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The Effectiveness of Variant Respiratory Muscles Training in Upper Thoracic Spinal Cord Injury Patients

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Article Details

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ABSTRACT

Background: Functional respiratory impairments & its complications are more common in upper thoracic cord injury as compared to lower spinal cord injuries. Ineffective breathing in upper thoracic cord injuries patients is the reason for increased rate of mortality & morbidity. The aim of this study is to find out the effectiveness of variant respiratory muscles training in upper thoracic spinal cord injury patients. Method: 20 upper thoracic injury patients, age 25-45years were enrolled based on connivance sampling & the inclusion criteria set for the study. To find out the effectiveness of different respiratory training various exercise regimes were intervened, which includes; a) diaphragmatic breathing b) incentive spirometry c) active breathing cycle technique with weight lifting. Upper thoracic injuries patients with cardiovascular complications, chest wall deformities, hypertensive patients & severe COPD patients were excluded from the study. Results: Based on the analysis of pre-test & post-test results of nipple level, auxiliary level & xiphisternum level variant respiratory training were found significantly effective in improving pulmonary functionality in patients with upper thoracic cord injuries patients. Conclusion; the result of the study can be concluded that, the effectiveness of combined respiratory training of different respiratory regimes, including a) diaphragmatic breathing b) incentive spirometry c) active breathing cycle technique with weight lifting were found to be more effective than the efficacy of a single respiratory training in patients with upper thoracic cord injuries patients.

INTRODUCTION

Functional respiratory impairments & its complications are more common in upper thoracic cord injury as compared to lower spinal cord injuries. Ineffective breathing in upper thoracic cord injuries patients is the reason for increased rate of mortality & morbidity. The ventilation system is based on the air exchange (O_2 & $CO2$) in the lungs through respiratory muscles, controlled by respiratory centre in the brain[1,2]. A healthy respiratory system is based on the coordination of various nerves, muscles, markers & controlling centre in the brain for the effective respiration & ventilation of the body cells & tissues. Any injury to the cortex, nerve roots, anterior motor horn cells or descending motor tracts may lead to impairments in the voluntary regulation of respiration due to the nerves impaired capacity to contact respiratory muscles below the level of lesion[3,4]. The respiratory impairments with its complications in patients with spinal cord injuries depend on the cord injury level. Mortality & morbidity in these patients increases due to chronic respiratory muscles impairments[5].

Respiratory rehabilitation is an essential component in the physical holistic rehabilitation of the post- spinal cord injuries patients[5]. Patients with spinal cord injuries recover fast with the earliest interventions of respiratory training in the ICU, acute, sub-acute stage of the lesions. Various respiratory muscles training is used across the world for the pulmonary rehabilitation of the spinal cord injuries patients, which includes; including a) diaphragmatic breathing b) incentive spirometry c) active breathing cycle technique with weight lifting. These respiratory trainings are basically based on resistive respiratory trainings, which imposes additional workload on the respiratory muscles during breathing. Incentive respiratory training is a source of instant visual feedback for the patients as well as a tool for the resistive pulmonary training[6–8].

Road traffic accidents are the leading cause of spinal cord injuries (47.7%), while fall (20.8%), sport injury (14.2%) & domestic violence (14.6%) & the remaining 14.4% are caused other-than the above causes. Spinal cord injuries vary based on the site of lesions, severity & the its associated pulmonary complications in the SCI patients[7]. The magnitude, direction & duration of the accident-induced impulse are the deciding factors in the lesion's severity of the spinal cord injuries patients[9,10]. The most common complications among SCI patients are pulmonary complications leading to complicated comorbid conditions & increased mortality. The site of lesion, types of the deficits & the duration of injury are the deciding factors for the pulmonary compromise of among SCI patients[9]. It has been reported that approximately 50-67% lower-SCI patients are having chronic pulmonary complications which leads to increased economic burden & mortality. The incidence rate of pulmonary complications in thoracic spinal cord injury patients is 70% & in the cervical spinal lesion pulmonary complications accounts for 16%. 37% patients with thoracic injuries or cervical injuries are found to be with atelectasis[11,12].

