CARDIORESPIRATORY FITNESS IN TERM OF ESTIMATED VO_2 MAX OF CHILDREN WITH CEREBRAL PALSY

By

RABINDRA SHRESTHA NAHA

Submitted in Partial Fulfillment of the Requirements for the Degree of

MSc in Rehabilitation Science

May 2018

Bangladesh Health Professions Institute (BHPI)

Faculty of Medicine

University of Dhaka

SUPERVISOR'S STATEMENT

SUPERVISOR'S STATEMENT

As the supervisor of **Mr. Rabindra Shrestha Naha's** Thesis work, I certify that I consider his thesis **"CARDIORESPIRATORY FITNESS IN TERM OF ESTIMATED VO_2 MAX OF CHILDREN WITH CEREBRAL PALSY"** to be suitable for examination.

.....08/06/18

Mohammad Anwar Hossain,

Associate Professor of Bangladesh Health Professions Institute,

Head of Department of Physiotherapy,

CRP, Savar, Dhaka-1343 Date: 08/06/2018

(Supervisor)

RECOMMENDATION

We, the undersigned, certify that we have carefully read and recommended to the Faculty of Medicine, University of Dhaka, for acceptance of this thesis entitled, "CARDIORESPIRATORY FITNESS IN TERM OF ESTIMATED VO_2 MAX OF CHILDREN WITH CEREBRAL PALSY"submitted by **Mr. Rabindra Shrestha Naha**, for the partial fulfillment of the requirements for the degree of M. Sc. in Rehabilitation Science.

Mohammad Anwar Hossain
Associate Professor,
Head of Department of Physiotherapy,
BHPI, CRP, Savar, Dhaka.

Md. Julker Nayam
Associate Professor,
Department of Occupational therapy,
BHPI, CRP, Savar, Dhaka

Md. Fazlul Karim Patwary
Professor, Institute of IT,
Jahangirnagar University

S.J.M. Ummul Ambia
Lecturer, Rehabilitation Science,
BHPI, CRP, Savar, Dhaka

Date of approval: 06/06/2018

DECLARATION

• This work has not previously been accepted in substance for any degree and is not concurrently submitted in candidature for any degree.

• This dissertation is being submitted in partial fulfillment of the requirements for the degree of MSc in Rehabilitation Science.

• This dissertation is the result of my own independent work/investigation, except where otherwise stated. Other sources are acknowledged by giving explicit references.

•A Bibliography is appended.

• I confirm that if anything identified in my work that I have done plagiarism or any form of cheating that will directly awarded me fail and I am subject to disciplinary actions of authority.

• I confirm that the electronic copy is identical to the bound copy of the Thesis.

Signature:

Name: Rabindra Shrestha Naha

Date: ……., 2018

ACKNOWLEDGEMENT

First of all, I would like to pay my gratitude to Almighty God who gave me the passion to complete this study. The second acknowledgement goes to my family members who had always inspired me and provided necessary supports. Then, I gratefully acknowledge to my honorable supervisor, Associate Professor of BHPI, Md. Anwar Hossain, Head of Department of physiotherapy, CRP, Savar for his supervision, guidance and feedback during study period.

I would like to thank Md. Abdullah AL Zubayer Principal, William and Marie Taylor School and Hosneara Perveen, in charge of pediatric unit Pediatric department for giving permission to collect data at William and Marie Taylor School and Pediatric department CRP, savar, Dhaka. I also gratefully acknowledge Dr. Dorine van Ravensberg, Human Movement Scientist, PhD, PT, Netherland for guidance and support throughout my study.

I am also thankful to Dr. Pradip Rai (PT), DPT, USA for the guidance, unlimited support, motivation for the study.

In addition, I am thankful to all of my honorable teachers especially principal, BHPI Nasirul Islam, Associate Professor, Principal (Acting), BHPI, CRP, Course Coordinator Muhammad Millat Hossain, Associate Professor, Shamima Islam Nipa and Ummul Ambia, Lecture of M.Sc. in rehabilitation science. I would like to thank to teacher of William tailor school and clinical physiotherapist of pediatric Unit of CRP. I thank all of my friends for their direct and indirect inspiration, suggestion as well as support. Lastly, I would like to thanks to those entire individuals who are directly or indirectly involve with the study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIX

LIST OF ABBREVIAT1ION AND ACRONYMS

12MWT: Twelves Minutes Walking Test

2MWT: Two Minutes Walking Test

6MWT: Six Minutes Walking Test

ACPR: Australian Cerebral Palsy Register

ACSM: American College of Sports Medicine

BHPI: Bangladesh Health Professional Institute

BMI: Basal Mass Index

Borg's RPE scale: Borgs Rate of Perceived Exertion Scale

CP: Cerebral Palsy

CRF: Cardiorespiratory Fitness

CRP: Centre for the Rehabilitation of the Paralyzed

GMFCS: Gross Motor Function Classification Scale

HR max: Maximum Heart Rate

HR: Heart Rates

HRR: Reserve Heart Rate

ICF: International Classification of Functioning, Disability and Health

METS: Metabolic Equivalents

PA: Physical Activity

SCPE: Cerebral Palsy in Europe

SPSS: Statistic and Statistical Package for Social Science

VO_2 max: Volume of maximum oxygen consumption

ABSTRACT

Background: Cerebral Palsy is a physically disabling condition limiting the physical activities caused by lesion in developing brain. Cardiorespiratory fitness **is** the important physiological variable in children with CP but they are more likely to have decreased cardiorespiratory fitness compared to their typically-developing peers.

Objectives: To determine cardiorespiratory fitness in term of estimated VO_2 max of Cerebral Palsy children.

Methods: In a cross-sectional study, 95 cerebral palsy children with GMFCS I, II, III were recruited and the participants were instructed to walk at their own pace as fast as possible for 2 minutes during 2MWT. Distance walked, heart rates and Borg RPE were calculated at different phase 2MWT.

Results: Children with CP have a poor cardiorespiratory fitness with lower level of VO_2 max than normal child of same age group. There was no significantly difference in cardiorespiratory fitness of male and female in term of calculated VO_2 max. However, female of age group 10-12 years has comparably better cardiorespiratory fitness than boys and more than half of the children with CP participant have a risk of developing Cardiovascular problem as determined by heart rate recovery.

Conclusion: Cardiorespiratory fitness was significantly poor in CP children than health children of same age and more than 50% have a risk of cardiorespiratory problems. Cardiorespiratory fitness doesn't affect locomotory capacity but heart rate recovery and heart rate reserve show high association with VO_2 max.

Keywords: Cerebral palsy, Cardiorespiratory fitness, VO_2 max

CHAPTER I INTRODUCTION

1.1 Background

Cerebral palsy (CP) is a physically disabling condition limiting the physical activities (Morris, 2007; Fowler et al., 2007). CP is an umbrella term for various neurological disorders caused by a non - progressive lesion in the developing brain, caused by brain injury or abnormal development of the brain that occurs while a child's brain is still developing — before birth, during birth, immediately after birth which result in abnormal postural tone and atypical movement patterns (Zaffuto-Sforza, 2005). Research suggests that children with CP also tend to have poorer physical fitness than children without disabilities and there is evidence for reduced VO2 max (Hoofdwijk et al., 1995; Verschuren & Takken, 2010; Balemans et al., 2013b), which may lead to a lower health status and higher risk for developing secondary conditions (Fowler et al., 2007). These facts are now familiar to most health and social service professionals along with many other members of the general public (Morris, 2007; Fowler et al., 2007).

The poorer physical fitness in CP child is due to reduced mobility caused by impairments (Maltais et al., 2010). Additionally, the clinical spectrum of CP in developing countries is different from that in the developed countries. The trend of increasing survival of preterm babies and advances in maternal and neonatal care in the developed world is not yet evident in most developing countries (Singhi, Ray and Suri, 2002).

The prevalence of CP is estimated throughout the world vary depending on the methodology of count, percentage ascertained and variations in selection criteria (Oskoui et al., 2013) and it has been reported between 0.6 to 5.9 cases per 1000 live births. But most statistics along with the two largest data sets, the Australian Cerebral Palsy Register (ACPR) Group and Surveillance of Cerebral Palsy in Europe (SCPE) both showed that there are two cases per 1000 live births (Kamali & Chabok, 2014) and (Oskoui et al., 2013) and other study in Europe showed the prevalence ranges of CP are from 1.39 to 2.80 per 1000 live births (Bent et al., 2002). The prevalence of cerebral palsy is also influenced by race and gender. The study shows that Asians has lower prevalence than whites (1.09 vs

1.36 per 1000) and males are affected more than females (except in America) (Lang et al., 2012). In Bangladesh the estimated prevalence of CP is up to 3.7/1000 children and there are around 260,000 children with CP in Bangladesh (Murthy et al., 2014). The incidence rates for cerebral palsy have remained the similar since first being recorded in the 1960 even with advanced medical care and improved knowledge of some causative factors and is due to the increased survival rate of very pre-term and low birth weight infants. Since pre-term infants are more likely to survive than previously they are more likely to have associated co-morbidities such as cerebral palsy (Blair & Watson, 2006).

The exact cause of cerebral palsy has not been well understood though it was believed to be caused from injuring the developing brain. However, it is associated with numerous prenatal and perinatal factors like congenital infections, birth defects, preterm birth, intrauterine growth restriction, sentinel events and multiple pregnancy, and with post-neonatal factors such as head trauma or cerebral infections within the first year of life (Wilton, 2003). It is also associated with child factors including the child's gender, birth order and birth interval and the socio-demographic factor including ethnicity, religion, and rural/urban residence (Khanal, et al., 2014).

There are wide range of classification systems available for CP. The prevailing classification systems of CP which are used in rehabilitation can be broadly divided into three categories: 1. Distribution of involvement (Monoplegia, Hemiplegia, Diplegia, Triplegia, quadriplegia) (Reid et al., 2011). 2. Types of motor disorder (spastic, ataxic, dyskinetic) (Westbom et al., 2007). 3. Functional motor classification also known as GMFCS (Level I - Walks without limitation, Level II – Walks with limitation, Level III - Walks using a hand-held mobility device, Level IV -Self-mobility with limitations; may use powered mobility, Level V - Transported in a manual wheelchair) (Palisano et al., 2008). Classification of the degree of severity of cerebral palsy varies greatly from mild, moderate or severe by convention; these descriptions of severity are quite broad and subject to interpretation which have often been used inconsistently. A considerable proportion of individuals with CP exhibits mixed motor types, e.g., a predominantly spastic motor pattern with dyskinesia and the likelihood that severity of associated impairments increases with severity of motor impairment (Smithers et al., 2016). However, most of the individuals

with CP have more than one associated impairment and their presence can complicate therapy, decrease quality of life for the individual and their family and increase economic costs for the family and society (McIntyre et al., 2011).

Gross Motor Function Classification Scale extended version (GMFCS E-R)

Gross motor classification scale is one of the classification systems which allows the categorization of people with CP according to their level of functional impairment. It is a five-point scale that distinguishes between levels of motor function based on functional mobility and the need for assistive technology, particularly mobility aids (Palisano1997; Palisano 2008). The extended and revised version of GMFCS includes descriptions of children's abilities for each level across five age bands: less than 2 years, 2 to 4 years, 4 to 6 years, and 6 to 12 years, and 12 to 18 years (Palisano et al., 2008) and it was based on self-initiated movements only, concentrating mostly on control in sitting and functional mobility and taking into consideration of everyday performance, rather than best capacity. However, observations showed that children with CP use a range of mobility methods across settings, particularly those categorized in GMFCS levels II to IV (Harvey et al., 2010; Palisano et al., 2003).

Children and adolescents with spastic CP often have poor physical fitness as has been well documented by means of exercise tests. Moreover, exercise testing has been used as a primary outcome measure of therapy and exercise programs in children and adolescents with CP (Verschuren et al., 2008; Verschuren et al., 2011). These studies also show for children and adolescents with CP who rely for short or longer distances on a manually propelled wheelchair for locomotion, there is a shortage of exercise tests to examine exercise capacity (Verschuren et al., 2011). Therefore, this classification system might help in categorization of CP children along with the developing of exercise and exercise parameters.

International Classification of Functioning, Disability and Health in relation to children with cerebral palsy

Cerebral palsy has a wide range of impairments with different severity, which certainly results in some degree of activity limitation. The motor and other impairments associated with cerebral palsy can be classified under the framework of the International Classification of Functioning, Disability and Health (ICF), which helps to describe and measure health and disability considering physical and social aspects of disability at both the individual and population levels (World Health Organization, 2001).

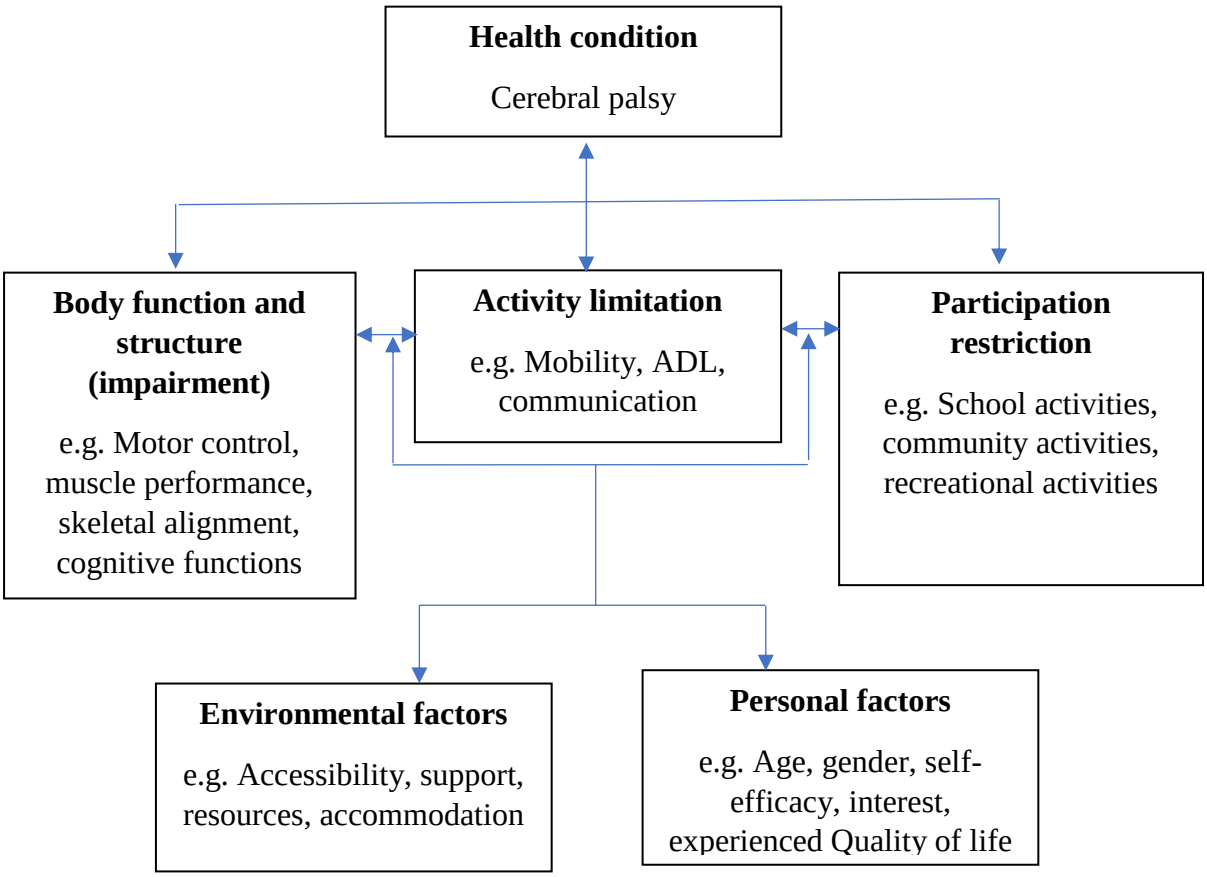


Figure: Cerebral palsy and the consequences in relation to the domains of the International Classification of Functioning, Disability, and Health (ICF) and the possible interactions.

The framework is divided into domains of body (comprising body functions and structure), activities and participation which allows rehabilitation specialist to consider the interaction

between child impairments, their daily activities and subsequent participation within community, in relation to the personal and environmental factors.

The above Figure shows examples of the different problems faced by a CP child. Most of them have physical and mental impairments which are shown in the 'body function and structures' cadre. And due to these and other problems, they are unable to perform their activities of daily living as shown in 'activity'/limitation cadre. Further impairments and activity limitations due to CP may affect their participation in education, community and in different games and program. Environmental and personal factors are further adding to the above problems and all these challenges might decrease the overall quality of life of the CP child.

Cardio respiratory fitness

Cardiorespiratory fitness (CRF) is an element of physical fitness which is described as the body's response or adaptation to the demands and stress of physical effort (American College of Sports medicine, 2000). It is a set of attributes that people are considered to either have or can achieve which relates to the ability of an individual to perform physical activity (PA) (Caspersen et al., 1985). It is often used interchangeably with terms like aerobic capacity, aerobic power, functional capacity, functional aerobic capacity, maximal functional capacity, cardiorespiratory endurance, cardiorespiratory fitness, cardiovascular fitness, maximal oxygen intake, and maximum oxygen uptake etc. (Girling-Butler, 2012). However, for the purpose of this study the term cardiorespiratory fitness (CRF) was used. It is a health-related component of physical fitness which is described as the ability to supply oxygen during sustained PA to the circulatory, respiratory and muscular systems (Lee et al., 2010). CRF is different for different individuals and it was found that it is lower in an individual suffering from impairments like CP. CP children have physical limitations due to motor incoordination and changes in autonomic postural adjustment, which directly influence the heart rate, leading to poor CRF along with more functional loss and comorbidities (Teixeira et al., 2016).

Therefore, CRF assessment is important and a critical component in the development of an individual's exercise program. It provides the clinician with baseline data that can be used to identify an individual's needs and subsequently develop an appropriate exercise program

(Laskin et al., 2004). It can be determined by laboratory exercise testing or field tests. Laboratory tests, being maximal exercise tests, require qualified personnel, sophisticated instrumentation and hampered in children and adolescents with spasticity, low muscle strength or skills etc. Therefore, submaximal exercise or field tests have been suggested as an alternative to maximal exercise testing and it is often used in these kinds of study (Verschuren et al., 2008). It is also a sensitive and reliable measure of physical activities associated with morbidity and mortality which is independent of other risk factors (Lee et al., 2010) and should be considered when estimating the risks of maximal exercise tests for each individual (Ekblom-Bak, 2010). In this study the CRF of CP children is investigated in terms of VO_2 max by using heart rate ratio equation through 2MWT and Borg's RPE scale.

VO_2 max

VO_2 max is the gold standard measure of CRF and is defined as a maximal oxygen uptake expressed as milliliters of oxygen consumed per kilogram of body weight per minute (ml O_2 /kg/min or ml/kg/min) or metabolic equivalents (METs), where 1 METs=3.5 ml/kg/min (Davis, 1995) (Noonam, 2000). It can be assessed through a direct procedure by ventilatory gas analysis at maximal exertion during graded exercise ergometry test or by an indirect procedure from maximal or submaximal exercise duration, peak workload and or heart rate (HR) responses achieved during submaximal or maximal exercise ergometry, amount of time required to walk, jog or run a specified distance (Davis, 1995) (American College of Sports Medicine, 2013). This study estimated VO_2 max by an indirect procedure through maximum heart rate measured by heart rate measurement device during 2MWT. The study has shown it as a determinant of CRF which is also required for different exercises like aerobic training. It is beneficial for CP patient in achieving the functional ability through a conditioning program with less energy expenditure, reduce cardiovascular risk, controlling blood pressure and improve VO_2 max (Batista et al., 2010). The VO_2 max value for normal children was shown in different values in different studies. A study done by Pate et al (2006), found that children between age 12-14 years, males and females, show 42.4 ± 4.1 ml/kg/min (Van Loon., 2010), between age 8-18years show 47 ± 7 ml/kg/min for male, and for female 42 ± 6 ml/kg/min. However, the VO_2 max is found to be lower in CP

children than in normal children due to CP related impairments. A study done by Maltais et al. (2005), in CP children between 10-16 years, shows 32.7 ml/kg/min. However, a study by Verschuren & Takken (2010) in CP children between 7-17 years shows VO_2 max of 42.0 ml/kg/min.

2 Minutes Walking Test

Two minutes walking test (2MWT) is a shorter duration version of 6MWT and 12MWT. There are wide ranges of walking tests described in literature which range in duration from 1-12 minutes and that are used to quantify the functional endurance of patients with different health problems like cardio-pulmonary, neurological, renal and amputation cases. 2MWT is a most notable short duration walking test with broad use which is now popular in literature. American thoracic society had recommendation that those who are not suited for the 6MWT due to time consuming, unable or unwilling to complete 6MWT, it is imperial to use the 2MWT (Bohannon et al., 2014). Since then, the 2MWT has been developed as the one test which is now applied during cardiac rehabilitation of patients with severe disabilities like CP (Casillas et al., 2013).

