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EFFECT OF REPEATED MUSCLE STRENGTHENING TRAINING OF UPPER EXTREMITY MUSCLES FOR PATIENTS WITH INCOMPLETE TETRAPLEGIC SPINAL CORD INJURY

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"EFFECT OF REPEATED MUSCLE STRENGTHENING TRAINING OF UPPER EXTREMITY MUSCLES FOR PATIENTS WITH INCOMPLETE TETRAPLEGIC SPINAL CORD INJURY"

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DECLARATION

I declare that the work presented here is my own. All sources used have been cited appropriately. Any mistakes or inaccuracies are my own. I also decline that for any publication, presentation or dissemination of information of the study. I bound to take written consent of Head of the Physiotherapy Department, BHPI.

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Acronyms

ASIA:	American Spinal Injury Association
AIS:	Asia Impairment Scale
BHPI	Bangladesh Health Professions Institute
BMRC	Bangladesh Medical Research Council
CRP	Centre for the Rehabilitation of the Paralysed
IRB	Institutional Review Board
SCI	Spinal Cord Injury
SPSS	Statistical Package for the Social Service
MMT	Manual Muscle Testing
WHO	World Health Organization

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Abstract

Purpose: Spinal Cord Injury is described as one of the most devastating neurological impairment. Individual with cervical injury has paralysis of both upper and lower limb. The present study was conducted to analyze and identify the therapeutic effect of repeated muscle strengthening training of upper extremity muscles for the treatment of patient with incomplete tetraplegic spinal cord injury. This study made the comparison, in order to discover the most effective treatment to alleviate the symptoms of the condition. **Objectives**: The objectives of the study is to investigate the effect of repeated muscle strengthening training of upper extremity muscles for following muscles strength (Elbow flexor, Elbow extensor, Wrist flexor, Wrist extensor) and VO_{2max} among the patients with incomplete tetraplegic SCI. **Methodology:** The study was randomized control trial design. Total 30 samples were selected conveniently and then randomly assigned to experimental and control groups from inpatient treatment service of Spinal Cord Injury Unit, Physiotherapy Department, Centre for the Rehabilitation of the Paralysed (CRP), Savar, Dhaka. Structured questionnaire was used to assess the socio-demographic and other information of the participants. Pre-test was performed before beginning the treatment. The same procedure was performed to take post-test at the end of 4 weeks of treatment. Total treatment sessions were 5 sessions per week for 4 weeks. Single blinding procedure was used during data collection. **Outcome measurement tools:** Oxford Grade Scale and Manual Muscle Testing were used to measure muscle strength. **Analysis of data:** Inferential statistics such as Mann-Whitney U test, Wilcoxon sign rank test, Unpaired t test and Paired t test was done using SPSS version 20. **Result:** The results were found to be significant in between group analysis, in case of right elbow extensor muscle strength (p value=0.04 for Oxford Grade Scale and p value= 0.013 for Manual Muscle testing scale) and VO_{2max} (P value= 0.034). But it was not found to be significant in case of left elbow extensor, right and left elbow flexor and right and left wrist flexor and extensor muscles strength. In within Group analysis, in case of the above mentioned variables, the results were found to be significant more in experimental group than control group. **Conclusion:** The study concluded as the repeated muscle strengthening training of upper extremity muscles for patients with incomplete tetraplegic spinal cord injury may not significantly capable of producing beneficial effects within this 4 weeks period on the improvement of their muscle strength comparing with conventional physiotherapy alone.

Keywords: SCI, tetraplegic, conventional physiotherapy, repeated muscle strengthening training.

CHAPTER –I INTRODUCTION

1.1. Background:

Spinal cord injury (SCI) is one of the major problem and catastrophic event related to the health of people. Spinal cord injury is one of the biggest health problem of human that leads to both physical and mental problems for disabled persons as well as their family (Moghimian et al., 2015). Symptoms can vary widely and produce pain, paralysis, sensory impairments and bowel-bladder dysfunction according to site of lesion on spinal cord and nerve roots (Ning et al., 2012).

Bangladesh is a developing country which has a large population. Almost 10% of total population are disable in here and from them physically disable are 43% (Haque, 2012). In Bangladesh, there has poor occupational safety measures, unusual roads and mixed traffic, vehicle users are not willing to use seat-belts. That's why the population of this country vulnerable to Spinal Cord Injury (Razzak et al., 2017). Spinal cord injury (SCI) is the most common injury which is not only medically complex but also a life-threatening condition (World Health Organization, 2013).

The epidemiology of spinal cord injury vary from one to another country such as developed and in developing countries around the world. Global prevalence following spinal cord injury is not estimated accurately. Around 250 000 to 500 000 people suffer from spinal cord injury (SCI) around the world every year (WHO, 2013). The incidence rates of spinal cord injury differs from perhaps 15 to 50 per million (Srivastava, et al., 2015). Male genders were found to be more vulnerable to have SCI than female (National Spinal Cord Injury Statistical Center, 2016). The most affected age range is found to be young adult (20-29 years) and older age >70 years. In case of female gender, adolescence aged from (15-19) are found to be more prone and older age >60 years. According to various study report, male female ratio is 2:1 and they also reported that this ration may be higher in sometime (WHO, 2013).

The social assistance and rehabilitation for the physical vulnerable (SARVE) identified that in Bangladesh, almost 10% of the total population are disabled. Also WHO reported the prevalence of the disable person around 10.5% and that is common in the rural areas. Physically disabled population rate is 27.5% (Disability in

Bangladesh, 2004). 4.6% people are disabled due to Spinal cord injury approximately (Hossain, 2001).

Fever, pulmonary complications, electrolyte disturbances, urinary tract infections, postural hypotension, autonomic dysreflexia, cardiovascular disease, osteoporosis and fractures, myositis ossification, deep vein thrombosis, pressure sore etcetera are the most common complications of patients with SCI (Yang et al., 2014).

Spinal cord injury (SCI) was one of the most devastating condition to the mankind (Rathore et al., 2008). In the developing countries like Bangladesh, road safety situation was come off day by day and the road traffic accident (RTA) is increasing each day in recent year (Razzak, 2013). RTA is the most common cause of spinal cord injury followed by fall and sports injury in developed country too (Rathore, 2010). Spinal cord injuries are narrated at various level incomplete and complete injuries. The incomplete injured patients have some functional preservation below the level of injury where in case of complete patients, there is no motor or sensory function being preserved below the level of injury (Lin et al., 2002).

The type and degree of impairments and functional ability depends on the level and the severity of the injury. According to study estimation, there are almost incomplete tetraplegia- 29.5%, complete paraplegia- 27.9%, incomplete paraplegia- 21.3% and complete tetraplegia- 18.5% and the most common neurologic level of injury is C5 (Hoque et al., 1999). The patients of SCI go in the different hospitals for getting treatment. But every hospitals have not adequate facilities about the SCI management. There is only one non-government organization CRP has realized the importance of producing a rehabilitation program for these patients through which the patients can improve their functional independency after SCI in Bangladesh (Hoque et al., 1999). And in Bangladesh, there are two specialized hospitals for conducting treatment of spinal cord injury (SCI). They are National Institute of Traumatology Orthopedics and Rehabilitation (NITOR) and Center for the Rehabilitation of the Paralyzed (CRP). Here, only CRP provides not only the treatment but also complete rehabilitation training to the patients SCI (Disability in Bangladesh, 2004), and management procedure is based on both multi- and inter-disciplinary approach through the community based rehabilitation programs (Hoque et al, 1999).

We know that spinal cord injuries are considered as either complete or incomplete.

The persons with complete spinal cord injury, there is complete loss of sensation and muscle function in the body below the level of the injury. But in case of incomplete spinal cord injury there may some remaining function below the level of the injury. Both sides of the body are affected equally mainly. Due to an injury or lesion of the cervical spinal cord, tetraplegia mainly occurs leading in a partial or total sensory and motor of the four limbs (Spooren et al., 2009).

The most common impairments after spinal cord injury (SCI) is muscle weakness secondary to partial paralysis. Any disruption to some but not all motor pathways results in partial paralysis. And due to this type of weakness in the upper limbs profoundly reduce hand functions. For example, people with C6 injuries effect on strength of the wrist extensor muscles that impacts on hand function (Bye et al., 2016).

To increase strength, many different interventions are used. And from them, the most common type of intervention is progressive resistance training. Progressive resistance training provides beneficial effect largely from various trials involving people with paralysis. Although it cannot be identified that what is effective for muscles of active individuals is also effective for the partially paralyzed muscles of a person with SCI (Lam et al., 2016).

Most complete and incomplete spinal cord injury (SCI) may lead to partial paralysis of muscles at or below the level of injury. For example, people complete SCI (AIS A) and motor level of C5 often have grade 1 or 2 strength in the wrist extensor and those with incomplete paraplegia (AIS C) often have grade 1 or 2 muscles strength in lower limb muscles. As affected muscles are very weak, it limits persons' mobility and independence. For increasing strength in the neurally-intact muscles of individuals, progressive resistance exercise is an effective way and that training is performed with sufficient resistance which is appropriately progressed (Munn et al., 2005).

According to American College of Sports Medicine 2005, the recommended intensity for dynamic training is 1–3 sets of 8–12 repetition maximum (resting for 1–3 minutes between sets), 2–3 times a week whilst the optimal parameters continue to be debated. The weight lifting with maximum repetition increases progressively as strength improves over time (Kraemer et al., 2002). Physiotherapy (PT) interventions are

extensively used to increase the voluntary strength of neurologically weak muscles that are affected by spinal cord injury (SCI).

1.2. Rationale of the study:

Spinal cord injury (SCI) results loss of ability to control functions of body systems that leads the patients unable to control their movements due to poor muscle power. The most common is neurologically-induced weakness of the upper limbs following tetraplegia that results from partial paralysis of muscles. Patients with spinal cord injury reduces motor functional control and self-care activities. The ability to use the hands are high priorities for people with SCI and important determinants of quality of life. Many different interventions are used and advocated to increase strength. However, the most common type of treatment is strength training. As the Bangladesh is a developing country and trying to develop health care system. So the spinal cord injury patient needs a specialized services to improve their functional ability which can be gained after strengthening muscle. Strength training increases strength in partially paralyzed muscles of people with incomplete SCI, although it is not clear whether the number of the repetition effect is clinically meaningful. It is believed that repeated contraction or even repeated attempts at contractions of weak muscles increases strength by promoting better connectivity between the brain and motor units. The underlying mechanisms are not well understood but are often imposed to neural plasticity. This training may also prompt hypertrophy and changes in the muscle itself. However it is not known if repeated contractions of muscles increases strength. Physiotherapy approaches and techniques play an important role in the treatment of patients with incomplete SCI.

As a physiotherapist, we need to maximize the functional independence of the people with SCI. That is why we have to set specific intervention that may help to strengthen muscle effectively. In Bangladesh, very little research revealed to determine the effectiveness of different strength training.

So this study was designed to investigate the effect of repeated muscle strengthening training of upper extremity muscles for the patients with incomplete spinal cord injury.

1.3 Aim

To compare the effectiveness of repeated muscle strengthening of upper extremity muscles combined with conventional physiotherapy versus conventional physiotherapy alone for increasing strength in people with incomplete spinal cord injury.

1.4 Objectives

1.4. a. General objective

To determine the effectiveness of repeated muscle strengthening training of upper extremity muscles combined with conventional physiotherapy and conventional physiotherapy alone.

1.4. b. Specific objectives

i. To identify the socio-demographic status of the participants.
ii. To explore the effects of repetitive muscle strengthening training.
iii. To investigate the changing of muscle strength.
iv. To compare between effectiveness of repeated muscle strengthening of upper extremity muscles combined with conventional physiotherapy and conventional physiotherapy alone.
v. To find out the effect of repeated muscle strengthening training on VO_{2max}.

1.5. Null Hypothesis and Alternate Hypothesis:

1.5.a. Null-Hypothesis

Repeated muscle strengthening training of upper extremity muscles is no more effective than only conventional physiotherapy for the patients with incomplete tetraplegic Spinal Cord Injury.

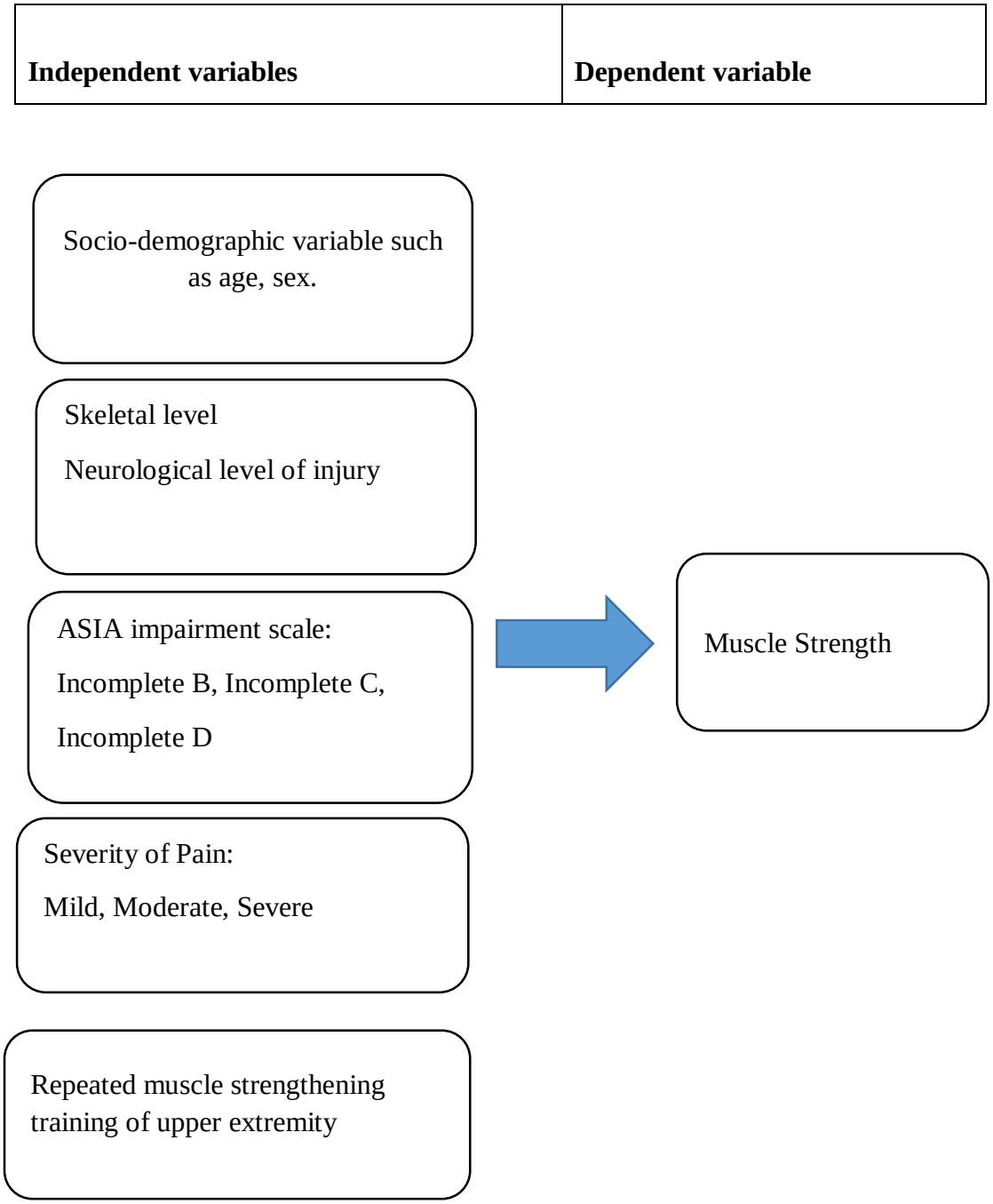
Ho: $\mu 1-\mu 2 = 0$ or $\mu 1=\mu 2$, where the experimental group and control group initial and final mean difference is same.

