EFFECTIVENESS OF ANKLE FOOT ORTHOSES FOR IMPROVING WALKING SPEED AMONG SPASTIC DIPLEGIC CEREBRAL PALSY CHILDREN ATTENDED AT CRP

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DECLARATION

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

Signature: **Date:**

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Abbreviations

&:	And
AFO:	Ankle Foot Orthosees
ALS:	Amyotrophic Lateral Schlerosis
BHPI:	Bangladesh Health Professions Institute
CP:	Cerebral Pals
CRP:	Center For Rehabilitation and paralyzed
DAFO:	Dynamic Anlke Foot Orthosis
EC:	Energy Cost
GBS:	Guillaine Barrie Syndrome
HAFO:	Hinged Ankle Foot Orthosis
ICP:	Infantile Cerebral Palsy
NINDS:	National Institute of Neurological Disorders and Stroke
P:	Probabibility
PLS:	Posterior Leaf Spring

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Abstract

Purpose: Effectiveness of Ankle Foot Orthoses for improving walking speed among spastic diplegic cerebral palsy children attended at CRP. *Objectives*: To assess the velocity of walking, to find out the stride length, step length, cadence and to discover the walking speed among cerebral palsy children while they were walking with and without AFO. *Methodology:* 10 participants with spastic diplegic cerebral palsy were selected through simple random sampling and they were allowed to walk at their self selected speed with and without AFO to compare the walking speed for this same subject study under experimental design. The study is conducted at pediatric Unit, Orthotic and Prosthetic Department and William and Marrie Tailor School of CRP. Ten meter walking test is used to measure the velocity of walking, stride length, step length and cadence while the participants were walking with or without AFO. Related "t" test is used to compare the result. *Results:* Ankle Foot Orthoses is an effective device to improve walking speed in spastic diplegic cerebral palsy children in compare with bare foot walking because it showed a significant improvement in case of velocity of walking ($p<0.025$), stride length ($p<0.01$) & step length ($p<0.025$). Cadence is the only one gait parameter which is not found to be significant. *Conclusion:* When wearing Ankle Foot Orthosis, statistically significant increases in stride length, step length and velocity were noted compared with bare foot walking. Cadence is the only one parameters which is not found to be significant. This experimental study demonstrates that Ankle Foot Orthosis in our population provide clinical improvements in the temporal and spatial parameters of gait listed above. As velocity is the product of stride length, step length and cadence, the increase in stride length and step length but not cadence resulted in an increase in velocity for cerebral palsy population.

CHAPTER – I: INTRODUCTION

1.1 Background

Bangladesh is a developing country in the World. Disability is the most common challenging issue in this country. A survey report on World Bank disability facts and statistics (2009) estimate that 15 % people in globally are disabled among the whole world population. About 80% of person with disability live in developing country (according to UN development programme 2004). According to WHO report on Yutaka July (2003), one out of ten persons have some type of disability in the Asian and Pacific region there are 400 million persons disability, comparison two third population. Bangladesh is a third world country, so disability is a burning issue here. A survey on prevalence of disability from 1994 by the Bangladesh Bureau of statistics shows a rate of 10.62 disabilities per 1000 population.