Borg scale (Modified)

Rate of perceived exertion (RPE) is widely used in exercise tests using cycle ergometers (incremental aerobic exercise) for patients with cardiovascular and metabolic diseases (Borg. 1977). It is used to determine how hard you feel like your body is working based on the physical sensations experienced by an individual during physical activity, including increased heart rate, increased respiration or breathing rate, increased sweating, and muscle fatigue. Although this is a subjective measure, a person's exertion rating may provide a fairly good estimate of the actual heart rate during physical activity (Borg, 1977). There have been significant advancements in assessing of the ratings of perceived exertion (RPE) to predict maximal oxygen uptake and the principle is now widely used to estimate VO_2 max in child and adult during exercise testing (Eston, 2009). This scale was used in this study to determine the participant’s felt exertion after the 2MWT. Children or parents reported the perception or effort during 2 MWT after completing the tests by marking marks on a graduated scale (very very easy to very very difficult) corresponding to the

Borg 0 to 10 scale. The researcher or volunteer explained and practiced with each subject how to complete he scale until they were able to report sensation reliably.

1.2 Justification of Study

The study was conducted to investigate the level of cardiorespiratory fitness of cerebral palsy children in term of estimated VO_2 max from their heart rate during 2MWT. Cardiorespiratory fitness is the most powerful marker of health, and important quantitative predictor of cardiovascular measures causing mortality of both normal and CP children. Generally, the CP children have low cardiorespiratory fitness compared with normal children and there is no sufficient research regarding the feasible way to evaluate and improve it. Since most of the studies showed that the child with higher cardiorespiratory fitness levels have been associated with a healthier cardiovascular profile in adulthood, evaluation of cardiorespiratory fitness may help to identify a target population for primary prevention both in children and adults, as well as for promotion of health policies.

Moreover, there are no sufficient data in literature regarding the cardiorespiratory profile of the CP children in comparison to adult. The procedure used in the study was submaximal field test in which VO_2 max was estimated using heart rates, distance covered and individual rate of perceived exertion. It is a safe, reliable, cost effective and efficient measurement for estimating the cardiorespiratory fitness of CP child. Along with this, the study will find out the different indicators of cardiorespiratory fitness during the study period like HR reserve, HR max etc. These indexes are very much important in determining the cardio respiratory related mortality and further preventing the risk to improve overall quality of life of CP children along with their parents. The purpose of this study was to determine whether the cardiorespiratory endurance of children with CP differ than that of normal child, and whether differences in the locomotion capacity among CP patients affect their cardiorespiratory endurance.

1.3 Significance of the Study

The study is believed to be the first in Bangladesh in term of determining cardiorespiratory fitness in term of VO_2 max on CP children of GMFCS level I, II, III. The main finding of the study will be the level of cardiorespiratory fitness of the CP children which is responsible for the overall quality of life of the CP child. The product of this work will also intend to increase understanding of cardio respiratory fitness of CP child in order to improve the effective planning of rehabilitation strategies based on expected outcomes. This study is expected to contribute data to parents, service providers and policy makers for designing the service needed for CP child for improving the cardiorespiratory health on the basis of evidence.

1.4 Research Question

What is the level of cardio respiratory fitness in term of estimated VO_2 max in cerebral palsy children classified in functional levels GMFCS I, II and III?

1.5 Operational Definition

Cerebral Palsy

CP is an umbrella term for various neurological disorders caused by a non - progressive lesion in the developing brain, caused by brain injury or abnormal development of the brain that occurs while a child's brain is still developing — before birth, during birth, or immediately after birth which result in abnormal postural tone and atypical movement patterns.

Cardio Respiratory Fitness

Cardio respiratory fitness is defined as the ability of heart and lungs to take in the oxygen and deliver it to all parts of body allowing the participation in physical activities over a long period of time.

VO_2 max

VO_2 max is the maximum capacity of an individual's body to use and transport oxygen during exercise.

Heart Rate

Heart rate is the speed of the heartbeat measured by the number of contractions of the heart per minute (bpm).

Maximum Heart Rate (HR max)

The maximum heart rate (HR max) is the highest heart rate an individual can achieve without severe problems through exercise stress; it generally decreases with age.

Recovery Heart Rate

Recovery heart rate is the measure of how much the heart rate fall during the first two minutes after maximal or sub maximal exercise

Reserve Heart Rate (HRR)

Reserve Heart Rate is the difference between resting heart rate (HR rest) and maximum heart rate (HR max).

2-Minute Walking Test

The 2MWT is a measurement of endurance that assesses walking distance over two minutes for determining the cardio respiratory fitness of an individual.

Borg Scale for Perceived Exertion (BRPE)(Modified)

Borg Rate of Perceived Exertion (RPE) is a 0 - 10 scale of perceived exertion which is used for quantifying, monitoring and evaluating the exercise tolerance and magnitude of exertion in healthy child populations and other groups

ABILOCO Kids

ABILOCO-Kids are tools to measure a locomotion ability for children with lower limb impairments which assess the wide range of walking ability of children with CP focusing on the activity domain of the ICF.

CHAPTER II LITERATURE REVIEW

Cerebral palsy (CP) is the most common cause of neuromuscular physical disability in children (Surveillance of Cerebral Palsy in Europe, 2000). It is described as a group of permanent disorders of development of movement and posture causing activity limitation due to non-progressive lesion that occurred in the developing fetal or infant brain. The motor disorders of CP are often accompanied by disturbances of sensation, perception, cognition, communication, behavior, epilepsy and secondary musculoskeletal problems (Rosenbaum et al., 2007). A study done in developed countries on children with CP have shown that1 in 3 cannot walk; 1 in 4 cannot talk; 1 in 2 have a cognitive impairment; 1 in 4 suffer from epilepsy; 1 in 25 are deaf and 3 in 4 experience pain (Baxter, 2013).

It is one of the major cause of childhood disability with an estimated global incidence between 2 and 3 per 1000 live births (Maloni et al., 2010). The prevalence of CP in Bangladesh was estimated up to 3.7 per 1000 children (Murthy et al., 2014). However, another pilot study showed that out of 859 children with severe physical impairment, 48.5 % had CP and over half of those children (57 %) had never received any rehabilitative support or services, only 21.1 % (182) of those children were attending regular school and just 0.2 % (2) were attending special schools (Khandaker et al., 2014). The prevalence of CP was substantially higher among preterm and extremely preterm infants (< 28 weeks) and infants with low birth weight (< 2.5 kg) (Ketelaar, Vermeer and Helders, 1998). Although CP is found in all socioeconomic groups, most of the CP is associated with low birthweight and low SES. However, even in the normal birth weight ranges, rate of CP was 2.42 per 1000 live births for those in the lowest socio-economic groups compared to 1.29 per 1000 for the most affluent groups (Solaski et al., 2014; Oskoui et al., 2016).

Most of the CP are result of a lesion or mal development of a brain which is non-progressive in character and existing from earliest childhood (Ketelaar et al., 2010). There are different risk factors for the different CP syndromes. e.g. unilateral and bilateral spastic, ataxic and dyskinetic cases. However, the possible risk factors of CP are decreased birth weight, gestational age, chorioamnionitis, inflammation with activation of coagulation and

the inflammatory response and the neonatal period hypoxia, respiratory and circulatory problems (Ravn et al., 2010).

CP children have different level of gross motor function impairment along with other associated neuro developmental problems. The Gross motor function can be described by Gross Motor Function Classification (GMFCS) Scale (Rosenbaum et al., 1997). It is a standardized observational instrument that was developed to measure change in gross motor function over time in children with cerebral palsy (Ketelaar, Vrmeer and Helders, 1998). The severity of motor involvement in CP can be classified using the GMFCS System (Palisano et al., 1997). It is based on gross motor development of self-initiated movement with the emphasis on sitting and walking which consists of a five-level classification system with descriptions on five age bands, <2, 2-4, 4-6, 6-12 and 12-18 years. The children with age 6- 12 years at levels-I walks without restriction, limitation in more advance gross motor skills. The children at level-II walk without aids, limitation walking outdoors and, in the community. The children at level-III walk with aids, limitation walking outdoors and, in the community. The children at level-IV self-mobility with limitation, uses wheelchairs or power mobility devices. The children at level-V have no means of independent mobility (Palisano et al., 2007).

A different study had shown that CP children display low levels of cardio respiratory fitness (CRF) in term of reduced peak VO_2 max or a higher submaximal energy demand of walking. The CP children who are able to walk, the locomotor energy demands increase with age 9 making it difficult to walk as they enter in phase of adolescence and adulthood (Hoofwijk et al., 1995; Unnithan et al., 1996 & Morgan et al., 2005). It was also found that low CRF was associated with adverse metabolic risk factors profiles, increased risk of cardiovascular disease, types type II diabetes and mortality and the strength of association between low CRF and mortality can be compared between mortality and convention health indicators (Jurca et al., 2005).

CRF is also known as an element of 'physical' fitness which is described as the body's response or adaptation to the demands and stress during physical effort (ACSM, 2013). The promotion and maintenance of CRF ensure adequate levels of physical activity and subsequent development of motor skills which is for desirable optimal health and for

prevention of age-related diseases (WHO 2001; Campbell et al., 2012 & Strong et al., 2005). Children with disabilities have the same activity requirement as children without disabilities (World Health Organization, 2010). Therefore, all children need to accumulate 60 minutes or more of moderate-vigorous intensity activity throughout the day (WHO, 2012) or 30 minutes of moderate intensity aerobic exercise 3-4 times a week for children with and without disabilities (American College of Sports Medicine (ACSM), 2010).

The main determinant of CRF is VO_2 max which is defined as measure of maximum oxygen uptake per kilogram of body weight per minute (ml O_2 /kg/min or ml/kg/min) (Davis, 1995). A VO_2 max value of 42 ml/kg/min for males and 35 ml/kg/min for females are considered to be indicative of good cardiorespiratory health (ACMS, 2000). However, studies had shown that VO_2 max is approximately 25% less in children than a young adult (Washington et al., 2008). Along with this, determining and measuring the CRF over and above natural activity level of children is difficult as most of the test requires voluntary participation to fatigue and compliance issue in children (American Academy of Pediatrics 1994). Therefore, VO_2 max plateau usually seen in adults is not usually found in children (Armstrong and Welsman, 1994).

A study done by Verschuren & Takken (2010), on children with age between 7-17 years showed VO_2 max value of 42 ml/kg/min. Maltais et al. (2005) found VO_2 max of 34.0 ml/kg/min on 11children (7 boys and 4 girls) of age between 10-16 years on different spastic CP type with GMFCS I or II while using progressive exercise test on treadmill. However, a minimum VO_2 max of 42 ml/kg/min for male (5 -17 years) and 40 ml/kg/min for females (5-9) was recommended. The other study showed VO_2 max of 40-50ml/kg/min in healthy children (Pryor & Prasad, 2008).

VO_2 max is also known as gold standard measure of CRF and it can be assessed with direct (most precise, obtained by ventilatory gas analysis at maximal exertion during graded ergometry test but expensive) or indirect procedure (submaximal exercise ergometry or amount of time required to walk, jog, or run specified distance and cost effective) (Davis, 1995; ACSM, 2013). It can also be estimated from physiological responses during submaximal exercise or in combination with performance measures (Uth et al., 2003).

A study also found that the treadmill protocols that were often used in clinical practice (Bruce protocol and Balke protocol) was not appropriate for CP children (Unnithan, Clifford and bar-Or-O, 1998). Therefore, for children who are able to walk independently a walking-based exercise test is preferable to directly measure CRF (Verschuren et al., 2006) because time walk test was less expensive, simple and safe alternative to laboratory testing for children with CP (Verschuren et al., 2007; McDowell et al., 2005 & Kerr et al., 2005). The sub-maximal exercise testing has many advantages over maximal testing and is preferred by clinicians working with individuals with chronic pain or physical limitations (Noonam and Dean, 2000).

A walking test (12 min walk test which was first describe in literature, adapted from cooper's test) can be used to assess the functional capacity of different population due to its simplicity, interpretability and representation in daily life activities. The study had shown that though 6 min walk test (6MWT) is most common methods for evaluating functional capacity and more informative for assessing, 2 MWT is reproducible and better tolerable to COPD (Butland et al., 1982 and Cooper et al., 1968). A study also found that 6MWT can predict CRF in both healthy and severely disable children with or without gas collection (Nixon et al., 1996, Gulmans et al., 1996, Li et al., 2005) and it had been frequently used in sport medicine and to assess functional capacity of CP children (Thompson et al., 2008).

Besides this, a high correlation on walking distance and 2MWT was found across multiple neuromuscular diseases of varying disease severities. This suggests that the 2MWT is a valid alternative to 6MWT to assess walking capability in patients with neuromuscular diseases (Andersen et al., 2016). A study also showed that 2MWT and 100 m were highly correlated with 6MWT ($r = 0.827$ and $r = 0.827$ respectively, $p = 0.002$) (Alfano et al., 2014). Along with this, another study suggested that the completion rate, values obtained, test-retest reliability and relationship of the distances walked in 2 and 6 minutes support documentation of 2-minute distance during the 6MWT. The literature also showed that 2MWT has been better tolerated in pediatric and older persons in geriatric rehabilitation than 6MWT (Pin, 2014). Recent research also showed that test retest reliability measured

by intraclass correlation analysis was very strong for both the 6MWD and 2MWD (Vill et al., 2015).

During cardiopulmonary test like maximal or submaximal exercise test, several objective and subjective signs like perceived exertion, physical signs of intense effort (facial flushing, sweating, unsteady gait or uncoordinated movements) and predicted maximum heart rate were used for evaluation (Paridon et al., 2006; Washingtpn et al., 1994). The HR rises in almost linear fashion and reaches its maximal value at VO_2 max value during most of exercise testing. Therefore, it served as an indicator of performance in exercise test. Among the CRF indicators, heart rate recovery after submaximal exercise is used as a measure of overall fitness and even shown to predict all cause of mortality in healthy adult (Cole et al., 2000). The study done by Ten Harkel et al., (2010), on a treadmill on CP children between 8-18 years shows HR max of 184 ±12 b/m.

There are different types of HR Max prediction equation developed for adult (Tanka et al., 2001; Wisen and Wohlfaet, 2004). However, prediction of HR max for the pediatric population are scarce and controversial in comparison to adult. The commonly used equation for calculating HR Max for pediatric population were (220 - age) and (208 - 0.7 × age) and it had been studied over Tanka equation. The study shows that Tanka equation performed better in prediction of HR max but it was unable to sufficiently observe HR max (Wisen and Wohlfaet, 2004). Therefore, HR max predictive equation of (208 – 0.7 × age) was used to calculate HR max during 2MWT of this study. According to research done by Uth et al., (2004), VO_2 max can be estimated indirectly from an individual's HR max and HR Rest with an accuracy and it can be compared favorably with other common VO_2 max tests. The formula is as follows: VO_2 max = 15 x (HR max ÷ HR rest) and it was also used to estimate the VO_2 max of participant in this study. Beside this, there was highly statistically significant correlations between measured VO_2 max and the estimated counterparts using the HR ratio method with correlation coefficients for VO_2 max in ml/kg/min with an averaged 0.91 ($P<0.001$) and for mass-specific VO_2 max with an average 0.87 ml/kg/min ($P<0.001$) (Uth et al., 2003).

Although VO_2 max is partly determined by genotype, it can be improved with systematic training and most of the research had shown the improvements up to 30% (Powers and

Howley, 2003). However, less research was conducted on the responsiveness of VO_2 max to training in children and adolescents than adult. The available research also showed variation in results (Baquet et al., 2003; Thompson and Baxter-Jones, 2002), ranging from no significant changes (e.g., Gilliam and Freedson, 1980) to improvements reaching 15% (Stansky et al., 1979; Helmantel et al., 2009). A study has shown that cardiorespiratory capacity of CP children can be enhanced through exercise- rehabilitation done 40-50 percent of VO_2 max or HR Reserve for 20-40 minutes per session, three to five days a week (Hui and Chan, 2006) and individual with high VO_2 max have ability to restore all pre-exercise reactions rapidly (Rowland et al., 2002). Therefore, a low HR during submaximal exercise and the consequence post exercise HR was considered to be an indicator of CRF (Fitchett, 1985).

A controlled clinical trial study conducted between 15 diplegic spastic CP and 18 normal subject without any neurological impairment performing 3 month of Mac Master Protocol based aerobic exercise found that there was no statistical significant difference in VO_2 Max between groups and it concluded that Spastic CP have higher energy cost and lower aerobic fitness than normal people due to high muscle tone, severe spasticity and involuntarily movements and the exercise program can improve physiological function of muscle and cardio-respiratory endurance in these patients (Izadi et al., 2006). At the mean time another study showed CP children have distinctly subnormal values for peak anaerobic power (Unnithan et al., 1998). In a study of 14 prepubertal girls, 5 (9.3 ± 0.5 years) participated in a swim training program of about one-year duration whereas the control group of 9 girls (9.3 ± 0.4) had no additional training (Obert et al., 1996). Both experimental and control groups increased significantly in absolute VO_2 max by 39% and 13%, respectively from 0.79 ± 0.12 to 1.10 ± 0.17 l/min and from 0.6 ± 0.10 to 0.78 ± 0.12 l/min. The experimental group showed significant improvement of relative VO_2 max from 26.2 ± 4.4 to 33.8 ± 5.0 ml/kg/min (29%) while that of the control group remained stable at about 24.7 ml/kg/min.

The study was conducted among 12 girls (9.3 ± 0.5 years) who participated in a cycle ergometer training protocol for 3 times per week for 20 minutes at a heart rate of 160 to 170 bpm and 11 girls (9.8 ± 0.4) who participated in sprint running for 8 weeks. The running protocol called for maximal sprints of 10 and 30 seconds in which the number of

sprints increased from 3 of each duration in the first week to 6 sprints of each duration in week 8 (McManus et al., 1997). A control group had no formal training. VO_2 max was assessed with incremental treadmill test. Both experimental groups improved significantly in absolute VO2 max, cycling group by 10% (1.30 ± 0.19 to 1.43 ± 0.20 l/min) and running group by 8.4% (1.54 ± 0.24 to 1.67 ± 0.22), while the control group did not change in absolute VO_2 max (1.49 l/min) after 8 weeks.

A study showed that increased CRF have inverse relation with difference between various cardiorespiratory indexes in each surface of exercise. The early studies showed that after six months aerobic exercise on adult that increased VO_2 max by 18% lead to higher relation between percentage of VO_2 max and HRR percentage (Graves et al., 1992)

According to Haekel et al. (2011), the cardiopulmonary exercise test performed on 175 school healthy school children (8 – 18 years) found that VO_2 max did not change with age. The mean VO_2 max for male was 184 ± 12 bpm and for female was 186 ± 10 bpm.

VO_2 max is highly correlated to body mass and in most studies boy's body mass-related VO_2 max has been reported to remain remarkably stable over the age range 8-16 years with values approximating 48-50 mL·kg-1.min-1, whereas VO_2 max of girls generally fall with increasing age, from about 45-35 mL·kg-1.min-1. Boys showed higher body mass-related VO_2 max than girls throughout childhood and adolescence, with the sex difference reinforced by girl with greater accumulation of body fat during puberty (Armstrong, 2006).

The study of 219 obese children between age 8-16 years with an average BMI 24.3–57.0 kg.m−2 performed a submaximal bicycle ergometry and interview concerning participation in organized physical activity and it was found that obese children had relatively lower VO_2 max ($p < 0.001$) and participated less in organized physical activity than the reference group (Berndtsson et al., 2007). Other study showed that when BMI increases, VO_2 max decreases (Loftin et al., 2001). But another study found strong relationship between VO_2 max and body mass because all exercise requires body movement (Tartaruga, et al., 2010). However, a study found that percentage of fat doesn't have a great influence on children VO_2 max and concluded that the difference between obese and normal weight children is due to other factors rather than fat percent (Reiersen, 2013).