1.5.b. Alternative Hypothesis

Repeated muscle strengthening training of upper extremity muscles is more effective than only conventional physiotherapy for patients with incomplete tetraplegic Spinal Cord Injury.

Ha: $\mu 1- \mu 2 \neq 0$ or $\mu 1 \neq \mu 2$, where the experimental group and control group initial and final mean difference is not same.

1.6 Conceptual Framework



1.8 Operational definition

Spinal Cord Injury-

A Spinal Cord Injury is defined as damage or trauma to the spinal cord that causes loss or impaired function and sensation in parts of the body served by the spinal cord below the level of the lesion.

Skeletal level-

The level at which the greatest vertebral damage is found after radiological examination.

Neurological level-

The neurological level of injury is determined by identifying the most caudal segment of the cord with both intact sensation and normal antigravity muscle function strength.

Tetraplegia-

Tetraplegia, also known as quadriplegia, is paralysis caused by illness or injury that results in the partial or total loss of use of all four limbs.

Paraplegia-

Paraplegia is an impairment in motor or sensory function of the lower extremities.

Complete injury-

A complete injury means there is no function, no sensation and no voluntary movement below the level of the injury. Both sides of the body are equally affected.

Incomplete injury-

An incomplete injury means there is some function below the primary level of injury. A person with an incomplete injury may be able to move one limb more than another.

Effectiveness-

Effectiveness is the capacity of producing a desired result. When something is seemed effective, it means it has an anticipated or expected outcome or produces a deep, vivid impression.

Conventional physiotherapy-

Treatment that is widely accepted and used by most health care professionals.

ASIA: American Spinal Injury Association.

AIS: Asia Impairment Scale.

AIS A: Complete. No sensory or motor function is preserved in sacral segments S4-S5.

AIS B: Incomplete. Sensory function below neurologic level and in S4-S5, no motor function below neurologic level.

AIS C: Incomplete. Motor function is preserved below neurologic level and more than half of the key muscle groups below neurologic level have a muscle grade less than 3.

AIS D: Incomplete. Motor function is preserved below neurologic level and at least half of the key muscle groups below neurologic level have a muscle grade 3.

AIS E: Normal. Sensory and motor function is normal.

MMT: Manual Muscle Testing.

VO_{2max}: The maximum or optimum rate at which the heart, lung and muscles can effectively use oxygen during exercise. It is measured as milliliters of oxygen used in one minute per kilogram of body weight (ml/kg/min).

CHAPTER –II LITERRATURE REVIEW

The spinal cord is a part of the central nervous system (CNS) that expands caudally and is protected by the bony structures of the vertebral column. Three membranes of the CNS cover the spinal cord, (the dura mater, arachnoid and the innermost pia mater). It diffuses only the upper two-thirds of the vertebral canal as the growth of the bones composing the vertebral column is proportionally more rapid than that of the spinal cord of the adult mammals (Snell, 2010). The spinal cord can be divided into four parts according to its rostrocaudal location which are cervical, thoracic, lumbar and sacral. From them, two are marked by an upper or cervical) and a lower or lumbar (Nogradi & Vrobova, 2010).

Spinal cord is around 42-45 cm long & it expands down from the brain to the L1−L2 vertebral level and terminate in the conus medullaris. The whole sequence is situated within the spinal column. Cauda equina (or "horse's tail") is continuing from the end of the spinal cord in the spinal canal. The spinal cord has neurological segmental levels which assemble to the nerve roots that exit the spinal column between each of the vertebrae. Total 31 pairs of spinal nerve roots are remain there. Among them cervical is 8, thoracic is 12, lumbar is 5, sacral is 5 and 1 is coccygeal (Snell, 2010). According to International perspective on spinal cord injury; WHO, 2013, due to the difference in length between the spinal column and the spinal cord, the neurological levels do not necessarily assemble to the vertebral segments.

Spinal cord is flattened shape in anterior and posterior portion and is cylindrical in form (Back, 2006). It is blooms on the foramen magnum inside the cranium and it continues with the medulla oblongata within the brain. It ends inferiorly at the border of the lower border of the first lumber vertebra. The region of the spinal cord within the vertebral foramen is regarded as the vertebral canal (Snell, 2010). The spinal cord is defended by the vertebral bodies anteriorly and safeguarded by vertebral arches laterally and posteriorly. The spinal nerves and the brain are attached by the spinal cord. Motor and sensory impulse travels between the brain and the body through the spinal canal (Kirshblum et al., 2011). The receptor of the body receives sensory stimuli from environment. The sensory stimuli sends information to the brain and then the received information is transferred by the brain to the spinal nerves via spinal cord. This information helps to produce movements of the body (Snell, 2010).

According to Lam et al. (2008), the spinal cord jumbles longitudinal orientation of spinal tracts called white matter and surrounding the central regions called gray matter in where maximum spinal neuronal cell bodies are placed. Sensory and motor neurons are consisted in the gray matter that is arranged into segments. Axons from spinal sensory neurons enter and from motor neurons, axons leave the spinal cord via segmental nerves or roots. The roots are numbered and named following the foramina through which they enter and exit the vertebral column. The right and left C6 roots pass through foramina which is situated among the C5 and C6 vertebrae. Sensory stimulation is accepted by each root from skin areas which is called dermatomes. Similarly, a group of muscles that are innervated by single spinal nerve is called myotome. Dermatome usually illustrates a discrete and contiguous skin area where maximum roots innervate more than one muscle and most muscles are innervated by more than one root.

Spinal cord injury (SCI) is an occurrence that can be traumatic or non-traumatic which results in impairment to normal sensory, motor or autonomic function and ultimately disrupts patient's physical, psychological and social well-being (Singh et al., 2014). This is one of the most dangerous public health problem in Bangladesh (Hoque et al., 2012). In medical term spinal cord injury may be defined as any kind of damage or trauma to the spinal cord that leads to loss or impaired activities ensuing in decreased mobility or feeling (Curtin et al., 2005).

In Bangladesh, most of the people live below economic level. As many of them are day laborer and something like that, it is a common practice to carry heavy load on the head. That's why it is a common cause of the SCI after accidental fall while carrying load (Hoque et al., 2012). In Bangladesh, during harvesting season the farmers and laborers have to carry heavy loads on their head and transfer them from harvesting areas to local store houses/ respective places or from one vehicle to another. Basically the common causes of SCI in Bangladesh are fall while carrying heavy load on head, road traffic accidents, falling from a height, fall of a heavy object on the head or neck, bull attack and shallow diving etc (Hoque et al., 2012). Razzak et al. (2011) reported that, each year, around 20-40 people per million of population acquire spinal injury. According to the report of National SCI statistical Centre (NSCISC) among the developed countries only in the U.S.A. every year almost 12000 new cases of SCI are identified. Perhaps 60% of cases held in people of the age range

(16-40 years) (Ottomaneli & Lind, 2009). There is no accurate number of people with SCI in Bangladesh recently. Therefore it is difficult to determine the total amount of patients with SCI in Bangladesh. In Bangladesh, the most common age ranges for SCI from 25-29 years and out of them 83% are male (Islam et al., 2011). According to UNICEF, the appropriate marriage age in Bangladesh for male is 21 and for female is 18.

The major complication of SCI is paralysis upper and lower extremities. Complications can vary from one to another SCI people. Lack of skin sensation, pressure sore, bowel and bladder complexities, respiratory complications, and autonomic dysreflexia, sexuality dysfunction etc may arise in the person with SCI (Somers, 2006). Some other complications such as deep vein thrombosis, reduced vital capacity, osteoporosis, postural hypotension, spasticity and heterotrophic ossification result from spinal cord injury (Sinclair et al., 2006). From the practical and clinical observation of the researcher at CRP, it has been seen that the most common complication is pressure sore, urinary tract infection, bowel and bladder problem, burning sensation, autonomic dysreflexia, abdominal distension, psychosocial distress etc. One of the major and common complication of patient with tetraplegia is paralysis of both upper and lower limb muscles. Khazaeipour, (2014) stated that Personality and the social, cultural, and economic situation may be impacted affect recovery from the persons with SCI. Persons with spinal cord injury (SCI) may face serious health problems like bowel and bladder disorders, pressure ulcers, UTI, self-care, sexual dysfunction and neuropathic pain. Both physical and psychological health conditions are recognized as secondary health conditions which are influenced directly or indirectly by the presence of disability or associated physical injury (Adriaansen et al., 2013).

Motor function deficit occurs after SCI that causes disturbance in daily living activities (Rahman et al., 2012). One of the deaden condition is paralysis of the limb after injury like compression, contusion or laceration. It disrupts autonomic function that occurs at the site of injury or below and then permanent disability such as paralysis, loss of sensation, neuropathic pain etc. Symptoms or complications arise depending on the level of the lesion (Mothe & Tator, 2013). Spinal cord injury or damage may lead wide range of impairments, activity limitations and participation restrictions which impacts adversely on the society (New et al., 2013).

Partial preservation of sensory and/or motor functions is found below the neurological level and includes the lowest sacral segment in case of incomplete injury (Hossain et al., 2008). Another study also explored that the main causes of poor integration of persons with SCI into community life in general is inadequate services, poverty, negative attitudes of society towards the person with SCI, inequitable laws, the inaccessible built environment and transport systems (Lysack et al., 2007).

The classification of SCI severity is –A (complete): no motor or sensory function is preserved in the sacral segments S4-S5. B (incomplete): sensory but no motor function is preserved bellow the neurological level and includes the sacral segment S4 -S5. C (incomplete): Motor function is preserved below the neurological level, and more than a half of key muscles below the neurological level have a muscle grade of <3. D (incomplete): Motor function is preserved below the neurological level, and at least half of key muscles below the neurological level have a muscle grade of ≥3. E (normal): Motor and sensory functions are normal (American Spinal Injury Association (ASIA) impairment scale). In case of C4 injury- tetraplegia, C6 injury- tetraplegia, T6 injury- paraplegia, L1 injury- paraplegia (Thuret et al., 2006).

After 10yrs investigation, it was found that the life expectancy of people with SCI only 16.4% of the study population who survived for 10 years in Bangladesh which was much lower than in developed countries like Finland (97.9%), Australia (86%), Canada (92%), UK (85%), and USA (80.7%) etc. Also this the study revealed that the situation of Bangladesh is worse than other developing countries in the world. The data indicates that medical facilities of Bangladesh is very poor to promote the safe and worthwhile life after having a spinal cord injury. “The person who is primarily involved in the care of the patient and provides the most support and/or assistance is called primary caregivers” (Blanes et al., 2007).

The symptoms of spinal cord lesion depend on the causes or types of the injury. There may loss of sensory or motor control of the lower limbs, trunk and the upper limbs, as well as loss of autonomic (involuntary) regulation of the body. It also affects breathing, heart rate, blood pressure, temperature control, bowel and bladder control and sexual function of the body. In case of cervical spine injury, SCI commonly causes sensory and motor loss (paralysis) in the arms, body and legs which is referred

to as tetraplegia. People with SCI often have significant functional limitations and lack of independence depending on their level of injury (Notara et al., 2012).

CRP is a non-profitable organization in Bangladesh especially for the people with SCI. Patients get physiotherapy treatment for SCI and different neurological condition, musculoskeletal conditions from CRP. CRP is the only rehabilitation centre to manage the patient with SCI. CRP provides multi-dimensional treatments like medical, surgical and therapeutic. Physiotherapists are autonomous practitioner who not only assess and treat disorders of movement, function, and human performance caused by activity, injury, disease, disability or ageing, particularly those that affect the muscles, bones, joints, nervous system, heart, circulation and lungs but also provide preventive advice to live healthy. Health promotion, preventative healthcare, treatment and rehabilitation using a variety of physical, electro-physical, cognitive and pharmacological agents are provided by them.

In rehabilitation process physiotherapy is a crucial element that covers a diverse range of approaches such as manual therapy, vertebral therapy, exercise therapy, and electrotherapy. The service is conducted in both in-patients and out-patients. In CRP, physiotherapists act like primary health care professionals in where patients do not require a physician referral to visit a Physiotherapist. In different areas including: Orthopaedics, Neurology and Paediatrics, physiotherapists at CRP have developed competency to perform differential diagnosis regarding each of the primary Physiotherapy.

In case of post-accident patients, improvement or survival rates and life expectancy mean that these patients are supported by a caregiver for longer. So the health of caregivers has great importance (Bardak et al., 2012). Caregivers have to undertake heavy lifting. So they need to perform bent or twisted posture and biomechanical investigations have ensured that such tasks generate high spinal stress. These risk factors have been experimentally affected the development of injuries in spinal tissues (Warming et al., 2009). Rehabilitation depends on the severity of the injury, on the rate of complications and on rehabilitation goals (Post et al., 2005).

