Faculty of Medicine

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EFFECTIVENESS OF SPIROMETRY EXERCISE ALONG WITH ACTIVE CYCLE OF BREATHING TECHNIQUE TO IMPROVE LUNG VOLUME OF TETRAPLEGIC SPINAL CORD INJURY PATIENTS

Farjana Akter Bristi

Bachelor of Science in Physiotherapy (B.Sc. in PT)

DU Roll no: 123

Registration no: 1753

BHPI, CRP, Savar, Dhaka-1343

Bangladesh Health Professions Institute (BHPI)

Department of Physiotherapy

CRP, Savar, Dhaka-1343.

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We are undersigned certify that we have carefully read and recommended to Faculty of Medicine, University of Dhaka, for the acceptance of this dissertation entitled.

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Submitted by **Farjana Akter Bristi** for partial fulfillment of the requirements for the degree Bachelor of science in physiotherapy.(B.Sc in PT)

……..
Mst. Fatema Akter
Senior Lecture of Physiotherapy
BHPI, CRP, Savar, Dhaka.

……
Mohammad Anwar Hossain
Associate Professor of Physiotherapy, BHPI
Senior consultant & Head, Department of Physiotherapy
CRP, Savar, Dhaka.

……
Ehsanur Rahman
Assistant Professor of Physiotherapy
BHPI, CRP, Savar, Dhaka.

……
Md. Shofiqul Islam
Assistant Professor of Physiotherapy
BHPI, CRP, Savar, Dhaka.

……
Professor Md. Obaidul Haque
Head of the Department of Physiotherapy
Vice Principal
BHPI, CRP, Savar, Dhaka.

Declaration

I declare that the work presented here is my own. All sources used in the study have been cited appropriately. Any mistakes or inaccuracies are my own. I also declare that for any publication, presentation or dissemination of information of the study. I would be bound to take written consent from the Department of Physiotherapy, Bangladesh Health Professions Institute (BHPI).

Signature **Date**

Farjana Akter Bristi

Bachelor of Science in Physiotherapy(B.Sc in PT)

Roll no:123

Registration no:1753

BHPI, CRP, Savar, Dhaka.

Contents

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Acronyms

&	And
BHPI	Bangladesh Health Professions Institute
CRP	Centre for the Rehabilitation of the Paralysed
SCI	Spinal Cord Injury
TSCI	Traumatic Spinal Cord Injury
NTSCI	Non- Traumatic Spinal Cord Injury
RCT	Randomized Control Trail
IV	Inspiratory Volume
ACBT	Active Cycle of Breathing Technique
P	Probability
WHO	World Health Organization

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Abstract

Purpose: The purpose of the study was to explore the effectiveness of spirometry exercise along with active cycle of breathing technique to improve the lung volume (Inspiratory volume) of tetraplegic SCI patients attended at CRP. ***Objectives****:* To measure the lung volume before and after intervention and to compare the differences of lung volume before and after study of both groups. ***Methodology****:* The study was double-blinded Randomized Control Trail. At the beginning of the study, 16 complete tetraplegic SCI patients were selected from SCI unit of CRP (Savar). Among them 14 were randomly assigned for the study. Then again, 7 patients were randomly assigned to experimental group (use spirometry exercise along with active cycle of breathing technique and rest of the 7 patients to the control group (use only spirometry exercise) for this RCTs study. During the study, the participants practice active cycle breathing technique 4-5 repetitions and spirometry exercise 5 repetitions at a time with 30 sec interval for experimental group. Parametric independent"t" test was used to compare the results between two groups and paired "t" test was used within the group. ***Results:*** In experimental group there was a significant improvement in the lung volume. The mean improvement of lung volume in experimental group was 1085 ml and control group was 914 ml. Independent "t" test of lung volume scores between two groups showed value of 2.110 and p value is 0.5 ($p<0.05$), which indicates that the mean difference between two groups were not significant**.** ***Conclusion:*** This experimental study shows that spirometry exercise along with active cycle of breathing technique is no more effective than spirometry exercise alone for the improvement of lung volume in tetraplegic SCI patients between the two groups but it is effective within the experimental group.

Key words: SCI, Tetraplegia, ACBT, Incentive Spirometer, Spirometry exercise, Lung volume.

CHAPTER – I: INTRODUCTION

1.1 Background

Spinal cord injury is one of the demolishing and disastrous condition that affect young and healthy individuals around the world. It not only affect patients physical condition but also affect different aspects of their lives including their goals, communications and their quality of life. It is also known as a disability oriented injury and it is the chief causes of disability in Asia including Bangladesh (Islam et al., 2011).

Spinal cord injury is a serious medical condition and it causes various disorder such as functional, psychological and socioeconomic. It is also an urgent clinical condition which causes lifelong disability. Following SCI there are some secondary complications occur especially the long term complications increase morbidity and decrease community participation. Also decreases the health related quality of life of the person. So it is necessary to be aware about complications of SCI and know how to manage these complications for the recovery process (Sezer et al., 2015).

According to World Health Organization (WHO), 10% of total populations are disabled in Bangladesh and most of those are physically disabled. These disabled people are very often deprived of social opportunities and their right in our country. Spinal cord injury is one of the major public health problem. Day by day the incidence of spinal cord injury is increasing and the annual rate is 15-40 cases per million. It is a male predominance injury and tendency of affecting the low socio economic group (Rahman et al., 2017).

In Bangladesh the overall age group of SCI ranged from (10 – 70) years old. The majority of the patient aged between 30-39 years. Spinal cord injury mainly affect the male than female. The male and female ratio is 6.6:1. (Rahman el al., 2017). Another study have shown that 54% of all spinal cord injury occurs between the age of 16 – 30 years and 75% of injury occurs below the age of 45 years old (Kiran et al., 2017).

According to the level of injury spinal cord injury divided into tetraplegia and paraplegia. Tetraplegia is partial or complete paralysis that involve all four limbs and affect the respiratory muscles because of damage to the cervical spinal cord (Bromley, 2012). In SCI the most evident consequence is paralysis. However, SCI also has widespread consequences for many body functions, including bladder, bowel, respiratory, cardiovascular and sexual dysfunction (Harvey, 2016).

SCI is characterized by profound respiratory compromise secondary to the level of lass of motor, sensory and autonomic control associated with the injury. In SCI respiratory impairment is more severe in high cervical injury and is characterized by low lung volumes and a weak cough secondary to respiratory muscle weakness. (Berlowitz et al., 2016).

Respiratory dysfunction is one of the major cause of morbidity and mortality in spinal cord injury (Fauzi et al., 2017). These dysfunction occurs due to reduction of inspiratory and expiratory volume. When the patients will not be able to perform adequate inspiration that result in decreased ventilation of the lungs and creates so many complications. For this reason tetraplegic patients require a comprehensive pulmonary rehabilitation to improve respiratory capacity (Joshi & Mathur, 2012).

Following SCI at the cervical region, paralysis or weakness occurs in the respiratory muscles with a reduction of vital capacity and lung and chest wall compliance. As a result it causes breathing difficulties as well as an excessive effort during breathing, patients will have an ineffective cough mechanism, that causes difficulty in the mobilization of bronchial secretions (Fauzi et al., 2017).

Still now respiratory complications are the main causes of hospitalization, re-hospitalization and death of individuals with spinal cord injury. It represent that more than 20% of the cause of deaths occur especially within the first six months following the injury (Macedo et al., 2017). As respiratory complication is life threatening for SCI so, respiratory care should started earlier as soon as possible. These include practice proper positioning, active cycle of breathing technique, coughing, suctioning,

spirometry exercises etc that will act as a preventative measure to arise respiratory complications. Chest physiotherapy plays a vital role in preventing the complication by improving the strength and endurance of respiratory system (Kiran et al., 2017).

Breathing exercise helps to maintain lung expansion and clear the secretion from airway(Berlowitz et al., 2016). Strengthening of respiratory muscle helps the tetraplegic patient to increase their respiratory capacity up to optimum level. Active cycle of breathing technique and the use of spirometer helps to decrease the ventilation perfusion mismatching, decrease atelectasis and increase vital capacity. Diaphragmatic strengthening exercise improves the strength and endurance of diaphragm that helps to reduce the work of breathing and ultimately improves the vital capacity (Baydur & Sassoon, 2018). Active cycle of breathing technique helps to mobilize the secretion and improves the ventilation of the lung. Maintain proper lung volume improves the ventilation of tetraplegic patient and helps to prevent the risk of respiratory complication.

So, all patients with high level of SCI or acute tetraplegia need prophylactic chest physiotherapy as soon as possible. Specialized pulmonary care and therapy can help the patients with tetraplegia to maintain a stable respiratory status and allow them active participation in active rehabilitation (Fauzi et al., 2017). We know active cycle of breathing technique and spirometry exercise both are important for better respiratory function, but about spirometry exercise along with active cycle of breathing technique there is no sufficient research. Therefore, this research will help the researcher to find out the effectiveness of spirometry exercise along with active cycle of breathing technique to improve lung volume of tetraplegic SCI patients.

1.2 Rationale

Spinal cord injury is a demolishing condition in Bangladesh, which not only cause physical disability and respiratory complication but also it can emotionally depress the patient. According to the level of injury spinal cord injury divided into tetraplegia or paraplegia. Respiratory complication is more common in tetraplegic patients.

Respiratory dysfunction remains a major cause of morbidity and death for the patient with SCI especially high level of tetraplegics due to reduction of lung compliance, insufficient diaphragmatic function and paralysis of rib case musculature. So, the prevention of respiratory complication is very much important for SCI patients. Lung volume and vital capacity indicates the ability to take a breath deeply, cough effectively for an injured person. The tetraplegic patient faces significant respiratory dysfunction if they do not obtain the proper lung function.

So, physiotherapist should provide special care to maintain good respiratory function of the tetraplegic patient as a part of rehabilitation programmed. There are no ICU unit in the institute of Centre for the rehabilitation of the paralyzed (CRP). Here more emphasize is given on the chest physiotherapy for the patient with SCI. In this case ACBT and spirometry exercise play an important role for keeping the patient relax. We know that active cycle of breathing technique helps to improve lung volume and capacity. It is important to remove sputum from lung that help to breathe more easily and prevent chest infections. ACBT also helps to improve cardiopulmonary status and respiratory function. Spirometry exercise also improves respiratory parameters, strengthen primary & accessory respiratory muscle and ultimately improve lung volume & capacities. So the researcher aims to find out the effectiveness of spirometry exercise along with active cycle of breathing technique for tetraplegic spinal cord injury patients for the improvement of lung volume (inspiratory volume).