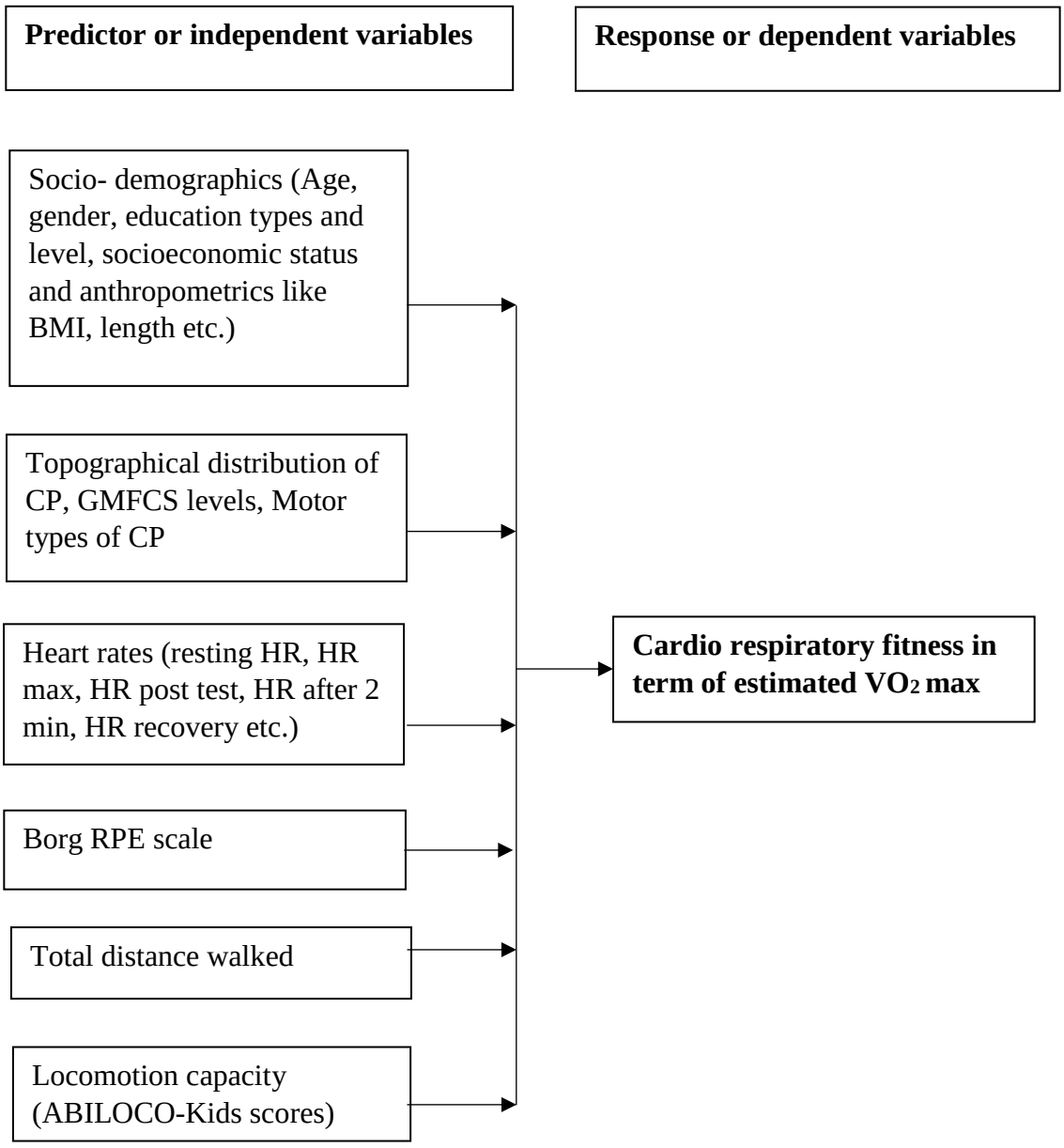
Though the literature showed a significant relation between HR Recovery and VO_2 max, a study done on 50 active subjects (23.2 ± 21.8 years) showed insignificant relation and moderate correlation between HR Recovery and resting HR (Bunn et al., 2017). The American College of Sport Medicine (ACSM) assumes that a percentage of HR reserve provides the same intensity as the equivalent percentage of VO_2 max but the certain study reported a conflict results due to the effective factors likes physical fitness, intensity in aerobic and anaerobic exercise, cardiovascular fitness and environment temperature (Mojtaba et al., 2010). The study done by McCulloch (2013), showed VO_2 max can be estimated using a submaximal graded exercise test when extrapolated to RPE and there was a strong correlation between predicted and actual VO_2 max values in healthy able-bodied individuals.

Children with CP have multiple musculoskeletal impairments which affect their ambulatory function (Rosenbaum, 2003) and the walking performance (locomotion) of children can be described by ABILOCO-Kids in a 10-item questionnaire (Caty et al., 2008). A study done by the developers of the ABILOCO-Kids with 113 children with CP and 108 parents had shown good psychometric properties with high test-retest reliability and high reproducibility of item hierarchy. It also had high concurrent validity tested by correlation with the GMFCS (McDowell et al., 2007). The study done by Chong et al. (2011) had found that in children with CP who are predominantly GMFCS levels I to III, 1MWT and 6MWT are strongly correlated with the parental reports of walking ability (AILOCO-Kids), providing evidence of convergent validity and supports the use of walk tests in the clinical settings. However, the level of association between walk tests and parental perceptions of walking ability was relatively weak for children who functioned at a high level (GMFCS I) and was stronger in children who were at GMFCS II or III.

A study done by Brehm et al. (2014), among 21 CP children age 6-14 and GMFCS I, II, III found the mean VO_2 max of 39.3 ml/kg/min during progressive maximal cycle ergometer and the VO_2 max was considered as the best indicator of cardiorespiratory fitness. It was reliable in children of GMFCS levels I through III and can be used as an evaluative measure to detect changes following interventions in this population.

CHAPTER III METHODOLOGY

3.1 Conceptual framework



3.2 Study Objectives

3.2.1 General Objectives

1. To determine the cardio respiratory fitness of cerebral palsy children with GMFCS I, II, III in terms of VO_2 max, heart rate and the Borg Scale for perceived exertion by 2 MWT.

3.2.2 Specific Objectives

1. To explore the socio-demographic characteristics of participant.
2. To assess factor associated with cardio respiratory fitness.
3. To study the association between different heart rates measured during 2MWT.
4. To study the association between cardio respiratory fitness and locomotion capacity of children with CP.
5. To determine the association between VO_2 max and HR during 2MWT.
6. To show the association between Perceived Exertion and VO_2 max.

3.3 Study Design

The study was conducted by using quantitative method that is cross sectional study with interview conducted with mothers or caregivers of CP child. This design was chosen because it was carried out at one center and with short duration time frame. The study was mainly focused on finding cardio respiratory fitness levels of cerebral palsy children with GMFCS I-III, in term of VO_2 max, heart rate and the Borg Scale for perceived exertion while performing the 2MWT. This study design was considered to collect the quantitative data effectively about different variables related to study and provide a picture of problems along with valuable insight to improve the overall physical fitness of children with cerebral palsy.

3.4 Study Population

The study population was the cerebral palsy children with GMFS I-III from the William and Marie Taylor School and Pediatric unit of Centre for Rehabilitation Paralyzed (CRP).

3.5 Study Period

The study period was for the duration of six months from December 2017 to May 2018 after approval of the research protocol.

3.6 Study Site

The study was conducted in Reed - way Hall of the Centre for the Rehabilitation of the Paralyzed (CRP) in Savar, Bangladesh.

3.7 Sample Size

The cerebral palsy had no exact prevalence rate throughout the literature. So, 50% prevalence was considered as prevalence of CP to calculate the desired sample size in this study by using the following formulae: -

$$n = \frac{Z^2 p(1-p)}{d^2}$$

Where: n = the desired sample size.

Z = the standard normal deviation, set at 1.96, which corresponds to 95% confidence level.

p = the prevalence proportion set at 50 %

d = degree of accuracy desired, here set at 0.05 corresponding to the 1.96.

While substituting the values in the formula, the sample size was 384. However, only 95 participants were included in the study because of technical, financial and time constraints.

3.8 Inclusion and Exclusion Criteria

3.8.1 Inclusion Criteria

- Cerebral Palsy,
- Male and female,
- Age 6 to 12 years,
- GMFCS levels I to III,
- On medication for CP,
- Ability to walk continuously for 2 minutes or wheel own wheel chair,
- Willing to participate (parents' informed consent is given).

3.8.2 Exclusion Criteria

- Not able to walk or wheel independently,
- Unstable epileptic seizures, several behaviour problems,
- Illness at the time of testing (fever),
- Inhibited by other medicine for exercise and other conditions that could affect the walking ability,
- Orthopedic surgery or neuro surgery within the past 18 months and/or botulinum toxin injection within the previous 6 months,
- Cardiac or respiratory conditions that have been negatively affected on the study,

- Those children and parents not willing to participate and parents unable to fill the form.

3.9 Sampling Techniques

Convenience sampling was used as it is effective when there were only limited numbers of participants who can serve as primary data sources due to the nature of research design, aims and objectives of this study. This sampling technique was easy to reach the study population according to inclusion and exclusion criteria.

3.10 Data Collection Tools/ Materials

Equipment Required for the study was as follows:

- 2 MWT and ABILOCO-Kids questionnaires,
- Data collection sheets (study questionnaires including demographic form, and the Borg Breathlessness Scale for participants),
- Device for measuring heart rate,
- Stopwatch,
- 15.2-meter trail line on ground,
- Measuring tapes to measure distance covered,
- Pen, paper or data collection sheets. Chairs etc. (Enright, 2003).

3.11 Data Collection Techniques

The data was collected after approval of the study by Dhaka University, Institutional Review Board of Bangladesh Health Professional Institute (BHPI) along with permission from Pediatric Physiotherapy Department of CRP and William and Marie Taylor School, CRP. All the subjects and parents received explanations regarding the purpose and procedure of the study before voluntarily agreeing to take part. Data were collected through face to face administration of prepared questionnaires. Before proceeding for the study, a pre-test was conducted to find out possible drawbacks in the study tools and procedure and necessary correction was made to the best of possible knowledge and effort.

Procedure

The data was collected from 2MWT which was performed in in the Reed-way Hall between two 15.2 m trail lines on the ground, using a standard procedure. The subjects were instructed to walk or wheel as fast as possible between the cones placed at 15.2 meters apart, had to turn around each of the cones and then walk or wheel the other way. The subjects received standardized and vigorous verbal encouragement and they were advised of the distance covered and time remaining every 30s. However, if they absolutely needed a rest due to high perceived exertion or tiredness, or any other problem, they were allowed to stop and stand still or sit on the chair for a while and also were advised to walk further till 2 minutes as soon as possible. Data were collected at rest, immediately after completing the 2 MWT and during a 2 minutes recovery period. The collected data during the 2MWT were heart rates, total walked/wheeled distance, number of rests taken during and immediately after the test as well as the Borg RPE scale. Besides, child's length, weight etc. And all variables from the questionnaires were filled out before or after the 2MWT.

3.12 Data management and Statistical analysis:

After the completion of data collection, quality control was checked for accuracy, utility and completeness and stored systematically and scientifically. Any errors, incompleteness and inconsistencies in data affecting the study result was excluded. The data entry and analysis were done by using Statistical Package for Social Science (SPSS 18.0). Data was analyzed through descriptive statistical analysis and use them to generate tabulated reports, charts, plots of distributions, trends and other descriptive statistics and then other complex statistical analyses was conducted. A descriptive statistic was used to attain research objectives.

Correlation were used to find the correlation among different continuous variables associated by cardiorespiratory fitness (VO_2 max). Independent t- test was used to show association between dependent and independent variables. Similarly, Paired t- test was used to find the association between different heart rates during 2MWT. Finally, one – way ANOVA was used to study association between different variables and VO_2 max.

3.13 Quality Control and Quality Assurance:

The questionnaire was developed based on literature review and some questions was modified from similar studies. To ensure and improve the quality of study, the questionnaire was translated into Bangla language after linguistic validation. Data collection was done only after a pilot study with the questionnaire to ensure face validation-through face to face interviews of the questionnaires. Then the questionnaires that was filled out was kept safely. The collected data was reviewed, recorded and entered into an SPSS program in order to reduce human error and technical errors during data analysis. All the data was digitalized systematically and scientifically.

3.14 Ethical consideration

The study was conducted after approval form Ethical Review Board of BHPI and permission from the respective data collection area. This study complied with the ethical principles of the Declaration of Helsinki, and data was collected from the respondents through face to face interview and self-administered questionnaire. The respondents were allowed to participate voluntarily in the study and were free from any kind of physical or mental assault. The informed consent in both written and verbal form were taken. Before interviewing the respondents were clearly explained about the aim, content and methods of the data collection and be assured that the collected information will be absolutely confidential. They had complete freedom to be involved in the study and the respondent had options to or not to respond to the interviewer's inquiry without any influence.

CHAPTER IV RESULTS

4.1. Sociodemographic Characteristics

Gender of participants

Among the 95 participants, the male was 64.2% (n=61) and female was 35.8% (n= 34).

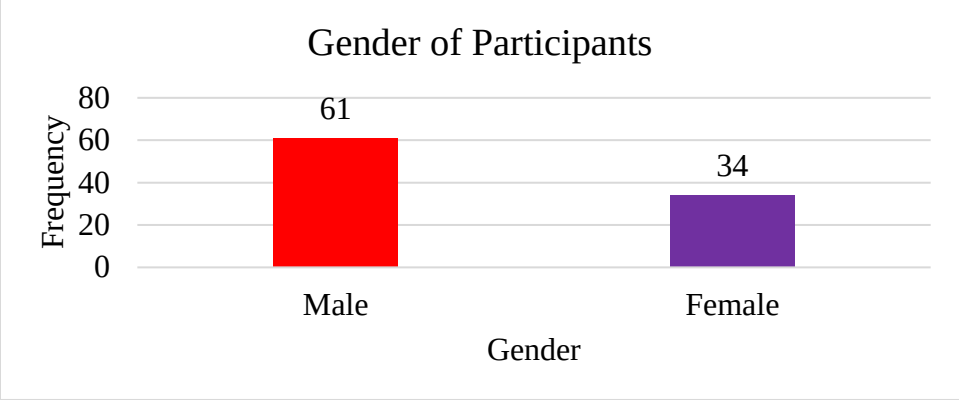


Figure 1: Gender of Participant

Age of participants

The average age of participants was 8.33 ± 2.01. Most of the respondents were aged 6-9 years with 71.6% (n=68) and participant with aged 10-12 years ware 28.4% (n=27).

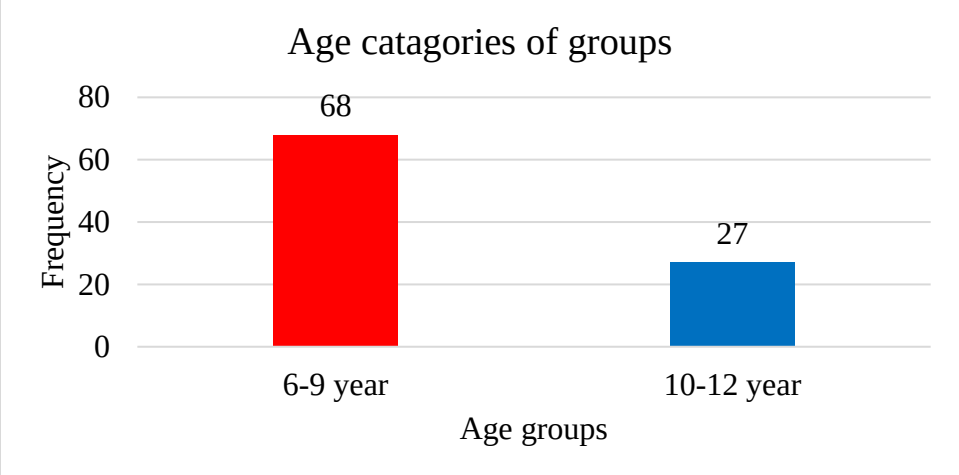


Figure 2: Age of participant

Religion of participants

Among the 95 total children's most of them belongs to Muslim 90.5 % (n = 86) followed by Hindu 8.4 % (n = 8) and Christian 1.1 % (n = 1).

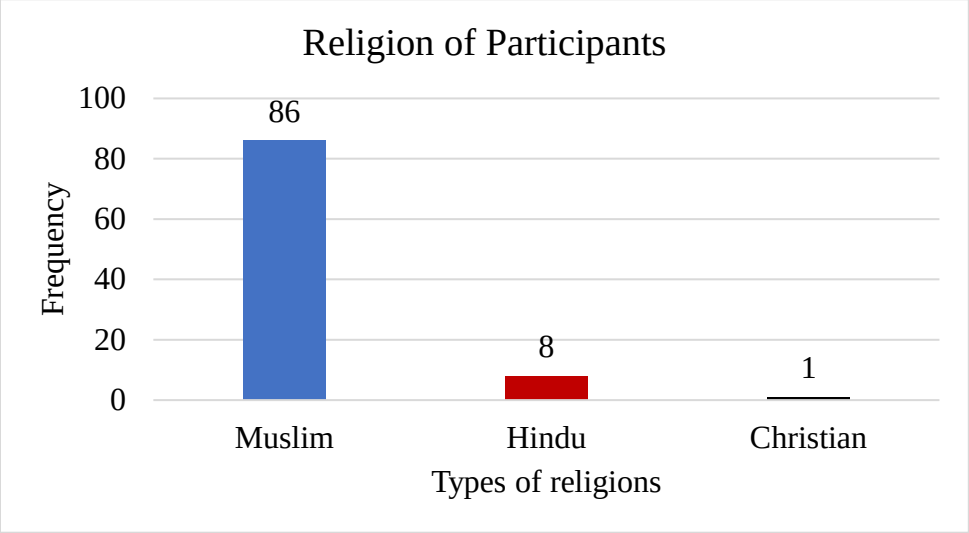


Figure 3: Religion of Participant

Education levels of participants

Most of the Participants were illiterate 33.7 % (n = 32), primary education level 29.5 % (n = 28) and K.G 23.2 % (n = 22). SENU had low participants that is 13.7 % (n = 13).

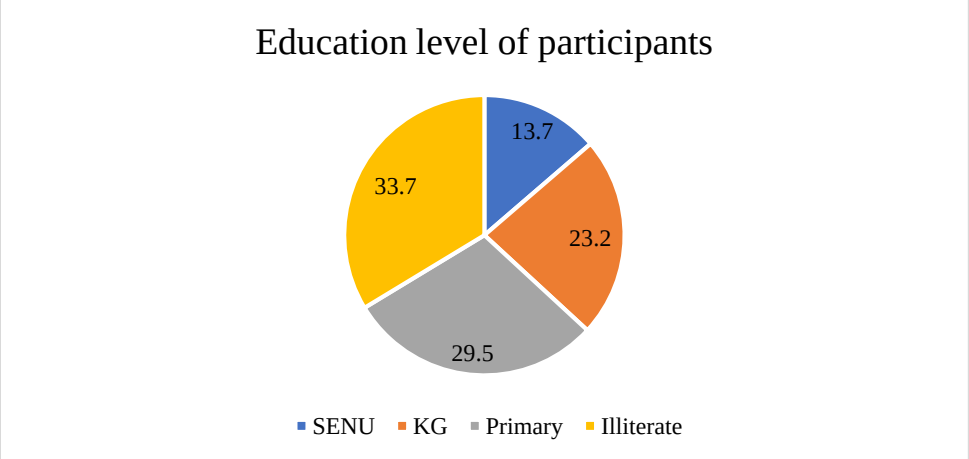


Figure 4: Educational level of Participant

Education type of participants

Most of the participant had attended integrated types of education 29.5 % (n = 28) followed by inclusive 24.2 % (n = 23) and special 12.6 5 (n = 12). And those who did not attend any types of education were 33.7 % (n = 32) which was higher than participant in integrated types of education.

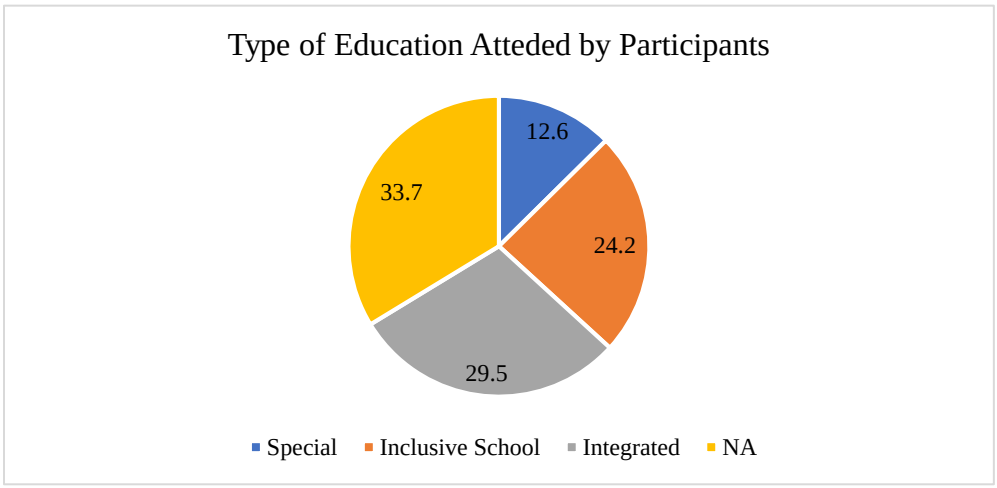


Figure 5: Education type of Participants

Family types of participants

Most of the participants had nuclear family types 81.1 5 (n = 77) and fewer participant had joint family type 18.9 % (n = 18).

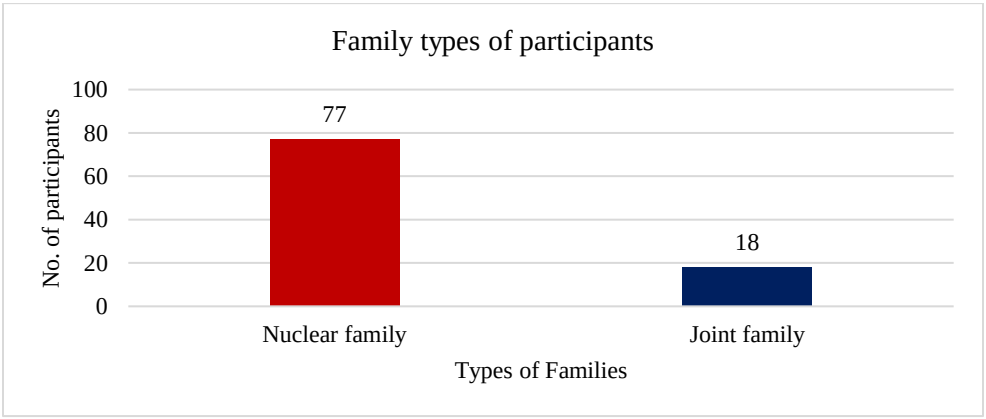


Figure 6: Family types of participants

Parents education level of participants

The secondary education level had highest response with 63.2 % (n = 60) for the parent's education level of participants followed by graduation 11.6 % (n = 11), primary 9.5 % (n = 9), higher-secondary 8.4 % (n = 8) and illiterate 4.2 % (n = 4). And the fewer participants parents had post-graduation education level 3.2 % (n = 3).