For the pulmonary rehabilitation of SCI patients various pulmonary respiratory training are utilized in the SCI patients, which includes; a) diaphragmatic breathing b) incentive spirometry c) active breathing cycle technique with weight lifting. The effectiveness of combined respiratory therapy in thoracic lesions patients has not been studied effectively. The aim of this study is to find out the effectiveness of variant respiratory muscles training in upper thoracic spinal cord injury patients.

METHODOLOGY

20 upper thoracic injury patients, age 25-45years (n=20, Male=13, Female=7) were enrolled for the pre- & post test experimental designs based on purposive sampling & the inclusion criteria set for the study. To find out the effectiveness of different respiratory training various exercise regimes were intervened, which includes; a) diaphragmatic breathing b) incentive spirometry c) active breathing cycle technique with weight lifting. Upper thoracic injuries

patients with cardiovascular complications, chest wall deformities, hypertensive patients & severe COPD patients were excluded from the study.

The inclusion criteria for the study were; a) upper thoracic spinal cord complete injuries patients (level T1-T4) with no motor or sensory functions preservation in the sacral segments S_4 to S_5. B) Upper thoracic injuries patients with no cardiovascular complications & chest deformities. The exclusion criteria are a) upper thoracic injury patients with COPD or pulmonary complications b) upper thoracic injury patients with chest deformities c) upper thoracic injury patients with cardiovascular abnormalities & hypertensions. The variant respiratory regimes used in the study to find out the effectiveness of combined respiratory training in the patients with upper thoracic injury includes; a) diaphragmatic breathing exercise b) incentive spirometry c) active cycle of breathing d) Inspiratory muscle training.

The procedure adopted for the interventions of diaphragmatic breathing exercise (DBE) were as follow; the patient in comfortable & relaxed position, the hand of the therapists is placed on the abdomen below the sternum & the patient is asked to take breath through nose slowly & deeply & hold the breath for 3-5s, followed out by the breath out through the mouth. The patient is instructed to place his/her hand on the upper abdomen below the sternum & asked to feel the movement of breathing in synchronized fashion. DBE were given 10 repetition/session/patient, 3 session/day, and 5 days/week for 5 weak.

The procedure of the active cycle of breathing (ACBT) was as follow; ACBT involves 3-phases repeated in cycles, which are a) controlled breathing b) thoracic expansion exercise c) forced expiratory technique (FET), breathing control, diaphragmatic breathing at normal tidal volume, 4-5 thoracic expansion exercise, breathing control, deep inhalation with relaxed exhalation at the vital capacity, with FET as ; a) 1-2 huffs at mid to low lung volume b) abdominal muscles contractions for the production of forced exhalation. 5-10s of rest was allowed in between the training to avoid respiratory muscle fatigue.

The procedure adopted for the incentive spirometry were as follow; patient is relaxed & comfortable sitting position & the patient is asked to take 3-5 breaths slowly, patient was asked to exhale maximally at the 5-6 breaths. Then incentive spirometry device is placed in the mouth & the patient is asked to maximally inhale through the spirometry device & hold it for few seconds. Spirometry was given 10 repetition/session/patient, 3 session/day, and 5 days/week for 5 weak.

Expiration is passive process; the patient is instructed to place his/her hands at the abdomen & the feel the synchronized movement of the belly with the respiration. FET is a technique, which is consisting of huffing (a huff is defined as; a rapid forced exhalation but not with maximally effort produced by the patients) interspersed with breathing control. In the effective huffing the patient is asked to keep the mouth open & the patient is asked to exhale forcefully by using the muscles of the abdomen. The patient was allowed to have a rest of 2-3s in between 2 consecutive huffing. Huffing was given 10 repetition/session/patient, 3 session/day, and 5 days/week for 5 weak.

The treatment of the Inspiratory muscles training was as follow; a) position of the patient supine a small sandbag is placed over the patient's abdomen & the patient is instructed to expire through mouth & inspire through nose & the patient is needed to raise the weight (sandbag) during respiration. The weight of the sandbag is increased gradually with the capacity of the patient to hold diaphragmatic breathing without the use of the accessory respiratory muscles for 15 minutes. B) The Delorme & Watikins procedure of resistive training were adopted, which are as follow; 1) 10 lifts with 0.5 10RM 2) 10 lifts with 3/410RM 3) 10

lifts with 10RM 4) 30 lifts / 4times/week 4) progression is made slowly & gradually at the rate of 10 RM/week & 2 sessions/day.