1.3 Hypothesis

Spirometry exercise along with active cycle of breathing technique is better than only spirometry exercise for the improvement of lung volume of tetraplegic SCI patients.

1.4 Null hypothesis

Spirometry exercise along with active cycle of breathing technique is no more effective than only spirometry exercise for the improvement of lung volume of tetraplegic SCI patients.

1.5 Aims

- To find out the effectiveness of spirometry exercise along with active cycle of breathing technique to improve lung volume of tetraplegic SCI patients

1.6 Objectives

1.6.1 General objective

- To evaluate the effectiveness of spirometry exercise along with active cycle of breathing technique to improve lung volume of tetraplegic SCI patients.

1.6.2 Specific objectives

- To measure the lung volume before and after treatment intervention.
- To compare the difference of lung volume before and after treatment intervention of both group.

1.7 List of variables

1.7.1 Independent variable

- Active cycle of breathing technique

- Spirometry exercise

1.7.2 Dependent variable

- Lung volume

1.8 Operational definition

The main key points of the research are the Spinal cord, SCI, Tetraplegia, Active cycle of breathing technique, Incentive Spirometer, Spirometry exercise, Lung volume.

Spinal cord

Cylindrical bundle of nerve fibers and associated tissue which is enclosed in the spine. It extends from medulla oblongata just above the foramina magnum to the level of the L1 or L2 vertebrae.

Spinal cord injury

Spinal cord injury may be defined as the damage to the spinal cord due to injury to the vertebral column or through a disease process resulting in either partial or total paralysis.

Tetraplegia

Tetraplegia may be defined as the paralysis of both legs and arms. It is also called quadriplegia.

Active cycle of breathing technique

It is an active breathing technique performed by the patient and can be used to mobilize and clear excess pulmonary secretions and to generally improve lung function. It includes breathing control, deep breathing, thoracic expansion exercise and huffing.

Incentive Spirometer

It is a medical device, which provides feedback as parent breaths so that the patient can set and achieve goals for lung function. Incentive spirometer includes a breathing tube and mouthpiece attached ta a gauge.

Spirometry exercise

The exercise that are performed by using incentive spirometer is known as Spirometry exercise. The patient breathe deeply into the mouthpiece of the spirometer, hold the breath for at least 3 seconds and then exhales, thus exercise is done.

Lung volume

The amount of air the lungs are of occupying is termed as lung volume. These volumes can vary depending on the depth of respiration, ethnicity, gender, age and in certain respiratory diseases. A normal human being can retain 6 liters of air in his lungs at any one time.

Inspiratory volume

The total amount of air that a person inspired during respiration.

CHAPTER – II: LITERATURE REVIEW

Spinal cord injury is a less occurrence injury but it causes high cost disability that affect young and healthy individuals. It causes remarkable changes in an individuals lifestyle. Now a days it is also a major public health problem in Bangladesh. There are many physiological and functional disorders can appear due to spinal cord lesions. These disorders influence the daily life of patients with spinal cord injury and gradually complicated the life. Patients working ability is limited day by day which have an impact on the health of that person and ultimately causes physiological deconditioning (Bele & Golhar, 2013).

According to National Spinal Cord Injury Strategy Board, Spinal cord injury (SCI) is a complex impairment due to traumatic insult, vascular disruption or a disease process resulting loss or reduction in voluntary motor function, sensory deprivation and disruption of autonomic function related to the level and severity of the cord damage (East, 2009).

The degree of respiratory impairment in patients with SCI depends on the level of injury. Patients with neurological complete lesions at C1 and C2 cannot breathe on their own. Individuals with complete C3 and C4 tetraplegia have impaired ventilation due to diaphragmatic paralysis and are typically ventilator dependent in the acute stage. Though a significant proportion of individuals with C4 tetraplegia are ultimately able to successfully wean off the ventilator. Low cervical cord lesions (C5-C8), will impair function of the intercostal, parasternal and scalenus. As the phrenic nerve origins are from C3 to C5, the diaphragmatic force generation will remain intact in lower cervical injuries even as other chest wall muscles lose function (Baydur & Sassoon, 2018).

With paralysis of the major respiratory muscles, individuals with tetraplegia can use the sternocleidomastoid and other accessory neck muscles to sustain brief periods of spontaneous breathing. During the acute period, forced vital capacity (FVC) in

tetraplegia is markedly reduced as a result of diaphragmatic weakness. Linn et al. (2010) reported that in patients with complete motor lesions, FVC ranged from near 100% of normal predicted values in the group with low paraplegia, to less than 50% in those with high tetraplegia. Incomplete lesions prevented FVC loss in tetraplegia (Baydur & Sassoon, 2018).

SCI can occur different level of the spine such as cervical, thoracic and lumbar spine. It has been shown that cervical spine affected 36.2%, Thoracic spine 34.3% and lumbar spine 29.5% (Bele & Golhar, 2013). For traumatic cases the most problem occurs at the C5 and T12-L1 level. For non traumatic cases the most problem occurs at C5 and between T7-L4 level. The Pott's disease, which is one of the causes of non traumatic SCI, is commonly occurring between the T7-T12 levels (Bromley, 2012).

According to the report from the National Spinal Cord Injury Database, about 56% of all SCI occur in the cervical spine. The regions of the spinal column which are flexible and more susceptible to injury associated with the severe neurological and respiratory impairments (Rowland et al., 2011).

To know the actual level of injury is important because the higher and more complete motor level of injury has the greater chance of impairment of respiratory muscle. Respiratory impairment gradually causes respiratory dysfunction which is prone to respiratory complication (Brown et al., 2009).

The frequency of respiratory complication is associated with injury level and severity of injury, age of the patient, pre existing condition and other associated injury. High level of injury (C1-C4) can cause pneumonia and low level of injury more likely to develop atelectasis (Berney et al., 2011).

Spinal cord injuries are classified into two types- Traumatic spinal cord injury (TSCI) and Non traumatic spinal cord injury (NTSCI). When spinal cord injury occurs due to any kind of pathological cause or any other cause without trauma then it is known as NT-SCI. Alternative name of NT-SCI is spinal cord damage or spinal cord

myelopathy. It can happen at anyone at any age. It has been found that the incidence of NT-SCI is larger than TSCI. The number of people with NTSCI is increasing day by day with population aging (New & Marshall, 2014).

Another study have shown that there are few public with NTSCI compared with traumatic spinal cord injury (TSCI). But it is assumed that in coming decades the incidence of NTSCI will increase with the aging of global population (New et al., 2014).

When the spinal cord injury occurs due to direct or indirect trauma then it is called TSCI. Patient with TSCI can suffer from spasticity, loss of sensation, exaggerated reflex, bowl-bladder problem etc. Sign symptoms of TSCI vary depending upon the level on which the lesion occurs (New & Marshall, 2014).

According to the severity of injury SCI are divided into complete injury and incomplete injury. In complete spinal cord injury, complete transaction of spinal cord occur that result in complete denervation below the level of the injury. In incomplete injury, partial transaction of the spinal cord occur resulting partial denervation below the level of the injury. According to the anatomical level of spine injuries sometimes can be classified as cervical, thoracic and lumbar cord injury (Hua et al., 2013).

In patients with tetraplegia the injury occur one of the 8 cervical segment of spinal cord and in patients with paraplegia the injury occurs in thoracic, lumbar or sacral region of spinal cord (Brown et al., 2009).

The incidence of tetraplegia is 51.9% and paraplegia is 46.27%. When injury occurs in cervical region then it is called tetraplegia and when injury occurs in thoracic or lumbar region then it is called paraplegia. The most common injury level for paraplegia is Thoracic 12 region. The ratio of paraplegia and tetraplegia was found 2:1 (Bele & Golhar, 2013).

Knowledge about the epidemiology of SCI is very much important because it can

provide the way of appropriate preventive measure which helps to reduce the incidence of SCI (Ning et al., 2011). In Bangladesh for spinal cord injury the maximum age range from 10-70 years due to poor socio- economic condition. Among the traumatic SCI 51.99% are paraplegia, 42.65% are tetraplegia and among non-traumatic SCI 4.12% are paraplegia and 1.14% are tetraplegia (Rahman et al., 2017).

In Japan the average age is between 40-70 years and the peak age is 59 years. Among the traumatic SCI 60% are paraplegia, 40% are tetraplegia and among the non-traumatic SCI 84% are paraplegia and 16% are tetraplegia. The male and female ratio is (7.5:1). The ratio is very high in Japan and Jordan. In United states the second most expensive condition is acute SCI (Winslow & Rozovsky, 2013). The average range of SCI incidence in the United states is between 29.4 cases per million to 50 cases per million. The peak ages between 16 and 25 years. Male incidence rate is higher than female and the average ratio is 2.4:1 (Lasfargues et al., 2010).

Historically, spinal cord injury is associated with high incidence and prevalence rates. In the United states there are approximately 17,000 new cases of spinal cord injury occur each year, affecting more than 282,000 people in the country. More than half of spinal cord-injured individuals experience an injury at the cervical level (Baydur & Sassoon, 2018).

The racial distribution is also seen in SCI. Since 2000, 62.9% of spinal cord injured were white and 22% were African American (Brown et al., 2009).

The global prevalence of traumatic spinal cord injury (TSCI) is about (236-1009 per million). The prevalence of TSCI in North America is (39 per million), in Australia is (16 per million) and in Western Europe is (15 per million), in Asia, South East and the Kashmir region in India is about (236-464 per million), in Canada approximately 1173 per million (Cripps et al., 2010).

Another study have shown that the incidence of acute traumatic SCI in worldwide is about 15-40 cases per million which is associated with remarkable physical, mental,

social and economic burdens on patients and their family life. The incidence of TSCI is 12.1 per million in the Netherland, 57.8 per million in Portugal and the incidence of NT-SCI is about 26.3 per million in Australia. Recent studies have found that length of stay in hospital for NT-SCI is shorter than TSCI patients (Kennedy & Chessell, 2013).