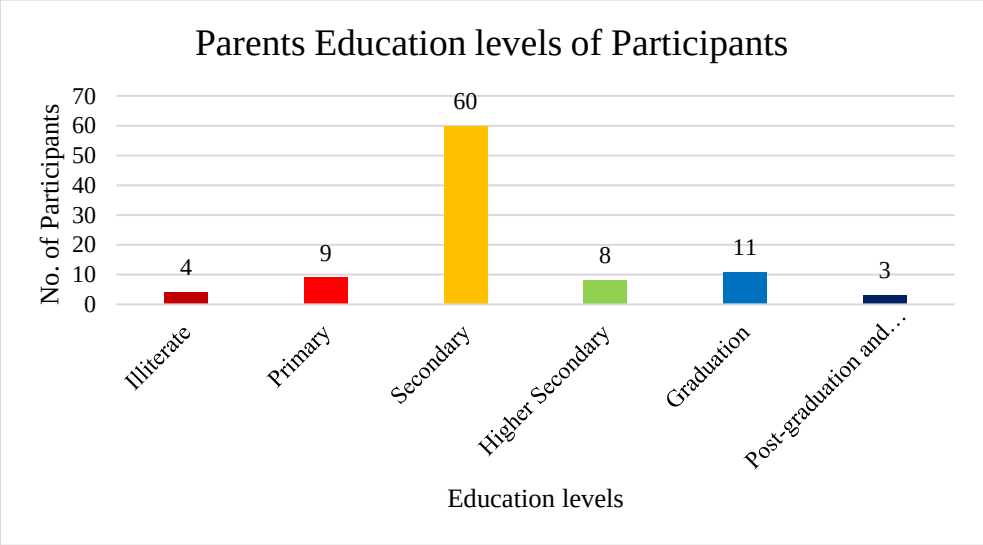


Figure 7: Parent education level of participants

Parents monthly income of participants

Among the 95 participants 2.1 % (n = 2) participants had their family monthly income less than 5,000 taka, 31.6 % (n = 30) participants had their family monthly income 5,000 - 10,000 taka, 42.1 % (n = 40) participants had their family monthly income 10,000 – 20, 000 taka, 12.6 % (n = 12) participants had their family monthly income 20,000 – 30,000 taka, 6.3 % (n = 6) participants had their family monthly income 30,000 – 40,000 taka, 2.1 % (n = 2) participants had their family monthly income 40,000 – 50,000 taka, 3.2 % (n = 3) participants had their family monthly income above 50,000 taka.

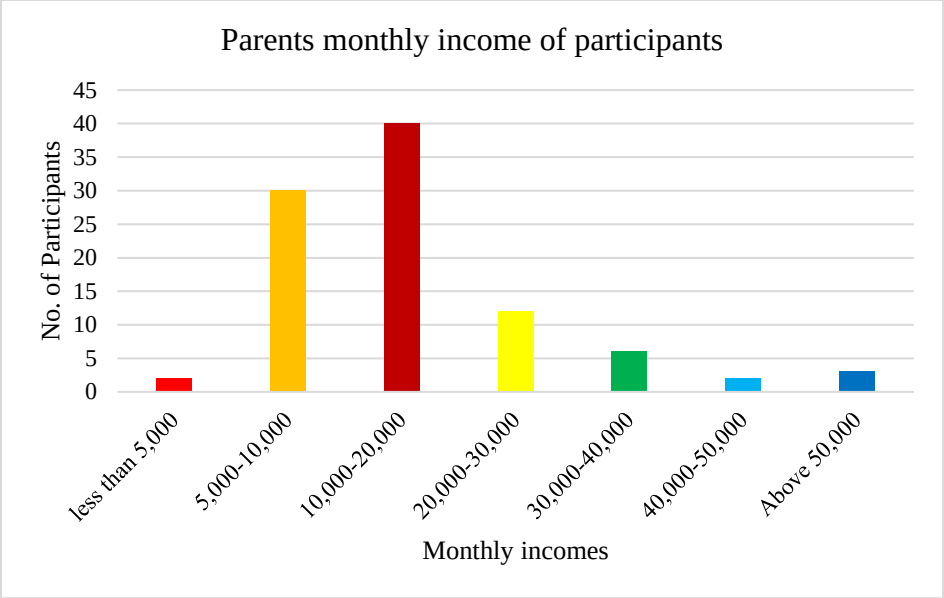


Figure 8: Parents monthly income of participants

BMI of participants

The average BMI of participant was 15.07 ± 2.96. Most of the children were underweight 87.4 % (n = 83) while few were overweight 2.1 % (n = 2.1) and moderately obese 1.1 % (n = 1). And only 9.5 % (n = 9) of child had normal BMI.

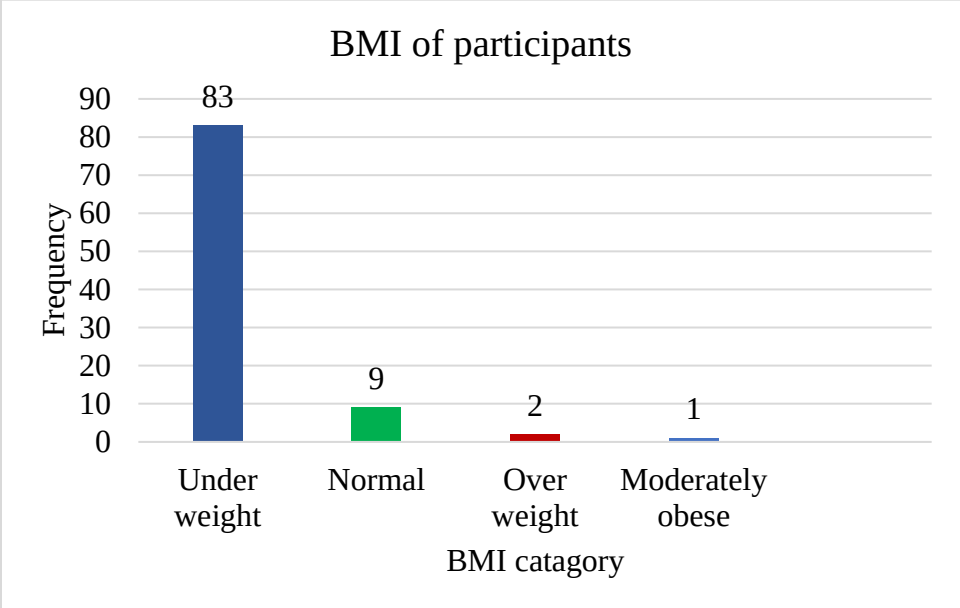


Figure 9: BMI of Participants

Topographical classification of CP

The topographical distribution of CP among the 95 participants shows that most of them were quadriplegic 26.3 % (n = 25) followed by diplegic 22.1 % (n = 21), paraplegic 20.0 % (n = 19), Rt. Hemiplegic 12.6 % (n = 12), triplegic 11.6 % (n = 11), Lt. hemiplegic 4.2 % (n = 4) and monoplegic 3.2 % (n = 3).

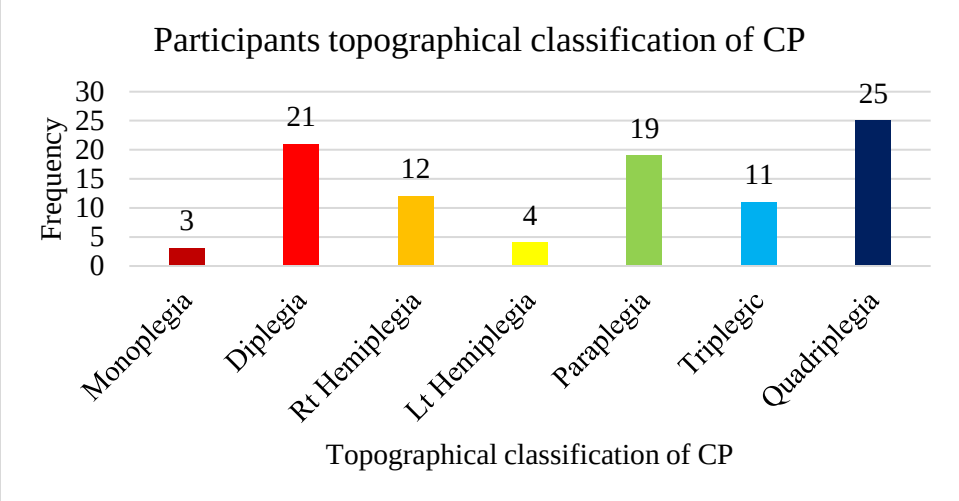


Figure 10: Topographical classification of CP

GMFCS classification of participants

Among the 95 participants, GMFCS I had a higher respondent 46.3 % (n = 44) followed by GMFCS III 38.9 % (N = 37) and lowest in GMFCS II 12.7 % (n = 14).

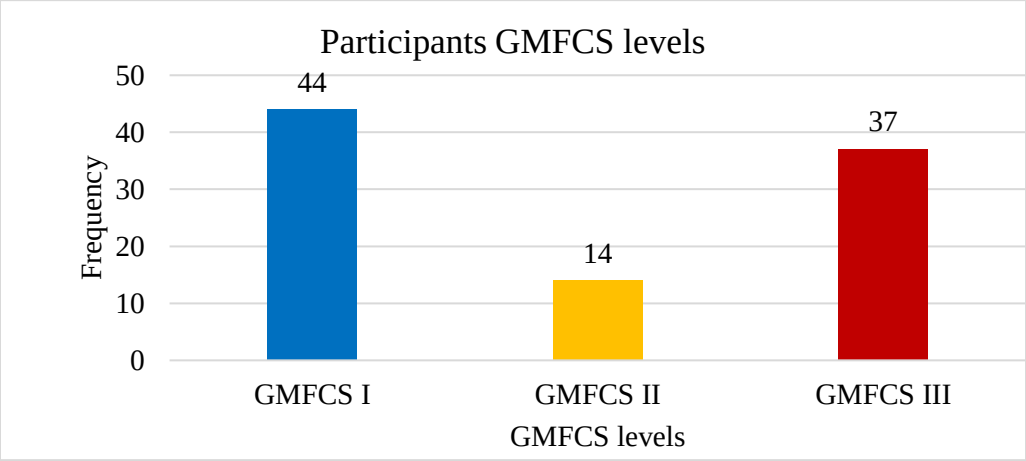


Figure 11: GMFCS classification of Participants

CP motor type

Most of the participant were spastic 73.7 % (n = 70) followed dystonic and mixed 6.3 % (n =6), ataxic 4.2 % (n = 4), flaccid and athetoid 3.2 % (n = 3), hypotonic 2.1 % (n = 2). Other was only 1.1 % (n = 1).

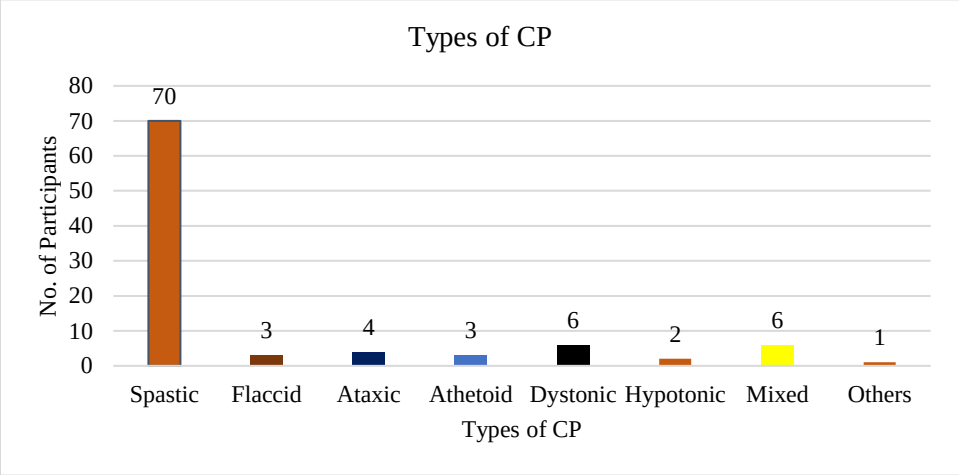


Figure 12: CP Motor Type

Assistive device used by participants

Most of the participants were using assistive device 52.6 % (n = 50) and 74.4 % (n = 45) did not use any kind of assistive device.

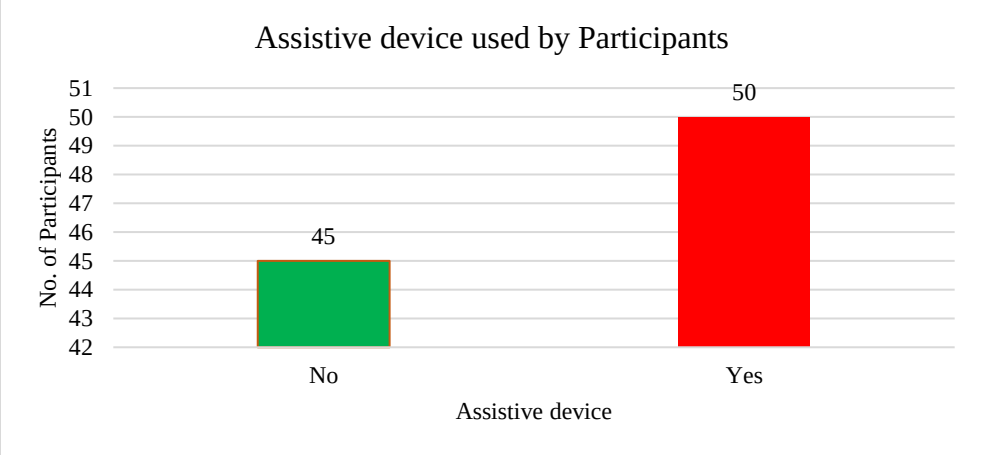


Figure 13: Assistive device used by participants

Types of assistive devices used by participants

Among the participants most widely used assistive device was AFO 26.3 % (n = 25) followed by walkers 10.5 % (n = 10), KAFO 6.3 % (n = 6), wheelchair and others 4.2 % (n = 4). And the foot orthosis was lowest used assistive device 2.1 % (n = 2).

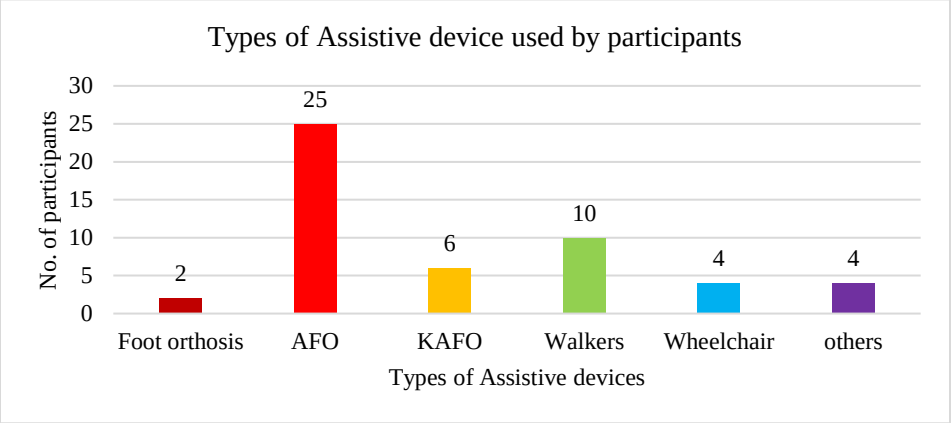


Figure 14: Types of assistive devices used by participants

Assistive device used by participant at different place

Among the participants who used assistive device, most of them used at home 41.0 % (n = 48), 36.8 % (n = 43) used at community and 22.2 % (n = 26) used at school.

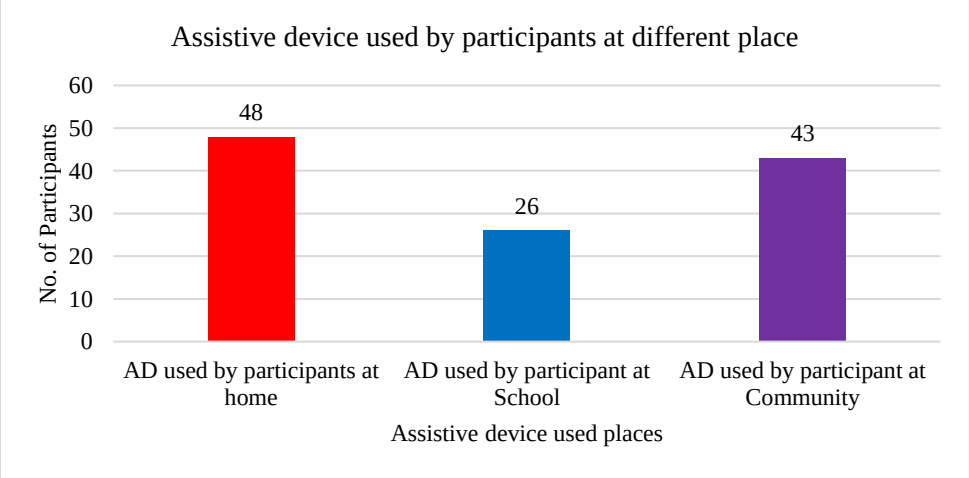


Figure 15: Assistive device used by participant at different place

4.2.Factors associated with cardiorespiratory fitness

Gender and VO_2 max

Table: 1 Independent t- test

Table: 1.1 VO_2 max difference on gender							
Variables	Gender of Participant	N	M ± S. D	SEM	T	df	P
VO_2 max of participant (ml.min-1.kg-1)	Male	61	30.89 ± 3.93	0.504	0.445	93	0.658
	Female	34	30.51 ± 4.21	0.723			
Table: 1.2. VO_2 max difference with Assistive device used.							
Variables	Mobility aids						
VO_2 max of participant in ml.min-1.kg-1	Yes	50	30.73 ± 4.37	0.62	-0.06	93.00	0.96
	No	45	30.78 ± 3.65	0.54			
Table:1.3. VO_2 max difference on Family types of Participants							
Variables	Family types						
VO_2 max of participant in ml.min-1.kg-1	Nuclear family	77	30.7 ± 3.9	0.5	-0.512	93	0.61
	Joint family	18	31.2 ± 4.4	1.0			

Independent T-test for Gender and VO_2 max

An independent sample t- test was conducted to compare the VO_2 max for males and females as shown in Table 1.1. Homogeneity of variances was not violated, as assessed by Levene's test for Equality of variances (p = 0.626). There was no significant difference in scores for males ($M \pm SD$ = 30.89 ± 3.93) and females ($M \pm SD$ = 30.51 ± 4.21); t (93) = 0.445, p = 0.658, 2- tailed). The magnitude of difference in means (mean difference = 0.38, 95 % *CI*: -1.33 to 2.10) was small (eta square = 0.002). That means there was sufficient reason to accept null hypothesis.

Table 2: Correlations among variables

	Variables	1	2	3	4	5	6	7	8	9	10	11
1	**VO_2 max**											
2	**Gender**	-0.05										
3	**Age**	0.15										
4	**BMI**	-0.13	0.09	.219*								
5	**Mobility aids**	0.01	0.04	0.08	0.09							
6	**Temperature**	-.22*	-0.02	-0.14	0.04	-0.09						
7	**HR recovery**	.232*	-0.02	0.02	0.05	0.04	-0.13					
8	**HR reserve**	.98**	-0.06	0.1	-0.17	0.02	-0.2	.206*				
9	**Total distance walk**	-0.08	-0.09	0.15	0.06	.315**	-0.08	0.17	-0.09			
10	**BPE in 2MWT**	0.12	-0.1	-0.06	-0.06	-0.09	-0.02	.	0.13	-0.15		
11	**ABILOCO sum**	-0.02	-0.12	0.05	-0.02	0.17	-.237*	0.16	-0.03	.560**	0.01	

Note: *N* = 95, *. *p* < 0.05, **. *p* < 0.01, **. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

Age and VO_2 max

There was no statistically significant correlation between age and VO_2 max. (Table 2).

BMI and VO_2 max

One -way between – group analysis of variance was conducted to explore the impact of BMI on VO_2 max, as measured from HR max as shown in Table 3.1. Participants were divided in to four groups according to the BMI of participants (under- weight, normal, over- weight and moderately over – weight). There was statistically non-significant difference at the $p > 0.05$ level in VO_2 max value for four BMI categories: $F(3, 91) = 2.62$, $P = 0.055$. Despite reaching the statistically significance, the actual difference mean value was small. The mean values for groups couldn't found as post hoc comparison using Tukey HSD was not possible. The effect size calculated using eta square was 0.006, which is medium effect.

Table 3: One - way ANOVA

Table 3.1: One-way ANOVA between VO_2 max and BMI categories.

Variables	SS	df	MS	F	P	Levene - P
BMI						
Between Groups	121.01	3.00	40.34	2.62	0.055	0.105
Within Groups	1399.70	91.00	15.38			
Total	1520.72	94.00				

Table: 3.2 One -way ANOVA between VO_2 max and Topographical CP of CP child.

Type of CP						
Between Groups	97.32	6.00	16.22	1.00	0.429	0.975
Within Groups	1423.40	88.00	16.18			
Total	1520.72	94.00				

Table: 3.3. One-way ANOVA between VO_2 max and GMFCS

Between Groups	63.0	2.0	31.5	2.0	0.143	0.096
Within Groups	1457.7	92.0	15.8			
Total	1520.7	94.0				

Table:3.4 One-way ANOVA between VO_2 max and CP motor types of participants.

Between Groups	191.37	7.00	27.34	1.79	0.1	0.248
Within Groups	1329.35	87.00	15.28			
Total	1520.72	94.00				

Table:3.5. One-way ANOVA between VO_2 max and education level of participants.

Between Groups	128.48	3.00	42.83	2.80	0.044*	0.73
Within Groups	1392.24	91.00	15.30			
Total	1520.72	94.00				

Table:3.6. One-way ANOVA between VO_2 max and education types of participants.

