wall muscles of respiration, the diaphragm can be recruited for maximal inspiratory and expiratory efforts.

Wein, M.F., et al found that after spinal cord injury (SCI), breathlessness during daily activities is common.

Ayas, N.T., et al indicated that little is known about the prevalence and predictor of breathlessness in individuals with neurologically complete chronic spinal cord injury.

Li-Cher Loh, et al assessed perception of dyspnoea at rest by incentive spirometer (Tri-flow II) as this test (3-MRET) was cheap and easy to perform to score maximum breathing capacity (MBC).

Our study also used incentive spirometer (Tri-flow type) to assess respiratory muscle strength which indicated decreased strength in inactive wheelchair bound paraplegics.

James W. Little studied that cough is primarily due to function of the abdominal muscles (innervated by T6-T12) and internal intercostals.

Dr. Tim Geroghty noted that following spinal cord injury above T12, the impulses traveling down the cord to stimulate abdominal muscle, is interrupted. Associated factors like weak internal intercostals which leads to decreased movement of chest wall and decreased volume of air able to flow in and out of the lungs, also effect the ability to forcefully expel sputum.

As cough is an act of forceful expiration, abdominal muscle has to contract to generate force for peak expiratory flow (forceful expiration) which indicates the strength of expiratory muscle. So this study utilized peak flow meter to measure peak expiratory flow rate (PEFR).

LeBlanc C., et al also used peak flow meter to measure peak cough flow.

Hiasma J.A., et al also found that if thoracic segment injured, muscles of expiration is affected.

The above studies showed effect of thoracic segment (T6-T12) injuries leads to impairment of efficiency of diaphragm which further leads to deficient inspiratory and expiratory effort which supported the inclusion criteria of our study (level: T6-T12).

Many studies showed that cervical spinal cord injury directly hamper the function of diaphragm muscle as this muscle is innervated by C5-C6 which leads to decrement of respiratory muscle strength. Our study included wheelchair bound traumatic paraplegics patients (T6-T12).

Many studies indicated that following spinal cord injury physiological and functional disorders had an impact on the everyday life of paraplegics often leads to a physiological deconditioning which further leads to reduction in aerobic capacity. These patients activate their respiratory muscles in daily life less than able-bodied person due to lack of whole-body physical activity may also explain the weakened respiratory system. Fitness is often poor in disabled and wheelchair propulsion does not seem to provide a sufficient stimulus for cardio-respiratory adaptation. In men whose lower limbs had been immobilized for years showed marked decrement in cardiopulmonary functions, related to the oxygen transport system. Paralysis of lower
limbs also altered autonomic control and inactivity to compromise physical capacity in paraplegia. Our study considered all these things as this study involved wheelchair bound paraplegics. This study carried out in rural area so most of the patients had hand-propelled wheelchair. They had experienced breathlessness while dressing and undressing and wheelchair propulsion. Brown R., et al also noted in their study that motorized wheel-chair users experienced dyspnoea while talking and hand-held propelled wheel-chair users experienced dyspnoea while dressing and undressing.

Various training programs like respiratory resistance or resistance endurance training, inspiratory muscle strength training (IMST), abdominal weights (AbWts) training with inspiratory muscle training, respiratory muscle training had been used to improve respiratory muscle strength, vital capacity and residual volume in spinal cord injury (SCI) patient. Our study utilized Incentive Spirometer and Peak Flow meter as an therapeutic tool to improve respiratory muscle strength and statistical analysis showed a highly significant improvement in respiratory muscles in wheelchair bound paraplegics. McMichan et al demonstrated in their study a significant reduction in mortality of quadriplegic patients with aggressive bronchial hygiene soon after injury. Their protocol consisted of incentive spirometry along with other breathing exercises. Dr. Sullivan C. recommended Incentive spirometer (e.g.: Tri-flow type) for home respiratory monitoring by patient. Little J.W., et al- studied precautions promote clearing and reduce the risk of pneumonia. They advised to offer incentive spirometry along with gravity-assisted postural drainage, intermittent positive pressure breathing.

Little J.W. advised incentive spirometer to strengthen respiratory muscles in SCI patients. Agency for Healthcare Research and Quality, Rockville also used patients that incentive spirometry along with frequent turning, suctioning [and bronchial lavage], chest percussion and assisted coughing, inhaled bronchodilator treatments, deep breathing,) and rotating beds as an aggressive multimodal respiratory therapy interventions to reduced atelectasis in C4-level SCI. Paralyzed veterans of America stated that along with various methods, Incentive spirometry is also useful for successful treatment of atelectasis or pneumonia in SCI patient requires re-expansion of the affected lung tissue and to clear the airway of secretions.

Gonon M., et al found that the home monitoring of peak expiratory flow (PEF) with a peak flow meter (PFM) is increasingly advocated as an aid to better management of diseases. Many studies found atelectasis or pneumonia is common complications following spinal cord injury and advised incentive spirometer and peak flow meter to prevent such complication post SCI and for better management of asthma. On these backgrounds our study also utilized these devices which can help patients involved in our study to prevent such complications along with respiratory muscle strength training and can be used as an aid for better management.
Our study utilized same device i.e. Incentive Spirometer and Peak Flow meter as a therapeutic as well as assessment tool which significantly improved respiratory muscle strength in wheelchair bound paraplegics in community of rural area throughout the study to avoid variation in readings.

Both the devices also utilized as an outcome measures for pre-test and post-test measurement of respiratory muscle strength.

As this study was carried out in rural community much attention was paid on patients counseling and motivation to get regular follow up as this study was carried out for 4 weeks/ individual patient. This study suggested that the further studies are necessary with larger samples of patient to get more reproducibility of result.

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**STATISTICAL ANALYSIS**

**Table I: Comparison of Max. Breathing Capacity Score (cc/min)**

pre and post test.

a: Descriptive Statistics

<table>
<thead>
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<th>Mean</th>
<th>N</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
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<td>118.28</td>
<td>30</td>
<td>12.05</td>
<td>2.20</td>
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<tr>
<td>Post Test</td>
<td>153.45</td>
<td>30</td>
<td>22.76</td>
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b: Paired Samples Test

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<th>Paired Differences</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
<th>95% Confidence Interval of the Difference</th>
<th>T</th>
<th>df</th>
<th>p-value</th>
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<td>Pre Test-Post Test</td>
<td>-35.16</td>
<td>13.01</td>
<td>2.37</td>
<td>-40.02 -30.30</td>
<td>14.79</td>
<td>29</td>
<td>0.000</td>
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</table>

HS, p<0.0001
Graph I: Comparison of Max. Breathing Capacity Score (cc/min)

pre and post test.
Table II: Comparison of Peak Expiratory Flow Rate (L/min) pre and post test.

a: Descriptive Statistics

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>N</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
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</thead>
<tbody>
<tr>
<td>Pre Test</td>
<td>185.00</td>
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<td>67.14</td>
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<td>Post Test</td>
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b: Paired Samples Test

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<th>Paired Differences</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
<th>95% Confidence Interval of the Difference</th>
<th>T</th>
<th>df</th>
<th>p-value</th>
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<tr>
<td>Pre Test-Post Test</td>
<td>-100.00</td>
<td>73.10</td>
<td>13.34</td>
<td>-127.29, -72.70</td>
<td>7.49</td>
<td>29</td>
<td>0.000 HS, p&lt;0.0001</td>
</tr>
</tbody>
</table>
Graph II: Comparison of Peak Expiratory Flow Rate (L/min) pre and post test.