Cerebral palsy is the most common condition that is responsible for the child disability. The calculation based on estimations and forecasts of the U.S. Bureau of the census, International data base indicate that in 2010 the number of patients with the infantile cerebral palsy (ICP) were increase to 17340000 people in the world (cerebral palsy statistics, 2010). According to statistics population with cerebral palsy in USA exceeded 75000. Currently there are more than 10000 new cases occur each year. Campbell (1998) stated that the prevalence rate of cerebral palsy is 2-25 per 1000 children in developing country. Bangladesh has recently seen an increase in the number of children diagnosed with cerebral palsy. According to disability profile, the client assess in the shishu bikash clinic (Rural Centre) during January to December 1998 showed a report of child disability were 42% of total disability was cerebral palsy, among these spastic cerebral palsy is 9%. Athetoid cerebral palsy is 2%, Ataxic cerebral palsy is 3% and rest of the patient is other type of cerebral palsy (Khan and Rahman 2000). Also according to data based report of CRP, s Pediatric Unit from July 2005 to June 2006 showed that types of conditions treated lead to impairment among 1178 patients, 1000 were cerebral palsy, autism 43, erbs palsy 20, down's syndrome 15 and others 86. But from July 2009 to 2010 it is shown that 91% is cerebral palsy patient and 4% is other patient. From this statistics it is clearly seen that cerebral palsy has covered a large area in the field of child disability of Bangladesh (CRP, Pediatric Unit 2011). Gages's study (cited in Brehm, Harlaar and Schwartz 2008) stated that cerebral palsy is primarily characterized by central nervous system abnormalities, such as loss of selective motor control and abnormal muscle tone. As a result of growth these primary characteristics often lead to secondary deficits, including bong deformities, muscle contractures and gait abnormalities. Among all type of cerebral palsy spastic cerebral palsy is the most common type of cerebral palsy.

Albert (2005) described that, in children with CP spastic tone on foot is the most common complication and also children suffer from foot drop or inability to raise the foot, abnormality in walking patterns, unwanted and uncontrolled movements associated with muscle imbalances and increased tone in the lower leg and foot and ankle. Abnormal movement with reference to the child with diplegia usually means a tip toe walking pattern (Equinus or aPlanterflexed Gait), with the added complication of the ankle become twisted outwards (varus ankle) or inwards (valgus ankle).

According to Campbell and Ball (1998), gait abnormalities in children with CP are known to cause a more than two fold increase in the energy cost (EC) of walking, compare a with healthy children. Such increase in EC has been shown to influence negatively with CP to early fatigue in carrying out activities of daily living. Therefore, interventions that aim to increase physical mobility by addressing gait abnormalities and reduce the EC of walking are important treatment modalities to maintain or improve independent functioning.

Morris'^s study (Brehm, Harlaar and Schwart, p. 529) stated that lower extremity orthoses such as ankle foot orthoses (AFOs) are often prescribed for ambulatory children with CP as a treatment modality to reduce gait abnormalities and related limitation in physical mobility. In 2004 according to Mark ankle foot orthosis (AFO) is a hard brace worn on the lower leg to support an ankle and foot and is used in the treatment of spastic diplegic CP to reduce in proximal muscle tone, correction, prevention delaying of contracture develop facilitation of functional or ambulation as well as effectiveness of the therapeutic programme.

The most typical use of an AFO is to optimize the normal dynamics of walking by applying a mechanical constraint (control moment) to the ankle to control motion and at the same time, produce a more efficient gait. According to Kogler (2002) the solid AFO (SAFO) achieves the maximum orthotic control by restricting the movements of both planter flexion and dorsiflexion in the stance & swing phases. Its rigid construction prevents ankle rocker function in stance. Kogler (2002) also said that SAFO are generally prescribed to reduce excessive planter flexion instance, and to prevent or eliminate an equine position.

Walking speed is closely related with the walking efficiency and pattern of gait as well as energy consumption during walking. As I described earlier that different literature shows, AFO improves walking efficiency of gait and decreases energy consumption during walking, so it may improve walking speed. Brawn (2007) discusses that physiotherapist often prescribe AFO which helps to maximize child function, adapt to limitation in life as much as possible and allow them to participate fully in his or her schooling programme that can facilitate independence of this client group in their activities of daily living. From this research the researcher wishes to explore the effectiveness of ankle foot orthosis in improving walking speed among cerebral palsy children so that their schooling and other functional activities will perform properly and more efficiently.

1.2 Justification of the study

Walking speed is accepted as a simple & effective means by which to asses gait & is clearly related to function. It can also be related to other gait parameters such as stride length, step length, step width, cadence & functional gait score. In cerebral palsy children AFO helps to maximize child function, adapt to limitation in life as much as possible that can facilitate independence of these child group in their activities of daily living. It will also allow them to participate fully in his or her schooling programme which is very essential and basic needs for a child. The purpose of this study is to identify or explore the effectiveness of using AFO in improving walking speed in cerebral palsy children. Because when the walking speed will increase that means the parameters of gait will increase & the child with cerebral palsy will be more able to walk properly & purposefully & will be able to do his or her functional activities more accurately & thus can reduce the walking disability & the child will be more independent. . From this research the researcher wishes to explore the effectiveness of ankle foot orthosis in improving walking speed among cerebral palsy children so that their schooling and other functional activities will perform properly and more efficiently.