Variables	SS	df	MS	F	P	Levene - P
Between Groups	195.3	3.0	65.1	4.5	0.006*	0.653
Within Groups	1325.4	91.0	14.6			
Total	1520.7	94.0				

Table:3.7. One-way ANOVA between VO_2 max and types of mobility aids used by participants.

Between Groups	66.98	5.00	13.40	0.72	0.615	0.746
Within Groups	842.20	45.00	18.72			
Total	909.18	50.00				

Table:3.8 One-way ANOVA between VO_2 max and parent education levels of participants.

Between Groups	212.52	5.00	42.50	2.89	0.018*	0.095
Within Groups	1308.20	89.00	14.70			
Total	1520.72	94.00				

Table:3.9 One-way ANOVA between VO_2 max and parents' monthly incomes of participants.

Between Groups	61.99	6.00	10.33	0.62	0.711	0.423
Within Groups	1458.73	88.00	16.58			
Total	1520.72	94.00				

Table:3.10. One-way ANOVA between VO_2 max and Borg RPE of participants.

Between Groups	0.00	1.00	0.00	0.00	0.994	0.485
Within Groups	1520.72	93.00	16.35			
Total	1520.72	94.00				

Topographical classification and VO_2 max

One -way between – group analysis of variance was conducted to explore the impact of topographical distribution of CP on VO_2 max, as measured from HR max as shown in Table 3.2. Participants were divided in to seven groups according to their distribution of CP (Monoplegia, Diplegia, Rt. Hemiplegia, Lt. Hemiplegia, Paraplegia, Triplegia, Quadriplegia and Others). There was statistically not significant difference at the $p > 0.05$ level in VO_2 max value for seven topographical distribution of CP: $F (6, 88) = 1.00$, $P = 0.429$. The effect size calculated using eta square was 0.004 which was small effect.

GMFCS classification and VO_2 max

One -way between – group analysis of variance was conducted as shown in Table 3.3 to explore the impact of GMFCS Levels of CP on VO_2 max, as measured from HR max. Participants were divided in to three groups according to their gross motor function (GMFCS Level I, II and III). There was statistically non-significant difference at the $p > 0.05$ level in VO_2 max value for three GMFCS group: $F (2, 92) = 2$, $p = 0.143$. The effect size calculated using eta square was 0.001, which is small.

CP Motor Type and VO_2 max

One -way between – group analysis of variance was conducted as shown in Table 3.4 to explore the impact of CP motor types of participants on VO_2 max, as measured from HR max. Participants were divided into eight levels according to their motor CP types (spastic, flaccid, ataxic, athetoid, dystonic, hypotonic, mixed and others). There was statistically non-significant difference at the $p > 0.05$ level in VO_2 max value for eight motor CP types group: $F (7, 87) = 1.79$, $p = 0.015$. The effect size calculated using eta square was 0.015, which was small effect.

Education level and VO_2 max

One -way between – group analysis of variance was conducted as shown in Table 3.5 to explore the impact of education levels of CP child on VO_2 max, as measured from HR max. Participants were divided into four groups according to their education levels (SENU, K.G, Primary and Secondary). There was statistically significant difference at the $p < 0.05$ level

in VO_2 max value for three levels of education of CP: F (3, 91) = 2.80, p = 0.04. Despite reaching statistical significant, the actual difference in mean score between education levels of CP was quite small. The effect size calculated using eta square was 0.007, which was moderate effect. Post hoc comparison using Tukey HSD test indicate that VO_2 max for SENU ($M \pm SD$ = 33.62 ± 4.57) differ significantly from primary ($M \pm SD$ = 30.68 ± 4.05) and illiterate ($M \pm SD$ = 30.23 ± 3.71). KG did not differ significantly from either of SENU, primary or illiterate.

Education type and VO_2 max

One -way between – group analysis of variance was conducted as shown in Table 3.6 to explore the impact of education types of CP Childs on VO_2 max, as measured from HR max. Participants were divided in to four groups according to types of their education (Special, Inclusive, Integrated and Illiterate). There was statistically significant difference at the $p < 0.05$ level in VO_2 max values for three types of education of CP: F (3, 91) = 4.5, p = 0.06. Despite reaching statistical significant, the actual difference in mean score between education types of CP child was quite small. The effect size calculated using eta square was 0.016, which is weak. Post hoc comparison using Tukey HSD test indicate that VO_2 max for special school ($M \pm SD$ = 33.46 ± 4.73) differ significantly from integrated school ($M \pm SD$ = 29.22 ± 3.33) and illiterate. Inclusive school and illiterate did not differ significantly from either Special nor Integrated school.

Independent sample t- test for VO_2 max and Assistive device used:

An independent sample t- test was conducted to compare the VO_2 max for assistive devices used by participants as shown in Table 1.2 Homogeneity of variances was not violated, as assessed by Levene's test for Equality of variances (p = 0.294). There was no significant difference in scores for assistive device used ($M \pm SD$ = 30.73 ± 4.36) and assistive device not used ($M \pm SD$ = 30.78 ± 3.65); t (93) = - 0.055, p = 0.956, 2- tailed). The magnitude of difference in means (mean difference = -0.046, 95 % *CI*: -1.69 to 1.60) was moderate (eta square = 0.003). That mean there was no sufficient evidence to rejects null hypothesis.

Type of assistive devices

One -way between – group analysis of variance was conducted as shown in Table 3.7 to explore the impact of assistive device used by participants on VO_2 max, as measured from HR max. Participants were divided on the basis of type of assistive devices used in to six groups (foot orthosis, AFO, AKFO, walkers, wheelchair and others). There was statistically non-significant difference at the $p > 0.05$ level in VO_2 max value for six groups: F (7, 87) = 1.79, p = 0.615. The effect size calculated using eta square was 0.005, which was small effect.

Independent sample t- test for VO_2 max and family types

An independent sample t- test was conducted to compare the VO_2 max for family types of participants as shown in Table 1.3 Homogeneity of variances was not violated, as assessed by Levene's test for Equality of variances (p = 0.483). There was no significant difference in scores for nuclear family ($M \pm SD$ = 30.65 ± 3.947) and joint family ($M \pm SD$ = 31.20 ± 4.421); t (93) = - 0.0512, p = 0.061, 2- tailed). The magnitude of difference in means (mean difference = 0.0542, 95 % *CI*: -2.641 to 1.558) was moderate (eta square = 0.010). That mean there was no sufficient evidence to rejects null hypothesis.

Parent education levels

One -way between – group analysis of variance was conducted as shown in Table 3.8 to explore the impact of parent education level of CP child on VO_2 max, as measured from HR max. Participants parents were divided in to six groups according to levels of their parent education (Illiterate, primarily, secondary, higher secondary, graduation and post-graduation and above). There was statistically significant difference at the $p < 0.05$ level in VO_2 max values of participants for parent six levels of education: F (5, 89) = 2.892, p = 0.01. Despite reaching statistical significant, the actual difference in mean score between parent education levels of CP child was quite small. The mean values for groups couldn't found as post hoc comparison using Tukey HSD was not possible. The effect size calculated using eta square was 0.016, which was weak.

Parents' monthly income

One -way between – group analysis of variance was conducted as shown in Table 3.9 to explore the impact of parent monthly incomes of CP child on VO_2 max, as measured from HR max. Participants were dividend in to seven groups according to their parent monthly (less than 5,000, 5,000- 10,000, 10,000-20,000, 20,000-30,000, 30,000-40,000, 40,000-50,000 and above 50,000). There was statistically non-significant difference at the $p > 0.05$ level in VO_2 max values of participants for seven parent monthly income: F (6, 88) = 0.62, $p = 0.711$. Effect size calculated was 0.001 which was small.

4.3.Association between different Heart Rate measured during 2 MWT.

Table 4: Paired t-test

Table 4.1: Difference between HR post-test and HR rest.

		M	*N*	*S. D*	*R*	*P*
Pair 1	Post Test HR of participant b/m	122.432	95.000	16.028	0.548	0.000
	Resting HR of participant b/m	100.263	95.000	12.949		

		M	**S. D**	**SE M**	**95% CI**		**t**	**df**	**P (2-tailed)**
					Lower	Upper			
Pair 1	Post-test HR of participant -Resting HR of participant b/m	22.17	14.04	1.44	19.31	25.03	15.39	94.00	0.00

A paired-sample t-test was conducted to evaluate the change in Heart Rate of participants as shown in table 4.1. There was a statistically significant increase in HR from Resting HR ($M \pm SD = 100.26 \pm 12.949$) to Post- test HR ($M \pm SD = 122.43 \pm 16.028$), t (94) = 15.39, $P < .001$ (two tailed). The men increased in HR was $M \pm SD = 22.17 \pm 14.04$ with a 95% CI (5 % significant level) and df (94.00) ranging from 19.31 to 25.39. The standard t value was 1.987 and observed t value was 15.39 at same df which was greater than standard t value, that mean there was significant evidence for alternative and against alternative hypothesis. The eta square statistic (0.7) indicated a large effect size.

Table: 4.2. Difference between HR posttest and HR after 2 min

		M	N	S. D	N	r	p
Pair 1	Post Test HR of participant b/m	122.43	95.00	16.03	95	0.46	0.00
	HR_2min of participant b/m	103.97	95.00	14.84			

					95% C I		*t*	*df*	*P (2-tailed)*
		M	*S. D*	*SEM*	*Lower*	*Upper*			
Pair 1	Post Test HR of participant b/m - HR_2min of participant b/m	18.46	16.05	1.65	15.19	21.73	11.21	94.00	0.00

A paired-sample t-test was conducted to evaluate the change in Heart Rate of participants as shown in table 4.2. There was a statistically significant decreased in HR from post – test HR ($M \pm SD = 122.43 \pm 16.03$) to HR after 2 min ($M \pm SD$ = 103.97 ± 14.84), t (94) = 15.39, $P < .001$ (two tailed). The men decreased in HR was $M \pm SD$ = 18.46 ± 16.05 with a 95% *CI* (5 % significant level) and df (94.00) ranging from 21.73 to 15.19. The standard t value was 1.987 and observed t value was 11.21 at same *df* which was greater than standard t value, that mean there was significant evidence for alternative and against alternative hypothesis. The eta square statistic (0.57) indicated a moderate effect size.

A paired-sample t-test was conducted to evaluate the change in Heart Rate of participants as shown in table 4.3. There was a statistically significant increase in HR from Resting HR ($M \pm SD$ =100.26 ± 12.949) to HR after 2 min of exercise ($M \pm SD$ 103.97 ± 14.840), t (94) = 4.164, $p < .001$ (two tailed). The mean increased in HR was $M \pm SD$ = 3.705 ± 8.67 with a 95% *CI* (5 % significant) ranging from 1.939 to 5.472. The standard t value was 1.987 and observed t value was 4.16 at same *df* which was greater than standard t value, that mean there was significant evidence for alternative and against alternative hypothesis. The eta square statistic (0.1) indicated a small effect size

Table: 4.3 Paired t- test between HR rest and HR after 2 min

		M	N	S. D	SEM	r	P
Pair 1	HR_2min of participant	103.97	95.00	14.84	1.52	0.81	0.00
	Resting HR of participant	100.26	95.00	12.95	1.33		

		M	S. D	SEM	95% CI		t	df	P (2-tailed)
					Lower	Upper			
Pair 1	HR_2min of participant - Resting HR of participant	3.71	8.67	0.89	1.94	5.47	4.16	94.00	0.00

.

4.4 Association between ABILOCO-kids and VO_2 max

There was no statistically significant correlation between locomotory capacity and cardiorespiratory fitness.

4.5 Association between heart rates during 2MWT and VO_2 max

Association between heart rate recovery and VO_2 max

There was intermediate, positive correlation between heart rate recovery and VO_2 max as shown in Table 2, $r = 0.0232$, $n = 95$, $p < 0.05$, with high level of VO_2 max associated with high HR Recovery.

Association between heart rate reserve and VO_2 max

There was strong, positive correlation between heart rate reserve and VO_2 max as shown in Table 2, $r = 0.988$, $n = 95$, $p < 0.01$.

4.6. Association between perceived exertion and VO_2 max

One -way between – group analysis of variance was conducted as shown in table 3.10 to explore the impact of participants Borg RPE on VO_2 max, as measured from HR max. Participants were divided in to three groups according to levels of RPE (mild, moderate and severe). There was statistically non-significant difference at the $p > 0.05$ level in VO_2 max values of participants for Borg RPE: F (1, 93) = 0.00, $p = 0.994$. There was no effect at all as eta square is zero.

Table 5 Distribution of VO_2 max value for different variables in relation to GMFSC

Variables	Category	GMFCS I Mean ± S. D	GMFCS II Mean ± S. D	GMFCS III Mean ± S. D
Gender	Male	30.39 ± 3.85	30.55 ±2.51	31.71 ± 4.59
	Female	30.17 ± 4.13	27.12 ± 0.77	31. 75 ± 4.42
	Total	30.32 ± 3.88	29.57 ± 2.66	31.73 v 4.46
Age	6 – 9years	29.53 ± 3.66	29.68 ± 2.93	31.75 ± 4.32
	10 – 12 years	31.83 ± 3.96	29.31 ± 2.20	31.64 ± 5.25
	Total	30.32 ± 3.88	29.57 ± 2.66	31.73 ± 4.46
BMI	Under weight	30.53 ± 3.68	29.57 ± 2.66	32.12 ± 4.28
	Normal	28.24 ± 3.95		30.88 ± 7.88
	Moderately obese	37.32		26.15 ± 0.03
	Total	30.32 ± 3.88	29.57 ± 2.66	31.73 ± 4.46
Topographical CP	Monoplegia	31.68 ± 4.76		
	Diplegia	30.17 ± 4.76	29.40 ± 2.38	33.18 ± 4.54
	Rt. Hemiplegia	31.41 ± 3.46		29.11
	Lt. Hemiplegia	33.40 ± 4.48	32.19	
	Paraplegia	27.60 ± 2.66	28.44 ± 1.75	31.46 ± 5.44
	Triplegia	30.73 ± 1.28	30.95 ± 6.50	32.51 ± 4.92
	Quadriplegia	30.54 ± 4.40	29.02 ± 1.78	30.78 ± 4.02
	Total	30.32 ± 3.88	29.57 ± 2.66	31.73 ± 4.46
CP motor Type	Spastic	30.31 ± 3.95	29.67 ± 2.65	31.64 ± 3.82
	Flaccid			25.52 ± 1.38
	Ataxic	32.03 ± 5.72		33.75 ± 3.46
	Athetoid	27.44 ± 3.00		
	Dystonic	33.39 ± 2.18		33.31 ± 6.28

	Hypotonic		31.67	33.97
	Mixed	28.31 ± 2.76	26.35	34.44 ± 6.53
	Others	33.32		
	Total	30.32 ± 3.88	29.57 ± 2.66	31.73 ± 4.46

Education levels	**SENU**	**30.53 ± 4.07**	**31.99 ± 5.02**	**36.75 ± 3.07**
	K. G	29.62 ± 4.48	30.25 ± 2.04	32.28 ± 3.83
	Primary	30.50 ± 3.61	27.02 ± 0.47	29.60 ± 4.59
	Illiterate	30.71 ± 4.32	29.32 ± 2.30	30.40 ± 4.02
	Total	30.32 ± 3.88	29.57 ± 2.66	31.73 ± 4.46
Education types	Special	30.53 ± 4.07	28.44	36.75 ±3.07
	Inclusive School	32.88 ± 3.67	35.55	30.68 ± 4.20
	Integrated	28.79 ± 3.25	28.96 ± 2.29	34.38 ± 3.10
	NA	30.71 ± 4.32	29.32 ± 2.30	30.40 ± 4.02
	Total	30.32 ± 3.88	29.57 ± 2.66	31.73 ± 4.46
Assistive devices	Yes	28.89 ± 3.53	30.14 ± 3.01	32.13 ± 4.86
	No	31.13 ± 3.89	28.55 ± 1.66	30.90 ± 3.52
	Total	30.32 ± 3.88	29.57 ± 2.66	31.73 ± 4.46
Types of A. D	Foot orthosis	33.01 ± 1.18		
	AFO	29.06 ± 3.83	29.54 ± 3.54	31.46 ± 4.54
	KAFO	28.26	32.52	30.41 ± 4.83
	Walkers	26.35	29.69 ± 3.52	31.36 ± 5.20
	Wheelchair			34.01 ± 6.20
	Others	27.08 ± 1.27	31.67	35.84
	Total	29.09 ± 3.51	30.14 ± 3.01	31.85 ± 4.82
Family types	Nuclear family	30.12 ± 3.32	29.28 ± 2.17	31.74 ± 4.81
	Joint family	31.07 ± 5.77	30.64 ± 4.50	31.66 ± 2.12
	Total	30.32 ± 3.88	29.57 ± 2.66	31.73 ± 4.46
Parents education	Illiterate	34.29 ± 0.91		35.66 ± 7.79
	Primary	33.05 ± 5.22	32.19	33.86 ± 8.57
	Secondary	29.28 ± 3.98	29.37 ± 2.65	30.64 ± 4.08
	Higher Secondary	31.40 ± 0.98		33.39 ± 3.10
	Graduation	29.65 ± 2.48		32.70 ± 2.95
	Post-graduation and above	33.12 ± 0.13		29.11
	Total	30.32 ± 3.88	29.57 ± 2.66	31.73 ± 4.46

Parent monthly income	**less than 5,000**	**27.98**	**27.35**	
	5,000-10,000	30.05 ± 4.51	29.36 ± 0.81	31.61 ± 4.24
	10,000-20,000	29.96 ± 3.92	30.61 ± 3.25	31.32 ± 4.67
	20,000-30,000	29.49 ± 3.26	27.20	34.50 ± 4.46
	30,000-40,000	33.36 ± 2.87	30.45	
	40,000-50,000			29.01 ± 4.01
	Above 50,000	31.00 ± 2.98	26.68	
	Total	30.32 ± 3.88	29.57 ± 2.66	31.73 ± 4.46

Above table: 5 shows the estimated VO_2 max values of CP children in different variables in relation to GMFCS levels.

Table 6: Parameters of VO_2 max

Variables	**Male**		**Female**	
	Mean ± S. D	Min – Max.	Mean ± S. D	Min – Max.
HR Rest	99.72 ± 12.62	74 - 131	101.24 ± 13.64	76 - 127
HR Post walk	122.44 ± 15.04	90 - 157	122.44 ± 17.89	88 - 160
HR After 2 min. walk	103.72 ± 13.70	75 - 135	104.41 ± 16.90	71 - 140
HR Max	202.17 ± 1.43	200 - 204	202.22 ± 1.39	200 - 204
HR Recovery	18.72 ± 15.53	-11 - 53	18.0 ± 17.16	-12 - 70
HR Reserve	102.44 ± 12.36	72 – 129.10	100.98 – 13.51	72 -127
No. of rest in 2MWT	0.10 ± 0.30	0 – 1	0.90 ± 0.288	0 - 1
Total distance walk	80.54 ± 41.27	8.60 – 163.30	73. 09 ± 38.40	10.70 – 152.20
VO 2 Max	30.89 ± 3.93	23 – 41	30.51 ± 4.21	24 - 40

The Table 6 shows the parameters of VO_2 max during 2MWT.

CHAPTER V DISCUSSION

The purpose of the study was to evaluate the cardiorespiratory fitness in term of estimated VO_2 max of Cerebral palsy children of age 6-12 years with Gross Motor Function Classification Scales level I, II and III. This study was the first of its kind to combine HR responses from 2MWT to estimate VO_2 max using the Uth et al. formula to investigate CRF in CP children age 6-12 years with GMFCS I, II and III. This study consisted of 95 CP children with higher male (64%) respondent than female (35.8%). Therefore, this study was supported by the study done of Lang et al. (2012), which also showed higher male respondent than female. This study also showed that most of them were between age group 6-9 years (71.6%) in comparison to age group 10-12 years (28.4%).

Most of the participants were from Islamic religion which is 86% followed by Hindu (8.4%). The other studies also showed higher prevalence of CP among Muslim religion and it was considered due to consanguinity and genetic cause (Bhatta, and Haque, 2014). This study also showed that 83% of the participant have their BMI in underweight category and only 9% of them had normal weight. This finding of BMI was also supported in the study done by Tarsuslu Simsek, and Tuc (2014) which showed that most of CP children were underweight due to malnutrition, poor oral motor function, insufficient function of the upper extremities, insufficient nutrition and growth retardation arising from cognitive disorders. This study had higher respondent in GMFCS level I (64.3%), followed by GMFCS III (38.9%) and GMFCS II (14.7%). Most of the CP children were diplegic (21.15) and spastic CP (70%) was found comparatively higher than other motor types of CP. Among 95 participants most of them were attending integrated education (29.5%) and 33.7% didn't receive any formal education. This showed that CP children were integrated well at normal education system and those who haven't receive any education is due to limitation of CP. The participant in this study at primary education level was higher (29.5%) than other education levels K.G (23.2%) and special education need unit (SENU) (13.7%).

This study also showed that most of them didn't use assistive aids (52.6%) and those who used assistive were 47.4%. Among assistive device user, most of them used AFO (26.3%)

followed by walkers (10.5%) and commonly used at home (41%), community (36.8%) and school (22.2%). The participant of this study mostly lived in small family (81.1%) than joint family (18.9%). This study also showed that most of the parents of participant had secondary education (63.2%) followed by graduation (11.6%), primary (9.5%), higher secondary (8.4%), post graduate (3.2%) and only 4.2 % of the participants parent were illiterate.