Following tetraplegia neurologically-induced weakness of the upper limbs is common that results from partial paralysis of muscles. Partial paralysis occurs due to disruption of some but not all neural pathways innervating muscles. So, strength of partially-

paralysed muscles is an important factor of independence and function in people with tetraplegia (Drolet et al 1999).

Sforzo and Touey (2013) found that exercises of the small-muscle group before exercises of the large-muscle group has less total force production in the exercises of the large-muscle group and in the total training session. These investigators also reported greater total force production in some but not all, single-joint exercises in case of performing exercise early in a training session that was composed of both upper- and lower-body exercises of the large-muscle and small-muscle groups. A clinical trial explored the effectiveness of progressive resistance training and electrical stimulation in muscles that were stronger and larger than those examined in the first trial. The results found a treatment effect in spite of the 95% confidence interval associated with the mean between-group difference was wide and failed to rule in or out the possibility of either a very small or very large treatment effect. Also the use of electrical stimulation made it more difficult to determine whether the electrical stimulation, the progressive resistance training or both were the important aspects for that training program (Harvey et al., 2010). Another randomized controlled trial involving the wrist muscles of people with SCI which failed to determine a clear therapeutic effect of progressive resistance training. However, many participants had strength of less than grade 3/5. Progressive resistance training may not be effective in these very weak participants due to insufficient neural drive to stimulate muscle fibre that was hypothesized. Repetitive practice with low resistance may be more important for those who were very weak people, because increasing in strength may be largely secondary to neural adaptation (Glinsky et al,. 2008). A small crossover trial of five participants compared isometric strength training with concentric strength training in the lower limbs of people with incomplete SCI where the between-group difference indicates that isometric strength training is superior to concentric strength training. Replication of these results in a larger trial but nonetheless suggest that the type of muscle contraction used in strength training may be important more (Roberto et al., 2005).

Physiotherapists provide huge time and effort to strengthening the partially-paralyzed upper limb muscles of people with tetraplegia although strengthening is carried out using the principles of progressive resistance exercise (Jacobs & Nash 2004). There are three trials examining the effectiveness of strength training but there is still

considerable uncertainty about the responsiveness of partially paralyzed muscles to any type of strength training program (Kraemer et al 2002).

For increasing strength, progressive resistance exercise is an effective way in the neurally-intact muscles of able bodied individuals provided that training is performed with sufficient resistance and it is appropriately progressed (Glinsky et al., 2008). While lifting weight, maximum repetition increases progressively as strength improves over time (Kraemer et al., 2002). It is now completely approved that strengthening does not increase spasticity. Once it was thought that high-intensity training was not recommended for individuals with central nervous system pathology due to fear of increasing their spasticity or tone (Jayaraman et al., 2013).

Usually upper extremity of SCI are focused for strength training. This is performed to help the individuals' transferring activities from their wheelchair and perform other activities of daily living. Progressive resistance exercise may have some effect on muscle endurance (American College of Sports Medicine, 2005). Long-term progressive resistance exercise with high repetition has been applied to a group of spinal cord injured patients including people with paraplegia who were taken for progressive resistance exercise for their neurally-intact upper limbs (Hicks et al., 2003). Spinal cord injury is an important determinant of function and improvements in strength are often used as an indication of neurological recovery that affects strength of muscles. Therapists applied various interventions with much effort to increase strength and promote neurological recovery. Out of them common methods are progressive resistance training, electrical stimulation, repetitious practice of functional activities and various types of robotic and treadmill assisted gait training programs. But few of us know about the effectiveness of any of these interventions on strength or neurological recovery.

''Position Stand on Progression Models in Resistance Training for Healthy Adults,'' that is recently published and the American College of Sports Medicine recommends that in a training session, exercises of the large-muscle group should be performed first. Because it improves the ability to use the heaviest resistances when performing the exercises of the large-muscle group and may result in the greatest long term strength gains. This sequence of exercises have also been recommended to allow the use of training resistances and volumes that optimize training adaptations. For

performing exercises of the large-muscle group first in a training session, the rational is that the total force production with this exercise order is greater than when performing exercises of the small-muscle group or single-joint exercises first.

Recent research shows that individuals with an incomplete spinal cord injury (SCI) have a capability to generate force that is observable during repeated intermittent maximal volitional effort contractions (Christopher et al., 2013). Maximal effort contractions, combined with intermittent rest associated with gaining function and strength in people with incomplete SCI (Thompson et al., 2016).

Exercise order in an upper-body–only session may affect the number of repetitions to volitional fatigue in exercises of both the large- and small-muscle groups. The number of repetitions to volitional fatigue is decreased if an exercise is performed end or late in a training or treatment session. The number of repetitions possible in an exercise performed in the middle of an upper-body session is not significantly affected (Roberto et al., 2005). It is important to gather knowledge about the effects of various physiotherapy interventions on strength. Researchers investigate drug or cellular therapies for neurological recovery and want to know how routinely application of physiotherapy affects the strength of neurologically-weak muscles, particularly the key muscles that are updated for the new 2019 International Standards for Neurological Classification of SCI (ISNCSCI) worksheet. Strength training increases strength in partially paralyzed muscles of people with recent SCI but it is not clear whether the size of the treatment effect is clinically significant or not. Strength training has no adverse effects on spasticity (Harvey et al., 2016). These results are important because weakness is a major problem for people with SCI and very little research revealed to determine the effectiveness of different strength training (Bye et al., 2016).

Every year many people come to CRP after SCI to take treatment. Most of them are tetraplegic. Physiotherapists ensure comprehensive rehabilitation services since patient’s admission until discharge of the patients. Among all of the physiotherapy intervention, strengthening training plays an important role not only for recovery anatomically but also improve functional ability too. So, the study was conducted to find out the effect of repetition on strengthening training for incomplete tetraplegic SCI.

CHAPTER –III METHODOLOGY

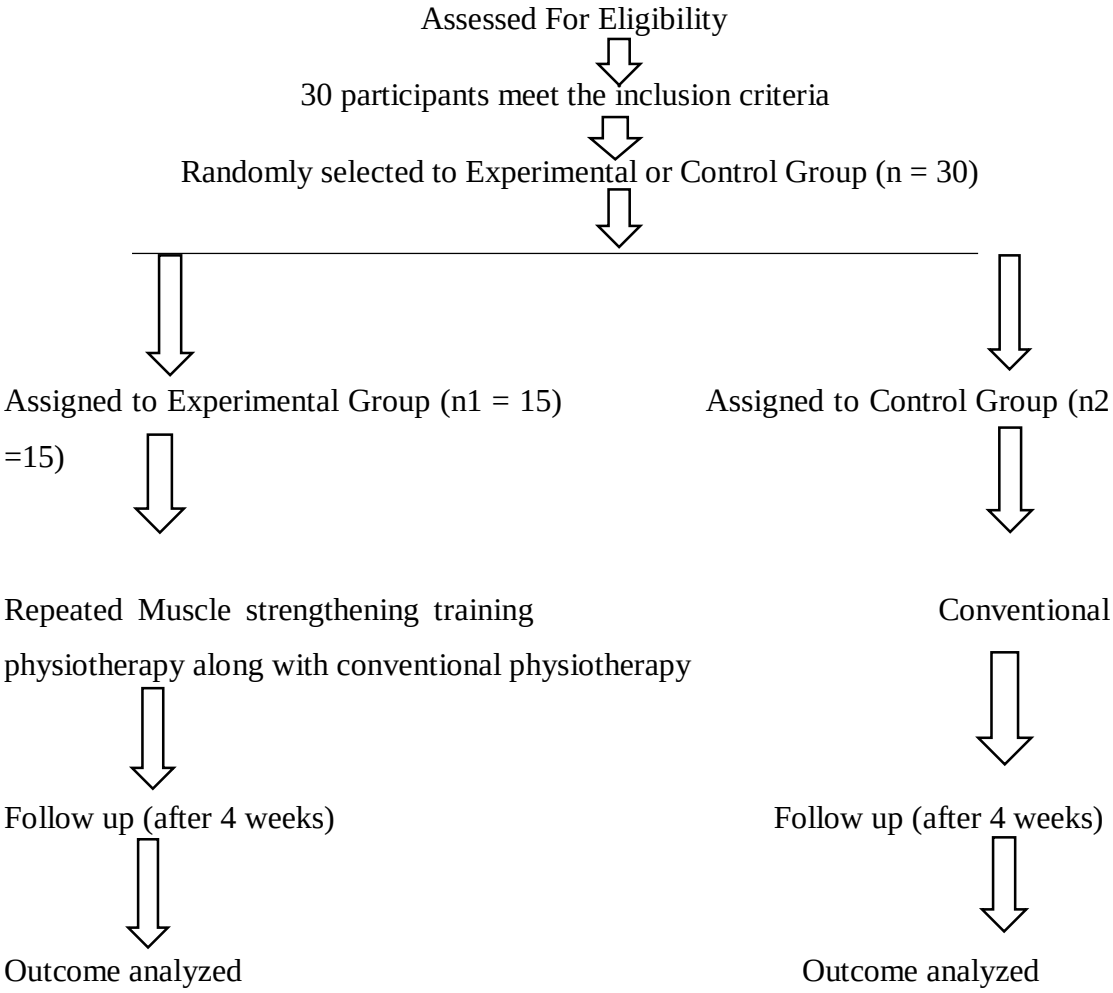
The study was an experimental design to evaluate the effectiveness of repeated muscle strengthening training of upper extremity for the patients with incomplete tetraplegic SCI and to compare between conventional physiotherapy and repeated muscle strengthening training of upper extremity combined with conventional physiotherapy for the patients with incomplete tetraplegic SCI. To identify the effectiveness of this treatment, the Oxford Grade Scale and Manual Muscle Testing were used as a measurement tool for measuring the muscles strength.

3.1 Study Design

Here Randomized controlled trial was used for the study design. The primary outcome of muscle strength was measured after 4 weeks trial. Eligible participants were randomized to one of two groups, either the Experimental group or the Control group.

Participants were assigned to the Experimental group received 50 repetitions of isolated contractions of the target muscle group only and also continued to receive "conventional physiotherapy". Participants were assigned to the Control group received conventional physiotherapy alone. Muscle strength was measured by using the Manual Muscle test on 12 points and Oxford Muscle Grade Scale.

Flowchart of the phases of randomized controlled trial



CONSORT flowchart for a randomized controlled trial of a treatment program including repeated muscle strengthening training of upper extremity muscles with conventional physiotherapy for patient with incomplete tetraplegic spinal cord injury.

3.2 Study Area

The study was conducted in Spinal Cord Injury Unit, Centre for the Rehabilitation of the Paralyzed (CRP), Chapain, Savar, Dhaka, 1343.

3.3 Study Population

The study population was the patients who were diagnosed as incomplete SCI attended in the SCI Unit of Physiotherapy Department at CRP, Savar, Dhaka.

3.4 Duration of Study

February, 2019 to August, 2019.

3.5. Selection Criteria

3.5.1. Inclusion Criteria

- **Study participants:** Incomplete tetraplegic Spinal Cord Injury patients were included. Gambhir et al. (2016) had demonstrated that tetraplegic spinal cord injury patients had problems with poor muscle strength of both upper and lower limb.
- **Age:** Age range 15-65 years. Ahn et al. (2015) had showed that within these age range, the participants had possibilities to get mostly affected with spinal cord injury.
- **Gender:** Both male & female patients could be included. According to Bowden et al. (2014), they had included that both male and female might get affected.
- Patients having American Spinal Injury Association (ASIA) Impairment Scale AIS B, C or D lesion (Jayaraman et al., 2013).
- The Patients with intact cognitive function were included. Allen & Dewilde, (2016) stated that in case of tetraplegic patients with SCI, cognition level might be intact at time of data collection as cognitive ability helps to identify the insight information from the participants.
- Patients had a grade 3 or 4 strength in the target muscle group on both sides of the body (Bye et al., 2016).

- The patients who had shown willingness to participate were included. Trgovcevic et al. (2014) explained that patient need have willingness to participate at the time of data collection for accurate information.

3.5.2. Exclusion Criteria

- Patients who were diagnosed with a deteriorating medical condition (Glinsky et al., 2008).
- Patients who had commenced rehabilitation elsewhere before admission to the SCI unit.
- Patients having American Spinal Injury Association (ASIA) Impairment Scale an AIS A and E lesion (Hagerman et al., 2002).
- If patients were not willing to participate in the trial (Melin et al., 2018).
- Patients who were psychologically unstable (Post & van Leeuwen 2012).

3.6 Sample Size

According to inclusion and exclusion criteria researcher selected 30 participants as a sample. From them 15 participants were assigned to experimental group and remaining 15 participants to control group.

3.7 Sampling Technique

Simple Random sampling technique was used in this study. An assessor-blind randomized controlled trial with pre-and post-measurements was conducted. Participants were measured by a blinded assessor once before intervention and again after completing 4 weeks intervention.

Participants, who met the inclusion criteria, were taken as sample in this study. 30 patients with incomplete SCI were selected from SCI unit of physiotherapy department of CRP, Savar and then 15 participants were randomly assigned to Experimental group comprising of treatment approaches of repeated muscle strengthening training of upper extremity muscles and 15 participants to the only the conventional physiotherapy for this study. The study was a single blinded technique. When the samples was collected, the researcher randomly assigned the participants into experimental and control group through Microsoft excel, because it improves 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 experimental group. Total 30 samples were included in this study, among them 15 patients were selected for the experimental group (Receive repeated muscle strengthening training of upper extremities in incomplete SCI) and rest 15 patients were selected for control group (Receive only conventional physiotherapy).

3.8. Data Processing

3.8.1. Data Collection tools

Data collective form, Consent form, Socio-demographic Questions, Structured Questionnaire, Close-ended Questionnaire, Pen, Papers were used for data collection.

3.8.2. Measurement Tools

Muscle Strength: Oxford Grade Scale (0-5) and Manual Muscle Testing Scale (0-11 points) were used to measure muscle strength of the participants before and after 4 weeks intervention.

