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Effectiveness of Balloon Blowing Exercise on Cough Strength in Patients with Spinal Cord Injury

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ABSTRACT

Aim of study: To study the effectiveness of balloon blowing exercise on cough strength (Peak cough flow & Maximal Expiratory Pressure) in patients with spinal cord injury.
Relevance of the study: Spinal cord injury results in weakness of respiratory and abdominal musculature. Abdominals are required for forceful expiration, paralysis or weakness of these results in impaired cough strength. Balloon blowing exercise are expiratory muscle training exercise which offer resistance against expiration which will improve strength more effectively. To improve strength of respiratory muscles in SCI many studies have been done but there is less evidence on the use of balloon blowing exercise to improve cough strength or expiratory flow rate in SCI.
Methodology: The study design was Pre-test and Post-test experimental study which consist of 40 patients with spinal cord injury were selected by convenient sampling. Balloon blowing exercise was given for 4 weeks. Outcome Measure were Peak cough flow (PCF) and Maximal Expiratory Pressure (PEmax).
Result and analysis: Pre-Intervention Value of Peak cough flow (PCF) was 242±33.4 L/Min and Post Intervention PCF was 319±36.7 L/Min which shows significant improvement in PCF with p-value <0.05. Pre-Intervention Value of PE_{max} was 41±5.8CmH_2O and post Intervention Value was 48±5CmH_2O which shows significant improvement in PEmax with p-value <0.05.
Conclusion: This study concluded that balloon blowing exercise improves cough strength (Peak cough flow & maximal expiratory pressure) in spinal cord injury patients.
Implications: Balloon blowing exercises can be added as routine physiotherapy treatment as it increases the cough strength and it helps in removing excessive secretions from the lungs.

Keywords: Peak Cough Flow (PCF), Maximum Expiratory Pressure (PE_{max}), Spinal Cord Injury (SCI), Balloon Blowing Exercise (BBE)

INTRODUCTION

A Spinal Cord Injury is trauma or lesion to spinal cord that results in paralysis of the muscles and affects sensory abilities and other body functions below the level of injury [1]. According to WHO every year, around the world between 2,50,000 and 5,00,000 people suffer from spinal cord injury [2]. In India the average annual incidence of SCI is 15,000 with prevalence of 0.15 million [4]. In their 20s to early 30s and into their 70s, males are at most risk. The highest risky years for females are adolescence (15-19) and senior age (60+). Studies show that among adults, the male to female ratio is at least 2:1 and frequently much higher [11].

The classification of SCI is based upon level of motor or sensory impairment-Complete or incomplete spinal cord injury; location of injury-Cervical, thoracic, lumbar; cause of injury- Traumatic and Non traumatic.

Traumatic when external force hit the spinal cord e.g., Road traffic accidents. Non-traumatic when injury results from an illness, degeneration, inflammation [5], compression from disc prolapse, bone metastasis from cancer [3] or abnormal development of spinal cord. SCI patients may show body structure and functional impairments, motor and sensory impairments, autonomic dysreflexia, spastic hypertonia, cardiovascular impairment, impaired temperature control, pulmonary impairment including respiratory insufficiency, bladder and bowel impairment, sexual dysfunction, pain, contractures, osteoporosis, etc. [1]

The severity of the spinal cord injury and the level of motor completion determine how severe the respiratory issues are. putting the largest risk of thoracic and upper cervical injuries, 80% of people with acute spinal cord injury may experience respiratory complications. Respiratory insufficiency is one cause of mortality and morbidity after SCI. The reduction in respiratory muscle strength and fatigue, respiratory neuroplasticity [10], a reduction in lung capacity, atelectasis, increased production of secretions, ineffective coughing, impaired cough reflex and autonomic dysfunction, bronchospasm and pulmonary oedema these respiratory complications may occur due to respiratory dysfunction [3].

The primary muscle of inspiration is diaphragm. The primary muscles of expiration are abdominals and internal intercostals. Normally relaxed expiration is a passive process that occurs through elastic recoil of lungs and thorax but can be boost by the forceful contraction of muscles of abdominal wall [3]. Control of these abdominal muscles originate from T6 toT12. They support viscera and assist in maintain the position of diaphragm. They also function to push the diaphragm upwards during forced expiration. With paralysis of abdominal musculature this support is lost causing diaphragm to achieve low position, lack of abdominal pressure to move the diaphragm upward result in decreased expiratory reserve volume and cough. Individuals with weak abdominal and intercostal musculature will have impaired airway clearance ability and be at the greater risk for developing pneumonia and atelectasis [1].

Coughing is a vital defense mechanism that facilitates secretion removal and aspiration of foreign particles from the airways and secretions (during infections). In order to curtail the possibility of respiratory issues, improvement of cough is a fundamental goal of SCI rehabilitation. Forced expiratory action serves as the primary definition of coughing. Therefore, it is essential for both inspiratory muscles to obtain a sufficient pre-cough volume and expiratory muscles to produce a high thoraco-abdominal pressure in order to produce an effective cough. According to earlier study, coughing capacity could be improved by respiratory muscle strength training [9].