This study found that average resting HR for male (99.72 ± 12.62 b/m) was lower than that of female (101.24 ± 13.64 b/m). Similarly, this study found that average HR max was statistically similar for male (202.17 ± 1.43 b/m) and female (202.22 ± 1.39 b/m). Along with this, the HR recovery was also statistically similar for male (18.72 ± 15.53 b/m) and female (18.0 ± 17.16 b/m) but the HR reserve for male (102.44 ± 12.36 b/m) was more than female (100.98 ± 13.51 b/m). The average walking distance during 2MWT was more for male (80.54 ± 41.27 m) than female (73. 09 ± 38.40 m). The study didn't show statistically difference in VO_2 max for male (30.89 ± 3.93) ml/kg/min and female (30.51 ± 4.21) ml/kg/min. On summary, CRF was similar for male and female in term of estimated VO_2 max. However, when the estimated VO_2 max was compared with VO_2 max of normal children, the participant in this study did not have good CRF. There are very few negligible literatures available on VO_2 max of children between 6- 12 years. Those few studies showed that VO_2 max varied for both normal children and children with CP.

Pryor & Prasad, (2008) showed VO_2 max of healthy children was 40-50ml/kg/min while other study recommended a minimum VO_2 max of 42 ml/kg/min for male (5 -17 years) and 40 ml/kg/min for females (5-9 year). The VO_2 max in this study was found to be comparatively lower than those found in literature.

This study showed significant positive correlation between VO_2 max and HR recovery ($P < 005$), HR reserve ($P < 0.01$), negative correlation with surrounding temperature ($P < 0.01$), while there was statistically insignificant correlation between Gender, BMI, mobility aid, total distance walked in 2MWT and locomotion capacity (ABILOCO-Kids). This study also showed that there was insignificant association between VO_2 max, gender, mobility assistive device and family types. The study done by Haekel et al. (2011) showed no any changes in VO_2 max with age. However, a literature showed significant association between that VO_2 max and gender (American College of Sports Medicine, 2000) and

currently there are very few literatures that shows association between VO_2 max and mobility aids, family types.

This study also showed that paired t-test was significant between HR post and HR rest, HR post and HR after 2 min, HR rest and HR after 2 min. Those significant difference between HR also showed that participants had poor CRF. The finding of this study was also supported by other study done by Granes et al. (1992). Analysis of variance between VO_2 max and sociodemographic variables showed significant association for participants BMI, education levels, education types and parents education but it didn't show significant association between VO_2 max and topographical CP types, GMFCS levels, motor CP types, types of mobility aids, monthly incomes of parents and Borg RPE. The study by Berndtsson et al. (2007) showed negative association between VO_2 max and BMI, whereas the study done by Loftin et al. (2001) showed that when BMI increased, the VO_2 max decreased and Tartaruga et al. (2010) also showed association between these two variables.

The another most compelling finding of this study was that HR recovery and HR reserve can be used to predict CRF of CP children and locomotion capacity of CP children depends on use of assistive devices. The limited literature showed VO_2 max for boys were slightly higher than girls but this study showed no significant difference in average VO_2 max for male (30.89 ± 3.93 ml/kg/min) and female (30.51 ± 4.21 ml/kg/min).

According to literature, HR response during the recovery period immediately following exercise can be used an indicator of an individual CRF level. It also showed that faster returning of HR to a resting HR following exercise indicates the higher fitness level (Webb et al., 2014), and HR recovery less than 12 beats /min fate 1 minutes and 22 beats /minutes after 2 minutes of exercise indicates poor CRF (Carnethon et al., 2012). This study found that HR recovery for male (18.72 ± 15.53) and for female (18.0 ± 17.16) after 2 minutes of 2MWT which indicates that, the participants are in the risk of Cardiorespiratory problems and poor CRF. However, this study showed HR post walk for male age group 6- 9 years was (123.05 ± 14.93 b/m), 10 -12 years was (121.11 ± 12.59 b/m) and for female age group 6-9years was (121.85 ± 17.31 b/m), 10-12 years was (124.25 ± 20.83 b/m). When this result of HR post walk was compared with classification range of reference values of mean post exercise heart rate of 1- 12 years children (Jankowski et al., 2014), the male participant

showed sufficient CRF for both age group and female showed good CRF for both age groups. Therefore, we can consider that female participant had a higher level of CRF than male participants.

The study was conducted based on submaximal field test i.e. 2MWT and different heart rate during different stages of 2MWT to determine the VO_2 max. Along with this, Borg RPE which evaluate the exertion level of participants was also used during test. VO_2 max of younger children with cerebral palsy between aged 6 – 12 years was completely new in the literature. Moreover, determination of HR at different stage of test was done digitally from participant during different stage of test with help of a reliable and valid HR measurement device. The maximum HR was determined through more précised Tanaka's equation available currently in the literature. The parameters of VO_2 max measured was considered highly précised. Therefore, the resultant determinant of cardiorespiratory fitness (VO_2 max) was also considered to be estimated safely and precisely under standard procedure.

Another new things in this study was age of participant and inclusion of GMFCS III in this study as there were very limited study done on Cerebral palsy children with inclusion of mentioned criteria. This study has no comparison groups. However, the result of this study was compared with the result of similar standard study found in literature. This study showed sufficient CRF for male and good CRF for female in term of post exercise HR. However, when the estimated VO_2 max of participants was compared with VO_2 max for normal children of same age group, CRF was poor.

5.1 Limitation of study

1. The sample size was small.
2. There was no comparison group for children with cerebral palsy.
3. VO_2 max estimation through respiratory rate or gas analysis method couldn't be used due to lack of resources and cost.
4. Researcher was not known to Bangla language. So, it was quite difficult to communicate with participant and their parents.
5. The study period was very limited.
6. There were very few researches focused on similar topic. Instead, studies were focused on physical functioning and other related topics.
7. The study was conducted in only one institutions.

CHAPTER VI CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Cardiorespiratory fitness is important for children to ensures physical development and prevent age-related disease associated with adulthood. Normally, children improve their CRF during their growth but this is not possible for children with CP. Therefore, they are more likely to have decreased CRF compared to their typically-developing peers. The gross motor function of CP can be defined by GMFCS which categorization of CP into 5 levels and used for developing different exercise protocols to improve the CRF of CP children. This study aims to find out the CRF in term of VO_2 max of CP children between the age group 6 - 12 years with GMFCS I- III. Therefore, VO_2 max was calculated from HR ratio by using formula though 2MWT and Borg RPE was used to determine participants level of exertion during study. This study found that CP children have poor CRF in term of VO_2 max (30.89 ml/kg/min for male and 30.51 ml/kg/min for female) than the normal children (40 -50 ml/kg/min) of same age group. It also found that female CRF was good for age group 10 -12 than male of same age group though there was no difference in mean VO_2 max for male and female participants of this study. There was direction correlation between VO_2 max and HR recover, HR reserve and surrounding temperature. The study also found association between VO_2 max and BMI, education levels, education types and parents education but it doesn't show significant association between VO_2 max and topographical CP types, GMFCS levels, motor CP types, types of mobility aids, monthly incomes of parents and Borg RPE. The study concluded that CP children have poor CRF and it can be improved through proper exercise training. For this it requires further studies on CRF of younger children with Cerebral palsy which can improve their quality of life.

6.2 Recommendation

- More participants could be studied at same time through uses of more HR measurement devices.
- The study consisting of large sample size can be conducted. The cardiorespiratory fitness of children with CP is recommended to compare with cardiorespiratory fitness of healthy children.
- The respiratory rate, spirometry, gas analysis method is recommended to get exact measure of VO_2 max.
- The longitudinal study is recommended to carry out to see the change in status of cardiorespiratory fitness along with age.

Reference

Alfano, L. N., Lowes, L. P., Dvorchik, I., Yin, H., Maus, E. G., Flanigan, K. M., & Mendell, J. R. (2014). The 2-min walk test is sufficient for evaluating walking abilities in sporadic inclusion body myositis. *Neuromuscular Disorders*, *24*(3), 222-226.

Alshryda, S., & Wright, J. (2013). Development and Reliability of a System to Classify Gross Motor Function in Children with Cerebral Palsy. *Classic Papers in Orthopaedics*, 575-577. doi:10.1007/978-1-4471-5451-8_152

American College of Sports Medicine (Ed.). (2013). *ACSM's health-related physical fitness assessment manual*. Lippincott Williams & Wilkins.

Andersen, L. K., Knak, K. L., Witting, N., & Vissing, J. (2016). Two-and 6-minute walk tests assess walking capability equally in neuromuscular diseases. *Neurology*, *86*(5), 442-445.

Armstrong, N. (2006). Aerobic fitness of children and adolescents. *Jornal de pediatria*, *82*(6), 406-408.

Armstrong, N., & Welsman, J. R. (1994). Assessment and interpretation of aerobic fitness in children and adolescents. *Exercise and sport sciences reviews*, *22*, 435-476.

Balemans, A. C., Van Wely, L., De Heer, S. J., Van den Brink, J., De Koning, J. J., Becher, J. G., & Dallmeijer, A. J. (2013). Maximal aerobic and anaerobic exercise responses in children with cerebral palsy. *Med Sci Sports Exerc*, *45*(3), 561-8.

Batista, K. G., Lopes, P. D. O., Serradilha, S. M., Souza, G. A. F. D., Bella, G. P., & Souza, R. C. T. D. (2010). Benefits of cardiorespiratory training in children or adolescents with cerebral palsy. *Fisioterapia em Movimento*, *23*(2), 201-209.

Baxter, P. (2013). Comorbidities of cerebral palsy need more emphasis–especially pain. *Developmental Medicine & Child Neurology*, *55*(5), 396-396.

Bent, N., Tennant, A., Swift, T., Posnett, J., Scuffham, P., & Chamberlain, M. A. (2002). Team approach versus ad hoc health services for young people with physical disabilities: a retrospective cohort study. *The Lancet*, *360*(9342), 1280-1286.

Berndtsson, G., Mattsson, E., Marcus, C., & Larsson, U. E. (2007). Age and gender differences in VO2max in Swedish obese children and adolescents. *Acta Paediatrica*, *96*(4), 567-571.

Bhatta, D. N., & Haque, A. (2015). Health problems, complex life, and consanguinity among ethnic minority Muslim women in Nepal. *Ethnicity & health*, *20*(6), 633-649.

Blair, E., & Watson, L. (2006). Epidemiology of cerebral palsy. *Seminars in Fetal and Neonatal Medicine*, *11*(2), 117-125. doi: 10.1016/j.siny.2005.10.010

Bohannon, R. W., Bubela, D., Magasi, S., McCreath, H., Wang, Y. C., Reuben, D., ... & Gershon, R. (2014). Comparison of walking performance over the first 2 minutes and the full 6 minutes of the Six-Minute Walk Test. *BMC research notes*, *7*(1), 269.

Borg, G. (1976). Simple rating methods for estimation of perceived exertion. *Physical work and effort*, 39-46.

Brehm, M. A., Balemans, A. C., Becher, J. G., & Dallmeijer, A. J. (2014). Reliability of a progressive maximal cycle ergometer test to assess peak oxygen uptake in children with mild to moderate cerebral palsy. *Physical therapy*, *94*(1), 121-128.

Bunn, J., Manor, J., Wells, E., Catanzarito, B., Kincer, B., & Eschbach, L. C. (2017). Physiological and emotional influence on heart rate recovery after submaximal exercise. *Journal of Human Sport and Exercise*, *12*(2).

Butland, R. J., Pang, J. A. C. K., Gross, E. R., Woodcock, A. A., & Geddes, D. M. (1982). Two-, six-, and 12-minute walking tests in respiratory disease. *British medical journal (Clinical research ed.)*, *284*(6329), 1607.

Campbell, S. K., Palisano, R. J., & Orlin, M. N. (2012). Physical therapy for children (4th ed.). St. Louis, Mo.: *Elsevier/Saunders.*

Cans, C. (2000). Surveillance of cerebral palsy in Europe: a collaboration of cerebral palsy surveys and registers. *Developmental Medicine & Child Neurology*, *42*(12), 816-824.

Carnethon, M. R., Sternfeld, B., Liu, K., Jacobs Jr, D. R., Schreiner, P. J., Williams, O. D., ... & Sidney, S. (2012). Correlates of heart rate recovery over 20 years in a population sample. *Medicine and science in sports and exercise*, *44*(2).

Casillas, J. M., Hannequin, A., Besson, D., Bénaïm, S., Krawcow, C., Laurent, Y., & Gremeaux, V. (2013). Walking tests during the exercise training: specific use for the cardiac rehabilitation. *Annals of physical and rehabilitation medicine*, *56*(7-8), 561-575.

Caspersen, C. J., Powell, K. E., & Christenson, G. M. (1985). Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public health reports*, *100*(2), 126.

Caty, G., Arnould, C., Thonnard, J., & Lejeune, T. (2008). ABILOCO-kids: A rasch-built 10-item questionnaire for assessing locomotion ability in children with cerebral palsy. *Journal of Rehabilitation Medicine*, *40*(10), 823-830. doi:10.2340/16501977-0267

Chong, J., Mackey, A. H., Broadbent, E., & Stott, N. S. (2011). Relationship Between Walk Tests and Parental Reports of Walking Abilities in Children with Cerebral Palsy. *Archives of Physical Medicine and Rehabilitation*, *92*(2), 265-270. doi: 10.1016/j.apmr.2010.10.010

Cole, C. R., Foody, J. M., Blackstone, E. H., & Lauer, M. S. (2000). Heart Rate Recovery after Submaximal Exercise Testing as a Predictor of Mortality in a Cardiovascular Healthy Cohort. *Annals of Internal Medicine*, *132*(7), 552. doi:10.7326/0003-4819-132-7-200004040-00007

Cooper, K. H. (1968). A means of assessing maximal oxygen intake: correlation between field and treadmill testing. *Jama*, *203*(3), 201-204.

Davis, J. A. (1995). Direct determination of aerobic power. *Physiological assessment of human fitness*, 9-17.

Ekblom-Bak, E., Hellénius, M. L., Ekblom, Ö., Engström, L. M., & Ekblom, B. (2010). Independent associations of physical activity and cardiovascular fitness with cardiovascular risk in adults. *European Journal of Cardiovascular Prevention & Rehabilitation*, *17*(2), 175-180.Enright, P. L. (2003). The six-minute walk test. Respiratory care, 48(8), 783-785.

Eston, R. G. (2009). Perceived exertion: Recent advances and novel applications in children and adults. *Journal of Exercise Science & Fitness*, *7*(2), S11-S17.Fitchett, M. A. (1985). Predictability of VO2 max from submaximal cycle ergometer and bench stepping tests. British Journal of Sports Medicine, 19(2), 85-88.

Fowler, E. G., Kolobe, T. H., Damiano, D. L., Thorpe, D. E., Morgan, D. W., & Brunstrom, J. E. (2007). Promotion of Physical Fitness and Prevention of Secondary Conditions for Children with Cerebral Palsy: Section on Pediatrics Research Summit Proceedings. *Physical Therapy*, *87*(11), 1495-1510. doi:10.2522/ptj.20060116

Girling-Butler, J. M. (2012). Current Evidence and Future Directions for Physiotherapy Intervention in Cerebral Palsy: Physical Activity and Physical Fitness.

Graves, J. E., Panton, L. B., Pollock, M. L., Garzarella, L., Carroll, J. F., Guillen, G., & Lowenthal, D. (1992). Influence of Aerobic Exercise Training on The Relationship Between Oxygen Uptake and Heart Rate Reserve in The Elderly. *Medicine & Science in Sports & Exercise*, *24*(Supplement), S186. doi:10.1249/00005768-199205001-01112

Gulmans, V. A. M., Van Veldhoven, N. H. M. J., De Meer, K., & Helders, P. (1996). The six-minute walking test in children with cystic fibrosis: Reliability and validity. *Pediatric pulmonology*, *22*(2), 85-89.

Harkel, A. D. J. T., Takken, T., Van Osch-Gevers, M., & Helbing, W. A. (2011). Normal values for cardiopulmonary exercise testing in children. *European Journal of Cardiovascular Prevention & Rehabilitation*, *18*(1), 48-54.

Harvey, A. R., Morris, M. E., Graham, H. K., Wolfe, R., & Baker, R. (2010). Reliability of the functional mobility scale for children with cerebral palsy. *Physical & occupational therapy in pediatrics*, *30*(2), 139-149.

Helmantel, A. J., Elferink-Gemse, M. T., & Visscher, C. (2009). Trainability of VO2max during childhood and adolescence. *Parte: http://hdl. handle. net/10316.2/3165*.

Hoofwijk, M., Unnithan, V., & Bar-Or, O. (1995). Maximal treadmill performance of children with cerebral palsy. *Pediatric exercise science*, *7*(3), 305-313.

Hui, S. S. C., & Chan, J. W. S. (2006). The relationship between heart rate reserve and oxygen uptake reserve in children and adolescents. *Research quarterly for exercise and sport*, *77*(1), 41-49.

Izadi, M., Nazem, F., & Hazavehei, M. (2006). The effect of Sub-maximal exercise-rehabilitation program on cardio-respiratory endurance indexes and oxygen pulse in patients with spastic cerebral palsy. *Journal of Research in Medical Sciences*, *11*(2), 93-100.

Jankowski, M., Niedzielska, A., Brzezinski, M., & Drabik, J. (2015). Cardiorespiratory fitness in children: a simple screening test for population studies. *Pediatric cardiology*, *36*(1), 27-32.

Jurca, R., Jackson, A. S., LaMonte, M. J., Morrow, J. R., Blair, S. N., Wareham, N. J., ... & Laukkanen, R. (2005). Assessing cardiorespiratory fitness without performing exercise testing. *American journal of preventive medicine*, *29*(3), 185-193.

Kamali, M., & Chabok, A. (2014). Rehabilitation needs of people with Cerebral Palsy: A qualitative study. *Medical journal of the Islamic Republic of Iran*, *28*, 16.

Kerr, C., McDowell, B. C., & Cosgrove, A. (2007). Oxygen cost versus a 1-minute walk test in a population of children with bilateral spastic cerebral palsy. *Journal of Pediatric Orthopaedics*, *27*(3), 283-287.

Ketelaar, M., Kruijsen, A. J., Verschuren, O., Jongmans, M. J., Gorter, J. W., Verheijden, J., ... & Lindeman, E. (2010). LEARN 2 MOVE 2-3: a randomized controlled trial on the efficacy of child-focused intervention and context-focused intervention in preschool children with cerebral palsy. *BMC pediatrics*, *10*(1), 80.

Ketelaar, M., Vermeer, A., & Helders, P. J. (1998). Functional motor abilities of children with cerebral palsy: a systematic literature review of assessment measures. *Clinical rehabilitation*, *12*(5), 369-380.

Khanal, V., Sauer, K., Karkee, R., & Zhao, Y. (2014). Factors associated with small size at birth in Nepal: further analysis of Nepal Demographic and Health Survey 2011. *BMC pregnancy and childbirth*, *14*(1), 32.

Khandaker, G., Muhit, M., Rashid, H., Khan, A., Islam, J., Jones, C., & Booy, R. (2014). Infectious causes of childhood disability: results from a pilot study in rural Bangladesh. *Journal of tropical pediatrics*, *60*(5), 363-369.

Kusano, S., Iwasaki, Y., Tobimatsu, Y., & Suyama, T. (2001). Cardiorespiratory endurance and work efficiency of people with cerebral palsy measured using an arm ergometer. *Journal of Physical Therapy Science*, *13*(1), 49-52.

Lang, T. C., Fuentes-Afflick, E., Gilbert, W. M., Newman, T. B., Xing, G., & Wu, Y. W. (2012). Cerebral palsy among Asian ethnic subgroups. *Pediatrics*, *129*(4), e992-e998.

Lankhorst, K., van der Ende-Kastelijn, K., Groot, J., Zwinkels, M., Verschuren, O., Backx, F., ... & Takken, T. (2015). Health in Adapted Youth Sports Study (HAYS): health effects of sports participation in children and adolescents with a chronic disease or physical disability. *SpringerPlus*, *4*(1), 796.

Lee, D. C., Artero, E. G., Sui, X., & Blair, S. N. (2010). Mortality trends in the general population: the importance of cardiorespiratory fitness. *Journal of psychopharmacology*, *24*(4_suppl), 27-35.

Li, A. M., Yin, J., Yu, C. C. W., Tsang, T., So, H. K., Wong, E., ... & Sung, R. (2005). The six-minute walk test in healthy children: reliability and validity. *European Respiratory Journal*, *25*(6), 1057-1060.

Loftin, M., Sothern, M., Trosclair, L., O'hanlon, A., Miller, J., & Udall, J. (2001). Scaling Vo2 Peak in Obese and Non-obese Girls. *Obesity*, *9*(5), 290-296.

Maloni, P. K., Despres, E. R., Habbous, J., Primmer, A. R., Slatten, J. B., Gibson, B. E., & Landry, M. D. (2010). Perceptions of disability among mothers of children with disability in Bangladesh: Implications for rehabilitation service delivery. *Disability and rehabilitation*, *32*(10), 845-854.

Maltais, D. B., Dumas, F., Boucher, N., & Richards, C. L. (2010). Factors related to physical activity in adults with cerebral palsy may differ for walkers and nonwalkers. *American journal of physical medicine & rehabilitation*, *89*(7), 584-597.

Maltais, D. B., Pierrynowski, M. R., Galea, V. A., & Bar-or, O. (2005). Physical activity level is associated with the O2 cost of walking in cerebral palsy. *Medicine & Science in Sports & Exercise*, *37*(3), 347-353.