The measurement tools used for this study were; a) Inch tape chest expansion; measurement level was; 1) auxiliary 2) nipple 3) xiphisternum b) Incentive spirometry c) peak flow meter; pre-test & post-test data were collected & analysed using Paired-t-test for the study variables.

RESULTS

On the analysis of pre-test & post-test results of nipple level, auxiliary level & xiphisternum level variant respiratory training were found significantly effective in improving pulmonary functionality in patients with upper thoracic cord injuries patients. The values at the Auxiliary level were 7.57, Nipple level 9.6 & Xiphisternum level 12.34 at the t-paired test. (Table-1) & Pre-test & post-test measurement of Peak flow meter & incentive spirometry are given in Table-2.

TABLE-1: CHEST EXPANSION AT NIPPLE, AUXILIARY & XIPHISTERNUM LEVEL

Measurement level	Auxiliary level		Nipple level		Xiphisternum level	
Means	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
	1.4	2.45	1.7	2.68	2.66	3.54
t-test	7.57		9.6		12.34	
P-value	>0.04		>0.03		>0.03	

TABLE-2: PRE-TEST & POST-TEST MEASUREMENT OF PEAK FLOW METER & INCENTIVE SPIROMETRY

Measurement level	Incentive spirometry		Peak flow meter	
Means	Pre-test	Post-test	Pre-test	Post-test
	1.48	4.85	250.45	454.34
t-test	8.87		17.6	
P-value	>0.05		>0.05	

DISCUSSION

Theoretically respiratory muscles must overcome inertial load & resistive load in order to sustain vital pulmonary functions. The respiratory muscles contraction is mandatory for the healthy maintenance of body tissues & cells. Failure of the respiratory muscles to overcome the combined loads yields in the respiratory failure. In the Post-SCI patient's atelectasis, pneumonia & COPD are some of the pulmonary complications leading to increase mortalities & co morbidities[13–16]. In order to decrease the mortalities & co morbidities in patients with upper spinal cord injury, combination therapy approach for the pulmonary rehabilitation of these patients were utilized in this study. Pre-test & post-test comparison of data shows that there is increase in the chest expansion at the nipple, sternum & auxiliary levels, which is in line with a study[14]. The increase in chest may be explained by continues breathing exercise leading to improved coughing mechanism & ventilation[14]. These respiratory training were found to increase endurance, strength & coordination of the muscles of respiration (primary & secondary) along with the increase mobility & spinal & chest level[14,15,16]. These pulmonary exercise collectively improves functional pulmonary capacity, relaxation & overall general health of these patients[14,15,16]. Incentive spirometry provides visual feedback as well as resistive

respiratory training for the muscles of respiration in these patients leading to improved pulmonary functionality[15,16]. Similarly, ACBT improves O_2 saturation level, improves dyspnoea symptoms & improved patient's pulmonary endurance[15,16]. ACBT is also effective in the mobilization of sputum in the patient/s lungs as well as in the postural drainage[16]. Inspiratory muscle training improves patient's functional pulmonary capacity, O_2 saturation & overall health of the patients in the post-SCI patients. The combined effects of these pulmonary rehabilitation are vital in the pulmonary rehabilitation of the SCI patients. This study recommends that, these techniques should be used extensively in these patients in order to decrease pulmonary complications, mortalities & other co morbidities in these patients[15,16].

LIMITATIONS

a) Small & homogenous sample size b) Targeted population needs to be followed up for comparatively longer period of time. c) Due to purpose sampling the initial baseline score among the study's participants were identical.