VO_{2max}: Resting heart rate was measured manually. Participants were instructed to rest for two minute and then heart rate was measured. Maximum heart rate was calculated by HR max=220-Age equation. Then, VO_{2max} = 15 x (HRmax ÷ HRrest) calculation was used to measure the $VO_{2max.}$

3.9 Intervention

3.9.1. Control group

Control group received conventional physiotherapy only according to patient's response to treatment. Before starting conventional physiotherapy, all the patients was assessed properly by Spinal Cord Assessment Form in the study clinical settings.

Regular intervention including bed mobility, transferring, strengthening, stretching, balance- coordination training, deep breathing exercise etc were conducted by qualified physiotherapists (SCI staff). The treating therapists responsible for providing conventional physiotherapy were blinded to whether the target muscle group was receiving the strength training intervention. This was possible because the therapist providing the conventional physiotherapy were not also provide the strength training. Total intervention time was 60 minutes, 6 days per week. Overall 4 weeks trial.

3.9.2 Experimental group

Continue regular exercise or conventional physiotherapy such as strengthening, stretching, balance- coordination training and deep breathing exercise etc that were provided by qualified physiotherapist (SCI staff). The target muscles group of upper extremity (elbow flexor, elbow extensor, wrist Flexor, wrist extensor) in the treatment group were trained once a day, 5 days a week for 4 weeks following the repeated strengthening training. Participants performed 50 maximal contractions in five sets of 10. The first set of 10 maximal contractions were performed with 10 second rest interval and the remaining sets of 10 were continued with same procedure. Long interval was allowed if any fatigability developed. But Psychological encouragement was provided to the participants so that they could try to perform this training with positive motivation. Those 5 days of the training was supervised by qualified therapists. Participants was encouraged to maximum contract their muscles for 2 seconds with a 2 seconds rest between each contraction. Resistance applied through the hands of the therapists or with theraband which ensured the muscle contractions with maximum effort from the participants. Each session along with conventional physiotherapy was completed within a 60 minutes time frame.

Repeated Muscle Strengthening training Protocol

Muscle	Grade 3	Grade 4
Elbow flexor	**Position:** Supine lying with elbow extension. **Resistance:** Adjust the theraband so that the direction of pull opposed elbow flexion against gravity.	**Position:** Supine lying and arm down beside body. **Resistance:** Instructed the patient to flex their elbow in where theraband was used as moderate to strong resistance to oppose the movement.
Elbow Extensor	**Position:** Supine lying with their elbow flexion. **Resistance:** Adjust the theraband so that the direction of pull opposed elbow extension against gravity.	**Position:** Supine lying with flexed shoulder to 90 degree and flexed elbow. **Resistance:** Instructed the patient to extend their elbow in where theraband was used as moderate to strong resistance to oppose the movement.

Muscle	Grade 3	Grade 4
Wrist flexor	**Position:** Supine lying and arm down beside body. **Resistance:** Therapist used theraband so that the direction of pull opposed elbow extension against gravity.	**Position:** Sitting with the arm supported on a table, forearm supinated, hand over the edge of the table and palm facing upwards. **Resistance:** Instructed the patient to flex wrist in where theraband was used as moderate to strong resistance to oppose the movement.
Wrist extensor	**Position:** Sitting with semi flexed shoulder fully extended elbow. **Resistance:** Therapist used theraband so that the direction of pull opposed elbow extension against gravity.	**Position:** Sitting with arm supported on a table, forearm pronated and hand over the edge of the table. **Resistance:** Instructed the patient to extend their wrist in where theraband was used as moderate to strong resistance to oppose the movement.

3.10. Data Collection Procedure

The study procedure was conducted through assessing the patient, initial recording, treatment and final recording. After screening the patients at the department, the patients was assessed by a qualified physiotherapist. 4 weeks of treatment was provided for every participant. 30 participants were chosen for data collection according to the inclusion criteria. All participants were divided into two groups and codes were used like E1, E2, E3 etc for experimental group and C1, C2, C3 etc for control group.

Data was gathered through a pre-test before intervention and a post-test after intervention in where the data was collected by using a structured and close-ended written questionnaire form which had been formatted by the researcher. Data collection procedure was single blinded. Data was collected by the data collector and intervention was given by the clinical physiotherapist with the supervision of a qualified physiotherapist. Pre-test was performed before beginning the intervention. The same procedure was performed to apply post-test at the end of 4 weeks of treatment. Researcher provided the assessment form to the data collector to collect information from the selected participants before starting treatment and after finishing 4 weeks of intervention. The data collector collected all the data from the group in front of the qualified physiotherapist and verified by a witness selected by the Head of clinical setting in order to reduce the biasness. Different tests were carried out for statistical analysis after completing data collection procedure.

3.11. Data Analysis

In order to ensure that 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.

Statistical analysis was performed by using descriptive statistics for demographic data and inferential statistics for group differences of muscle strength and VO2 Max through Statistical Package for the Social Science (SPSS) version 20.

3.11.1. Statistical Test

According to Hicks (2009), "Experimental studies with the different participant design where two groups are used and each will be tested in two different conditions and the data is nominal or scale should be analyzed with the unrelated t test." The between group analysis of muscle strength was analyzed by Mann-Whitney U-test. The within group analysis of muscle strength was done by Wilcoxon singed rank test and VO2 max was done by Paired t test.

Mann-Whitney U test is a non-parametric test that is simply compares the result obtained from the each group to see if they differ significantly.

Assumption:

The independent variable should be two independent.

Categorical groups.

Observations should be independent.

Observations are not normally distributed.

The formula of Mann-Whitney U test:

$$\mathbf{U} = n_1 n_2 + \frac{n_x(n+1)}{2} - T_x$$

Here,

n_1 = the number of the subjects in trail group

n_2= the number of the subject in control group.

T_x= the larger rank total.

n_x= the number of the subjects of the group with larger rank total.

Table 1: Researcher has calculated all the U value and have presented in the following tables in this way (Mann-Whitney U test)

No	Muscle Strength (Oxford Grade Scale) between experimental and control group	Observed "U" value	Significance Level
01	Right Elbow flexor	121.500	0.713
02	Right elbow extensor	64.500	0.0453*
03	Right Wrist flexor	78.500	0.160
04	Right Wrist extensor	118.500	0.806
05	Left Elbow flexor	142.500	0.216
06	Left Elbow extensor	107.500	0.838
07	Left Wrist flexor	119.500	0.775
08	Left Wrist extensor	111.500	0.968

Table 2: Researcher has calculated all the U value and have presented in the following tables in this way (Mann-Whitney U test)

No	Muscle Strength (Manual Muscle Testing Scale) between experimental and control group	Observed "U" value	Significance Level
01	Right Elbow flexor	132	0.436
02	Right elbow extensor	53	0.013*
03	Right Wrist flexor	95	0.486
04	Right Wrist extensor	121.500	0.713
05	Left Elbow flexor	122	0.713
06	Left Elbow extensor	90	0.367
07	Left Wrist flexor	119.500	0.775
08	Left Wrist extensor	121.500	0.713

Wilcoxon sign-ranked test: This test is an alternative to the paired t test when the assumption of normality or equality of variances is not met.

Assumption:

Data are paired and come from the same population.

Each pair is chosen randomly and independently.

The data are measured on at least an interval scale when, as is usual, within-pair differences are calculated to perform the test (though it does suffice that within-pair comparisons are on an ordinal scale).

Formula of Wilcoxon sign-ranked test:

$$Z = \frac{W_x - \frac{n(n+1)}{4}}{\sqrt{\frac{n(n+1)(2n+1)}{24}}}$$

n= total number of participants

W_x= lowest value among positive and negative rank

Table 3: Researcher has calculated all the Z value and have presented in the following tables in this way (Wilcoxon Signed rank test) within experimental group

No	Muscle Strength (Oxford Grade Scale) within experimental group	Observed "Z" value	Significance Level
01	Right Elbow flexor	2.236	0.025*
02	Right elbow extensor	2.646	0.008*
03	Right Wrist flexor	2.646	0.008*
04	Right Wrist extensor	2.828	0.005*
05	Left Elbow flexor	2.00	0.046*
06	Left Elbow extensor	2.236	0.025*
07	Left Wrist flexor	2.646	0.008*
08	Left Wrist extensor	3.162	0.002*

Table 4: Researcher has calculated all the Z value and have presented in the following tables in this way (Wilcoxon Signed rank test) within control group

No	Muscle Strength (Oxford Grade Scale) within control group	Observed "Z" value	Significance Level
01	Right Elbow flexor	1	0.317
02	Right elbow extensor	1.414	0.157
03	Right Wrist flexor	1.732	0.083
04	Right Wrist extensor	2.00	0.046*
05	Left Elbow flexor	1.414	0.157
06	Left Elbow extensor	1.00	0.317
07	Left Wrist flexor	2.00	0.046*
08	Left Wrist extensor	2.00	0.046*

Table 5: Researcher has calculated all the Z value and have presented in the following tables in this way (Wilcoxon Signed rank test) within experimental group

No	Muscle Strength (Manual Muscle Testing Scale) within experimental group	Observed "Z" value	Significance Level
01	Right Elbow flexor	2.859	0.004*
02	Right elbow extensor	2.565	0.010*
03	Right Wrist flexor	2.807	0.005*
04	Right Wrist extensor	2.701	0.007*
05	Left Elbow flexor	2.070	0.038*
06	Left Elbow extensor	2.326	0.020*
07	Left Wrist flexor	2.970	0.003*
08	Left Wrist extensor	2.754	0.006*

Table 6: Researcher has calculated all the Z value and have presented in the following tables in this way (Wilcoxon Signed rank test) within control

No	Muscle Strength (Manual Muscle Testing Scale) within Control group	Observed "Z" value	Significance Level
01	Right Elbow flexor	2.449	0.014*
02	Right elbow extensor	1.00	0.317
03	Right Wrist flexor	2.079	0.038*
04	Right Wrist extensor	2.333	0.020*
05	Left Elbow flexor	1.633	0.102
06	Left Elbow extensor	1.00	0.317
07	Left Wrist flexor	2.640	0.008*
08	Left Wrist extensor	2.251	0.024*

The paired sample t-test: It is used to compare difference means of paired samples.

Assumptions:

The dependent variable must be continuous (interval/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 of related/ paired t- test:

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

Here,

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

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

SD= standard deviation of difference d, and

n= number of values in each pair.

Table 7: Researcher has calculated all the t value and have presented in the following tables in this way (Paired t test)

		Within Experimental group		**Within Control Group**	
	df	**'t' value**	**Significance Level**	**'t' value**	**Significance Level**
VO_{2max}					
	14	3.325	0.005*	4.468	0.001*

Unpaired t-test

Unpaired t-test was used to compare difference between two means of independent variables.

Assumption:

Different and independent variables

Variables are quantitative

Normal distribution of the variables

Formula:

$$t = \frac{\overline{X_1} - \overline{X_2}}{s\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

Here,

$\bar{x_1}$ = Mean of the Experimental Group,

$\bar{x_2}$ = Mean of the Control Group,

n_1 = Number of participants in the Experimental Group,

n_2= Number of participants in the Control Group

S = Combined standard deviation of both groups.

Table 8: Researcher has calculated all the t value and have presented in the following tables in this way (Unpaired t test)

	Observed "t" value	**df**	**Significance Level**
Difference between experimental and control group in VO_{2max} (ml/kg/min)	2.225	28	0.034*

3.11.2. Level of significance

In order to find out the significance of the study, the "p" value was calculated. The p values refer to 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. If the p value is equal or smaller than the significant level, the results are said to be significant. On the other hand when p value is greater than the significance level, the results are said to be not significant.

3.12. Ethical consideration

The researcher maintained some ethical considerations: A research proposal was submitted to the physiotherapy department of BHPI for approval and the proposal was approved by the faculty members and gave permission initially from the supervisor of the research project and from the course coordinator before conducting the study. The dissertation proposal including methodology was presented to the Institutional Review Board (IRB). Then the dissertation proposal including methodology was approved and obtained permission from the concerned authority of ethical committee of Bangladesh Health Professions Institute (BHPI). Again before the beginning of the data collection, researcher had to obtain the permission from the concerned authorities ensuring the safety of the participants. The confidentiality regarding participants condition and treatments were strictly maintained by the researcher. Researcher followed the Bangladesh Medical Research Council (BMRC) guideline & WHO research guideline.

3.13. Informed Consent

An information sheet and consent form in Bengali was used by the researcher to take the consent of participants. The researcher obtained consent of participation from every individuals. A signed informed consent form was received from each participant. The participants informed that they had the right to meet with outdoor doctor if it was found by them that the treatment was not enough to control the condition or if the condition became worsen. That's why, it had been informed to all the participants that they were completely free to decline answering any question as well as to withdraw their consent and terminate participation at any time during the study. The researcher also ensured that withdrawal of participation from the study

would not affect their treatment in the physiotherapy department and they could get the same facilities. Every individuals had the opportunity to discuss their problem and ask any questions related to their problem with the senior authority or administration of CRP for their own satisfaction.

CHAPTER –IV RESULTS

30 patients with incomplete tetraplegic Spinal Cord Injury were taken for this study. 15 participants received repeated muscle strengthening training of upper extremity muscles along with conventional physiotherapy (experimental group) and another 15 recieved conventional physiotherapy only (control group). All participants of both experimental and control group scored their muscle strength on Oxford muscle grade scale and Manual Muscle Testing scale before and after completing treatment. The characteristics of participants in each group were described details in Table -9 and Table -10.

4.1. Demographic Characteristics

The study was conducted on 30 participants with incomplete tetraplegic spinal cord injury. Out of the participants the mean age of the participants was 37.47 ± 9.999 years at experimental group and 32.20 ± 13.471 years at control group. Also 75% participants' age was ≥30 years in experimental group where in control group, 75% participant's age was ≥22. More male were affected (around 86.7% n= 13) than female (about 13.3% n=2) in experimental group and also in control group male were (around 93.3% n=14) which is greater than female. Most of the participants were married (around 86.7% n= 13) and unmarried (about 13.3% n=2) in experimental group when in control group married (60.0% n=9) and unmarried (40.0% n=6). Most of them (80%, n=36) were from the rural area in both experimental and control group. The most common occupation was businessman (around 33.3% n=5) in experimental group and in control group common occupation was day labor and student which was approximately 33.3% n=5. The mean average monthly income of experimental group participants was (around 15667±6965.903) and in control group (about 18400 ±13356.646). And 75% participants' income was ≥10000 in both experimental group & control group. (Table 9).