Earlier surgical intervention may improve neurological outcomes by decompressing the spinal cord and thereby improving perfusion. A novel approach that is currently being researched and developed is cell therapy [11].

Conservative management is done for respiratory dysfunction having injury in region below C_5, which encompass physiotherapy [3]. Physiotherapy management include secretion clearance technique include assisted coughing, percussion, vibrations, aspiration, and assisted postural drainage postural drainage. Treatment to improve ventilation includes, respiratory exercises that can be used for muscle training like deep breathing exercises, glossopharyngeal breathing, diaphragmatic breathing, thoracic expansion exercises, non-invasive positive air pressure support and high tidal volumes in patients on mechanical ventilation, abdominal binders, positioning, incentive spirometry, balloon blowing exercises, cough assisted techniques, and inspiratory muscle training [5]. Coughing and expiratory muscle function can be improved by electrical

surface stimulation directly on abdominal muscle [3].

Balloon blowing exercises are type of expiratory exercises which upgrade expiratory flow rate and endurance of respiratory muscles [6]. The aim of this therapy is to train the expiratory breathing to be longer than inspiration The balloon blowing exercises performed consist of inflation of balloon with air blow in when patient is able to breathe deeply in lungs exhale via mouth and tighten abdominal muscles. The remaining air from lungs will be squeezed out, this will increase expiratory pressure. The elastic force of rubber increased resulting in more resistance to abdominal muscles [7,8]. Balloon blowing might allow SCI patients to be more excited and enable easier performance.

MATERIALS & METHODS

The study was approved by the institutional ethical committee of Dr.A.P.J. Abdul Kalam College of Physiotherapy with Ref no. IEC/2022/215, Pravara Institute of Medical Sciences Loni. The pre and post experimental study on 40 Spinal Cord Injury patients was conducted in Smt. Sindhu Tai Vitthalrao Vikhe Patil Spinal Cord Injury Rehabilitation Centre, PIMS, Loni. Participants were selected according to inclusion and exclusion criteria. Informed consent was given to each participant. Pre-Measurements of PC and PEmax were taken by Peak Flow meter and Maximum expiratory pressure Manometer respectively. The intervention was given for 4 weeks. Data analysis and paired t-test was done by INSTAT software.

Inclusion Criteria:

1.Patients with thoracic and lumbar Spinal Cord Injury.
2. Those willing to Participate.
3. Patients with subacute and chronic stage of Spinal Cord Injury.
4. Peak Cough Flow below 300L/min.

Exclusion Criteria:

1. Patients with known case of respiratory condition.
2. Patients with high cervical cord injury.
3.Patients with Acute condition of injury.
4. Patients who require Ventilator or oxygen therapy

Intervention – Elastic balloon of approximately 10 cm was selected. Every participant was provided with separate balloon. The patient was in the sitting position. Instruction was given to participant to hold balloon in one or both hand, inhale through nose and asked to blow out into balloon as much as he can at one time. After exhalation release the air from balloon. Then again participant puts the same balloon into the mouth and asked to blow the balloon as much as he/she can.

Protocol - Balloon Blowing exercises are given 4-5 times in one set. 3 sets in one session. 2 sessions per day, for 4 weeks. After each set take 2 min break for relaxation to avoid hypotension. After 4 weeks check peak cough flow and PEmax.

RESULT

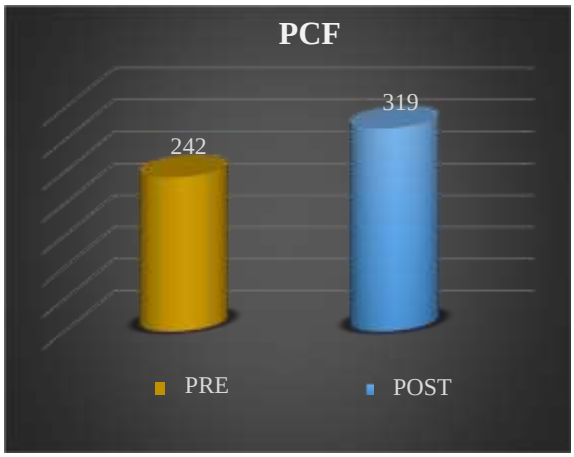
The study was conducted in Spinal cord injury patients with age mean ±SD value of 37±10.4 years. There was total 40 participants out of which 35 were males and 5 were females. Out of the total sample, the number of patients with cervical level of injury were 6, thoracic level injury was 30 and at lumbar level were 4.