Spinal cord injury can occur as a result of traumatic or non- traumatic cause. Trauma is the most common and frequent cause for occurring SCI. Traumatic spinal cord injury may be defined as acute traumatic lesion of neural element of spinal canal (spinal cord and cauda equine) that result in temporary or permanent loss of sensation or motor function with or without bowel-bladder dysfunction (Ning et al., 2011).

The most common traumatic events which are responsible for SCI are motor vehicle accidents, fall from height followed by falling during carrying a heavy load on the head (very common in Bangladesh) or gunshot wound. In Bangladesh the causes of spinal cord injury are fall from height (45.4%), fall of object (17.8%), road traffic accident (25.9%), bull attack (1.8%), other traumatic cause (3.8%) and non-traumatic causes are 5.2%. (Rahman et al., 2017).

Transportation accident (52.2%), tamping (8.6%), stumbling (8%), stabbing (3%), crushing (1.8%) are also the common cause of TSCI (Hua et al., 2013). Kiran et al. (2017) also showed that motor vehicle accidents are the most common cause (47.7%) of spinal cord injury. Falls or falling objects (20.8%), sports (14.2%), acts of violence (14.6%). Remaining 14.6% of spinal cord injuries comes from variety of causes (Kiran et al., 2017).

Among the traumatic SCIs, motor vehicle accidents are the most frequent and first cause of injury, falling from height is the second and thirdly the violence in South Africa (Draulans et al., 2011). In Australia, Western Europe and North America, SCI most commonly occurs secondary to motor vehicle accidents, whereas falls from trees and rooftops are the most frequent cause in South-East Asia and Oceania. Worldwide, the average people with traumatic SCI is most likely to be male, in the age of 30s,

with a 70% chance of being paraplegic and 50% of having a motor and sensory complete lesion (Berlowitz et al., 2016).

With the increasing in general population age, the average age of injury is also increasing. The incidence of traumatic SCI varies from 8 to 246 cases per million residents per year with a global prevalence from 236 to 1298 per million. A SCI may also be secondary to non-traumatic reasons such as vascular abnormalities, tumors or infection (Berlowitz et al., 2016).

According to Kennedy & Chessell (2013), traumatic spinal cord injury can occur due to motor vehicle accident (17.8%), fall from height (19.6%), recreational sports injuries (10.7%), acts of violence (17.8%) and due to other causes (Stab injury, bull attack) (6.3%). Non traumatic spinal cord lesion can occur due to Pott's disease (28%), tumors (21%), Transverse myelitis (10%), Prolapsed inter-vertebral disc, Guillain Barre syndrome (6%), cervical spondylosis (1%) and due to unknown cause (25%). A study in Ethiopia have shown that tuberculous spondylitis is the main cause of non traumatic SCI (27%), Human immunodeficiency virus (HIV) associated myelopathy (17%), metastatic cord compression (15%), tropical sastic paraperesis (14%), cervical spondylosis (9%).

Initial medical management should start from the history of patient such as age of the patient, past history of smoking, pulmonary disease, associated injury or complication. Then physical and neurological examination should be done for proper diagnosis. The respiratory function of the patient also measured through chest x-ray, lung volume, vital capacity and flat plate of the abdomen. The initial respiratory management should start with a facemask for IPPB 4 times per day with bronchodilators and mucolytes. Extra O2 is added to the face mask to reduce hypoxia. IPPB is done followed by suctioning, chest clapping and assisted coughing. Also instruct the patient to practice spirometry exercise 2 or 3 times per day. When patient is become stable then should start stretching, isotonic exercise and gradually strengthening exercise (Carter, 2008).

The prevalence of person living with SCI has increased due to the improvement of medical care and it is assumed that in future there will be greater number of older patients with SCI. The survival rate of traumatic SCI is improved significantly in developed country compared with developing country mainly for the tetraplegia (Bele & Golhar, 2013).

The mean life expectancy of SCI patient in Australia is about 86% of normal for complete paraplegia and 70% of normal for complete tetraplegia (Cripps et al., 2010). The rate of hospital mortality of SCI patients is about 26% among them tetraplegia are doubled than paraplegia (Draulans et al., 2011).

Through many studies it has been found that atelectasis and pneumonia are the most common complication of SCI. So, we should advice the patient to use incentive spirometer and peak flow meter regularly after spinal cord injury for the better management of asthma and prevent pulmonary complication (Bele & Golhar, 2013).

People with SCI frequently experience many complications. The most common complaints are respiratory dysfunction, pain, muscle fatigue pressure ulcer and urinary tract infection. Long term respiratory complications in the form of pneumonia or atelectasis are the major cause of morbidity and mortality in these people. Pneumonia is the leading cause of their deaths (Vetkasov & Hoskova, 2014).

Mainly urinary tract infection (UTI), pressure sore, spasticity, pain, deep vein thrombosis, heterotrophic ossification, constipation, depression are the overall common complications of SCI that are seen during rehabilitation. According to present study, during rehabilitation about 90.62% patients with SCI have at least one complication. UTI is the first with 50%, spasticity is the second with 35.93%, urinary incontinence 31.25%, pressure sore 25% and 60% of patient has one episode of UTI (Gupta et al., 2009).

Spinal cord injury can cause serious respiratory compromise, impaired cough ability and respiratory failure. Respiratory failure is the primary cause of morbidity and

mortality in high cervical cord lesion (Baydur & Sassoon, 2018). Smoking habits can adversely contribute to poor lung function and influence the respiratory complication (Vetkasov & Hoskova, 2014).

The most common respiratory complications are atelectasis, pneumonia, respiratory failure, pleural complication, thrombo-embolic disease etc. A study reported that among SCI patient 36% have respiratory complication and among tetraplegia 100% have respiratory complication. More recent study have reported that 50-67% of patient with any type of SCI has respiratory complication (Winslow & Rozovsky, 2013).

Pulmonary oedema can affect as many as 50% of individuals with acute tetraplegia. The causes are multifactorial and include excessive fluid resuscitation in the presence of hypotension in the acute post injury setting. Following acute SCI the risk of pulmonary embolism is increased, with an incidence of 4.5% and a mortality rate of 3.5% in the first 3 months of injury. In the first month after injury, SCI patients have 500 times the risk of death due to pulmonary embolism (Berlowitz et al., 2016).

In the acute phase of hospitalization, 84% patients with C1-C4 injuries and 60% patients with C5-C8 injuries experienced the respiratory complication. These respiratory complications significantly increase the length of stay in hospital and treatment cost of the patient. On the other hand, immediately after traumatic cervical SCI a period of spinal shock occurs that indicates the severity of injury and the possibility of severe respiratory complication. The effect of shock over the respiratory system is too severe so the patient may need artificial ventilation. Therefore, early respiratory management should be started to prevent and treat the complication for better outcome. Early respiratory management includes airway management, respiratory care and physiotherapy intervention (Berney et al., 2011).

Active cycle of breathing technique is very effective for the airway clearance in patient with SCI. It is also effective in improving the pulmonary functions, ventilation and improve the strength, endurance and coordination of respiratory muscles in cervical spinal cord injuries (Kiran et al., 2017).

Respiratory complication due to CSCI is very serious. The diaphragm will be affected if the neurological level is C5 or above C5, then the abdominal and intercostals muscles will be paralyzed. As a result, inspiratory and expiratory function will be impaired. For this reason, most patients with CSCI may require artificial mechanical ventilation (MV) or endotrachial intubation. If MV is failed then sometimes may require tracheotomy. About 40% of patients with CSCI may require ventilator support (Arora et al., 2012).

In neurological level C1-C3 ventilator dependent secondary to severe diaphragm weakness or paralysis occurs in tetraplegic SCI patients. In C3-C4 diaphragm function will be impaired and reduce tidal volume and vital capacity. In neurological level C5 diaphragm function intact but intercostal and abdominal muscle paralysis results in decreased lung volumes and cough strength and effectiveness. And neurological level in C6-C8 patient typically can augment inspiration and cough with accessory muscles, particularly pectoralis major and minor (Berlowitz et al., 2016).

Lung volume is beneficial for evaluating respiratory diseases. Reduction of lung volume and capacity may lead to chronic airway obstruction. When inspiratory and expiratory volume decrease patient can feel breathlessness which is an extra disability for the patient (Linn et al., 2010). So, effective management should started as soon as possible which include initial or prolonged mechanical ventilation, maintain position, early physiotherapy (breathing exercise, breathing control exercise, active cycle of breathing technique, mobilization, use of incentive spirometer and peak flow meter etc), bronchodilator and abdominal binder. Though physiotherapy is essential but specific component such as bronchodilators which are most beneficial if the patient has obstructive airway (Arora et al., 2012).

Incentive spirometer and peak flow meter are used to measure maximum breathing capacity and peak expiratory flow rate of SCI patient. Weakness of respiratory muscle can exhibit reduced lung volume and flow rates in SCI patient (Baydur et al., 2001). This indicates the reduction of lung and chest wall compliance and increase oxygen cost of breathing. Most of the studies use the spirometer as outcome measurement tool

after intervention (Bele & Golhar, 2013). Therefore, by using spirometer we can measure the lung volume of SCI patient and know the respiratory status.

To my knowledge, there are no studies documenting the effectiveness of spirometry exercise along with active cycle of breathing technique to improve lung volume of tetraplegic SCI patient. These results may provide the rational basis protocol for improving lung volume of tetraplegic spinal cord injured patients. The advantage of this procedure are- it is non-invasive, inexpensive, strengthen the inspiratory and expiratory muscle and can be administered in any situation even at home. So all rehabilitation centre should use this type of pulmonary therapy for the respiratory management of SCI patients.

CHAPTER – III: METHODOLOGY

This research is a quantitative evaluation of the comparison between the spirometry exercise along with active cycle of breathing technique and the spirometry exercise alone to improve lung volume of tetraplegic SCI patients. To identify the effectiveness of this treatment approach spirometer itself was used as measurement tools for measuring the lung volumes.