4.2. Clinical Characteristics

Fall from a height was the most common cause of SCI for approximately 40.0% (6) of the participants in control group while the second most common cause was fall while carrying heavy load for about 33.3% (5) in experimental group. According to ASIA Impairment Scale (AIS), 53.3% (8) and 60.0% (9) of the respondents were Incomplete – B in experimental and control group, while about 40.0% (6) and 26.7% (4) were Incomplete C and remaining 6.7% (1) and 13.3% (2) were Incomplete D in experimental and control group. Among total participants most common skeletal level was C5 and Neurological level was C4. In both group around 80% participants received surgical management and most of them are using assistive device. Pain was the most common symptoms in both group which was mild. In majority cases, no major disease was found. In experimental group, mean of right motor score was (13.07± 4.511) and left motor score was (14.33± 5.108) where in control group, mean of both right and left motor score were (9±4.053). In case of sensory score, mean of right and left light touch were (25.20± 8.419) and (26.27± 9.415) while pin prick were (18.47± 9.665) and (20± 9.657) in experimental group. And in case of control group participants, mean of right and left light touch were (23.07± 6.431) and (22.40± 8.373) where pin prick were (19.20± 8.521) and (18.33± 8.508). (Table 10).

Table 9: Demographic Characteristics

		Group Type					
		Experimental Group			Control Group		
		Mean (SD)	Median (IQR)	% (n)	Mean (SD)	Median (IQR)	% (n)
Age		37.47 ±9.999	40(30-45)		32.20 ± 13.471	32(22-40)	
Gender	Male			86.7% (13)			93.3% (14)
	Female			13.3% (2)			6.7% (1)
Marital Status	Married			86.7% (13)			60% (9)
	Unmarried			13.3% (2)			40% (6)
Occupation	Agriculture			20% (3)			20% (3)
	Rickshaw puller			6.7% (1)			0% (0)
	Driver			6.7% (1)			6.75 (1)
	Businessman			33.3% (5)			6.7% (1)
	Day Laborer			20% (3)			33.3% (5)
	Student			6.7% (1)			33.5% (5)
	Housewife			6.7%(1)			0% (0)
Monthly Income		15667 ±6965.903	15000 (10000-20000)		18400 ±13356.646	15000 (10000-18000)	
Residential area	Rural			73.3% (11)			86.7% (13)

Urban	26.7% (4)	13.3% (2)

Table 10: Clinical Characteristics

		Group types	
		Experimental group (n=15)	**Control group (n=15)**
		% (n)	**% (n)**
Cause of injury	Motor vehicle injury	20.0% (3)	26.7% (4)
	Fall from height	26.7% (4)	40.0% (6)
	Fall while carrying heavy load	33.3% (5)	26.7% (4)
	Sports injury	0% (0)	6.7% (1)
	Others	20.0% (3)	0% (0)
Initial neurological level by ASIA	Incomplete B	53.3% (8)	60.0% (9)
	Incomplete C	40.0% (6)	26.7% (4)
	Incomplete D	6.7% (1)	13.3% (2)
Skeletal level	C2	0% (0)	0% (0)
	C3	0% (0)	6.7% (1)
	C4	6.7% (1)	13.3% (2)
	C5	20.0% (3)	73.3% (11)
	C6	53.3% (8)	0% (0)
	C7	6.7% (1)	6.7% (1)
	C8	13.3% (2)	0% (0)
Neurological level	C2	0% (0)	6.7% (1)
	C3	20.0% (3)	20.0% (3)
	C4	46.7% (7)	66.7% (10)
	C5	33.3% (5)	6.7% (1)
Type of management	Surgical	80.0% (12)	80.0% (12)
	Conservative	20.0% (3)	20.0% (3)
Any assistive device	Yes	46.7% (7)	80.0% (12)
	No	53.3% (8)	20.0% (3)
Constant symptoms	Pain	73.3% (11)	66.7% (10)
	Paresthesia	26.67% (4)	33.3% (5)
Severity of pain	Mild	66.7% (10)	66.7% (10)

	Moderate	20.0% (3)	26.7% (4)
	Severe	13.3% (2)	6.7% (1)
Any major disease	Diabetes Mellitus	6.7% (1)	6.7% (1)
	No abnormalities detected	93.3% (14)	93.3% (14)

4.3. Muscle Strength that was measured by OXFORD GRADE SCALE (Mann-Whitney U test) between experimental and control group

4.3.1. Right Elbow Flexor strength

This study found that for right elbow flexor muscle strength, Mann-Whitney U test in between group at 5% level of significance observed U value was 121.500 and at the same significant level standard table value was 64. The observed U value was greater than the table value that means the null hypothesis was accepted and alternative hypothesis was rejected which means there was no difference between repeated muscle strengthening training of upper extremity and conventional Physiotherapy.

4.3.2. Right Elbow Extensor strength

This study found that for right elbow extensor muscle strength, Mann-Whitney U test in between group at 5% level of significance observed U value was 64 and at the same significant level standard table value was 64. The observed U value was not greater than the table value that means the null hypothesis was rejected and alternative hypothesis was accepted which means there was difference between repeated muscle strengthening training of upper extremity and conventional Physiotherapy.

4.3.3. Right Wrist Flexor strength

This study found that for right wrist flexor muscle strength, Mann-Whitney U test in between group at 5% level of significance observed U value was 78.500 and at the same significant level standard table value was 64. The observed U value was greater than the table value that means the null hypothesis was accepted and alternative hypothesis was rejected which means there was no difference between repeated muscle strengthening training of upper extremity and conventional Physiotherapy.

4.3.4. Right Wrist Extensor strength

This study found that for right wrist extensor muscle strength, Mann-Whitney U test in between group at 5% level of significance observed U value was 118.500 and at the same significant level standard table value was 64. The observed U value was greater than the table value that means the null hypothesis was accepted and alternative hypothesis was rejected which means there was no difference between repeated muscle strengthening training of upper extremity and conventional Physiotherapy.

4.3.5. Left Elbow Flexor strength

This study found that for left elbow flexor muscle strength, Mann-Whitney U test in between group at 5% level of significance observed U value was 142.500 and at the same significant level standard table value was 64. The observed U value was greater than the table value that means the null hypothesis was accepted and alternative hypothesis was rejected which means there was no difference between repeated muscle strengthening training of upper extremity and conventional Physiotherapy.

4.3.6. Left Elbow Extensor strength

This study found that for left elbow extensor muscle strength, Mann-Whitney U test in between group at 5% level of significance observed U value was 107.500 and at the same significant level standard table value was 64. The observed U value was greater than the table value that means the null hypothesis was accepted and alternative hypothesis was rejected which means there was no difference between repeated muscle strengthening training of upper extremity and conventional Physiotherapy.

4.3.7. Left Wrist Flexor strength

This study found that for left wrist flexor muscle strength, Mann-Whitney U test in between group at 5% level of significance observed U value was 119.500 and at the same significant level standard table value was 64. The observed U value was greater than the table value that means the null hypothesis was accepted and alternative hypothesis was rejected which means there was no difference between repeated muscle strengthening training of upper extremity and conventional Physiotherapy.

4.3.8. Left Wrist Extensor strength

This study found that for left wrist extensor muscle strength, Mann-Whitney U test in between group at 5% level of significance observed U value was 111.500 and at the same significant level standard table value was 64. The observed U value was greater than the table value that means the null hypothesis was accepted and alternative hypothesis was rejected which means there was no difference between repeated muscle strengthening training of upper extremity and conventional Physiotherapy.

4.4. Muscle Strength that was measured by OXFORD GRADE SCALE (Wilcoxon Signed rank test) within experimental and control group

4.4.1. Right Elbow Flexor strength

This study found that in experimental group, no participants had decreased muscle strength, 5 participants had higher muscle strength score and 10 participants had equal amount of muscle strength after application of repeated muscle strengthening training. By examining the final test statistics by Wilcoxon signed- ranked test, it was discovered that for n=15, Wilcoxon table gives Z= 2.236 and p value 0.025 which was less than 0.05. So, the null hypothesis was rejected and alternative hypothesis was accepted at the level of 5% significance which means repeated muscle strengthening training showed statistically significant change in right elbow flexor muscle strength. And in case of control group, no participants had decreased muscle strength, 1 participants had higher muscle strength score and 14 patients had equal amount of muscle strength after conventional physiotherapy. By examining the final test statistics by Wilcoxon signed- ranked test, it was discovered that for n=15, Wilcoxon table gives calculated Z= 1 and p value 0.317 which was greater than 0.05. So, the null hypothesis was accepted and alternative hypothesis was rejected which means conventional physiotherapy showed no statistically significant change in right elbow flexor muscle strength among individuals with incomplete tetraplegic SCI.

4.4.2. Right Elbow Extensor strength

This study found that in experimental group, no participants had decreased muscle strength, 7 participants had higher muscle strength score and 8 participants had equal amount of muscle strength after application of repeated muscle strengthening training. By examining the final test statistics by Wilcoxon signed- ranked test, it was discovered that for n=15, Wilcoxon table gives Z= 2.646 and p value 0.008 which was less than 0.05. So, the null hypothesis was rejected and alternative hypothesis was accepted at the level of 5% significance which means repeated muscle strengthening training showed statistically significant change in right elbow extensor muscle strength. And in case of control group, no participants had decreased muscle strength, 2 participants had higher muscle strength score and 13 patients had equal amount of muscle strength after conventional physiotherapy. By examining the final test statistics by Wilcoxon signed- ranked test, it was discovered that for n=15, Wilcoxon

table gives calculated Z= 1.414 and p value 0.157 which was greater than 0.05. So, the null hypothesis was accepted and alternative hypothesis was rejected which means conventional physiotherapy showed no statistically significant change in right elbow extensor muscle strength among individuals with incomplete tetraplegic SCI.

4.4.3. Right Wrist Flexor strength

This study found that in experimental group, no participants had decreased muscle strength, 7 participants had higher muscle strength score and 8 participants had equal amount of muscle strength after application of repeated muscle strengthening training. By examining the final test statistics by Wilcoxon signed- ranked test, it was discovered that for n=15, Wilcoxon table gives Z= 2.646 and p value 0.008 which was less than 0.05. So, the null hypothesis was rejected and alternative hypothesis was accepted at the level of 5% significance which means repeated muscle strengthening training showed statistically significant change in right wrist flexor muscle strength. And in case of control group, no participants had decreased muscle strength, 3 participants had higher muscle strength score and 12 patients had equal amount of muscle strength after conventional physiotherapy. By examining the final test statistics by Wilcoxon signed- ranked test, it was discovered that for n=15, Wilcoxon table gives calculated Z= 1.732 and p value 0.083 which was greater than 0.05. So, the null hypothesis was accepted and alternative hypothesis was rejected which means conventional physiotherapy showed no statistically significant change in right wrist flexor muscle strength among individuals with incomplete tetraplegic SCI.

4.4.4. Right Wrist Extensor strength

This study found that in experimental group, no participants had decreased muscle strength, 8 participants had higher muscle strength score and 7 participants had equal amount of muscle strength after application of repeated muscle strengthening training. By examining the final test statistics by Wilcoxon signed- ranked test, it was discovered that for n=15, Wilcoxon table gives Z= 2.828 and p value 0.005 which was less than 0.05. So, the null hypothesis was rejected and alternative hypothesis was accepted at the level of 5% significance which means repeated muscle strengthening training showed statistically significant change in right wrist extensor muscle strength. And in case of control group, no participants had decreased muscle strength, 4 participants had higher muscle strength score and 11 patients had equal amount of

muscle strength after conventional physiotherapy. By examining the final test statistics by Wilcoxon signed- ranked test, it was discovered that for n=15, Wilcoxon table gives calculated Z= 2 and p value 0.046 which was less than 0.05. So, the null hypothesis was rejected and alternative hypothesis was accepted which means conventional physiotherapy showed statistically significant change in right wrist extensor muscle strength among individuals with incomplete tetraplegic SCI.

4.4.5. Left Elbow Flexor strength

This study found that in experimental group, no participants had decreased muscle strength, 4 participants had higher muscle strength score and 11 participants had equal amount of muscle strength after application of repeated muscle strengthening training. By examining the final test statistics by Wilcoxon signed- ranked test, it was discovered that for n=15, Wilcoxon table gives Z= 2 and p value 0.046 which was less than 0.05. So, the null hypothesis was rejected and alternative hypothesis was accepted at the level of 5% significance which means repeated muscle strengthening training showed statistically significant change in left elbow flexor muscle strength. And in case of control group, no participants had decreased muscle strength, 2 participants had higher muscle strength score and 13 patients had equal amount of muscle strength after conventional physiotherapy. By examining the final test statistics by Wilcoxon signed- ranked test, it was discovered that for n=15, Wilcoxon table gives calculated Z= 1.414 and p value 0.157 which was greater than 0.05. So, the null hypothesis was accepted and alternative hypothesis was rejected which means conventional physiotherapy showed no statistically significant change in left elbow flexor muscle strength among individuals with incomplete tetraplegic SCI.

4.4.6. Left Elbow Extensor strength

This study found that in experimental group, no participants had decreased muscle strength, 5 participants had higher muscle strength score and 10 participants had equal amount of muscle strength after application of repeated muscle strengthening training. By examining the final test statistics by Wilcoxon signed- ranked test, it was discovered that for n=15, Wilcoxon table gives Z= 2.236 and p value 0.025 which was less than 0.05. So, the null hypothesis was rejected and alternative hypothesis was accepted at the level of 5% significance which means repeated muscle strengthening training showed statistically significant change in left elbow extensor muscle strength.

And in case of control group, no participants had decreased muscle strength, 1 participants had higher muscle strength score and 14 patients had equal amount of muscle strength after conventional physiotherapy. By examining the final test statistics by Wilcoxon signed- ranked test, it was discovered that for n=15, Wilcoxon table gives calculated Z= 1 and p value 0.317 which was greater than 0.05. So, the null hypothesis was accepted and alternative hypothesis was rejected which means conventional physiotherapy showed no statistically significant change in left elbow extensor muscle strength among individuals with incomplete tetraplegic SCI.