Result of the current study shows that the pre and post intervention value of peak cough flow was 242±33.4 and 319±36.7 respectively having t-value 16.9 and p-value 0.0001. Mean difference of pre and post peak cough flow was 77±28.66 L/min. (Table No.1 and Graph No.1) Similarly, pre and post intervention value of PEmax was 41±5.8 and 48±5.4 respectively having t-value 13.4 and p-value 0.0001. Mean difference of pre and post intervention was 7.2±3.3CmH2O.(Table No.1 and Graph No.2). Study shows that, 4 weeks of balloon

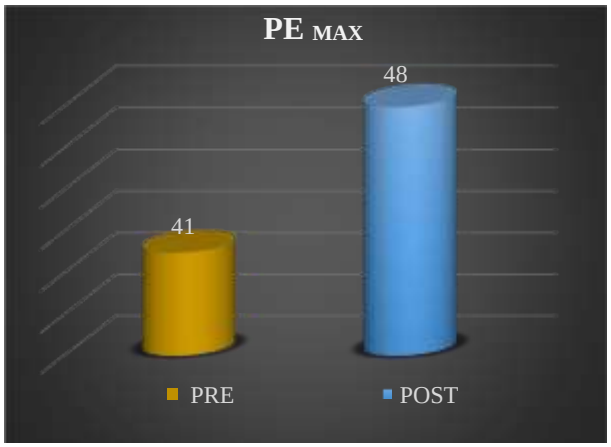
blowing exercise improved Cough Strength (Peak cough flow and Maximal Expiratory Pressure) in Spinal Cord Injury Patients.

VARIABLES	PRE (Mean±SD)	POST (Mean±SD)	t-value	p-value
PCF	242± 33.4	319±36.7	16.9	0.0001 (Extremely Significant)
PE_{MAX}	41±5.8	48±5.4	13.4	0.0001 (Extremely Significant)

Table No.1



Graph No.1
(pre and post values of PCF)



Graph No.2
(Pre and post values of PE_{max})

DISCUSSION

It is a known fact that respiratory exercises with an assist of device such as balloon are found to be effective not only in healthy young population but also in populations with cardiorespiratory disorders like COPD, asthma, COVID-19 [6,12,13]. Numerous breathing exercises have been proven to be effective in enhancing lung capacity and function in neurological conditions like SCI [3]. The present study conducted on effect of balloon blowing exercise on cough strength in 40 patients of spinal cord injury with mean age of 37±10.4.

The probable mechanism behind Improvement in post intervention cough strength is, balloon blowing Means expiration against resistance which is produced by elasticity of balloon and it is kind of expiratory muscle training. Mainly the abdominal and intercostal muscles are strengthened and these muscles are worked during forceful expiration and coughing. So, when patient is performing balloon blowing exercise it improves peak cough flow and maximal expiratory pressure of the patient [8].

The intercostal muscles that expand and elevate the diaphragm and rib cage which is moved by blowing a balloon. This allows more surface area to lungs. As soon as gust begins gaseous exchange in the alveoli and blood capillaries takes place. It could increase lung capacity and improve the lung's ability to maintain adequate oxygen supply. As a result, the airways open, enhancing the air volume expiratory process and back pressure airway. Due to increase in end expiratory volume and tidal volume, more exacerbation of carbon dioxide occur [6].

Lack of cough strength might develop due to prolonged immobility or compromised nerve supply to the abdomen and respiratory muscles. The effectiveness of manual aided coughing technique on peak cough flow in individuals with spinal cord damage was studied by Kinjal Parmar et al.[5] The average difference between the peak cough flow before and after the intervention was 56.00 L/min. It is concluded that patients with spinal cord injuries who use the manual assisted cough technique have improved peak cough flow.

The comparison of breathing strengthening exercises and balloon blowing training was done by Hyun ju Jun et al.[14] to find out its impact on the pulmonary function of elderly smokers. They got results as follows, the feedback breathing training resulted in a significant increase in the FVC, FEV1/FVC, PEF, and VC of the elderly smokers after 4 weeks and a significant decrease in the FVC, FEV1/FVC, and PEF after 6 weeks. The balloon blowing training resulted in a significant increase in the FVC, FEV1, FEV1/FVC, PEF, and VC of the elderly smokers after 4 weeks and a "Effectiveness of Balloon Blowing Exercise on Cough Strength in Patients with Spinal Cord Injury" 23 significant decrease in the FVC, FEV1/FVC, and PEF after 6 weeks. In conclusion, Both the methods had positive impact on pulmonary function and minor respiratory muscles of elderly smokers.

Karin Postma, PhD at el.[9] Conducted a study on longitudinal association between respiratory muscle strength and cough capacity in persons with spinal cord injury: an explorative analysis of data from a randomized controlled trial. 40 patients were selected on basis of inclusion and exclusion criteria. Measurements was performed four weeks after the start of intervention 9 and 17 weeks after the start of intervention and one year after discharge from inpatient rehabilitation. Peak cough flow was measured with a spirometer. Maximum inspiratory and expiratory pressures (MIP and MEP), expressed in CmH2 O, were measured at the mouth. Results showed that Both MIP and MEP were significantly positively associated with peak cough. Taking everything in count they concluded that improvement in respiratory muscle strength is associated with improvement in cough capacity in persons with recent spinal cord injury who have impaired pulmonary function.

Thus, from present study, balloon blowing exercises can improve cough strength in spinal cord injury patients.

CONCLUSION

This study concluded that balloon blowing exercise improves cough strength (PCF and PEmax) in spinal cord injury patients which aids in removing excessive secretions from the lungs. Henceforth balloon blowing can be added to routine physiotherapy intervention for spinal cord injury patients.

Declaration by Authors

Ethical Approval: Approved

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Conflict of Interest: The authors declare no conflict of interest.

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