McCulloch, J. P. (2013). *Validation of a rpe-based submaximal oxygen consumption test using a total body recumbent stepper for individuals with spinal cord injury: A proof of concept study*. University of Louisville.

McDowell, B. C., Kerr, C., & Parkes, J. (2007). Interobserver agreement of the Gross Motor Function Classification System in an ambulant population of children with cerebral palsy. *Developmental Medicine & Child Neurology*, *49*(7), 528-533.

McDowell, B. C., Kerr, C., Parkes, J., & Cosgrove, A. (2005). Validity of a 1-minute walk test for children with cerebral palsy. *Developmental medicine and child neurology*, *47*(11), 744-748.

McIntyre, S., Morgan, C., Walker, K., & Novak, I. (2011). Cerebral palsy—don't delay. *Developmental disabilities research reviews*, *17*(2), 114-129.

Mojtaba, E., Davood, K., Housein, D., & Fatemeh, K. (2010). Investigation relationship between% VO2MAX versus% HRMAX in children with cerebral palsy. *Procedia-Social and Behavioral Sciences*, *2*(2), 5412-5416.

Morgan, D., Keefer, D. J., Tseh, W., Caputo, J. L., Craig, I., Griffith, G., & Vint, P. (2005). Walking energy use in children with spastic hemiplegia. *Pediatric Exercise Science*, *17*, 91-92.

Morris, C. (2007). Definition and classification of cerebral palsy: a historical perspective. *Developmental Medicine & Child Neurology*, *49*(s109), 3-7.

Murthy, G. V., Mactaggart, I., Mohammad, M., Islam, J., Noe, C., Khan, A. I., & Foster, A. (2014). Assessing the prevalence of sensory and motor impairments in childhood in Bangladesh using key informants. *Archives of disease in childhood*, *99*(12), 1103-1108.

Nixon, P. A., Joswiak, M. L., & Fricker, F. J. (1996). A six-minute walk test for assessing exercise tolerance in severely ill children. *The Journal of pediatrics*, *129*(3), 362-366.

Noonan, V., & Dean, E. (2000). Submaximal exercise testing: clinical application and interpretation. *Physical therapy*, *80*(8), 782-807.

Obert, P., Courteix, D., Lecoq, A. M., & Guenon, P. (1996). Effect of long-term intense swimming training on the upper body peak oxygen uptake of prepubertal girls. *European journal of applied physiology and occupational physiology*, *73*(1-2), 136-143.

Oskoui, M., Coutinho, F., Dykeman, J., Jetté, N., & Pringsheim, T. (2013). An update on the prevalence of cerebral palsy: a systematic review and meta-analysis. *Developmental Medicine & Child Neurology*, *55*(6), 509-519.

Oskoui, M., Messerlian, C., Blair, A., Gamache, P., & Shevell, M. (2016). Variation in cerebral palsy profile by socio-economic status. *Developmental Medicine & Child Neurology*, *58*(2), 160-166.

Palisano, R. J., Copeland, W. P., & Galuppi, B. E. (2007). Performance of physical activities by adolescents with cerebral palsy. *Physical therapy*, *87*(1), 77-87.

Palisano, R. J., Rosenbaum, P., Bartlett, D., & Livingston, M. H. (2008). Content validity of the expanded and revised Gross Motor Function Classification System. *Developmental Medicine & Child Neurology*, *50*(10), 744-750.

Palisano, R. J., Rosenbaum, P., Bartlett, D., & Livingston, M. H. (2008). Content validity of the expanded and revised Gross Motor Function Classification System. *Developmental Medicine & Child Neurology*, *50*(10), 744-750.

Palisano, R. J., Tieman, B. L., Walter, S. D., Bartlett, D. J., Rosenbaum, P. L., Russell, D., & Hanna, S. E. (2003). Effect of environmental setting on mobility methods of children with cerebral palsy. *Developmental Medicine and Child Neurology*, *45*(2), 113-120.

Palisano, R., Rosenbaum, P., Walter, S., Russell, D., Wood, E., & Galuppi, B. (1997). Development and reliability of a system to classify gross motor function in children with cerebral palsy. *Developmental Medicine & Child Neurology*, *39*(4), 214-223.

Paridon, S. M., Alpert, B. S., Boas, S. R., Cabrera, M. E., Caldarera, L. L., Daniels, S. R., ... & Yetman, A. T. (2006). Clinical stress testing in the pediatric age group: a statement from the American Heart Association Council on Cardiovascular Disease in the Young, Committee on Atherosclerosis, Hypertension, and Obesity in Youth. *Circulation*, *113*(15), 1905-1920.

Pate, R. R., Wang, C. Y., Dowda, M., Farrell, S. W., & O'Neill, J. R. (2006). Cardiorespiratory fitness levels among US youth 12 to 19 years of age: findings from the 1999-2002 National Health and Nutrition Examination Survey. *Archives of pediatrics & adolescent medicine*, *160*(10), 1005-1012.

Pin, T. W. (2014). Psychometric properties of 2-minute walk test: a systematic review. *Archives of physical medicine and rehabilitation*, *95*(9), 1759-1775.

Pryor, J. A., & Prasad, A. S. (2008). *Physiotherapy for respiratory and cardiac problems: adults and paediatrics*. Elsevier Health Sciences.

Ravn, S. H., Flachs, E. M., & Uldall, P. (2010). Cerebral palsy in eastern Denmark: declining birth prevalence but increasing numbers of unilateral cerebral palsy in birth year period 1986–1998. *european journal of paediatric neurology*, *14*(3), 214-218.

Reid, S. M., Carlin, J. B., & Reddihough, D. S. (2011). Classification of topographical pattern of spasticity in cerebral palsy: A registry perspective. *Research in developmental disabilities*, *32*(6), 2909-2915.

Reiersen, S. M. (2013). *Maximal oxygen uptake in children of different body mass: should maximal oxygen uptake be expressed differently for children of different body mass?* (Master's thesis, Universitetet i Agder; University of Agder).

Rosenbaum, P. (2003). Cerebral palsy: what parents and doctors want to know. *BMJ: British Medical Journal*, *326*(7396), 970.

Rosenbaum, P., & Stewart, D. (2004, March). The World Health Organization International Classification of Functioning, Disability, and Health: a model to guide clinical thinking, practice and research in the field of cerebral palsy. In *Seminars in pediatric neurology* (Vol. 11, No. 1, pp. 5-10). Elsevier.

Rosenbaum, P., Paneth, N., Leviton, A., Goldstein, M., Bax, M., Damiano, D., ... & Jacobsson, B. (2007). A report: the definition and classification of cerebral palsy April 2006. *Dev Med Child Neurol Suppl*, *109*(suppl 109), 8-14.

Rowland, T. W., & Freedson, P. S. (1994). Physical activity, fitness, and health in children: a close look. *Pediatrics*, *93*(4), 669-672.

Rowland, T., Goff, D., Martel, L., & Ferrone, L. (2000). Influence of cardiac functional capacity on gender differences in maximal oxygen uptake in children. *Chest*, *117*(3), 629-635.

Singhi, P. D., Ray, M., & Suri, G. (2002). Clinical spectrum of cerebral palsy in North India—an analysis of 1000 cases. *Journal of tropical pediatrics*, *48*(3), 162-166.

Smithers-Sheedy, H., McIntyre, S., Gibson, C., Meehan, E., Scott, H., Goldsmith, S., ... & Blair, E. (2016). A special supplement: findings from the Australian Cerebral Palsy Register, birth years 1993 to 2006. *Developmental Medicine & Child Neurology*, *58*, 5-10.

Solaski, M., Majnemer, A., & Oskoui, M. (2014). Contribution of socio-economic status on the prevalence of cerebral palsy: a systematic search and review. *Developmental Medicine & Child Neurology*, *56*(11), 1043-1051.

Strong, W. B., Malina, R. M., Blimkie, C. J., Daniels, S. R., Dishman, R. K., Gutin, B., ... & Rowland, T. (2005). Evidence based physical activity for school-age youth. *The Journal of pediatrics*, *146*(6), 732-737.

Tanaka, H., Monahan, K. D., & Seals, D. R. (2001). Age-predicted maximal heart rate revisited. *Journal of the American College of Cardiology*, *37*(1), 153-156.

Tarsuslu Simsek, T., & Tuc, G. (2014). Examination of the relation between body mass index, functional level and health-related quality of life in children with cerebral palsy. *Türk Pediatri Arşivi*, *49*(2), 130-137. doi:10.5152/tpa.2014.1238

Tartaruga, M., De Medeiros, M., Alberton, C., Cadore, E., Peyré-Tartaruga, L., Baptista, R., … Kruel, L. (2010). Application of the allometric scale for the submaximal oxygen uptake in runners and rowers. *Biology of Sport*, *27*(4), 297-300. doi:10.5604/20831862.927496

Teixeira, J. S., Santos, L. M. L. D. J., Santos, N. L. D., Casali, C. C. C., & Chaves, C. M. C. M. (2016). A case study of the effect of cardiovascular training on cerebral palsy. *Fisioterapia em Movimento*, *29*(4), 713-721.

Thompson, P., Beath, T., Bell, J., Jacobson, G., Phair, T., Salbach, N. M., & Wright, F. (2008). Test–retest reliability of the 10-metre fast walk test and 6-minute walk test in ambulatory school-aged children with cerebral palsy. *Developmental Medicine & Child Neurology*, *50*(5), 370-376.

Unnithan, V. B., Clifford, C., & Bar-Or, O. (1998). Evaluation by exercise testing of the child with cerebral palsy. *Sports medicine*, *26*(4), 239-251.

Unnithan, V. B., Dowling, J. J., Frost, G. A. I. L., & Bar-Or, O. D. E. D. (1996). Role of cocontraction in the O2 cost of walking in children with cerebral palsy. *Medicine and science in sports and exercise*, *28*(12), 1498-1504.

Uth, N., Sørensen, H., Overgaard, K., & Pedersen, P. K. (2004). Estimation of VO2max from the ratio between HRmax and HRrest–the heart rate ratio method. European journal of applied physiology, 91(1), 111-115.

Van Loon, R. L. E., Roofthooft, M. T., Delhaas, T., van Osch-Gevers, M., ten Harkel, A. D., Strengers, J. L., ... & Berger, R. M. (2010). Outcome of pediatric patients with pulmonary arterial hypertension in the era of new medical therapies. *American Journal of Cardiology*, *106*(1), 117-124.

Verschuren, O., & Takken, T. (2010). Aerobic capacity in children and adolescents with cerebral palsy. *Research in developmental disabilities*, *31*(6), 1352-1357.

Verschuren, O., Ketelaar, M., Gorter, J. W., Helders, P. J., Uiterwaal, C. S., & Takken, T. (2007). Exercise training program in children and adolescents with cerebral palsy: a randomized controlled trial. *Archives of pediatrics & adolescent medicine*, *161*(11), 1075-1081.

Verschuren, O., Ketelaar, M., Keefer, D., Wright, V., Butler, J., Ada, L., ... & Wiart, L. (2011). Identification of a core set of exercise tests for children and adolescents with cerebral palsy: a Delphi survey of researchers and clinicians. *Developmental Medicine & Child Neurology*, *53*(5), 449-456.

Verschuren, O., Ketelaar, M., Takken, T., Helders, P. J., & Gorter, J. W. (2008). Exercise programs for children with cerebral palsy: a systematic review of the literature. *American Journal of Physical Medicine & Rehabilitation*, *87*(5), 404-417.

Verschuren, O., Zwinkels, M., Ketelaar, M., Reijnders-van Son, F., & Takken, T. (2013). Reproducibility and validity of the 10-meter shuttle ride test in wheelchair-using children and adolescents with cerebral palsy. *Physical therapy*, *93*(7), 967-974.

Vill, K., Ille, L., Schroeder, S. A., Blaschek, A., & Müller-Felber, W. (2015). Six-minute walk test versus two-minute walk test in children with Duchenne muscular dystrophy: Is more time more information? *european journal of paediatric neurology*, *19*(6), 640-646.

Washington, R. L., Bricker, J. T., Alpert, B. S., Daniels, S. R., Deckelbaum, R. J., Fisher, E. A., ... & Marx, G. R. (1994). Guidelines for exercise testing in the pediatric age group. From the Committee on Atherosclerosis and Hypertension in Children, Council on Cardiovascular Disease in the Young, the American Heart Association. *Circulation*, *90*(4), 2166-2179.

Webb, C., Vehrs, P. R., George, J. D., & Hager, R. (2014). Estimating VO_2max using a personalized step test. *Measurement in Physical Education and Exercise Science*, *18*(3), 184-197.

Westbom, L., Hagglund, G., & Nordmark, E. (2007). Cerebral palsy in a total population of 4–11year olds in southern Sweden. Prevalence and distribution according to different CP classification systems. *BMC pediatrics*, *7*(1), 41.

Williams, C. A., McManus, A., & Armstrong, N. (1994). 470 Effects of Continuous and Interval Training on Anaerobic Performance in Prepubescent Girls. *Medicine & Science in Sports & Exercise*, *26*(5), S83.

Wilton, J. (2003). Casting, splinting, and physical and occupational therapy of hand deformity and dysfunction in cerebral palsy. *Hand Clinics*, *19*(4), 573-584.

Wisén, A. G., & Wohlfart, B. (2004). Aerobic and functional capacity in a group of healthy women: reference values and repeatability. *Clinical physiology and functional imaging*, *24*(6), 341-351.

World Health Organization. (2001). *International Classification of Functioning, Disability and Health: ICF*. World Health Organization.

World Health Organization. (2010) Global Recommendations of Physical Activity for Health. Retrieved 2/21/2013 from whqlibdoc.who.int/publications/2010/9789241599979_eng.pdf.

World Health Organization. (2012) Global Strategy on Diet, Physical Activity and Health: Physical activity and young people. Retrieved 2/21/2013 from http://www.who.int/dietphysicalactivity/factsheet_young_people/en/index.html

Zaffuto-Sforza, C. D. (2005). Aging with cerebral palsy. *Physical Medicine and Rehabilitation Clinics*, *16*(1), 235-249.

APPENDIX

Appendix I: Parent Information Sheet (English)

Information sheet

Namaste,

I am Rabindra Shrestha Naha, student of the Bangladesh Health Professions Institute (BHPI) which is the academic institute of the Centre for the Rehabilitation of the Paralyzed (CRP), Savar, Dhaka. I am studying M.Sc. in Rehabilitation. In regards to the fulfillment of M.Sc. Degree, it is mandatory to conduct a research in final year of study. I request you to participate in this research study **"Title: Cardiorespiratory Fitness in Term of Estimated VO_2 max of Children with Cerebral."** It will be very helpful if you accept my invitation and take part in my study.

If you agree to participate in this study, you and your child need to come to study sites. You will be asked a certain question regarding the socio-demographic data regarding walking performance, cardiorespiratory fitness and motor ability required for the study. In the second part of the study, your child will be asking to wear heart rate measurement device on the left wrist to measure heart rate at different interval. Then child has to covered a distance in 2 minutes (walking or self-propelled wheeling), in child's own wheelchair (adapted to its needs); walking with assistive devices as required. It is a self-paced speed but as quickly as the child is able to walk or wheel. This will take approximately 10 minutes and you can give needful minimal assistance if required.

This research study aims to improve further medical knowledge and cardiorespiratory fitness of cerebral palsy, it may not be of direct benefit to you or your child. Please try to give truthful answer as much as possible and you can also refuse to give answer if you are not comfortable at sharing the information. If you have any questions regarding the questionnaire, you can ask it anytime. The confidentiality of all records will be highly maintained and all details will be kept on a confidential database that is only accessible to me and my supervisor. The identity of your will not be disclosed in any presentation or publication without your agreement. If you have any queries now regarding this study please feel free to ask. I am accountable to answer all questions regarding this study.

Rabindra Shrestha Naha

M. Sc. in Rehabilitation Science, CRP, BHPI, Savar, Dhaka.

Parent signature: …… Date: ……

Investigator's signature: …… Date: ……

Witness Name and Signature…… Date: ……...

Appendix II: Parent Information Consent (Bangla)

সম্মতি পত্র

আসসালামু আলাইকুম/নমস্কার,

আমি রবীন্দ্র শ্রেষ্ঠা ণাহা রিহ্যাবিলিটেশন সায়েন্স, বাংলাদেশ হেলথ প্রফেশন্স ইন্সটিটিউট (বি এইচ পি আই), ঢাকা বিশ্ববিদ্যালয়ের একজন ছাত্র। স্নাতকোত্তর ডিগ্রী প্রাপ্তির জন্য আমার একটি গবেষণামূলক প্রকল্প পরিচালনা করা প্রয়োজন এবং আমার গবেষণা প্রকল্পটি হচ্ছে **" অক্সিজেনের সর্বোচ্চ আয়তনের উপর নির্ভর করে সেরেব্রাল পালসি বাচ্চাদের হৃদপিন্ড ও ফুসফুসের সক্ষমতা।"** এর জন্য আমি একটি জরিপ সঞ্চালন করছি সেরেব্রাল পালসি সহ বাচ্চাদের উপরে। এই গবেষনায় অংশগ্রহনের জন্য আপনার বাচ্চার হাতে ফিট বিট পরতে বলা হবে এবং ২ মিনিট হাটা বা হুইলচেয়ার চালানোর মাধ্যমে ১৫.২ মিটার পারকর/লাইন পার করতে হবে। বাচ্চা হুইলচেয়ার/ নিজে হেটে/প্রয়জনিয় সাহায্যকারি যন্ত্র নিয়ে গবেষনায় অংশ নিতে পারবে।দেখবো সে কত দ্রুত হাটতে বা হুইল চেয়ার চালাতে পারে তার হাটাচলা, শারিরিক সক্ষমতা এবং গবেশনায় প্রয়োজনীয় মোটর সক্ষমতা পরিমাপ করার যন্য ।।হয়ত আপনার বাচ্চা এতে সরাসরি উপকৃত হবে না তবে এই গবেষনার ফলাফলে ওন্য অনেকে উপকৃত হতে পারে।তথ্য পাওয়ার জন্য আমার আপনাকে কিছু প্রশ্ন জিজ্ঞাসা করতে হবে। আপনার সরবরাহকৃত যাবতীয় তথ্য গোপন রাখা হবে এমনকি প্রতিবেদন এবং প্রকাশনের সময়েও। আপনার সাহায্য যথাযথ ভাবে সমাদৃত হবে; আমি আপনাকে সত্য তথ্য দিতে অনুরোধ করবো।এই অধ্যয়নে আপনার অংশগ্রহণ স্বেচ্ছাকৃত এবং যে কোন নেতিবাচক প্রভাবে আপনি এই অধ্যয়ন থেকে নিজেকে প্রত্যাহার করে নিতে পারবেন। সাক্ষাতকার নিতে হয়ত ২০ মিনিট এর মত সময় লাগবে এবং কম সাহায্যের প্রয়োজন হবে। আপনার যদি কোন অনুসন্ধান থাকে তাহলে কোন সংকোচ ছাড়াই জিজ্ঞাসা করতে পারেন।

রবীন্দ্র শ্রেষ্ঠা নাহা

মাস্টার্স ইন রিহেবিলিটেশন সায়েন্স(বি এইচ পি আই)

পিতামাতার স্বাক্ষর: ..... তারিখ: .....

তদন্তকারীর স্বাক্ষর: ..... তারিখ: .....

প্রত্যক্ষকারীর নাম ও স্বাক্ষর:..... তারিখ: .....

Appendix III: Parent (Or Guardian) Consent Form

Please read the following statements and put tick (√) on yes or no to say that you understand the content of the information sheet, your involvement, and that you agree to take part in the above-named study.

I, ... agree to permit .....……..., who is aged ..... years, to participate in the research project –

Title: Cardiorespiratory Fitness in Term of Estimated VO_2 max of Children with Cerebral.

In giving my consent, I acknowledge that:

1. I have read the Information Statement and the time involved for my child's participation in the project. The researcher/s has given me the opportunity to discuss the information and ask any questions, I have about the study and they have been answered to my satisfaction.

2. I understand that I can withdraw my child from the study at any time without prejudice to my or my child's relationship with the researcher/s now or in the future.

3. I understand that withdrawal from the study will not affect my relationship with receiving services from CRP or in the future.

4. I agree that research data gathered from the results of the study may be published provided that neither my child nor I can be identified.

5. I understand that if I have any questions relating to my child's participation in this research I may contact the researcher/s who will be happy to answer them.

6. I acknowledge receipt of the Information Statement.

7. I give permission for my child's everyday activities to be observed by one of the researchers

YES □ NO □

…… …….

Signature of Parent/Guardian Signature of Child

…… ……..

Date Date

Investigator

I have explained the study to the above participant precisely and he/she has indicated a willingness to take part.