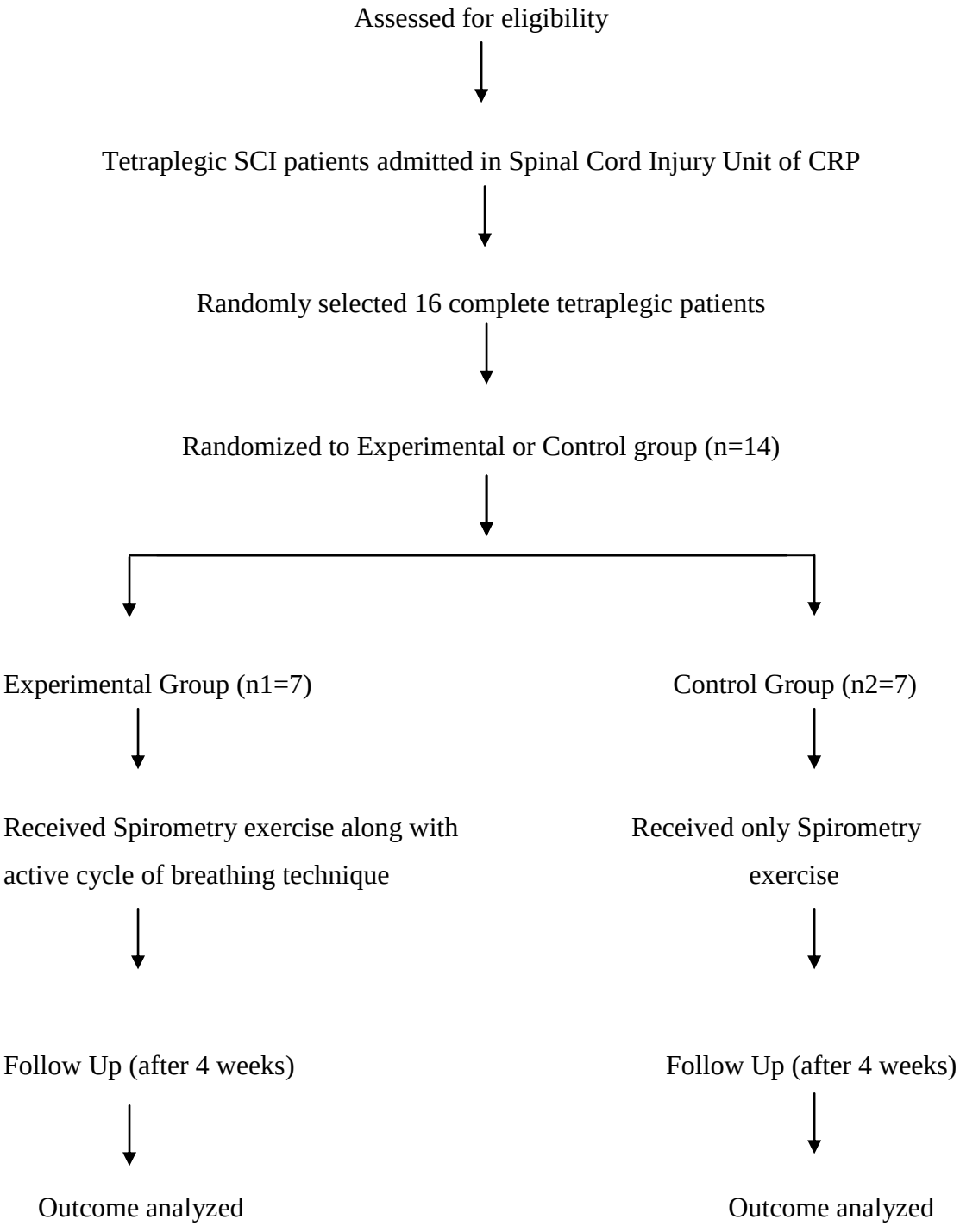
3.1 Study Design

The study was directed by using Randomized Control Trail (RCT).

From the spinal cord injury unit 16 patients were randomly selected and then again 14 patients were randomly selected from them and then 7 patients were randomly assigned to experimental group and 7 patients to the control group. The study was a double- blinded study.

A pre test (before intervention) and post test (after intervention) was administered with each subject of both group to compare the lung volume effects before and after the treatment.

A flowchart of the phases of randomized controlled trial including treatment programmed:



3.2 Study area

Spinal Cord Injury Unit of Centre for the Rehabilitation of the Paralyzed (CRP), Savar, Dhaka-1343 was chosen for the collection of data.

3.3 Study population

A population refers to the entire group of people that meet the criteria set by the researcher. The populations of this study were the spinal cord injury patients who were complete tetraplegic.

3.4 Sampling technique

Simple random sampling technique was selected to conduct the study.

3.5 Sample selection

The participants, who met the inclusion criteria, were taken as sample in this study. At first 16 patients of complete tetraplegic SCI were selected from SCI unit of CRP (Savar). After that, 14 patients were randomly assigned for the study. Then again, 7 patients were randomly assigned to experimental group (use spirometry exercise along with active cycle of breathing technique) and 7 patients to the control group (use only spirometry exercise) fir this RCTs study. When the samples were collected, the researcher randomly assigned the participants into the experimental and control group for improving the internal validity of experimental research. The samples were given numerical number C1, C2, C3 etc for the control group and E1, E2, E3 etc for the experimental group.

3.6 Inclusion criteria

- Tetraplegic SCI patient (C4-C7).
- Both male and female patients were included.
- Patient with intact cognition.
- Included those who showed willingness to participation

3.7 Exclusion criteria

- Acute tetraplegic SCI patient (C1-C3)
- Rib fracture patient
- SCI with head injury patient
- Subject who are unwillingness to participate
- Medically unstable patient

3.8 Sample size

This study was conducted with 14 patients. 7 patients for Control group and 7 patients for Experimental group.

3.9 Method of data collection

Data was collected through questionnaire, pre-test, intervention and post-test.

3.9.1 Data collection tools

A written questionnaire, pen, paper, pencil and incentive spirometer were used as data collection tools in this study.

3.9.2 Questionnaire

Patients personal details and outcome measurement form was used as questionnaire for the study.

3.9.3 Measurement tool

In this study, the incentive spirometer itself was used as a measurement tool for the measurement of lung volumes. There was slide inside spirometer which point down to zero. When the patient inhaled through the mouthpiece the slide move upwards. The result was written when maximum inspiration occurred and when the slide level gone upto the maximum level. In this way patient performed 5 times, on an average result written down. Data of the First day considered as a pre-test and data after 4 weeks considered as a post-test.

Spirometer rating:

Table- 1: Measurement rate in spirometer

Number of balls	Lung volume in ml/sec
1 ball	600 ml
2 ball	900 ml
3 ball	1200 ml

3.9.4 Data collection procedure

The study procedure was conducted through assessing the patient, initial recording, treatment and final recording. At first 16 subjects were chosen for data collection. The witness of the researcher chose this 16 subjects. Then the researcher randomly chose 14 subjects from 16. Again randomly divided all the participants into two groups for experimental group code E and for control group code C. Experimental group received spirometry exercises along with active cycle of breathing technique and control group received only spirometry exercise.

Data was gathered through a pre-test, intervention, post-test, spirometer and a questionnaire form. In experimental group, 4 patients were bed mobile and 3 patients were wheel chair bounded. In control group, 3 patients were in traction bed, 2 patients were bed mobile and 2 patients were wheel chair bounded. All the data were collected in supine lying position to reduce the bias because according to literature posture have an effect on lung volume. Pre test was performed before beginning the treatment and the lung volume was noted on questionnaire form by student. The same procedure was performed to take post test at the end of 4 weeks of treatment. The treatment was given in both experimental and control group by the qualified physiotherapist and the researcher. At the end of the study, statistical analysis was performed by specific test.

3.9.5 Intervention protocol

The participants of control group were received only spirometry exercise and experimental group were received spirometry exercise along with active cycle of breathing technique. Both group performed the specific treatment 3 times/day.

Active cycle of breathing technique: 5 repetition at a time

Spirometry exercise: 5 repetition at a time.

3.10 Duration of data collection

The total duration of data collection was 5 weeks.

3.11 Unrelated t- test

The data was analyzed by Unrelated t test and Paired t test.

3.12 Ethical consideration

Ethical issue was maintain in every aspects of the study. The study followed the World Health Organization (WHO) guidelines and strictly maintained the confidentiality. At the very beginning, research proposal was submitted to local ethical review committee of Bangladesh Health Profession's Institute (BHPI) for being approval. Then permission was taken from the head of the Physiotherapy Department of CRP, Savar to collect data from the Spinal Cord Injury Unit, CRP, Savar. The ethical consideration was making sure by an informed consent letter to the participants.

It was ensured that the actual name of the participants will be hidden from others. All the data was kept in a secured place. Only principle investigator had the access of that information. It was ensured that safe intervention was given to them and there would be no potential or any other risk to them resulting from participation in the research. It was also explained that participants can withdraw from the study at any time without any problems.

3.13 Informed Consent

The participants and their career was clearly explained about the title, aims and purpose of the research project. It was explained verbally and their relatives sign it, as tetraplegic patients cannot sign due to paralysis of the upper limb participation. A sign in the informed consent form was received from each participants, responsible physiotherapist as a witness. The researcher had also signed in the consent form. The participants were informed that they have the right to refuse at any time if the condition become worsens. Withdrawal of participation from the study would not affect their treatment in the physiotherapy department and they would still get the same facilities. There is no discomfort or risk associated with the study. Researcher nothing hide to the subjects ensure that everything is confidential and mentioned it ia a part of physiotherapy course of 4^{th} year B. Sc (Hons).

3.14 Data analysis

The research have some values, the meaning of collected data has to be presented in ways that other research workers can understand. In other words the researcher has to make sense of the results. As the result came from an experiment in this research, data analysis was done with statistical analysis by independent t test and paired t test.

All participants were coded according to group to maintain participant's confidentiality. All subjects of both experimental and control group score their lung volume according to spirometer rating before starting treatment and after completing treatment. The improvement of lung volume was calculated by comparing the pre test and post test score. It was experimental and had unmatched groups of different patients, who were randomly assigned to spirometry exercise along with active cycle of breathing technique group and only spirometry exercise group and the measurement of the outcome came from spirometer, with considering interval data, so the parametric independent "t" test was used in this study to calculate the level of significance between the group and paired "t" test was used to calculate the level of significance within the group.