4.4.7. Left Wrist Flexor strength

This study found that in experimental group, no participants had decreased muscle strength, 7 participants had higher muscle strength score and 8 participants had equal amount of muscle strength after application of repeated muscle strengthening training. By examining the final test statistics by Wilcoxon signed- ranked test, it was discovered that for n=15, Wilcoxon table gives Z= 2.646 and p value 0.008 which was less than 0.05. So, the null hypothesis was rejected and alternative hypothesis was accepted at the level of 5% significance which means repeated muscle strengthening training showed statistically significant change in left wrist flexor muscle strength. And in case of control group, no participants had decreased muscle strength, 4 participants had higher muscle strength score and 11 patients had equal amount of muscle strength after conventional physiotherapy. By examining the final test statistics by Wilcoxon signed- ranked test, it was discovered that for n=15, Wilcoxon table gives calculated Z= 2 and p value 0.046 which was less than 0.05. So, the null hypothesis was rejected and alternative hypothesis was accepted which means conventional physiotherapy showed statistically significant change in left wrist flexor muscle strength among individuals with incomplete tetraplegic SCI.

4.4.8. Left Wrist Extensor strength

This study found that in experimental group, no participants had decreased muscle strength, 5 participants had higher muscle strength score and 10 participants had equal amount of muscle strength after application of repeated muscle strengthening training. By examining the final test statistics by Wilcoxon signed- ranked test, it was discovered that for n=15, Wilcoxon table gives Z= 3.162 and p value 0.002 which was less than 0.05. So, the null hypothesis was rejected and alternative hypothesis was

accepted at the level of 5% significance which means repeated muscle strengthening training showed statistically significant change in left wrist extensor muscle strength. And in case of control group, no participants had decreased muscle strength, 4 participants had higher muscle strength score and 11 patients had equal amount of muscle strength after conventional physiotherapy. By examining the final test statistics by Wilcoxon signed- ranked test, it was discovered that for n=15, Wilcoxon table gives calculated Z= 2 and p value 0.046 which was less than 0.05. So, the null hypothesis was rejected and alternative hypothesis was accepted which means conventional physiotherapy showed statistically significant change in left wrist extensor muscle strength among individuals with incomplete tetraplegic SCI.

4.5. Muscle Strength that was measured by MANUAL MUSCLE TESTING SCALE (Mann-Whitney U test) between experimental and control group

4.5.1. Right Elbow Flexor strength

This study found that for right elbow flexor muscle strength, Mann-Whitney U test in between group at 5% level of significance observed U value was 132 and at the same significant level standard table value was 64. The observed U value was greater than the table value that means the null hypothesis was accepted and alternative hypothesis was rejected which means there was no difference between repeated muscle strengthening training of upper extremity and conventional Physiotherapy.

4.5.2. Right Elbow Extensor strength

This study found that for right elbow extensor muscle strength, Mann-Whitney U test in between group at 5% level of significance observed U value was 53 and at the same significant level standard table value was 64. The observed U value was less than the table value that means the null hypothesis is rejected and alternative hypothesis was accepted which means there was significant difference between repeated muscle strengthening training of upper extremity and conventional Physiotherapy.

4.5.3. Right Wrist Flexor strength

This study found that for right wrist flexor muscle strength, Mann-Whitney U test in between group at 5% level of significance observed U value was 95 and at the same significant level standard table value was 64. The observed U value was greater than the table value that means the null hypothesis was accepted and alternative hypothesis

was rejected which means there was no difference between repeated muscle strengthening training of upper extremity and conventional Physiotherapy.

4.5.4. Right Wrist Extensor strength

This study found that for right wrist extensor muscle strength, Mann-Whitney U test in between group at 5% level of significance observed U value was 121.500 and at the same significant level standard table value was 64. The observed U value was greater than the table value that means the null hypothesis was accepted and alternative hypothesis was rejected which means there was no difference between repeated muscle strengthening training of upper extremity and conventional Physiotherapy.

4.5.5. Left Elbow Flexor strength

This study found that for left elbow flexor muscle strength, Mann-Whitney U test in between group at 5% level of significance observed U value was 122 and at the same significant level standard table value was 64. The observed U value was greater than the table value that means the null hypothesis was accepted and alternative hypothesis was rejected which means there was no difference between repeated muscle strengthening training of upper extremity and conventional Physiotherapy.

4.5.6. Left Elbow Extensor strength

This study found that for left elbow extensor muscle strength, Mann-Whitney U test in between group at 5% level of significance observed U value was 90 and at the same significant level standard table value was 64. The observed U value was greater than the table value that means the null hypothesis was accepted and alternative hypothesis was rejected which means there was no difference between repeated muscle strengthening training of upper extremity and conventional Physiotherapy.

4.5.7. Left Wrist Flexor strength

This study found that for left wrist flexor muscle strength, Mann-Whitney U test in between group at 5% level of significance observed U value was 119.500 and at the same significant level standard table value was 64. The observed U value was greater than the table value that means the null hypothesis was accepted and alternative hypothesis was rejected which means there was no difference between repeated muscle strengthening training of upper extremity and conventional Physiotherapy.

4.5.8. Left Wrist Extensor strength

This study found that for left wrist extensor muscle strength, Mann-Whitney U test in between group at 5% level of significance observed U value was 121.500 and at the same significant level standard table value was 64. The observed U value was greater than the table value that means the null hypothesis was accepted and alternative hypothesis was rejected which means there was no difference between repeated muscle strengthening training of upper extremity and conventional Physiotherapy.

4.6. Muscle Strength that was measured by MANUAL MUSCLE TESTING (Wilcoxon Signed rank test) within experimental and control group

4.6.1. Right Elbow Flexor strength

This study found that in experimental group, no participants had decreased muscle strength, 10 participants had higher muscle strength score and 5 participants had equal amount of muscle strength after application of repeated muscle strengthening training. By examining the final test statistics by Wilcoxon signed- ranked test, it was discovered that for n=15, Wilcoxon table gives Z= 2.859 and p value 0.004 which was less than 0.05. So, the null hypothesis was rejected and alternative hypothesis was accepted at the level of 5% significance which means repeated muscle strengthening training showed statistically significant change in right elbow flexor muscle strength. And in case of control group, no participants had decreased muscle strength, 6 participants had higher muscle strength score and 9 patients had equal amount of muscle strength after conventional physiotherapy. By examining the final test statistics by Wilcoxon signed- ranked test, it was discovered that for n=15, Wilcoxon table gives calculated Z= 2.449 and p value 0.014 which was less than 0.05. So, the null hypothesis was rejected and alternative hypothesis was accepted which means conventional physiotherapy showed statistically significant change in right elbow flexor muscle strength among individuals with incomplete tetraplegic SCI.

4.6.2. Right Elbow Extensor strength

This study found that in experimental group, no participants had decreased muscle strength, 8 participants had higher muscle strength score and 7 participants had equal amount of muscle strength after application of repeated muscle strengthening training. By examining the final test statistics by Wilcoxon signed- ranked test, it was

discovered that for n=15, Wilcoxon table gives Z= 2.565 and p value 0.010 which was less than 0.05. So, the null hypothesis was rejected and alternative hypothesis was accepted at the level of 5% significance which means repeated muscle strengthening training showed statistically significant change in right elbow extensor muscle strength. And in case of control group, 1 participants had decreased muscle strength, 3 participants had higher muscle strength score and 11 patients had equal amount of muscle strength after conventional physiotherapy. By examining the final test statistics by Wilcoxon signed- ranked test, it was discovered that for n=15, Wilcoxon table gives calculated Z= 1 and p value 0.317 which was greater than 0.05. So, the null hypothesis was accepted and alternative hypothesis was rejected which means conventional physiotherapy showed no statistically significant change in right elbow extensor muscle strength among individuals with incomplete tetraplegic SCI.

4.6.3. Right Wrist Flexor strength

This study found that in experimental group, no participants had decreased muscle strength, 9 participants had higher muscle strength score and 6 participants had equal amount of muscle strength after application of repeated muscle strengthening training. By examining the final test statistics by Wilcoxon signed- ranked test, it was discovered that for n=15, Wilcoxon table gives Z= 2.828 and p value 0.005 which was less than 0.05. So, the null hypothesis was rejected and alternative hypothesis was accepted at the level of 5% significance which means repeated muscle strengthening training showed statistically significant change in right wrist flexor muscle strength. And in case of control group, no participants had decreased muscle strength, 5 participants had higher muscle strength score and 10 participants had equal amount of muscle strength after conventional physiotherapy. By examining the final test statistics by Wilcoxon signed- ranked test, it was discovered that for n=15, Wilcoxon table gives calculated Z= 2.079 and p value 0.038 which was less than 0.05. So, the null hypothesis was rejected and alternative hypothesis was accepted which means conventional physiotherapy showed statistically significant change in right wrist flexor muscle strength among individuals with incomplete tetraplegic SCI.

4.6.4. Right Wrist Extensor strength

This study found that in experimental group, no participants had decreased muscle strength, 9 participants had higher muscle strength score and 6 participants had equal amount of muscle strength after application of repeated muscle strengthening training. By examining the final test statistics by Wilcoxon signed- ranked test, it was discovered that for n=15, Wilcoxon table gives Z= 2.701 and p value 0.007 which was less than 0.05. So, the null hypothesis was rejected and alternative hypothesis was accepted at the level of 5% significance which means repeated muscle strengthening training showed statistically significant change in right wrist extensor muscle strength. And in case of control group, no participants had decreased muscle strength, 6 participants had higher muscle strength score and 9 participants had equal amount of muscle strength after conventional physiotherapy. By examining the final test statistics by Wilcoxon signed- ranked test, it was discovered that for n=15, Wilcoxon table gives calculated Z= 2.333 and p value 0.020 which was less than 0.05. So, the null hypothesis was rejected and alternative hypothesis was accepted which means conventional physiotherapy showed statistically significant change in right wrist extensor muscle strength among individuals with incomplete tetraplegic SCI.

4.6.5. Left Elbow Flexor strength

This study found that in experimental group, no participants had decreased muscle strength, 5 participants had higher muscle strength score and 10 participants had equal amount of muscle strength after application of repeated muscle strengthening training. By examining the final test statistics by Wilcoxon signed- ranked test, it was discovered that for n=15, Wilcoxon table gives Z= 2.070 and p value 0.038 which was less than 0.05. So, the null hypothesis was rejected and alternative hypothesis was accepted at the level of 5% significance which means repeated muscle strengthening training showed statistically significant change in left elbow flexor muscle strength. And in case of control group, no participants had decreased muscle strength, 3 participants had higher muscle strength score and 12 patients had equal amount of muscle strength after conventional physiotherapy. By examining the final test statistics by Wilcoxon signed- ranked test, it was discovered that for n=15, Wilcoxon table gives calculated Z= 1.633 and p value 0.102 which was greater than 0.05. So, the null hypothesis was accepted and alternative hypothesis was rejected which means

conventional physiotherapy showed no statistically significant change in left elbow flexor muscle strength among individuals with incomplete tetraplegic SCI.

4.6.6. Left Elbow Extensor strength

This study found that in experimental group, no participants had decreased muscle strength, 9 participants had higher muscle strength score and 6 participants had equal amount of muscle strength after application of repeated muscle strengthening training. By examining the final test statistics by Wilcoxon signed- ranked test, it was discovered that for n=15, Wilcoxon table gives Z= 2.326 and p value 0.020 which was less than 0.05. So, the null hypothesis was rejected and alternative hypothesis was accepted at the level of 5% significance which means repeated muscle strengthening training showed statistically significant change in left elbow extensor muscle strength. And in case of control group, no participants had decreased muscle strength, 1 participants had higher muscle strength score and 14 patients had equal amount of muscle strength after conventional physiotherapy. By examining the final test statistics by Wilcoxon signed- ranked test, it was discovered that for n=15, Wilcoxon table gives calculated Z= 1 and p value 0.317 which was greater than 0.05. So, the null hypothesis was accepted and alternative hypothesis was rejected which means conventional physiotherapy showed no statistically significant change in left elbow extensor muscle strength among individuals with incomplete tetraplegic SCI.

4.6.7. Left Wrist Flexor strength

This study found that in experimental group, no participants had decreased muscle strength, 10 participants had higher muscle strength score and 5 participants had equal amount of muscle strength after application of repeated muscle strengthening training. By examining the final test statistics by Wilcoxon signed- ranked test, it was discovered that for n=15, Wilcoxon table gives Z= 2.970 and p value 0.003 which was less than 0.05. So, the null hypothesis was rejected and alternative hypothesis was accepted at the level of 5% significance which means repeated muscle strengthening training showed statistically significant change in left wrist flexor muscle strength. And in case of control group, no participants had decreased muscle strength, 8 participants had higher muscle strength score and 7 patients had equal amount of muscle strength after conventional physiotherapy. By examining the final test statistics by Wilcoxon signed- ranked test, it was discovered that for n=15, Wilcoxon

table gives calculated Z= 2.640 and p value 0.008 which was less than 0.05. So, the null hypothesis was rejected and alternative hypothesis was accepted which means conventional physiotherapy showed statistically significant change in left wrist flexor muscle strength among individuals with incomplete tetraplegic SCI.

4.6.8. Left Wrist Extensor strength

This study found that in experimental group, no participants had decreased muscle strength, 9 participants had higher muscle strength score and 6 participants had equal amount of muscle strength after application of repeated muscle strengthening training. By examining the final test statistics by Wilcoxon signed- ranked test, it was discovered that for n=15, Wilcoxon table gives Z= 2.754 and p value 0.006 which was less than 0.05. So, the null hypothesis was rejected and alternative hypothesis was accepted at the level of 5% significance which means repeated muscle strengthening training showed statistically significant change in left wrist extensor muscle strength. And in case of control group, no participants had decreased muscle strength, 6 participants had higher muscle strength score and 9 patients had equal amount of muscle strength after conventional physiotherapy. By examining the final test statistics by Wilcoxon signed- ranked test, it was discovered that for n=15, Wilcoxon table gives calculated Z= 2.251 and p value 0.024 which was less than 0.05. So, the null hypothesis was rejected and alternative hypothesis was accepted which means conventional physiotherapy showed statistically significant change in left wrist extensor muscle strength among individuals with incomplete tetraplegic SCI.