CONCLUSION

The result of the study can be concluded that, the effectiveness of combined respiratory training of different respiratory regimes, including a) diaphragmatic breathing b) incentive spirometry c) active breathing cycle technique with weight lifting were found to be more effective than the efficacy of a single respiratory training in patients with upper thoracic cord injuries patients

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REFERENCES

1. Improvement in Pulmonary Function with Short-term Rehabilitation Treatment in Spinal Cord Injury Patients - PubMed. Accessed September 1, 2022. https://pubmed.ncbi.nlm.nih.gov/31745108/
2. Kim SH, Shin YB, Yoon JA, Lee JS, Lee BJ, Park HE. Revisiting respiratory muscle strength and pulmonary function in spinal cord injury: The effect of body positions. *Neuroendocrinol Lett.* 2018;39(3):189-195.
3. Devivo MJ. Epidemiology of traumatic spinal cord injury: Trends and future implications. *Spinal Cord.* 2012;50(5):365-372. doi:10.1038/SC.2011.178
4. Cardozo CP. Respiratory complications of spinal cord injury. *J Spinal Cord Med.* 2007;30(4):307-308. doi:10.1080/10790268.2007.11753945
5. Getsy PM, Coffee GA, Hsieh YH, Lewis SJ. Loss of Cervical Sympathetic Chain Input to the Superior Cervical Ganglia Affects the Ventilatory Responses to Hypoxic Challenge in Freely-Moving C57BL6 Mice. *Front Physiol.* 2021;12:619688. doi:10.3389/fphys.2021.619688
6. Wang HC, Lin YT, Huang CC, Lin MC, Liaw MY, Lu CH. Effects of Respiratory Muscle Training on Baroreflex Sensitivity, Respiratory Function, and Serum Oxidative Stress in Acute Cervical Spinal Cord Injury. *J Pers Med.* 2021;11(5). doi:10.3390/jpm11050377
7. Randelman M, Zholudeva L V, Vinit S, Lane MA. Respiratory Training and Plasticity After Cervical Spinal Cord Injury. *Front Cell Neurosci.* 2021;15:700821. doi:10.3389/fncel.2021.700821
8. Toor H, Kashyap S, Yau A, et al. Efficacy of Incentive Spirometer in Increasing Maximum Inspiratory Volume in an Out-Patient Setting. *Cureus.* 2021;13(10):e18483.

doi:10.7759/cureus.18483
9. Kang D, Park J, Eun SD. A preliminary study on the feasibility of community game-based respiratory muscle training for individuals with high cervical spinal cord injury levels: a novel approach. *BMC Sport Sci Med Rehabil.* 2022;14(1):137. doi:10.1186/s13102-022-00534-x
10. Berlowitz D, Tamplin J. Respiratory muscle training for cervical spinal cord injury. *Cochrane Database Syst Rev.* 2013;2013(7). doi:10.1002/14651858.CD008507.pub2
11. Wang X, Zhang N, Xu Y. Effects of Respiratory Muscle Training on Pulmonary Function in Individuals with Spinal Cord Injury: An Updated Meta-analysis. *Biomed Res Int.* 2020;2020. doi:10.1155/2020/7530498
12. Xi J, Jiang H, Wang J, et al. Respiratory muscle endurance training with normocapnic hyperpnoea for patients with chronic spinal cord injury: A pilot short-term randomized controlled trial. *J Rehabil Med.* 2019;51(8):616-620. doi:10.2340/16501977-2572
13. Gee CM, Williams AM, Sheel AW, Eves ND, West CR. Respiratory muscle training in athletes with cervical spinal cord injury: effects on cardiopulmonary function and exercise capacity. *J Physiol.* 2019;597(14):3673-3685. doi:10.1113/JP277943
14. Shin JC, Han EY, Cho KH, Im SH. Improvement in Pulmonary Function with Short-term Rehabilitation Treatment in Spinal Cord Injury Patients. *Sci Rep.* 2019;9(1). doi:10.1038/S41598-019-52526-6
15. The effectiveness of variant respiratory muscles... - Google Scholar. Accessed September 1, 2022. https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&as_ylo=2022&q=The+effectiveness+of+variant+respiratory+muscles+training+in+upper+thoracic+spinal+cord+injury+patients&btnG=
16. Kralj A, Bajd T. *Functional Electrical Stimulation: Standing and Walking after Spinal Cord Injury: Standing and Walking After Spinal Cord Injury.*; 2022. Accessed September 1, 2022. https://www.taylorfrancis.com/books/mono/10.1201/9780203755402/functional-electrical-stimulation-standing-walking-spinal-cord-injury-tadej-bajd-alojz-kralj