3.15 Statistical Test

According to Hicks (2000), Experimental studies with the different subject design where two groups are used and each tested in two different conditions and the data is interval or ratio should be analyzed with unrelated "t" test. The between group analysis of lung volume was analyzed by Unrelated or Independent t test. The within group analysis of lung volume was done by Paired t test.

Unrelated t- test

Unrelated t- test was used to compare the result between the group and to find out the level of significance.

Assumption:

Data were interval
Variables are quantitative
Normal distribution of the variables.

Formula:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\left[\sqrt{\frac{\left(\sum x_1 2 - \frac{(\sum x_1)^2}{n_1}\right) + \left(\sum x_2 2 - \frac{(\sum x_2)^2}{n_2}\right)}{(n_1 - 1) + (n_2 - 1)}} \times \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}\right]}$$

Here,

$\overline{X_1}$ = mean of score from treatment group.

$\overline{X_2}$ = mean of score from control group.

$\sum {x_1}^2$ = The square of the each individual score of experimental group totaled.

$\sum {x_2}^2$ = The square of the each individual score of control group totaled.

$(\sum x_1)^2$ = The total of the individual score from experimental group squared.

$(\sum x_2)^2 =$ The total of the individual score from control group squared.

$n_1 =$ Number of participants in the experimental group.

$n_2 =$ Number of participants in the control group.

Table 2: variable in this study and level of significance calculated by Unrelated t test

Variable	Degree of freedom	Observed t value	Significance level
Lung volume	12	2.110	0.5

The paired sample t- test: This test used to compare the means of two related samples. It is also used when two values present for the same samples.

Assumptions:

The dependent variable must be continuous (interval or ratio).
The observations are independent of one another.
The dependent variable should be approximately normally distributed.
The dependent variable should not contain any outliers.

Formula:

$$t = \frac{\bar{d}}{SE(\bar{d})} = \frac{\bar{d}}{\frac{SD}{\sqrt{n}}}$$

Here,

$\bar{d} =$ Mean of difference (d) between paired values,

$SE(\bar{d}) =$ Standard error of mean difference,

SD = Standard deviation of difference d, and

n = Number of values in each pair.

Table 3: Variable in this study and level of significance calculated by Paired t test

Lung volume	Degree of freedom	Within Experimental group		Within Control group	
		't' value	Significance Level	't' value	Significance Level
	6	7.816	0.001	4.596	0.026

3.16 Significant level

This experimental study hypothesis was one tailed because it was producing specific directions of the results. If P value is <0.05 which will be accepted by the researcher to show the significant result of the study to prove or support the hypothesis and reject the null hypothesis. In order to find out the significance of the study, the researcher calculated the "p" value. The "p" value refers the probability of the results for experimental study. The word probability refers to the accuracy of the findings. A p value is called level of significance for an experiment and a p value of <0.05 was accepted as significant result for health service research. According to Hicks (2000), if p value is equal or very small it could reject null hypothesis. When the null hypothesis is rejected in this way the results are said to be significant.

3.17 Elimination of confounding variables

Confounding variable has an effect on the study that can affect the result of the study. There were some confounding variables in this study such as patient's age, sex, history of smoking and any respiratory disease, using of bronchodilator etc that could influence the result of the study. Researcher found no significant difference between the mean age of two groups, the mean age of control group was 39, and the mean age of experimental group was 35. So there was no effect of age, which can influence the result. To control confounding variables, researcher set the inclusion and exclusion criteria.

Presented at a glance of participant details of control and experimental group:

Control group:

Table 4: Participant details of control group

Code	Age	Sex	Level of injury	Cause	ASIA scale
C1	40 Years	Male	C7	RTA	Complete A
C2	50 Years	Male	C5	RTA	Complete A
C3	32 Years	Male	C4	Fall from height	Complete A
C4	32 Years	Male	C5	Fall while carrying heavy load on head	Complete A
C5	38 Years	Female	C6	RTA	Complete A
C6	48 Years	Male	C5	Fall of heavy object on neck	Complete A
C7	33 Years	Male	C4	Fall from height	Complete A

Experimental group:

Table 5: Participant details of experimental group

Code	Age	Sex	Level of injury	Cause	ASIA scale
E1	45 Years	Male	C5	Fall from height	Complete A
E2	26 Years	Female	C5	RTA	Complete A
E3	28 Years	Male	C6	RTA	Complete A
E4	32 Years	Male	C7	Fall while carrying heavy load on head	Complete A
E5	35 Years	Male	C7	Fall from height	Complete A
E6	38 Years	Male	C4	Fall while carrying heavy load on head	Complete A
E7	38 Years	Male	C7	Fall from height	Complete A

CHAPTER–IV: RESULTS

In this study the results that were found have been shown in different histogram, bar charts and tables.

Table 6: Demographic variable of Experimental and Control group

Variables	Experimental	Control
	n = 7	n = 7
Age, Mean (SD), years	35±10.013 years	39±11.210 years
Gender	6 males (85.7%), 1 female (14.3%)	6 males (85.7%), 1female(14.3%)

Difference of mean age and standard deviation between two groups: 4±1.197.

At the beginning of the research, among 16 patients 14 patients were randomly selected for the study. Among them again 7 patients are chosen randomly for the experimental group and rest of the 7 patients were chosen for the control group.

The lung volume was measured for the study. All of the data were collected by using incentive spirometer. Measurement technique of both control group and experimental group were same.

Table 7: The lung volumes (IV) of control group

Weeks	Patient						
	1 P	2 P	3 P	4 P	5P	6 P	7 P
During 1st weeks	1000	600	700	600	800	900	500
After 4 weeks	1200	900	800	800	800	1100	800

In the above table (Table-6) which is for the control group after 4 weeks of intervention the lung volume was same for 1 patient's 5p means the lung volume did not increase. However, the lung volume of the other patient's 1p, 2p, 3p, 4p, 6p, 7p was increased though it is not big enough.

Table 8: The lung volumes (IV) of experimental group

Weeks	Patient						
	1 P	2 P	3 P	4 P	5 P	6 P	7 P
During 1st weeks	900	700	800	500	600	900	900
After 4 weeks	1200	1100	1100	900	900	1200	1200

In the above table (Table-7) which is for the experimental group after 4 weeks of intervention the lung volume of all subjects were increased but 1p, 6p, 7p got better result than the others.

Improvement of lung volume score in control group and experimental group were different in post-test scores. These have been shown in the graph below:

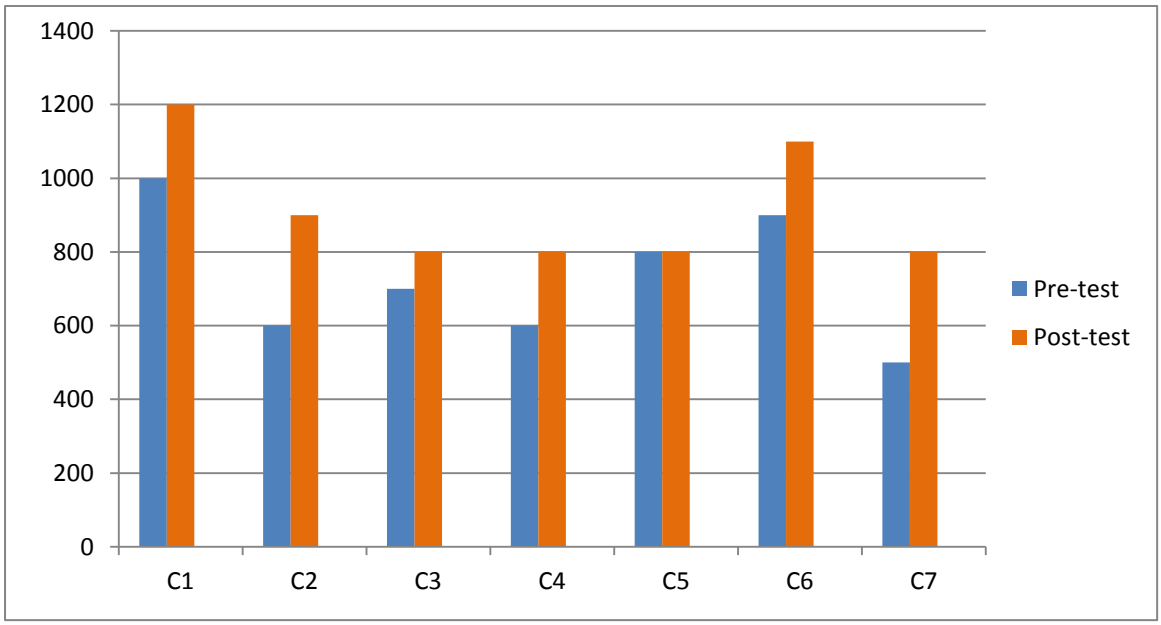


Fig-1: Improvement of lung volume in control group

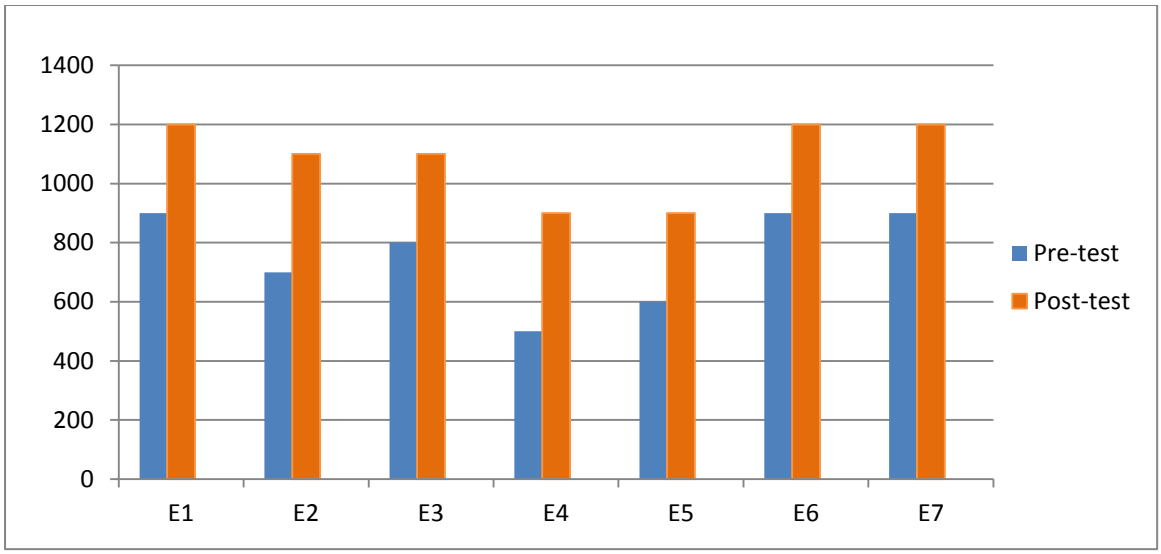


Fig-2: Improvement of lung volume in experimental group

The mean improvement of lung volume in control group is about 914 ml and mean improvement of lung volume in experimental group is about 1085 ml. The mean difference of both groups have been shown in the following figure:

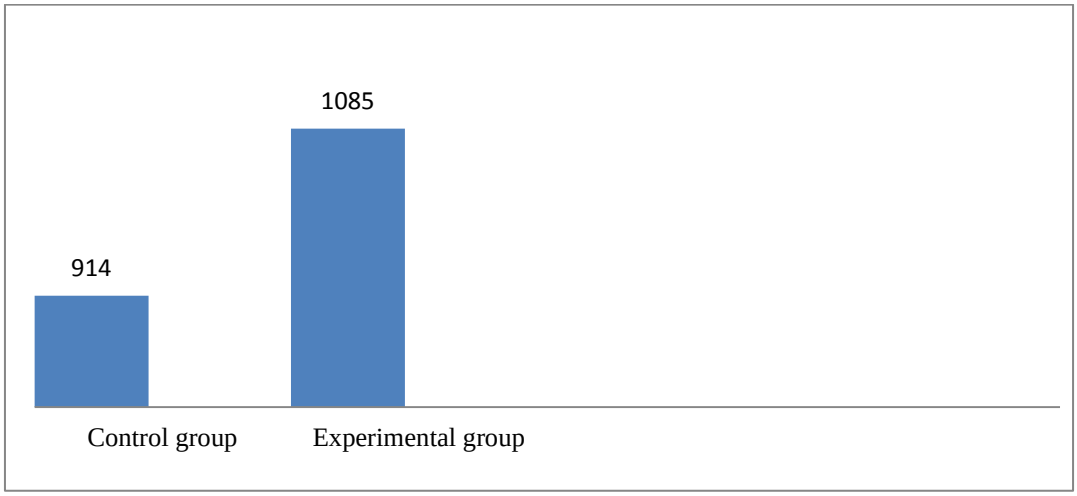


Fig- 3: Mean improvement of lung volume in both group

Baseline of mean lung volume (IV) measured by spirometer and changes after 4 weeks of intervention in both control group and experimental group are shown in the table-7 below:

Table 9: The baseline of lung volume of both control and experimental group

Variables	Baseline in Control group	Baseline in Experimental group	After 4 weeks of intervention in control group	After 4 weeks of intervention in experimental group
Lung volume (IV) measured by Spirometer	729 ml	757 ml	914 ml	1085 ml

Interpreting the result

In this study between the two groups an unrelated t test was done and found the observed t value was 2.110, degree of freedom was 12 and significance level was 0.5 which is larger than 0.05 that means the result is non significant and it rejected hypothesis and null hypothesis is accepted. In this way it found that spirometry exercise along with active cycle of breathing technique is no more effective than only spirometry exercise. So, the research suggests that there is no significant improvement of lung volume after spirometry exercise along with active cycle of breathing technique between the two groups. But using a paired t test within the experimental group there was found the observed t value was 4.596 and significance level was 0.026 that means the result is significant. Within the control group here also a paired t test was done and found the observed t value was 7.816 and level of significance was 0.001 here also occurred significant improvement of lung volume in this group. This research also suggests that there is significant improvement of lung volume within the experimental group and control group by using spirometry exercise along with active cycle of breathing technique and only spirometry exercise.

CHAPTER – V: DISCUSSION

The purpose of the study was to evaluate the effectiveness of spirometry exercise along with active cycle of breathing technique exercise compare to only spirometry exercise for the improvement of lung volume of complete tetraplegic SCI patients. In this experimental study among 16 patients 14 were randomly selected. Then among 14 patients 7 were randomly assigned to the experimental group who received spirometry exercise along with active cycle of breathing technique exercise and rest of the 7 were included in the control group, who received only spirometry exercise. Each group received the specific intervention up to 4 weeks and 3 times daily in order to demonstrate the improvement. The incentive spirometer was used for measuring the outcome of lung volume (IV) before and after intervention.

The researcher found significant improvement of lung volume within the experimental and control group in this study. In experimental group the mean of lung volume in pre test is 757 ml and post test is 1085 ml which is 328 ml more than pre test score. In control group the mean of lung volume in pre test is 729 ml and post test is 914 ml. Here also improvement of lung volume occured. The result of the experiment indicated that the lung volume (IV) of complete tetraplegic SCI patient increased significantly within the experimental and control group by using spirometry exercise along with active cycle of breathing technique and only spirometry exercise but there was no significant improvement of lung volume between the two groups, thereby not supporting the hypothesis

The study demonstrated that the mean of lung volume of experimental group was not significantly changes than the control group. The result was said to be non significant in this study because here significance level was 0.5 which is larger than 0.05. In this study the null hypothesis was accepted because significance level was large and in this way the result are said to be non significant between two groups.

In experimental group it was seen that all subjects lung volume increased but 1p, 6p and 7p improved more than others. Researcher asked the patients to use the intervention 3 times daily but sometimes they fail to follow the advice because of their physical illness. It can influence the result but it was difficult for the researcher to overcome the situation.

A spirometer was used for collecting the data as well as intervention of the study. During pre test and post test the measurement was taken by using a spirometer in both the experimental group and the control group.

The participants of the experimental group used both spirometry exercise and active cycle of breathing technique exercise. The combination of spirometry exercise and active cycle of breathing technique exercise is more effective than only spirometry exercise.

Active cycle of breathing technique helps to maintain lung expansion and clear the secretion from airways and increase the ventilation of the lung. One study have shown that Diaphragmatic strengthening exercise improves the strength and endurance of diaphragm, helps to decrease the work of breathing and ultimately improves the vital capacity (Baydur & sassoon, 2018).

A study was conducted in 2017 for improving the pulmonary function of spinal cord injury patients by using various treatment technique in India. This study with 25 patients was done to evaluate the improvement of ventilation, improvement of strength, endurance of respiratory muscles and improvement of vital capacity. The study design is pre test and post test experimental design. The participants received spirometry exercise, active cycle of breathing technique and diaphragmatic breathing exercise for a period of one month. The results indicated that there was a significant changes in the patients treated with the above techniques. Based on the obtained results it can be concluded that the combined effect of incentive spirometry, diaphragmatic breathing exercises and active cycle of breathing technique is more effective in improving the pulmonary functions in patients with spinal cord injury.

The use of incentive spirometer has been shown to decrease atelectasis, decrease ventilation perfusion mismatching and increased vital capacity. It is also used as outcome measurement tool after intervention. Active cycle of breathing technique is very useful in promoting airway clearance in patients with tetraplegic SCI patients. It also increases pulmonary function as well as lung volume (Kiran et al., 2017).

In this study the researcher used spirometry exercise and active cycle of breathing technique exercise for the improvement of lung volume. So, my research is quite similar with above research. Because when total lung capacity will improve lung volume will also improve. Recent studies found that spirometry exercise, active cycle of breathing technique, respiratory muscle training, strengthening of chest wall muscles, phrenic nerve stimulation have all been used with varying degrees of success in the prevention of respiratory complications in patients with spinal cord injury (Vetkasov & Hoskova, 2014).

As other research used active cycle of breathing technique and incentive spirometer for the respiratory care, increasing the strength and endurance of respiratory muscles, for reducing pulmonary complication, improvement of ventilation and respiratory status etc. Moreover, the researcher used spirometry exercise along with active cycle of breathing technique and only spirometry exercise for the improvement of lung volume and found significant improvement of lung volume within the experimental and control group. So, researcher could say the treatment was effective and acceptable.

5.1 Limitations

There are some obstacles and limitation while conducting the research project. They are as follows-

- The duration of data collection was too short. It was the main limitation to complete such a research project fully.
- The study was conducted with 14 patients of SCI, which was a very small number of samples in both groups and was not sufficient for the study to generalize the wider population of this condition.
- The study was conducted by 12 males and 2 females participant. There was no choice for this but during sampling the researcher did not find more female patient. This was one of the limitations.
- When asked the patient to continue active cycle of breathing technique exercise, sometimes they might not follow the advice. But if asked them to practice active cycle of breathing technique exercise and then spirometry exercise they psychologically become motivated as spirometer is an equipment and it is more effective. They thought it would get better result. It was also a limitation of the study.
- Another problem was the patient was physically disabled and it affected their mental and psychological state. They were think about moving limb or walk again and neglect their other problems. Sometimes they were not motivated to receive the intervention.
- There was no available research done in this topic in Bangladesh. So relevant information with specific intervention for Bangladesh was very limited in this study.

CHAPTER – VI: CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The result of this experimental study have found that spirometry exercise along with active cycle of breathing technique is no more effective than the spirometry exercise alone for improving lung volume (IV) of complete tetraplagic SCI patients between the two groups. But the result also showed that the combination of active cycle of breathing technique and spirometry exercise is very effective within the experimental group. This combination has a possibility to provide greater benefits to the participants such as it helps to improve ventilation, oxygen exchange, clear the secretion from lung, increase the strength and endurance of respiratory muscle which will decrease the risk of chest infection and enhance exercise tolerance of the tetraplegic patients. This is indicated that the spirometry exercise along with active cycle of breathing technique can be effective treatment approach for respiratory management of patients with SCI.

Spinal cord injury is a major public health problem in Bangladesh. People with SCI frequently experience a range of complications. Respiratory complication is the major cause of morbidity and mortality in these people. These complications occur due to reduction of inspiratory and expiratory ability. In most cases, such severe respiratory complications lead to impaired function and sometimes even death (Vetkasov & Hoskova, 2014). As respiratory complications are life threatening mainly for acute cervical sponal cord injury patients So, an effective respiratory care should start as early as possible. It is an integral part of their rehabilitation programmed.