1.3.1 Hypothesis: Ankle foot orthosis improves walking speed among cerebral palsy children.

1.3.2 Null Hypothesis: Ankle foot orthosis does not improve walking speed among cerebral palsy children.

1.4 Study objectives

1.4.1 General objective: To explore the effectiveness of Ankle foot orthosis in improving walking speed among cerebral palsy children.

1.4.2 Specific objective:

- To assess the velocity of walking among cerebral palsy children while they were walking with and without AFO.
- To find out the stride length among cerebral palsy children while they were walking with and without AFO.
- To explore the step length among cerebral palsy children while they were walking with and without AFO.
- To assess the cadence among cerebral palsy children while they were walking with and without AFO.
- To discover the walking speed among cerebral palsy children while they were walking with and without AFO.

1.5 List of variable

1.5.1 Independent variable: Ankle foot orthosis

1.5.2 Dependent variable: Walking speed.

1.6 Operational definitions

AFO AFO is a hard brace worn on the lower limb to support ankle and foot in children with cerebral palsy and it is the most common treatment for ankle and foot deformities caused by CP. This device keeps the ankle in a neutral position

Walking speed Walking speed means increase the efficiency of walking with increasing the parameters of gait.

Velocity of walking The ten meter walking test will be used and the time will be measured by using a stop watch .This is converted into unites of velocity of walking. (M/min)

Stride length It is the distance between two successive placements of the same foot .Stride length can be also measured by dividing the total walking distance by total step. (Cm/step)

Step length It is the distance between two successive placements of the opposite foot

Cadence Cadence is measured by counting total steps per minute. (steps/min)

CHAPTER – II: LETERATURE REVIEW

Cerebral palsy

'Cerebral' refers to the brain and 'Palsy' to a disorder of movement or pressure. If someone has cerebral palsy it means because of an injury to the brain (cerebral) he or she is not able to use some of the muscles of body in normal way (palsy) .CP is a group of condition that affects the movement and posture of body.

Sunder (2002) had described that cerebral palsy is not a single or any illness. The disability of CP persistent and caused by a non progressive brain lesion arising before, during or after birth, during the period of brain development. According to Gordon (1996) CP can be defined as a disorder of movement and posture that is caused by a non progressive brain lesion that occurs in uterus during or shortly after birth and is expressed throw variable impairments in the co- ordination of muscles action and sensation.

Albert (2008) stated that a group of disorder of the development of movement and posture causing activity limitations that are attribute to non-progressive disturbances that occurred in the developing fetal or infant brain. The motor disorders of cerebral palsy are often accompanied by disturbances of sensation, cognition, communication, perception and disturbances in gait and other active movement.

CP is neither progressive nor communicable disease. But due to lesion or damage in immature brain at early stages of development motor impairment syndrome occurs. One literature also supported this, "Cerebral palsy is an umbrella term covering a group of non-progressive, but often changing motor impairment syndromes secondary to lesions or anomalies of the brain arising in the early stages of development" (Leviett 2004).

Damage of one or more parts of the brain affect the ability to control muscles in CP. Symptoms range from mild to severe but the condition does not get worse with the childs age (Cerebral Palsy statistics, 2010).

Types of cerebral palsy

CP is classified into four categories according to the type of disturbance in movement:

Spastic cerebral palsy

Spastic cerebral palsy is the most common type of CP. This affects approximately 70 to 80 percent of individuals with the disorder. It occurs due to damage of motor cortex of the brain (cerebral palsy statististics 2010). In this type of CP muscle become stiff and the child face difficulty to move the body parts (cerebral palsy statistics, 2010). There are varying degrees of spastic cerebral palsy. Some patients have mild causes that affect vary few movement and some have moderate spasticity. Other with more severe causes can have their entire bodies affected. Spastic cerebral palsy also limits stretching of muscle in daily activity and causes the development of muscle and joints deformity. Children born with spastic cerebral palsy do not have any deformity of the extremity but develop them over time due to joint contracture (Brody, 2005).