Investigator's signature_____ Date_____

Appendix IV: Parent (Or Guardian) Consent Form (Bangla)

পিতামাতা অথবা (অভিবাবক) সম্মতি পত্র)

দয়াকরে নিম্নোক্ত বিবৃতি গুলো পড়ুন এবং হ্যাঁ অথবা না এর পাশে টিক চিহ্ন (√) দিন যেটা তথ্য পত্রের বিষয়বস্তু পড়ে বুঝতে পারবেন,এবং উপরোক্ত নামের গবেষনার জন্য আপনি অংশগ্রহনে রাজি।

আমি, ... সম্মতি দিতে রাজি .....……....., যার বয়স) ..... বছর, গবেষনা প্রকল্পে অংশ গ্রহনের জন্য –

শিরোনাম: ''অক্সিজেনের সর্বোচ্চ আয়তনের উপর নির্ভর করে সেরেব্রাল পালসি বাচ্চাদের হৃদপিন্ড ও ফুসফুসের সক্ষমতা ''

আমার সম্মতি দেবার ক্ষেত্রে আমি, স্বীকার করছি যে:

1. আমি বিবৃতির তথ্যগুলো পড়েছি এবং প্রজেক্টে সময় যেটা যুক্ত ছিল আমার বাচ্চার অংশগ্রহনে।গবেষক আমাকে প্রজেক্টের সাথে যুক্ত তথ্যগুলো নিয়ে আলোচনা ও এটা নিয়ে প্রশ্ন করার সুযোগ দিয়েছেন এবং সন্তোষজনক উওর দিয়েছেন।

2. আমি বুঝতে পেরেছি আমি আমার বাচ্চাকে যেকোন সময় এই গবেষনার থেকে সরিয়ে নিতে পারি এখন অথবা ভবিষ্যতে আমার সাথে অথবা আমার বাচ্চার সাথে গবেষকের সম্পর্ক পূর্ব বিচার ছাড়াই ।

3. আমি বুঝেছি যে গবেষনা থেকে সরিয়ে নেয়াটা আমার বাচ্চার স্পাষ্টিক কেন্দ্র থেকে সেবা নেবার সম্পর্কের ক্ষেত্রে বাধা প্রদান করবে না।

4. আমি রাজি যে গবেষনার সংগ্রহকৃত তথ্যের ফলফল হয়তবা প্রকাশিত হবে তবে এতে আমি অথবা আমার বাচ্চা চিহ্নিত হব না ।

5. আমি বুঝেছি যে গবেষনায় আমার বাচ্চার অংশগ্রহন সম্পর্কিত যেকোন প্রশ্ন গবেষককে জিজ্ঞেস করলে উনি খুশী মনে উত্তর দিবেন।

6. বিবৃতি তথ্যের প্রাপ্তি আমি স্বীকার করেছি।

7. আমার বাচ্চার প্রতিদিনের কাজগুলো একজন গবেষক দ্বারা পর্যবেক্ষনের জন্য আমি অনুমতি দিচ্ছি।

হ্যাঁ □ না □

পিতামাতা/অভিভাবকের স্বাক্ষর _____ বাচ্চার স্বাক্ষর _____

তারিখ _____ তারিখ_____

তদন্তকারী

গবেষনা সম্পর্কে আমি অংশ গ্রহন কারীকে সঠিকভাবে ব্যাখা করেছি এবং উনি এখানে অংশগ্রহনের ইচ্ছা পোষন করেছেন।

তদন্তকারীর স্বাক্ষর_____ তারিখ _____

Appendix V: Questionnaires (English/Bangla)

Patient identification no (রোগীর সনাক্তকরণ সংখ্যা): _____

Title: Cardiorespiratory Fitness in Term of Estimated VO_2 max of children with Cerebral Palsy. (শিরোনাম: সাভার সি আর পি তে অক্সিজেনের সর্বোচ্চ আয়তনের উপর নির্ভর করে সেরেব্রাল পালসি সহ বাচ্চার হৃদপিন্ড ও ফুসফুসের সক্ষমতা।)

Part 1(অংশ ১): **Socio-demographic Information (সামাজিক-**জনতাত্ত্বিকতথ্য)

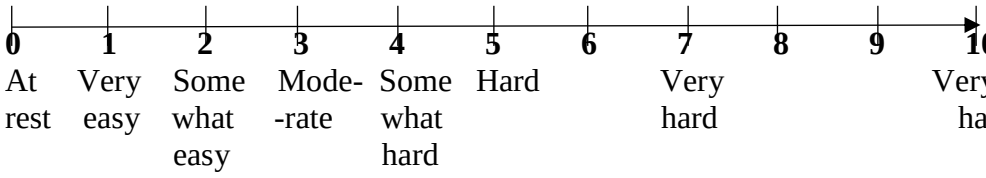
1. Gender (লিঙ্গ)	1. Male (পুরুষ) 2. Female (মহিলা)
2. Age of Participant (অংশগ্রহন কারীর বয়স)	…….
3. Religion (ধর্ম):	1. Muslim মুসলিম) 2. Hindu(হিন্দু) 3. Buddhist (বৌদ্ধ) 4. Christian (খৃস্টান) 5. Other (অন্যান্য)
4. Height (উচ্চতা):	……(cm) (সেন্টিমিটার)
5. Weight (ওজন):	……(Kg) (কেজি)
6. Topographical classification of CP (সি.পি এর ট্রপোগ্রাফিকাল শ্রেণিবিভাগ):	1. Monoplegia 2. Diplegia 3. Rt. Hemiplegia 4. Lt. hemiplegia 5. Paraplegia 6. Triplegia 7. Quadriplegia 8. Unknown
7. GMFCS level (জিএমএফসিএস স্তর):	1. I 2. II 3. III
8. CP motor type (সিপি মোটর টাইপ):	1. Spastic(স্পাষ্টিক) 2. Flaccid (ফ্লাক্সিড) 3. Ataxic(এটাক্সিক) 4. Athetoid(এথটয়েড) 5. Dystonic(ডিসটোনিক) 6. Hypotonic(হাইপারটোনিক) 7. Unknown(অজানা) 8. Mixed(মিশ্রিত)
9. Educational level (শিক্ষাগত যোগ্যতা):	1. SENU 2. Kinder garden(KG) 3. Primary 4. Illiterate
10. Type of education attended (শিক্ষাগত উপস্থিতির প্রকার):	1. Special 2. Inclusive 3. Integrated 4. NA

11. Assistive device used (সহায়ক যন্ত্র ব্যবহৃত	1. Yes (হ্যা)	2. No (না)
12. If yes, which types of assistive device do you use? (যদি হ্যাঁ, কোন ধরনের সহায়ক ডিভাইসটি আপনি ব্যবহার করেন?)	1. Foot orthosis 2. AFO 3. KAO	4. Walkers 5. Walking sticks & canes 6. Wheelchair
13. Place of Assistive device used (গতিশীলতা সাহায্যের জায়গা ব্যবহৃত)	1. Home(বাসা) 2. School (স্কুল)	3. Community (সম্প্রদায়) 4. All
14. Family structure (পরিবারের আকার):	1. Nuclear family (একক পরিবার) 2. Joint family (যৌথ পরিবার)	
15. Parents educational level (মাতাপিতা শিক্ষাগত স্তর):	1. Illiterate (অশিক্ষিত) 2. Primary (প্রাথমিক) 3. Secondary (মাধ্যমিক)	4. Higher Secondary (উচ্চমাধ্যমিক) 5. Graduation (স্না তক) 6. Post-graduation and above (স্নাতকোত্তর এবং এর উপরে)
16. Parents economic status (মাতাপিতা অর্থনৈতিক অবস্থা), Taka (টাকা)	1. less than 5,000 2. 5,000-10,000 3. 10,000-20,000 4. 20,000-30,000	5. 30,000-40,000 6. 40,000-50,000 7. Above 50,000
17. Other comments (অন্যান্য বক্তব্য):		

<u>Part 2</u>(অংশ ২): 2-Minute Walking Test (২-মিনিট হাঁটা পরীক্ষা) (2MWT) OR(অথবা) Wheeling Test (হুইলচেয়ার চালানোর পরীক্ষা)

18. Date (তারিখ):	
19. Time (সময়):	
20. Temperature (surrounding) in Degree Celsius (ডিগ্রি সেলসিয়াস তাপমাত্রা (পার্শ্ববর্তী)):	
21. Humidity (আদ্রতা):	
22. Resting HR (বিশ্রাম হৃদ কম্পন) 23. Post-test HR (পরীক্ষার পর হৃদ কম্পন) 24. HR after 2 minutes (২ মিনিট পরে হৃদ স্পন্দন) 25. Maximum HR (সর্বচ্চ হৃদ কম্পন)	_____Bpm _____Bpm _____Bpm _____Bpm
26. Vo2 Max (সর্বোচ্চ অক্সিজেনের আয়তন)	
27. Number of rests (বিশ্রাম সংখ্যা):	
28. Number of laps (ল্যাপ সংখ্যা):	
29. Distance walked (দূরে হাঁটা):	

30. The Borg Scale for perceived exertion (অনুভূত পরিশ্রমের জন্য বরগ স্কেল) (modified)



Part 3(অংশ ৩): ABILOCO-Kids Questionnaires (এবিলকো-কিডস প্রশ্নাবলী**)**

How do you feel while performing the following activities? (নিম্নলিখিত কার্যক্রমগুলি সম্পাদন করার সময় আপনার কেমন লাগে?)	**Impossible** (অসম্ভব) 1	**Difficult** (কঠিন) 2	**Easy** (সহজ) 3	? 4
31. Going up an escalator alone (একা একটি চলন্ত সিঁড়ি দিয়ে উপরে যাওয়া).				
32. Going up stairs putting each foot on the next step (সিঁড়ির পরবর্তী ধাপ গুলোতে প্রতিটা পা রেখে উপরের দিকে যাওয়া).				
33. Walking or wheeling backwards (পিছন দিকে হাঁটা বা হুইলচেয়ার চালানো).				
34. Walking or wheeling several minutes at the same speed as a healthy child (একটি স্বাস্থ্যকর শিশুর মত একই গতিতে কয়েক মিনিট হাঁটা বা হুইল চেয়ার চালানো).				
35. Going down stairs putting each foot on the next step (সিঁড়ির পরবর্তী ধাপ গুলোতে প্রতিটা পা রেখে নিচের দিকে যাওয়া).				
36. Running correctly even if you have to turn (সঠিকভাবে দৌড়ানো যদিও আপনাকে ঘুরতে হয়).				
37. Walking or wheeling while holding a fragile object (such as a full glass) (একটি ভঙ্গুর বস্তু (যেমন একটি পূর্ণ গ্লাস) ধরে রেখে হাটা বা হুইল চেয়ার চালানো).				
38. Walking or wheeling less than five meters, indoors, holding onto pieces of furniture (আসবাবপত্র টুকরো ধরে রেখে ঘড়ের ভেতরে ৫ মিটারের কম জায়গার মাঝে হাটা বা হুইলচেয়ার চালানো)				
39. Turning and walking or wheeling in a narrow space (একটি সংকীর্ণ স্থানের মাঝে ঘোরা এবং হাটা অথবা হুইলচেয়ার চালানো).				
40. Going up and down stairs without holding onto the banisters (রেলিং না ধরে সিঁড়ির উপরে বা নিচে যাওয়া).				

Thank you for your assistance(আপনার সহায়তা করার জন্য আপনাকে ধন্যবাদ).....

Appendix VI: Approval of thesis proposal by ethics committee of BHPI

BANGLADESH HEALTH PROFESSIONS INSTITUTE

বাংলাদেশ হেল্‌থ প্রফেশন্স ইনস্টিটিউট (বিএইচপিআই)

Bangladesh Health Professions Institute (BHPI)

(The Academic Institute of CRP)

Ref. CRP-BHPI/IRB/01/18/187 *Date:* 07/04/2018

To,
Rabindra Shrestha Naha
Part-II, M.Sc. in Rehabilitation Science (MRS)
Session: 2016-2017, Student ID:181160068
BHPI, CRP-Savar, Dhaka-1343, Bangladesh

Subject: Application for review and ethical approval- "Cardiorespiratory Fitness in Term of Estimated VO_2 Max of children with Cerebral Palsy" by ethics committee.

Dear Rabindra Shrestha Naha,

Congratulations.
The Institutional Review Board (IRB) of BHPI has reviewed and discussed your application on April 29, 2017 to conduct the above-mentioned thesis, with yourself, as the Principal Investigator the Following documents have been reviewed and approved:

S.N.	Name of Documents
1.	Thesis Proposal
2.	Questionnaire (English and Bangla version)
3.	Information sheet & consent form.

The purpose of the study is to determine the cardiorespiratory fitness of Cerebral Palsy (CP) children with GMFCS I, II and III in term of $VO_{2\ max}$. This research will help to develop appropriate interventions like educational strategy, awareness program and health promotional activities which will be helpful to CP child and their parents. The questionnaire will be used to achieve related information from the participant which will take about 10 to 15 min and the study have no likelihood of any harm to the participant. Data collector will receive informed consents from all participants. Any data collected will be kept confidential. The members of the Ethics committee have approved the study to be conducted in the presented form at the meeting held at 9.00 AM on 08-05-2017.
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, MRS
Member Secretary, Institutional Review Board (IRB)
BHPI, CRP, Savar, Dhaka-1343. Bangladesh

সিআরপি-চাপাইন, সাভার, ঢাকা-১৩৪৩, বাংলাদেশ, ফোন ঃ ৭৭৪৫৪৬৪-৫, ৭৭৪১৪০৪ ফ্যাক্স ঃ ৭৭৪৫০৬৯
CRP-Chapain, Savar, Dhaka-1343, Tel : 7745464-5, 7741404, Fax : 7745069, E-mail : contact@crp-bangladesh.org, www.crp-bangladesh.org

Appendix VII: Recommendation letter from BHPI

BANGLADESH HEALTH PROFESSIONS INSTITUTE

বাংলাদেশ হেল্‌থ প্রফেশন্স ইনস্টিটিউট (বিএইচপিআই)

Bangladesh Health Professions Institute (BHPI)

(The Academic Institute of CRP)

Ref. CRP-BHPI/MRS/01/18/0083

Date: 07/01/2018

To Whom It May Concern

This is to certify that Mr. Rabindra Shrestha Naha, a student of M.Sc. in Rehabilitation science at Bangladesh Health Professions Institute(BHPI) under the faculty of Medicine of University of Dhaka(DU). This is 2-year full time course under the project of "Regional Inter-Professional Master's program in Rehabilitation Science" funded by SAARC Development Fund (SDF). I have to conduct a thesis entitled, **"Cardio respiratory Fitness in Term of Estimated VO_2 Max of children with Cerebral Palsy"** under honorable supervisor, Mohammad Anwar Hossain, Associate Professor, BHPI, CRP. The purpose of the study is to evaluate the cardiorespiratory fitness of Cerebral Palsy (CP) child with GMFCS I, II, III in term of VO2 max which will be directly beneficial for CP child and their parents to maintain an appropriate level of cardiorespiratory fitness for improving the child quality of life. This research will help to develop appropriate interventions like educational strategy, awareness program and health promotional activities which will be helpful to CP child and their parents. The questionnaire will be used to achieve related information from the participant which will take about 10 to 15 min and the study have no likelihood of any harm to the participant. Data collector will receive informed consents from all participants. Any data collected will be kept confidential. The research proposal has been approved by Institutional Review Board(IRB) of this institute. To accomplish research objectives, he will collect data from William and Marie Taylor School CRP.

We request you to provide her necessary support from the William and Marie Taylor School CRP.

I wish him every success in order to accomplish his research.

Best regards.

Millat Hossain

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

সিআরপি-চাপাইন, সাভার, ঢাকা-১৩৪৩, বাংলাদেশ, ফোন ঃ ৭৭৪৫৪৬৪-৫, ৭৭৪১৪০৪ ফ্যাক্স ঃ ৭৭৪৫০৬৯
CRP-Chapain, Savar, Dhaka-1343, Tel : 7745464-5, 7741404, Fax : 7745069, E-mail : contact@crp-bangladesh.org, www.crp-bangladesh.org

Appendix VIII: Permission letter for data collection from William and Marie Taylor School, CRP

Date: 07/01/2018

To,

The Principal

William and Marie Taylor School

CRP, Chapain, Savar, Dhaka-1343

Subject: Application for the permission of data collection for master's thesis.

Dear respected sir,

With due respect and humble submission, I would like to draw your kind attention that I am a student of M.Sc. in Rehabilitation Science program at Bangladesh Health Professions Institution (BHPI)- an academic institution of CRP under Faculty of Medicine of university of Dhaka (DU). This is a two- year full-time course under the project of "Regional Inter-Professional Master's Program in Rehabilitation Science" funded by SAARC Development Fund (SDF). As per approved by ethical review committee of BHPI. I have to conduct a thesis entitled, "**Cardiorespiratory Fitness in Term of Estimated VO_2 Max of children with Cerebral Palsy**" under supervision of honorable supervisor Mr. Mohammad Anwar Hossain, Associate Professor and Head of Physiotherapy Department of CRP.

The purpose of the study is to determine the cardiorespiratory fitness of Cerebral Palsy (CP) children with GMFCS I, II and III in term of $VO_{2\ max}$. This research will help to develop appropriate interventions like educational strategy, awareness program and health promotional activities which will be helpful to CP child and their parents. The questionnaire will be used to achieve related information from the participant which will take about 10 to 15 min and the study have no likelihood of any harm to the participant. Data collector will receive informed consents from all participants. Any data collected will be kept confidential.Ethical approval is received from the Institutional Review Board of Bangladesh Health Professions Institute (BHPI).

I therefore, pray and hope that you would be kind enough to grant my application and permit me to collect required data to accomplish my research objective.

Thank You

Your Sincerely,

Rabindra Shrestha Naha

M.Sc. in Rehabilitation Science (3rd Batch)

BHPI, CRP, Chapain, Savar, Dhaka-1343

Permitted for Data collection from WMTS.

7.1.18

Md. Abdullah Al Zubayer
Principal (Acting)
William and Marie Taylor School (WMTS)
CRP, Chapain, Savar
Dhaka-1343

Appendix IX: Permission letter form Department of Physiotherapy, CRP

Date:24/02/2018

To,

The Head of Physiotherapy department

CRP, Chapain, Savar, Dhaka-1343

Subject: Application for the permission of data collection for master's thesis.

Dear respected sir,

With due respect and humble submission, I would like to draw your kind attention that I am a student of M.Sc. in Rehabilitation Science program at Bangladesh Health Professions Institution (BHPI)- an academic institution of CRP under Faculty of Medicine of university of Dhaka (DU). This is a two- year full-time course under the project of "Regional Inter-Professional Master's Program in Rehabilitation Science" funded by SAARC Development Fund (SDF). As per approved by ethical review committee of BHPI. I have to conduct a thesis entitled, **"Cardiorespiratory Fitness in Term of Estimated VO_2 Max of children with Cerebral Palsy."** under supervision of honorable supervisor Mr. Mohammad Anwar Hossain, Associate Professor and Head of Physiotherapy Department of CRP.

The purpose of the study is to determine the cardiorespiratory fitness of Cerebral Palsy (CP) children with GMFCS I, II and III in term of $VO_{2\ max}$. This research will help to develop appropriate interventions like educational strategy, awareness program and health promotional activities which will be helpful to CP child and their parents. The questionnaire will be used to achieve related information from the participant which will take about 10 to 15 min and the study have no likelihood of any harm to the participant. Data collector will receive informed consents from all participants. Any data collected will be kept confidential. Ethical approval is received from the Institutional Review Board of Bangladesh Health Professions Institute (BHPI).

I therefore, pray and hope that you would be kind enough to grant my application and permit me to collect required data from pediatric physiotherapy department to accomplish my research objective.

Thank You

Your Sincerely,

Rabindra Shrestha Naha 26/02/018

M.Sc. in Rehabilitation Science (3rd Batch)

BHPI, CRP, Chapain, Savar, Dhaka-1343

Approved
26/02/18
Mohammad Anwar Hossain
Associate Professor & Head
Physiotherapy Dept., CRP
CRP, Chapain, Savar, Dhaka-1343

Appendix X: Permission letter form In Charge of Pediatric unit, CRP

Date:24/02/2018

To,

The In-Charge of Pediatric Unit

CRP, Chapain, Savar, Dhaka-1343

Subject: Application for the permission of data collection for master's thesis.

Dear respected sir,

With due respect and humble submission, I would like to draw your kind attention that I am a student of M.Sc. in Rehabilitation Science program at Bangladesh Health Professions Institution (BHPI)- an academic institution of CRP under Faculty of Medicine of university of Dhaka (DU). This is a two- year full-time course under the project of "Regional Inter-Professional Master's Program in Rehabilitation Science" funded by SAARC Development Fund (SDF). As per approved by ethical review committee of BHPI. I have to conduct a thesis entitled, **"Cardiorespiratory Fitness in Term of Estimated VO_2 Max of children with Cerebral Palsy."** under supervision of honorable supervisor Mr. Mohammad Anwar Hossain, Associate Professor and Head of Physiotherapy Department of CRP.

The purpose of the study is to determine the cardiorespiratory fitness of Cerebral Palsy (CP) children with GMFCS I, II and III in term of $VO_{2\ max}$. This research will help to develop appropriate interventions like educational strategy, awareness program and health promotional activities which will be helpful to CP child and their parents. The questionnaire will be used to achieve related information from the participant which will take about 10 to 15 min and the study have no likelihood of any harm to the participant. Data collector will receive informed consents from all participants. Any data collected will be kept confidential. Ethical approval is received from the Institutional Review Board of Bangladesh Health Professions Institute (BHPI).

I therefore, pray and hope that you would be kind enough to grant my application and permit me to collect required data from pediatric physiotherapy department to accomplish my research objective.

Thank You

Your Sincerely,

Rabindra Shrestha Naha 25/02/2018

M.Sc. in Rehabilitation Science (3rd Batch)

BHPI, CRP, Chapain, Savar, Dhaka-1343

He will collect data from paediatric unit please help him.
25-2-18

HOSNEARA PERVEEN
Incharge Paediatric Unit
CRP, Savar, Dhaka.

Approved
26/02/18

Mohammad Anwar Hossain
Associate Professor & Head
Physiotherapy Dept., CRP
CRP-Chapain, Savar, Dhaka-1343