I hope this research will help the professionals to decide an evidence based treatment for providing the effective respiratory care of the complete tetraplegic SCI patients.

6.2 Recommendations

The study has been conducted with small populations, which cannot generalize the result for the whole population. In future if anybody is interested to do research in this area, sample size and duration of intervention should be increased and study design should be triple blinded RCT to generalize the whole population and get the more valid result.

In this study the female participants were very less than male. To increase the validity it is recommended to do with equal number of male and female participant and compare the lung volume difference male and female.

The researcher compared the lung volume difference of all participants only in supine lying position. Further study recommended comparing the lung volume difference in difference position.

The study was conducted with complete tetraplegic patients in acute and stabilization phase due to limitation of participants. It will be better if the study is conducted with only acute complete tetraplegic patients.

The research only focused on lung volume mainly inspiratiry volume after 4 weeks of treatment. As SCI is a lifelong disability, the long lasting effect of the intervention is needed to investigate. The further study is recommended to investigate the long lasting effects of intervention by using follow up design.

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APPENDIX

মৌখিক সম্মতিপত্র

আসসালামুয়ালাইকুম/নমস্কার,

আমি ফারজানা আক্তার বৃষ্টি, ঢাকা বিশ্ববিদ্যালয়ের চিকিৎসা অনুষদের অধিভুক্ত বাংলাদেশ হেলথ প্রফেশনস্ ইনস্টিটিউট এর বি.এস.সি ইন ফিজিওথেরাপী কোর্সের ৪র্থ বর্ষের একজন ছাত্রী। অধ্যায়নের অংশ হিসেবে আমাকে একটি গবেষণা সম্পাদন করতে হবে এবং এটা আমার প্রাতিষ্ঠানিক কার্যকলাপের একটা অংশ। নিম্নোক্ত তথ্যাদি পাঠ করার পর অংশগ্রহণকারীদের অধ্যায়নে অংশগ্রহণের জন্য অনুরোধ করা হলো। আমার গবেষণার বিষয় হল- ''মেরুরজ্জুতে আঘাতপ্রাপ্ত টেট্রাপ্লেজিক রোগীদের সক্রিয় চক্রাকার শ্বাসপ্রশ্বাস পদ্ধতির সহিত স্পাইরোমিটার দিয়ে থেরাপী করার ফলে ফুসফুসের বাতাস তথা অক্সিজেন ধারণের ক্ষমতা বৃদ্ধির কার্যকারিতার প্রভাব"। এই পরীক্ষামূলক গবেষণার মাধ্যমে আমি একটি অনুমান পরীক্ষা করব যে, মেরুরজ্জুতে আঘাতপ্রাপ্ত টেট্রাপ্লেজিক রোগীদের সক্রিয় চক্রাকার শ্বাসপ্রশ্বাস পদ্ধতির সহিত স্পাইরোমিটার দিয়ে থেরাপী করার ফলে ফুসফুসের বাতাস তথা অক্সিজেন ধারনের ক্ষমতা বৃদ্ধিতে সক্ষম। আমার গবেষণার উদ্দেশ্য হলো থেরাপী দেবার পূর্বে ও পরে রোগীদের ফুসফুসের বাতাস ধারণের ক্ষমতা পরিমাপ করা। ফুসফুসের বাতাস ধারণের ক্ষমতা পরিমাপ করলে ফুসফুসের স্বাভাবিক কাজ সম্পর্কে একটা পরিষ্কার ধারণা পাওয়া যাবে। আমি যদি আমার গবেষণাটি সার্থকভাবে সম্পূর্ণ করতে পারি তবে যেসব রোগী শ্বাসপ্রশ্বাস জনিত সমস্যায় ভুগতেছে তারা উপকৃত হবে এবং পরবর্তীতে তাদের শ্বাসপ্রশ্বাস জনিত জটিলতা হবার সম্ভাবনা কমে যাবে। গবেষণাটি সম্পাদন করার জন্য আমাকে যেসব রোগী টেট্রাপ্লেজিক তাদের কাছ থেকে কিছু তথ্য সংগ্রহ করা প্রয়োজন। এই কারনে আপনি আমার গবেষণার একজন মূল্যবান অংশগ্রহণকারী হতে পারেন।

আমি প্রতিজ্ঞা করছি যে এই গবেষণা আপনার জন্য কোন ঝুকিপূর্ণ হবে না অথবা আপনার কোন ক্ষতি করবে না। গবেষণা চলাকালীন সময়ে কোন রকম দ্বিধা বা ঝুকি ছাড়াই যেকোন সময়ে আপনি এটাকে বাদ দিতে পারবেন। এই গবেষণার প্রাপ্ত তথ্য সম্পূণভাবে গোপনীয় থাকবে এবং অংশগ্রহণকারীর ব্যক্তিগত তথ্য অন্য কোথাও প্রকাশ করা হবে না।

এই গবেষণা সম্পর্কে কোন কিছু জানার থাকলে আপনি গবেষক ফারজানা আক্তার বৃষ্টি এর সাথে যোগাযোগ করবেন। এই গবেষণা শুরু করার আগে আপনার কি কোন প্রশ্ন আছে?

তাহলে আপনি কি এই অধ্যায়নে অংশগ্রহণের সম্মতি প্রদান করছেন? হ্যাঁ ..... না .....

অংশগ্রহণকারীর স্বাক্ষর .....

গবেষকের স্বাক্ষর .....

সাক্ষীর স্বাক্ষর .....

VERBAL CONSENT STATEMENT

Assalamualaikum/Namasker,

I am Farjana Akter Bristi, the 4th year B.Sc.(Hon's) in physiotherapy student of Bangladesh Health Professions Institute (BHPI) under Medicine faculty of University of Dhaka. To achieve my Bachelor degree I shall have to conduct a research and it is a part of my study. The participants are requested to participate in the study after reading the following.

My research title is "Effectiveness of spirometry exercise along with active cycle of breathing technique to improve lung volume of tetraplegic SCI patients". Through this experimental study, I will test a hypothesis "Spirometry exercise along with active cycle of breathing technique is effiective to improve lung volume of tetraplegic SCI patients". The objectives of my study are to measure the lung volume before and after intervention. Measurements of lung volume provide a clear understanding about normal function of lungs or a disease condition. Different literatures have shown that spirormetry exercise and active cycle of breathing technique both are beneficial for improvement of lung volume. If I can complete the study successfully, the patients may get the benefites who are suffering from respiratory problems and also reduce the chance of further respiratory complications. To implement my research project, I need to collect data for the cases who are tetraplegic. Therefore, you could be one of my valuable subjects for my study.

I am committed that the study will not pose any harm or risk to you. You have the absolute right to withdraw or discontinue at any time without any hesitation or risk. I will keep all the information confidential which I obtained from you and personal identification of the participant would not be published anywhere.

If you have any query about the study, you may contact with the researcher Farjana Akter Bristi.

Do you have any questions before I start?

So,may I have your consent to proceed with the interview? Yes.....,No…..

Signature of the participant & Date …….....

Signature of the researcher & Date ……..

Signature of the witness & Date ……..

প্রশ্নপত্র

গবেষনার বিষয়: মেরুরজ্জুতে আঘাতপ্রাপ্ত টেট্রাপ্লেজিক রোগীদের সক্রিয় চক্রাকার শ্বাসপ্রশ্বাস পদ্ধতির সহিত স্পাইরোমিটার দিয়ে থেরাপী করার ফলে ফুসফুসের বাতাস তথা অক্সিজেন ধারণের ক্ষমতা বৃদ্ধির কার্যকারিতার প্রভাব।

অংশ - ১ (রোগীদের পরিচয়)

- রোগীর আইডি নম্বর:
- রোগীর নাম:
- বয়স:
- লিঙ্গ:
- ঠিকানা: গ্রাম: পোস্ট অফিস: থানা:

  জেলা:
- শিক্ষাগত যোগ্যতা:
- আঘাত পাবার তারিখ:
- আঘাত পাবার কারন:
- ডায়াগনসিস:
- আঘাত পাবার পর্যায়:
- যোগাযোগ নম্বর:
- সম্মতি গ্রহন:

  হা: না:
- চিকিৎসা শুরু হবার সময়:
- চিকিৎসা শেষ হবার সময়:

অংশ - ২ (বস্তুগত পরিমাপ)

১. আপনি কি শ্বাস নেবার সময় বুকে ব্যথা অনুভব করেন?

ক) হা খ) না

২. আপনি কি কথা বলার সময়,খাবার সময়, ড্রেস বদলানোর সময় শ্বাসকষ্ট অনুভব করেন?

ক) হা খ) না

৩. আপনি কি আঘাত পাবার আগে শ্বাসকষ্ট অনুভব করতেন?

ক) হা খ) না

৪. আপনার কি আঘাত পাবার পর যন্ত্রচালিত শ্বাসপ্রশ্বাস নেবার দরকার হয়েছিল?

ক) হা খ) না

৫. আপনার কি কোন শ্বাসজনিত রোগ যেমন শ্বাসকষ্ট, নিউমোনিয়া এগুলো আছে?

ক) হা খ) না

৬. আপনি কি কখনো নেবুলাইজার নিয়েছেন?

ক) হা খ) না

অংশ - ৩ (উদ্দেশ্যগত পরিমাপ)

- রোগীর অবস্থা: ক) চিৎ হয়ে শুয়া খ) উপুর হয়ে শুয়া গ) অর্ধেক শুয়া ঘ) কাত হয়ে শুয়া
- বুকের আকার: ক) নরমাল খ) পিজিওন গ) সমতল ঘ) ফানেল
- রোগীর শ্বাসপ্রশ্বাসের হার:
- স্পাইরোমিটার এবং চক্রাকার শ্বাসপ্রশ্বাস পদ্ধতি ব্যবহারের সময়সীমা:
- কন্ট্রোল গ্রুপ: (স্পাইরোমিটার এর সাহায্যে ফুসফুসের বাতাস ধারনের ক্ষমতা পরিমাপ)

রোগীর নং	প্রি টেস্ট স্কোর	পোস্ট টেস্ট স্কোর

পরীক্ষামূলক গ্রুপ: (স্পাইরোমিটার এর সাহায্যে ফুসফুসের বাতাস ধারণের ক্ষমতা পরিমাপ)

রোগীর নং	প্রি টেস্ট স্কোর	পোস্ট টেস্ট স্কোর

Questionnaire

Research Title: Effectiveness of spirometry exercise along with active cycle of breathing technique to improve lung volume of tetraplegic SCI patients.