Ataxic Cerebral palsy

According to Raj (2006), this is a rare form of cerebral palsy which affects an estimated 5 to 1o percent of individuals with cerebral palsy. Ataxic cerebral palsy affects sense of balance and depth perception. Ataxic cerebral palsy is caused by damage to the cerebellum that is responsible for balance and coordination and coordinates the actions for different groups of muscle. Ataxic cerebral palsy therefore affects coordination of movement. Ataxic cerebral palsy usually affects all four limbs and trunk. Typically, persons affected by ataxic cerebral palsy have poor coordination, unsteady walking and difficulty with precise movements such as using a pen or buttoning a shirt.

Athetoid Cerebral palsy

The athetoid children have certain features in common. Tone is abnormal and varies in character & intensity, ranging in the one child from hypotonia to hypertonia, frequently with surprisingly sudden fluctuations. Involuntary movement occurs which may not be movements at all but really tonus changes, and the lower the tone the greater the fluctuation appears to be. These tonus changes may occur as intermittent tonic spasms occurring in recognizable patterns, or as repetitive rhythmical movements, or as fleeting, irregular and localized contraction of muscle groups, muscle or muscle fibres. These children show little or no co-contraction, therefore are unable to maintain aposture or develop enough fixation for a moving limb. There is poor grading between the agonist and antagonists during a movement or if a posture is to be maintained. According to Shepherd (1990), when this type of children attempt to move a limb there is an immediate relaxation of the lengthening group of muscles and control over middle ranges of movement in in particular is very poor.

Mixed types

This type of CP was the result of injury of pyramidal and ex-pyramidal tract (Gillette's annual report, 2007). It was common for children to have symptoms that didn't correspond to any single type of cerebral palsy. There symptoms were a mix of types.

There are four main types of cerebral palsy according to movement:

Hemiplegic/hemiperesis

According to Dietz (1995), this type of cerebral palsy typically affected the arm and hand on one side of the body, but it can also include the leg. Children with spastic hemiplegic generally walk later and on tiptoe because of tight heel tendons. The arm and leg of the affected side are frequently shorter thinner. Some children would develop an abnormal curvature of the spine (scoliosis).

Diplegia/diperesis:

In this type of cerebral palsy, muscle stiffness was predominantly in the legs and less severely affects the arms and face, although the hands may be clumsy. The word diplegia breaks down into “di” meaning two and “plegia” the latin word for weakness. Therefore, spastic diplegia means two extrimities causing weakness. Spastic diplegic CP shows a pattern similar to that of the average developing child. According to Dietz (1995) the characteristics of spastic diplegic CP include the legs often turn in and cross at the knees. Tendon reflexes are hyperactive. Toes point up. Tightness in certain leg muscle makes the legs move like arms of a scissor, in which the hips are flexed, the knees nearly touch, the feet are flexed, and the ankles turn out from the leg, causing toe walking. Children with this kind of cerebral palsy may require a walker or leg braces.

Quadriplegic/quadriparesis:

This the most severe form cerebral palsy, often associated with moderate to severe mental retardation. It caused by widespread damage to the brain or significant brain malformations. Children will often have severe stiffness in their limbs but a floppy neck. They are rarely able to walk Raj (2006).

Based on degree of severity: Forfar (1998) has described the following types of cerebral palsy:

Mild: Spastic hemiplegic, diplegia and ataxia type of CP. Independent living, walking, intelligence ≥ 70.

Moderate: Spastic hemiplegic, diplegia and ataxia type of CP. Supported self propelled wheelchair, independent or assisted walking with brace and other orthotic devices.

Severe: Spastic quadriplegic, athetosis type of CP. Totally dependent, pushchair, and intelligence ≤50.