4.7.1. VO_{2max} (ml/kg/min) between Experimental and Control group:

This study found that for $VO_{2max,}$ unpaired t test in between group at 5% level of significant and 28 degree of freedom, observe t value was 2.225 and at the same significant level and same degree of freedom standard table value was 2.048. The observe t value was greater than the table value that means the null hypothesis was rejected and alternative hypothesis was accepted which means there was statistical significance between repeated muscle strengthening training of upper extremity muscles and conventional Physiotherapy only.

4.7.2. VO_{2max} (ml/kg/min) within groups (Experimental and Control):

This study found that for VO_{2max}, paired t test in experimental group at 5% level of significance and 14 degree of freedom observe t value was 3.325 and at the same significant level and same degree of freedom standard table value was 2.145.The observe t value was greater than the table value that means the null hypothesis was rejected and alternative hypothesis was accepted which means repeated muscle strengthening training showed statistically significant change in VO_{2max} experimental group. And in case of control group calculated value was 4.468 which was also greater than standard table value that also indicates that the null hypothesis was rejected and alternative hypothesis was accepted which means conventional physiotherapy showed statistically significant change in VO_{2max} among individuals with incomplete tetraplegic SCI.

CHAPTER –V: DISCUSSION

The purpose of this study was to determine the effect of repeated muscle strengthening of upper extremity in patients with incomplete tetraplegic spinal cord injury. Total 30 participants were taken in this study. In this experimental study 30 incomplete tetraplegic participants with SCI were randomly assigned with computer generated random numbers. Among these 30 participants, they were divided into two groups. One was experimental group and other was control group. These group attended in the SCI indoor department of physiotherapy, CRP, Savar from which this study aimed to determine the effect of repeated muscle strengthening training of upper extremity muscles. The outcome was measured by using structured questionnaire. In this study, Oxford grade scale and Manual Muscle Testing were used to measure the muscle strength. Age, gender, marital status and occupational status were taking into consideration as demographic variables.

The study found some similarities on demographic and clinical characteristics in gender, occupation, residence, total motor score, and total sensory score between both groups of the participants in pretest. Boer et al. (2015) stated that, successful randomization may be done when there is similarities on baseline characteristics. 30 incomplete tetraplegic spinal cord injury patients were included as sample of the study, among them 90% (n=27) were male and about 10% (n=3) were female. Anderson et al. (2009) found that male were 63% and female were 37% among 231 participants following SCI. So, it seems that male participants are more permeable than female participants in spinal cord injury. Male genders were found to be more prone to have SCI than female (National Spinal Cord Injury Statistical Center, 2016). The reason may majority of women are remain in home in Bangladesh and are not subjected to violent form of work to which men are more exposed. Out of the participant 75% participants' age was ≥30 in experimental group & ≥22 in control group. In this study most of the participants were from (25-40years) age group. Similarly Bombardier et al. (2008) also found age range from (25-35 years) in their study. Both results claim that active younger are more vulnerable with the incidence of spinal cord injury.

In this study out of 30 participants, students and businessman such as shopper, hawker etc occupation rate were higher due to traumatic spinal cord injury. Day labor was the

second most common occupation where spinal cord injury was seen. Tzanos et al. (2016) stated that in Greece, the Spinal cord injury is mostly occurred who were found poorly engaged with occupation and the same picture had emerged from the present study in case of occupation. In this study, 75% participants' average monthly income was ≥10000 in both group. It manifested that most of spinal cord injured patient came from middle or lower income family. It is nearly similar with Singh et al. (2003) within 483 participant's 217 participants' family income less than Rs.5000 per month. This type of population are less concern with safety measure and more vulnerable to injury.

In this study participants who lived in rural area were more affected than the people who lived in urban area. Among these approximately 80% (n=24) were in rural and 20% (n=6) were in urban area. The people of rural area are mostly poor and they are engage in risky work that may causing SCI. Majority of the participants lived in rural area also seen in a study conducted in India (Singh et al., 2003). In Bangladesh, more than 80% people lives in the village and about 60% of the total labor forces are involved in agriculture (Jahan, 2008).The people of rural area are mostly poor and they are engage in risky work that may causing SCI.

After completion of discussion on socio-demographic aspects, focus should be given on spinal cord injury related information. It may include- the causes of injury, the types of injury according to ASIA impairment scale, the length of injury from the date of occurrence, the neurological level, skeletal level, total motor score and total sensory score of the spinal cord injury participants. Etiology of spinal cord injury varies from region to region. According to these study, it was also found that fall from height was the highest cause of injury, secondly due to fall while carrying heavy load and then due to RTA. 33.33% (n=10) were injured by fall from height, fall while carrying heavy loads were 30% (n=9), 23.33% (n=7) were by motor vehicle or road traffic accident. Study conduct in Jordan, Otom, Doughan & Kawar, (1997) showed cause of SCI percentage that are- fall 21.2% & RTA 44%, in Iran Chabok, et al (2009) RTA 52% & fall 45.4%. But in India Singh et al, 2003, p.185 fall was 47% & RTA 34.78%.

Bye et al. (2016) on their study of spinal cord injury which had covered the overall population that were recent complete or incomplete spinal cord injury participants.

But in this study, only the participants of a particular region was included and here the tetraplegic spinal cord injury participants were included only. So, in this study, the percentages of types of injury were found- 57% was Incomplete B, 33% was Incomplete C and 10% was Incomplete D. the neurological level of injury had checked specifically in this study as the study population was limited and it had been found here that neurological level of injury was predominant in C4 level. These are the specific differences between two studies.

In case of skeletal level of spinal cord injury participants, the recent study had demonstrated that the most common site for injury was in the cervical spine which had similarities with an ancient study. In spite of having similarities, there were some differences too. In this study, among 30 participants, it had been showed that C5 skeletal level was predominant whereas in the previous research they had not included any specific area of cervical (Rathore et al., 2008).

On the research of Koskinen (2015), they had checked total motor and sensory score and in this research, we had also checked the total motor score and sensory score and this was the main similarities of these two studies. The dissimilarities were, in their research they had checked motor and sensory score for both upper and lower extremity and for functional +outcome but here in this research, we had checked only the motor and sensory score of upper extremity and it had been checked to know the patient's physical condition.

Overall, the findings of muscle strength indicated that participants in experimental group did not show significant improvement in muscle strength after repeated strengthening training of upper extremity compared with the control group. In this study, 30 participants were involved. From which 15 participants in experimental group received repeated strengthening training (50 repetitions) of upper extremity over 4 weeks session and significant change was not seen comparing repeated muscle strengthening group with only conventional physiotherapy group. Similarly, another research of Glinsky et al. (2008) explored that, Short-term progressive resistance exercise may not be effective at increasing wrist strength in people with tetraplegia. 32 participants were involved on that study protocol who received strengthening training (30 repetitions) of wrist muscles over 8 week sessions. That study showed that the experimental group did not perceive that progressive resistance exercise

improved performance of or satisfaction with their activities of daily living compared with the control group. There were insufficient participants to explore these possibilities also. The results of that study also indicate that progressive resistance exercise has no effect on participants' perceptions about hand function. Also another study of Bye et al. (2016) stated that strength training increases strength in partially paralysed muscles of people with recent SCI in which there were also 30 participants involved who received 40 repetitions of strengthening training. But in that study, participants received strengthening training over 12 weeks session. And duration of the session was dissimilar with this study. Repeated strengthening training of muscles with neurologically-induced weakness might not generate a large enough stimulus. For an example, contraction of a small group of the muscle mass may not induce sufficient stimulation to stir up hypertrophy (Wernbom et al., 2007). There may another possible explanations for the failure to demonstrate of increasing muscle strength. It is possible that the training dosage or number of repetition was not sufficient and more frequent training sessions may be required.

In this study, in experimental group, the mean difference of VO_{2max} pre-test (mean=35.70 ml/kg/min) and post-test (mean=37.51 ml/kg/min) was 1.81 ml/kg/min and in control group, the mean difference of pre-test (mean= 43.09 ml/kg/min) and post-test (mean=41.04 ml/kg/min) was -2.05ml/kg/min and it showed that mean difference of VO_{2max} higher in experimental group than control group. After final statistical test between experimental and control group, it was observed that p value was 0.034 which was less than 0.05 that means there is statistical significance between repeated muscle strengthening training of upper extremity muscles and conventional Physiotherapy only for increasing the amount of oxygen consumption. Another research Kusunoki et al. (2011) was conducted where 10 participants were involved who received 9 weeks training program and revealed that resistance exercise benefits cardiovascular fitness of spinal cord injured patients. That study also showed that amount of oxygen consumption after resistance training was improved due to changing of resting heart rate. These were the similarities between both researches. Similarly 16 participants received heavy strengthening training (10 repetitions in 5 sets) in where there was also seen improving amount of oxygen consumption (Turbanski et al., 2010).

Limitation of the study:

The aim of this study was to compare between the repeated muscle strengthening training and conventional physiotherapy only. Despite of researcher willingness and effort still there is some limitation of this study. The main limitation was the shorter sample size. As the samples were collected only from CRP- Savar, it could not represent the wider spinal cord injury patients. In addition to this, it should be included here that the study was conducted with 30 incomplete tetraplegic patients with Spinal Cord Injury, which was a very small number of samples and was not sufficient for the study in comparison with the world wide prevalence. For this reason, the study has lacking in generalizability of results to the wider population of this condition. Also there was limitations of advanced mechanical measurement tools, which was a major limitation of this research. In this study, interventions were given by clinical physiotherapists. So, the inter-rater reliability was not maintained due to lack of time and patient's availability. There may another possible limitation that the training dosage or number of repetition was not sufficient and more frequent training sessions may be required. The study did not offer any follow up for participants which was essential component to find out effectiveness of treatment for longer period of time.

CHAPTER –VI: CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Tetraplegic Spinal Cord injury is known as illness or injury causes paralysis that results in the partial or total loss of use of all four limbs. The current study was randomized control trial containing experimental and control group. Pre-test and post-test design were used in this study to examine the effectiveness of repeated muscle strengthening training of upper extremity muscles for patients with incomplete tetraplegic spinal cord injury. This study found no significant difference between experimental and control groups after repeated muscle strengthening training of upper extremity muscles except right elbow extensor muscle group. Average muscle strength score was almost similar in both experimental and control group. In case of incomplete tetraplegic spinal cord injury patients, it is very important to increase muscle strength of upper extremity. It has an impact on patient activity of daily living and functional level. The study concluded as the repeated muscle strengthening training of upper extremity for patients with incomplete tetraplegic spinal cord injury is not significantly capable of producing beneficial effects within this 4 weeks period on the improvement of their muscle strength.

6.2 Recommendation

As physiotherapist play a vital role and holistic treatment techniques for the persons with tetraplegic spinal cord injury, it is necessary to update their knowledge in this area. Physiotherapists need to provide more concentration on strengthening muscle power after spinal cord injury during the treatment period. And for these reason, it is necessary to involve the patients in repeated strengthening training sessions. A recommendation for the further studies could be suggested that study should include large sample size and following the process of randomization when selecting sample from population. Both male and female patient should be included. Also treatment session and time duration should be increased in the future study. This study was conducted through 4 weeks of period only. A recommendation for further studies could be suggested to take at least 8-12 weeks for intervention and also increase the number of repetition of muscle contraction.

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Appendix-A

IRB Permission Letter

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/7/19/1311 Date: 23/09/2019

To
Eshika Saha Koushy
B.Sc. in Physiotherapy
Session: 2014-15, Student ID:112140242
BHPI, CRP, Savar, Dhaka-1343, Bangladesh

Subject: Approval of the thesis proposal **"Effect of repeated muscle strengthening training of upper extremity muscles for patients with incomplete tetraplegic spinal cord injury"** by ethics committee.

Dear Eshika Saha Koushy,

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

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

The study involves use of a Manual Muscle Test (MMT), Oxford Grade Scale to explore the muscle strength of incomplete tetraplegic SCI patients that may take 15 to 20 minutes to answer & fill in the questionnaire by assessor. Since there is no likelihood of any harm to the participants; the members of the Ethics committee have approved the study to be conducted in the presented form at the meeting held at 9 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

Appendix-B

Permission Letter

Permission Letter

March 28, 2019
The Head of the Department
Department of Physiotherapy
Bangladesh Health Professions Institute (BHPI)
CRP, Chapain, Savar, Dhaka.
Through: The Head of the Department, Department of Physiotherapy, BHPI.

Subject: Prayer for seeking permission for collecting data as part of research project conduction.

Sir,
With due respect I state that I am a 4th year student of B. Sc. in Physiotherapy Department of BHPI, the academic Institute of CRP. I sincerely seeking permission to collect data for my research project as the partial fulfillment of the requirement for the degree of B.Sc. in Physiotherapy. The title of my research project is "Effect of repeated muscle strengthening training of upper extremity muscles for patients with incomplete tetraplegic spinal cord injury". Now I am seeking kindness to permit me to start data collection as part of the research project conduction and I would like to assure that anything of my research project will not be harmful for the participants.
So, I therefore, pray and hope that your honor would be kind enough to give me the permission for data collection and your permission will help me to conduct a successful study as a part of my course.

Sincerely Yours

Eshika Saha Koushy

Eshika Saha Koushy
4th Year, B. Sc. in Physiotherapy,
Department of Physiotherapy
Roll no: 10
Session: 2014-15
Bangladesh Health Professions Institute (BHPI),
CRP, Chapain, Savar, Dhaka.