Part-1: (patient's identification)

- Patients's ID no:
- Name of the respondent:
- Age
- Adderss: vill: p.o: p.s:
  Dist:
- Educational status:
- Date of injury:
- Diagnosis:
- Injury level:
- Contact no:
- Consent taken
  Yes: No:
- Start time of intevention:
- End time of intervention:

Part – 2: (Subjective measurement)

1. Do you feel pain on chest during breathing?
   a) Yes b) No
2. Do you feel breathlessness during talking, eating & dressing?
   a) Yes b) No
3. Did you feel breathlessness before the injury?
   a) Yes b) No
4. Did you need mechanical ventilation after injury?
   a) Yes b) No
5. Do you have any respiratory disease such as asthma, pneumonia etc?
   a) Yes b) No
6. Have you taken any bronchodilator?
   a) Yes b) No

Part – 3: (Objective measurement)

- Patient's position: a) Supine b) Prone c) half lying d) side lying
- Chest shape: a) normal b) pigeon c) flat d) funnel
- Normal respiratory rate of the patient:
- Duration of using spirometer & active cycle of breathing technique:

Control group (lung volume measurement by spirometer):

Patient no	Pre test score	Post test score
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

Experimental group (lung volume measurement by spirometer):

Patient no	Pre test score	Post test score
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

Improvement of lung volume score in spirometer along with active cycle of breathing technique group and only using spirometer group were different in post- test scores. These have been shown in the Table below:

Using spirometry exercise along with active cycle of breathing technique group			Only using spirometry exercise group		
Subjects	Lung volume scores (xl)	X_1^2	Subjects	Lung volume scores (x2)	X_2^2
E1	1200	1440000	C1	1200	1440000
E2	1100	1210000	C2	900	810000
E3	1100	1210000	C3	800	640000
E4	900	810000	C4	800	640000
E5	900	810000	C5	800	640000
E6	1200	1440000	C6	1100	1210000
E7	1200	1440000	C7	800	640000
$\sum x_1 = 7600$		$\sum x_1^2 = 8360000$	$\sum x_2 = 6400$		$\sum x_2^2 = 6020000$

$\overline{x_1} = 1085$

‘$\sum x_1^2 = 8360000$

$(\sum x_1)^2 = 57760000$

$n_1 = 7$

$\overline{x_2} = 914$

$\sum x_2^2 = 6020000$

$(\sum x_2)^2 = 40960000$

$n_2 = 7$

The ‘t’ test formula-

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\left[\sqrt{\frac{\left(\sum x_1 2 - \frac{(\sum x_1)^2}{n_1}\right) + \left(\sum x_2 2 - \frac{(\sum x_2)^2}{n_2}\right)}{(n_1 - 1) + (n_2 - 1)}} \times \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}\right]}$$

$\overline{X_1}$ = mean of score from treatment group = 1085.71

$\overline{X_2}$ = mean of score from control group = 914.29

$\sum {x_1}^2$ = The square of the each individual score of experimental group totaled = 8360000

$\sum {x_2}^2$ = The square of the each individual score of control group totaled = 6020000

$(\sum x_1)^2$ = The total of the individual score from experimental group squared = 57760000

$(\sum x_2)^2$ = The total of the individual score from control group squared = 40960000

n_1 = Number of participants in the experimental group = 7

n_2 = Number of participants in the control group = 7

If we substitute these value in the formula,

$$t = \frac{1085.71 - 914.29}{\left[\sqrt{\frac{\left(8360000 - \frac{57760000}{7}\right) + \left(6020000 - \frac{40960000}{7}\right)}{(7 - 1) + (7 - 1)}} \times \sqrt{\left(\frac{1}{7} + \frac{1}{7}\right)}\right]}$$

$$= \frac{171.42}{\sqrt{\frac{(8360000 - 8251428.57) + (6020000 - 5851428.57)}{12}} \times \sqrt{\frac{2}{7}}}$$

$$= \frac{171.42}{\left[\sqrt{\frac{108571.43 + 168571.43}{12}} \times \sqrt{\frac{2}{7}}\right]}$$

$$= \frac{171.42}{\sqrt{\frac{277142.86}{12}}} \times 0.5345$$

$$= \frac{171.42}{151.97 \times 0.5345}$$

$$= 2.110$$

Permission letter

12th May, 2019

The Head

Department of Physiotherapy,

CRP, Chapain, Savar, Dhaka-1343.

Through: The Head of the Department, Department of Physiotherapy, BHPI.

Subject: Seeking permission to collect data to conduct 4th year Physiotherapy research project.

Dear sir,

With due respect and humble submission to state that I am Farjana Akter Bristi, student of 4th professional B.Sc. in physiotherapy at Bangladesh Health Professions Institute (BHPI). As a part of our course curriculum, we have to conduct a research project for the partial fulfillment of the requirement for the degree of B.Sc in physiotherapy. My dissertation title is "Effectiveness of spirometry exercise along with active cycle of breathing technique to improve lung volume of tetraplegic SCI patients" under the supervision of Mst. Fatema Akter, Senior lecturer, BHPI, CRP, Savar, Dhaka-1343, Bangladesh. The aim of the study is to improve lung volume of tetraplegic SCI patients. I have chosen spinal cord injury unit to collect required data. So, I need to collect the data of those patients who use incentive spirometer of your department. Now I am waiting for your kind approval to start my data collection.

So, I therefore pray and hope that you would be kind enough to give me the permission to collect data and complete the project successfully from your department.

Yours obediently,
Farjana Akter Bristi

Farjana Akter Bristi

4th professional B.Sc. in Physiotherapy

Roll No: 09, Session: 2014-15

Bangladesh Health Professions Institute (BHPI)

(An academic Institute of CRP)

CRP,Chapain, Savar, Dhaka-1343.

Forwarded & Recommended
12.05.19
Prof. Md. Obaidul Haque
Head, Department of Physiotherapy
BHPI, CRP, Savar, Dhaka-1343

Approved
Forward
12.05.19
12/05/19
Mohammad Anwar Hossain
Associate Professor & Head
Physiotherapy Dept., CRP
CRP-Chapain, Savar, Dhaka-1343

Date: 15/06/2019
The Chairman
Institutional Review Board (IRB)
Bangladesh Health Professions Institute (BHPI)
CRP-Savar, Dhaka-1343, Bangladesh

Subject: **Application for review and ethical approval.**

Sir,

With due respect I would like to draw your kind attention that I am a student of B.Sc. in Physiotherapy at Bangladesh Health Professions Institute (BHPI)- an academic institute of CRP under Faculty of Medicine of University of Dhaka (DU). I have to conduct a thesis entitled "**Effectiveness of spirometry exercise along with active cycle of breathing technique to improve lung volume of tetraplegic SCI patients**" under honorable supervisor, Mst. Fatema Akter, Senior lecturer, Department of Physiotherapy, BHPI, CRP, Savar, Dhaka-1343, Bangladesh. The purpose of the study is to evaluate the effectiveness of spirometry exercise along with active cycle of breathing technique to improve lung volume of tetraplegic SCI patients.

The study involves use of a questionnaire. It may take approximately 15 to 20 minutes to fill in the questionnaire. There is no likelihood of any harm to the participants. Related information will be collected from the patients' guide books. Data collectors will receive informed consents from all participants. Any data collected will be kept confidential.

Therefore I look forward to having your kind approval for the thesis proposal and to start data collection. I can also assure you that I will maintain all the requirements for study.

Sincerely,

Farjana Akter Bristi
4th year Student of B. Sc in physiotherapy
Session: 2014-2015 Student ID: 112140241
BHPI, CRP, Savar, Dhaka-1343, Bangladesh

Recommendation from the thesis supervisor:

Mst. Fatema Akter
Senior lecturer , Department of Physiotherapy
BHPI, CRP, Savar, Dhaka-1343, Bangladesh

বাংলাদেশ হেল্‌থ প্রফেশন্স ইনস্টিটিউট (বিএইচপিআই)

BANGLADESH HEALTH PROFESSIONS INSTITUTE (BHPI)

(The Academic Institute of CRP)

CRP-Chapain, Savar, Dhaka-1343. Tel: 02-7745464-5, 7741404

Ref: CRP-BHPI/IRB/7/19/1355

Date: 24/09/2019

To
Farjana Akter Bristi
4th professional B.Sc. in Physiotherapy
Session: 2014-2015, Student ID: 112140241
BHPI, CRP, Savar, Dhaka-1343, Bangladesh.

Subject: Approval of the thesis proposal "**Effectiveness of Spirometry exercise along with active cycle of breathing technique to improve lung volume of tetraplegic SCI patients**" by ethics committee.

Dear Farjana Akter Bristi,

Congratulations.
The Institutional Review Board (IRB) of BHPI has reviewed and discussed your application to conduct the above mentioned dissertation, with you, as the Principal investigator. The Following documents have been reviewed and approved:

Sr. No.	Name of the Documents
1	Dissertation Proposal
2	Questionnaire (English & Bangla version)
3	Information sheet & consent form.

The purpose of the study is to evaluate the effectiveness of spirometry exercise along with active cycle of breathing technique to improve lung volume of tetraplegic SCI patients. The participant may take 5 minutes to answer the questionnaire. There is no likelihood of any harm to the participants. Data collectors will receive informed consents from all participants. Any data collected will be kept confidential. The members of the Ethics committee have approved the study to be conducted in the presented form at the meeting held at 10 AM on 11th August, 2018 at BHPI.

The institutional Ethics committee expects to be informed about the progress of the study, any changes occurring in the course of the study, any revision in the protocol and patient information or informed consent and ask to be provided a copy of the final report. This Ethics committee is working accordance to Nuremberg Code 1947, World Medical Association Declaration of Helsinki, 1964 - 2013 and other applicable regulation.

Best regards,

Muhammad Millat Hossain
Assistant Professor, Dept. of Rehabilitation Science
Member Secretary, Institutional Review Board (IRB)
BHPI, CRP, Savar, Dhaka-1343, Bangladesh