The various sub types of CP vary with the reporting surface, a series for Sweden noted-

Hemiplegia-36.4%, Quadriplegia- 7.3%, Diaplegia-41.5%, Athetosis- 10%, Ataxic-5% .

In this research, researcher selected for the study only participants with spastic diplegic CP because AFO is used usually for the treatment for the treatment purpose in children with spastic diplegic CP. Also CRP pediatric unit and orthotic prosthetic department are frequently providing AFO for children with spastic diplegic CP. Albert (2008) stated that AFO is prescribe for the management of walking patterns in children with spastic diplegic CP.

Ankle foot orthosis

Epler's study (cited in Lin 2004, p. 159) stated that an ankle foot orthosis (AFO) can be prescribed for patients with musculoskeletal or neuromuscular dysfunction to accomplish a variety of goals. For patient with unstable ankle, whether from injury or muscular imbalance, an AFO can be used to support the foot and ankle, to maintain optimal functional alignment during activity, or to limit motion to protect healing structure. For patients with neuromotor dysfunction, the AFO can substitute for inadequatemuscle function during key points in the gait cycle, can optimize alignment and help to manage abnormal tone, or can minimize the risk of deformity (e.g. equinovarus) associated with long term hypertonicity.

According to Laura (2008). AFO is a hard brace worn on the lower to support ankle and foot in children with cerebral palsy and it is the most common treatment for ankle and foot deformities caused by CP. This device keeps the ankle in a neutral position during walking and other daily activities. People who suffer from a foot drop or inability to raise the foot, often wear an AFO to assist clearing the toes during walking.

Yates (1998) described that AFO most commonly used in children with CP for correction, prevention or delay of contracture, facilitation of function or ambulation, either by obtaining functional goals at an earlier time, improving the parameters of gait, and/or reducing energy expenditures and the reduction in proximal muscle tone in order to facilitate functions at a higher level.

Chris & Rorth (cited in Albert, 2008) reported that ankle and foot splints, or orthoses, have been used for many years in the management of walking patterns in children with diplegia.They are used in preventing unwanted and uncontrolled movements associated with muscle imbalance increased tone in the lower leg and the foot and ankle. Abnormal movement with reference to the child with spastic diplegia usually means a tip toe walking pattern (Equinus or planter flexed gait).The adaption of a toe walking gait also leads to secondary problems related to control of the knee which in many cases tends to snap backwards further than it would normally (hyperextention), this in turn has a subsequent effect on hip position and a general reduction in the child's balance.

Biomechanical principles of Ankle Foot Orthosis

To understand the biomechanical principles of AFOs, we must understand the functional anatomy of the ankle foot complex itself. According to Frankel and Nordin (2007) dorsiflexion and planter flexion of the ankle occurs as the talus rotates through the mortise of the ankle. The interior of the mortise is formed from the syndesmosis (fibrous articulation) between the distal tibia and distal fibula. The medial malleolus is the downward extension of the tibia. The corresponding lateral malleolus of the fibula is slightly longer and more posterior located. The shape of the articular surface of the talus and mortise, combined with spatial orientation of the malleoli, result in a joint axis that is slightly oblique. Because the axis of motion runs in an anteromedial to posterolateral direction, motion occurs in more than one plane. Dorsiflexion is associated with forefoot pronation with abduction and hind foot valgus, whereas planter flexion is accompanied by forefoot supination with adduction and hind foot varus.

Lower extremity orthotic includes mechanical ankle joints, it is essential that the axis of the mechanical joints be aligned, as closely as possible, to the obliquely orientated anatomic axis of motion. Although non mechanical ankle joints are able to model the multiplaner motion of the anatomic ankle exactly.

Epler’s study (cited in Lin 2004, p. 161) stated that a pair of mechanical joints incorporated into the medial and lateral aspects of the orthosis. The distal border of the medial malleolus is used as reference point for placement of the mechanical joint in the coronal plane. A horijontal line that bisects the medial and lateral malleolus at the same height from the ground is used to to position the lateral joint. In the transverse plane , the mechanical joint axis should be parallel to each other, to follow the line of progression and degree of external rotate ion dictated by the patient’s tibial tortion.The specific mechanical joint heads are placed at approximately midline of the malleoli in the malleoli in the sagital plane. If significant incongruency is present between the anatomic and mechanical axes, excessive motion of the extrimitywithin the orthosis and a limitation of motion and efficiency of the mechanical joint often occur.