Allow for data collection from SCI unit.
MUZAFFOR HOSSAIN 24/3/19 Forwarded
Junior Consultant & Incharge SCI Unit
Physiotherapy Department
CRP, Savar, Dhaka
ERH 28/3/19
Recommended Forwarded
28/03/19
Approved
Prof. Md. Obaidul Haque
Head, Department of Physiotherapy
BHPI, CRP, Savar, Dhaka-1343
Mohammad Abdul Hossain
Associate Professor & HOD
Physiotherapy Dept., CRP
CRP-Chapain, Savar, Dhaka-1343

Appendix-C

সম্মতিপত্র

আসসালামুয়ালাইকুম/নমস্কার,

আমি ঈষিকা সাহা কৌশি, আমি এই গবেষণা প্রকল্পটি বাংলাদেশ হেল্‌থ প্রফেশন্স ইনস্টিটিউট এ পরিচালনা করছি যা আমার ৪র্থ বর্ষ বি এস সি ইন ফিজিওথেরাপি কোর্সের অধিভুক্ত। আমি "মেরুরজ্জুতে আঘাতের পর দুর্বল মাংসপেশির উপর পুনরাবৃত্ত বলকারক প্রশিক্ষণের প্রভাব "এর উপর গবেষণা করছি। এই গবেষণার উদ্দেশ্য" মেরুরজ্জুতে আঘাতের পরবর্তী দুর্বল মাংসপেশির উপর পূনরাবৃত্ত বলকারক প্রশিক্ষণ কতটুকু প্রভাবিত করছে তা খুঁজে বের করা"। আমি এক্ষেত্রে আপনাকে কিছু ব্যক্তিগত, রোগ সম্পর্কিত আনুষাঙ্গিক প্রশ্ন করতে চাচ্ছি। এতে ১০-১৫ মিনিট সময় লাগবে। এই গবেষণা সম্পূর্ণ ভাবে কোর্সের কাজ ছাড়া অন্য কোন উদ্দেশ্যে ব্যবহার করা হবে না এবং গবেষণাপত্র প্রকাশকালে অংশগ্রহণকারীর পরিচয় ও অন্যান্য তথ্য সমূহের গোপনীয়তা রক্ষা করা হবে। অংশগ্রহণকারীগণ যে কোন সময় গবেষণার কার্যক্রম থেকে নিজেকে প্রত্যাহার করতে পারবেন।

এই অধ্যয়নে অংশগ্রহণকারী হিসেবে যদি আপনার কিছু জানার থাকে তাহলে আপনি আমাকে অথবা / এবং আমার সুপারভাইজার এহসানুর রহমান, সহকারী অধ্যাপক, ফিজিওথেরাপি বিভাগ, বিএইচপিআই, সিআরপি, সাভার, ঢাকা-১৩৪৩ উনার সাথে যোগাযোগ করতে পারেন।

সাক্ষাৎকার শুরু করার আগে আপনার কি কোন প্রশ্ন আছে?

আমি কি আপনার সম্মতি সাপেক্ষে সাক্ষাৎকার গ্রহণ করতে পারি? হ্যাঁ.....

আমি ..... এই সম্মতিপত্রটি পড়েছি ও বুঝেছি। আমি স্বেচ্ছায় এই গবেষণায় অন্তর্ভুক্ত হচ্ছি।

আমি কি আপনার অনুমতি নিয়ে সাক্ষাৎকার শুরু করতে পারি?

অংশগ্রহণকারীর স্বাক্ষর ও তারিখ……...

গবেষকের স্বাক্ষর ও তারিখ…….

সাক্ষীর স্বাক্ষর ও তারিখ……..

Consent Form

Assalamualaikum/ Namashker,

I am Eshika Saha Koushy, 4th professional B.sc. in physiotherapy student of Bangladesh Health Professions Institute (BHPI) under the Medicine faculty of University of Dhaka .To obtain my Bachelor degree, I shall have to conduct a research which is a part of my study. The participants are requested to participate in the study after reading the following.

My research title is **"Effect of repeated muscle strengthening training of upper extremity muscles for patients with incomplete tetraplegic spinal cord injury"**. Through this Study I will find the effectiveness of repetition in upper extremities muscle strengthening training for incomplete tetraplegia. If I can complete this study successfully, Patient may get the benefits who are incomplete tetraplegia and it will be an evidence based treatment. To fulfill my research project, I need to collect data. Considering the area of my research, which criteria is necessary for my research is present of you. So you can be a respected participant of my research and I would like to request you as a subject of my study. I want to meet you few couple of session, during your regular therapy. This exercise that will be given are pain free and safe for you.

I would like to inform you that this is a purely academic study and will not be used for any other purpose. I assure that all data will be kept confidential. Your participation will be voluntary. You may have the right to withdraw consent and discontinue participation at any time of the experiment. You also have the right to answer a particular question that you don't like.

If you have any query about the study or right as a participant, you may contact with me and/ or Assistant Professor Ehsanur Rahman, BHPI, CRP.

Do you have any question before I start?

So, may I have your consent to proceed with the interview? Yes……

I…….. have read and understand this. I agree to participate in this research.

Signature of the participant and Date……..

Signature of the researcher and Date……..

Signature of the witness and Date……...

Appendix-D

প্রশ্নমালা/ প্রশ্নাবলী

শিরোনাম: "মেরুরজ্জুতে আঘাতের পর দুর্বল মাংসপেশির উপর পুনরাবৃত্ত বলকারক প্রশিক্ষণের প্রভাব"

সাক্ষাৎকারের সময়সূচী পর্ব-১: রোগীর সনাক্তকরণ/পরিচয় (রোগী অথবা সহকারী তথ্য প্রদান করবেন)		
১.১	সনাক্তকরণ নম্বরঃ	
১.২	সাক্ষাৎকারের তারিখঃ	
১.৩	ঠিকানাঃ	
১.৪	ফোন/ মোবাইল নম্বরঃ	
১.৫	অনুমতি নেওয়া হলোঃ	হ্যাঁ / না

পর্ব-২: রোগীর আর্থসামাজিক অবস্থার তথ্যাবলী(রোগী অথবা সহকারী তথ্য প্রদান করবেন)

ক্রমিক নং	প্রশ্ন	উত্তর	কোড
২.১	বয়স	……..বছর	
২.২	লিঙ্গ	মহিলা পুরুষ	০১ ০২
২.৩	বৈবাহিক অবস্থা	বিবাহিত অবিবাহিত	০১ ০২
২.৪	পেশা	কৃষিকাজ রিকশা চালক ফ্যাক্টরী/ পোশাক কারখানার শ্রমিক গাড়ী চালক ব্যাবসায়ী শ্রমিক শিক্ষকতা ছাত্র গৃহিণী অন্যান্য	০১ ০২ ০৩ ০৪ ০৫ ০৬ ০৭ ০৮ ০৯ ১০

২.৫	মাসিক আয়		টাকা
২.৬	আবাসিক এলাকা	গ্রাম শহর	০১ ০২

পর্ব ৩: ফিজিওথেরাপী সংক্রান্ত তথ্যাবলী (রোগী অথবা সহকারী তথ্য প্রদান করবেন)

ক্রমিক নং	**প্রশ্ন**	**উত্তর**	**কোড**
৩.১	আঘাতপ্রাপ্তি তারিখঃ		
৩.২	ভর্তির তারিখঃ		
৩.৩	আঘাতের কারণঃ	মটর যান দূর্ঘটনা উচ্চতা থেকে পরে যাওয়া ভারী কিছু নিয়ে পরে যাওয়া খেলাধূলার কারণে অগভীরে ডুব দিয়ে অন্যান্য	০১ ০২ ০৩ ০৪ ০৫ ০৬
৩.৪	প্রারম্ভিক স্নায়ুতন্ত্রীয় অবস্থা (এশিয়ার স্কেল অনুযায়ী)ঃ	অসম্পূর্ণ B অসম্পূর্ণ C অসম্পূর্ণ D	০১ ০২ ০৩
৩.৫	চিকিৎসার ধরণঃ	অস্ত্রোপচার অস্ত্রোপচার ছাড়া	০১ ০২
৩.৬	কোন ধরণের সাহায্যকারী যন্ত্রঃ	হ্যাঁ না	০১ ০২
৩.৭	নিয়মিত লক্ষণঃ	ব্যথা ঝিমঝিম ভাব অবস ভাব অন্যান্য	০১ ০২ ০৩ ০৪
৩.৮	ব্যাথার তীব্রতাঃ	মৃদু মোটামুটি তীব্র	০১ ০২ ০৩
৩.৯	কোন গুরুতর অসুখঃ	বহুমূত্র উচ্চরক্তচাপ ফুসফুসের অসুখ	০১ ০২ ০৩

		হৃদযন্ত্রের অসুখ খিঁচুনি অন্যান্য	০৪ ০৫ ০৬

পর্ব ৪: মাংসপেশির শক্তি সম্পর্কিত তথ্যাবলী

(পরীক্ষক অথবা রোগসম্পর্কিত বিবরণী হতে সংগ্রহ করা হবে)

ক্রমিক নং	**প্রশ্ন**	**উত্তর**	**কোড**
৪.১	অক্সফোর্ড মাসল গ্রেড স্কেল	এলবো ফ্লেক্সর (ডান) এলবো এক্সটেনশর (ডান) রিস্ট ফ্লেক্সর (ডান) রিস্ট এক্সটেনশর (ডান) এলবো ফ্লেক্সর (বাম) এলবো এক্সটেনশর (বাম) রিস্ট ফ্লেক্সর (বাম) রিস্ট এক্সটেনশর (বাম)	
৪.২	মেনুয়াল মাসল টেস্ট	এলবো ফ্লেক্সর (ডান) এলবো এক্সটেনশর (ডান) রিস্ট ফ্লেক্সর (ডান) রিস্ট এক্সটেনশর (ডান) এলবো ফ্লেক্সর (বাম) এলবো এক্সটেনশর (বাম) রিস্ট ফ্লেক্সর (বাম) রিস্ট এক্সটেনশর (বাম)	

পর্ব ৫: VO_{2max} সম্পর্কিত তথ্যাবলী

(পরীক্ষক অথবা রোগসম্পর্কিত বিবরণী হতে সংগ্রহ করা হবে)

ক্রমিক নং	**প্রশ্ন**	**উত্তর**
৫.	সর্বোচ্চ হার্ট রেট রেস্টিং হার্ট রেট VO_{2max} = ১৫ ×(সর্বোচ্চ হার্ট রেট ÷ রেস্টিং হার্ট রেট) মিলি/কিগ্রা/মিনিট	

Questionnaire

Title: Effect of repeated muscle strengthening training of upper extremity muscles for patients with incomplete tetraplegic spinal cord injury.

Interview Schedule Part I: Patient's Identification (to be provided by patient or attendant)		
1.1	Identification number:	
1.2	Date of interview:	
1.3	Address:	
1.4	Mobile number:	
1.5	Consent Taken:	Yes / No

Part II: Socio-demographic questions

(To be provided by Record/Patient/Care giver/Clinical examination)

2.1	Age		years
2.2	Sex	Male Female	01 02
2.3	Marital status	Married Unmarried	01 02
2.4	Occupation	Agriculture Rickshaw puller Garments worker Driver Businessmen Day laborer Teacher Student Housewife	01 02 03 04 05 06 07 08 09

		Other (Specify)	10
2.5	Average monthly income		Taka
2.6	Residential area	Rural Urban	01 02

Part III: Physiotherapy Related Information

(To be provided by Record/Patient/Care giver/Clinical examination)

QN	Questions	Response/Answer	Code
3.1	Date of injury		
3.2	Date of admission		
3.3	Causes of injury	Motor Vehicle Injury Fall From Height Fall while carrying heavy Load Sports related Shallow diving Other (Please Specify)	01 02 03 04 05 06
3.4	Initial neurological level by ASIA	Incomplete B Incomplete C Incomplete D	01 02 03
3.5	Skeletal Level	C2 C3 C4 C5 C6 C7 C8	01 02 03 04 05 06 07
3.6	Neurological level	C2 C3	01 02

		C4 C5 C6 C7 C8	03 04 05 06 07
3.7	Type of management	Surgical Non-surgical	01 02
3.8	Any assistive device	Yes No	01 02
3.9	Constant symptoms	Pain Paresthesia Numbness Other (Specify)	01 02 03 04
3.10	Severity of pain	Mild Moderate Severe	01 02 03
3.11	Any major Disease	Diabetes Mellitus Hypertension Lung disease Cardiovascular disease Epilepsy Others	01 02 03 04 05 06
3.12	Motor Score	Right Left	
3.13	Sensory Score	Right (Light touch) Right (Pin prick) Left (Light touch) Left (Pin prick)	

Part IV: Objective Findings (Muscle Power) (To be provided by Record/ Clinical examination)			
QN	**Questions**	**Response/Answer**	**Grade**
4.1	Oxford Muscle Grade Scale	Elbow Flexor (Right) Elbow Extensor (Right) Wrist Flexor (Right) Wrist Extensor (Right) Elbow Flexor (Left) Elbow Extensor (Left) Wrist Flexor (Left) Wrist Extensor (Left)	
4.2	Manual Muscle Testing Scale	Elbow Flexor (Right) Elbow Extensor (Right) Wrist Flexor (Right) Wrist Extensor (Right) Elbow Flexor (Left) Elbow Extensor (Left) Wrist Flexor (Left) Wrist Extensor (Left)	

Part V: Objective Findings (VO_{2max}) (To be provided by Record/ Clinical examination)		
QN	**Question**	**Response/ Answer**
5.	Maximum Heart Rate (MHR) Resting Heart Rate (RHR) VO_{2max} = 15.3 x (MHR÷RHR) $ml.kg^{-1}.min^{-1}$	

Appendix-E

Measurement Tools

Muscle Strength Grading (Oxford Grade Scale):

- 0-Z (Zer0) - No contraction.
- 1-T (Trace) - Flicker contraction but no movement.
- 2-P (Poor) - Active full range of movement with gravity eliminated position in horizontal plane.
- 3-F (Fair) - Active full range of movement against gravity in vertical plane.
- 4-G (Good) - Active full range of movement against some resistance in vertical plane.
- 5-N (Normal) - Active full range of movement against strong resistance in vertical plane.

MANUAL MUSCLE TESTING PROCEDURES

Key to Muscle Grading

	Function of the Muscle	**Grade**		
No Movement	No contractions felt in the muscle	0	0	Zero
	Tendon becomes prominent or feeble contraction felt in the muscle, but no visible movement of the part	1	1	Trace
Test Movement	**MOVEMENT IN HORIZONTAL PLANE**			
	Moves through partial range of motion	2	2-	Poor-
	Moves through complete range of motion	3	2	Poor
	ANTIGRAVITY POSITION			
	Moves through partial range of motion	4	2+	
Test Position	Gradual release from test position	5	3-	Fair-
	Holds test position (no added pressure)	6	3	Fair
	Holds test position against slight pressure	7	3+	Fair+
	Holds test position against slight to moderate pressure	8	4-	Good-
	Holds test position against moderate pressure	9	4	Good
	Holds test position against moderate to strong pressure	10	4+	Good+
	Holds test position against strong pressure	11	5	Normal