Value of walking in walking efficiency

Thompson (2001) describes that therapists often recommended, the FAO for patients with gait deviations that relate to muscle weakness. The AFO substitutes for weak dorsiflexors during swing and more importantly, for weak plantar flexors during stance.

The AFO's effect on supporting the forefoot and preventing plantar flexion or ‘foot drop’ during swing is straightforward. Less obvious is the AFO's role as a substitute for plantar flexor muscles. The plantar flexors must be active during midstance and terminal stance to counter the dorsiflexor moment that is produced by the ground reaction force. If the plantar flexors are weak, the ankle dorsiflexors too rapidly and, because of lower extremity is positioned in closed chain, the knee flexes. When child bears weight on an AFO that he or she wears inside the shoe, the AFO's rigid wall transfer the ground reaction force thus, the AFO direct a force posteriorly against the anterior tibia during midstance and terminal stance, and prevents and controls tibia advancements. In this way, the AFO's force produces a plantar flexon moment that counters the ground reaction forces (GRF) tendency to dorsiflex the ankle. The AFO's ability to redirect the ground reaction force, and thereby produce a plantar flexor moment, depend on its rigidity. An AFO that is flexible or articulated (hinged at the ankle) does not serve this purpose.

Types of ankle foot orthosis

Robert (2001), discusses various types of AFO that are most frequently fabricated for children with spastic diplegic CP on lower extremity function. Although there are numerous variation in design details.

a. Solid AFO: A solid AFO conforms to the shape of the calf and foot as one continuous plastic brace. It is used to prevent plantar flexion of the foot and to provide mediolateral ankle stability. Robert (2009) described that AFOs of this type may be used to support in children with CP who are beginning to learn how to walk. They provide a base of support by counteracting the tendency to walk on the forefoot or toes. Solid or hinged AFO s also may be used to provide a sustained static stretch at the ankle to prevent loss of range of motion due to spasticity-related countractures. Usually at least 6 hours of per day, preferably while asleep, are needed to prevent progressive loss of range of motion.
b. Hings AFO: A hinged AFO constructed from two plastic parts joined by an articulation at the ankle is used as an assist to gait in children with CP who have mastered the basics of walking. They are used when the children has passive range of motion at the ankles past the neutral position into dorsiflexion. This promotes slight flexion at the ankle and knees that contribute to a more fluid and normal gait. The articulated AFOs also provide a passive stretch of tight tendons during gait (Robert 2009).
c. Posterior leaf spring AFO: A PLSO is a rigid AFO trimmed aggressively posterolately and posteromedially at the supramalleolar area. This provides flexibility at the ankle and allows passive ankle dorsiflexion during the stance phase. A PLSO provides smoother knee ankle motion during walking while preventing excessive ankle dorsiflexion, particularly in larger children who have the strength to deform the material. However it also increase knee

flexion in stance. Varus- valgus control is also poor because it is repeatedly deformed during weight bearing (Grander2009).

d. GRAFO or FRO (Ground reaction or floor reaction AFO): This AFO is made with a solid ankle at neutral. The upper portion wraps around the anterior part of the tibia proximately with a solid front over the tibia. The rigid front stars just below the tuberositas with a brand at the back to create a three point pressure distribution and provide strong ground reaction support for patients with weak triceps surae. The foot plate extends to the toes (Gardner 2009).

e. Supramalleoler orthosis (SMO): Extends to just above the malleoli and to the toes. Consider in mild dynamic equines, varus valgus instability.

From all kinds of AFO, the most commonly are used in solid AFO for severe spasticity diplegic CP (Richie brace 2009).

Purpose of ankle foot orthosis:

Albert (2008) discusses whatever types of orthosis is recommended or fitted; they share many. Common design points and tries to provide some or all of the features below.Restoration of normal function and ability, Control of motion, Correction of deformity,Compensation for weakness,Provide hind for stability (close moulding around heel),Provide mid forefoot stability (medial and lateral extensions, good arch supported),Control unwanted, exaggerated and abnormal movements, Reduce the effects of increased tone (spasticity), Promote a stable base, Encourage proximal stability, Built in near foot ⁄forefoot wedging or posting (valgus or varus), Toe and Metatarsal support (tone management), Contoured sole plates to assist in foot stabilities (reduce tone), Manufactured from: semi flexible or rigid materials (polypropylene, polytheneetc.), The goal of orthotic management should be encourage and promote the child's own ability to achieve a normal gait, Thompson (2009) stated that the AFO's effect on supporting the fore foot and preventing planter flexion or foot drop during swing is straightforward. Less obvious is the AFO's role as a substitute for planter flexor muscles. The planter flexor must be active during midstance and terminal stance to counter the dorsiflexor moment that is produced by the ground reaction force. If the planter flexors are weak, the ankle dorsiflexes too rapidly and, because the lower extremity is positioned in a closed chain, the knee flexes. When a person bears weight on an AFO that he or she wears inside the shoes, the AFO's rigid walls transfer the ground reaction force. Thus the AFO's directs a force posteriorly against the anterior tibia during midstance and terminal stance, and prevents or control tibial advancement. In this way the AFO's force produces a planter flexion moment that counters the ground reaction force's (GRF) tendency to dorsiflex the ankle.

Effect of ankle foot orthosis on spatiotemporal parameters and walking speed

This has been suggested by Mark et al. (1998) In spastic diplegia motor deficits and spasticity typically produce a walking pattern characterized by an equines ankle position at floor contact, exaggerated stance phase during knee flexion (crouch) and increased hip adduction and internal rotation. Persistent equines and crouch are often associated with pesplano valgus deformities. Gage's study (cited in Mark et al. 1998) showed that this foot deformity theoretically reduces stability because the ground reaction force shifts posteriorly and laterally, increasing the flexion, valgus, and external rotation moments at the knee. These gait abnormality are present in proportion to the severity of neurological involvement. According to Park (cited in Mark et al. 1998) commonly prescribed treatments to address these gait abnormalities include physical therapy, surgery and braces. The orthotic approach is conservative therefore its application is particularly widespread. In general braces are prescribed to prevent and controt joint position and thus improve stability. Condie (1993, p.99-123) in the context of improving the gait of patients with spastic diplegia, the Ankle Foot Orthosis (AFO) (with a rigid ankle) is designed to prevent or eliminate an equines position. The effects of AFO s on walking function have been studied using both simple and more sophisticated gait analysis techniques. Using video technology alone Powel and Colleagues showed that AFOs had significant effect cadence, velocity and stride length.

Peter et al. (2009) suggested that many different types of ankle foot orthsis are available for controlling dynamic equines in children with spastic diplegic cerebral palsy. The ankle foot orthosis improves gait by providing mediolateral stability in stance phase (limiting ankle and subtalar movement) and by facilitating toe clearance during swing phase and heel strike during initial contact.

Tyson (2001), White et al. (2002), Buckon et al. (2004), Morris et al. (2002), Radtka et al. (2005) studied that in with cerebral palsy, braces have been found to increase temporal gait parameters, including walking speed ,stride length, step length, and single limb stance time while significantly decreasing cadence and oxygen consumption. Normal gait has five major attributes: stability in stance phase, sufficient foot clearance during swing phase, and appropriate swing phase preposition of the foot, conservation of energy and adequate step length.Gage (2004) suggested that these may be lost in pathological gait but can be improved with braces.

Holden (1986), Hill (1994) and Waters (1999) described that in diplegic patients spatiotemporal parameters are significantly different from those of healthy subjects: speed is lower, the rate and length of steps are lower, the swing phase of the affected limb is shorter. According to Fischer and Burdett (cited in Franceschini et al. 2007) orthosis can limit kinesiological problems of the foot ankle complex, improves the stride‘s spatiotemporal parameters, lower the energy cost of walking.

Walking speed is closely related with the walking efficiency and pattern of gait as well as energy consumption during walking. As I described earlier that different literature shows, AFO improves walking efficiency of gait and decreases energy consumption during walking, so it may improve walking speed. Brawn (2007)discusses that physiotherapist often prescribe AFO which helps to maximize child function, adapt to limitation in life as much as possible and allow them to participate fully in his or her schooling programme that can facilitate independence of this client group in their activities of daily living. From this research the recherchér wishes to explore the effectiveness of ankle foot orthosis in improving walking speed among cerebral palsy children so that their schooling and other functional activities will perform properly and more efficiently.

CHAPTER – III: MATHODOLOGY

3.1 Study design

This research was a quantitative explorative study; aims to find out the effectiveness of Ankle Foot Orthosis in improving walking speed among cerebral palsy children. Quantitative research was chosen by the researcher because it allowed the researcher to measure and counts the outcomes. Here, it was used the same subject design under the experimental design because here the one group of patient was tested under two conditions. Condition A was allowed to walk with AFO and Condition B was allowed to walk by bare foot. Thus two outcomes were compared to see if there were any differences between them. During walking with AFO, the subjects in the group acted as a experimental group and during walking by bare foot the same subjects acted as a control group. In the same subject design each subject is exposed to all level of independent variable. Each participant performance is measured under both conditions. This design is also called within-subjects design because comparison of the treatment effect involves looking at changes in performance within each participant across treatment. Because subject behavior is measured repeatedly. So same subject design is some time also called "repeated measures design".

According to Hicks (1999, p. 131) some hypothesis are more suited to being tested by designs which are only one group of subject, but this group is measured under all the condition and its performance in each condition is compared.

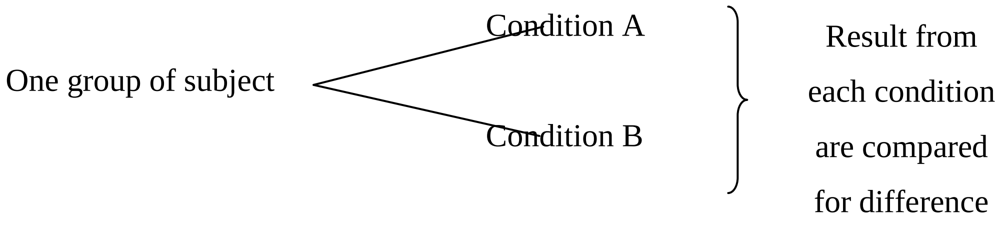


Figure: same-subject design; one group of subject and two conditions.

In the same subject design each subject is matched with other subjects who are virtual clones of each other, because they are in fact the same subject. All subject related factors (such as age, weight, types of disability, and types of AFO) are literally identical across treatments.

3.2 Study site

The researcher is a 4th year BSc in physiotherapy student of Bangladesh Health Professions Institute (BHPI) and the research was conducted as part of the course module. For this reason the researcher had to collect data within short time to maintain the contrasts of the course module time. So pediatric Unit, Orthotic and Prosthetic Department and William and Marrie Tailor School of Centre for the Rehabilitation of the Paralyzed (CRP) was chosen as the venue to collect data. Besides this in CRP patient come from all sectors of Bangladesh from all economical condition so it reflexed the entire population.

3.3 study population

Cerebral palsy children with spastic diplegia.

3.4 Sample selection

10 Participants with spastic diplegia cerebral palsy were selected through simple random sampling from Pediatric Unit, Orthotic and Prosthetic Department and William and Marrie Tailor School of CRP. Sample frame was made from the appointment record of respective units and after that the investigator has given particular ID to each participant of the sample frame. Subsequently, individual sample was picked up from the sample frame through lottery. Participants were selected from CRP because they were easily accessible for the researcher. Simple random sampling is the most commonly used and best way of selecting a sample. The fundamental principle of simple random sampling is that every member of the target population should have an equal chance of being selected for study. It is therefore more representative. Bowling (1997, p. 164) stated that, in simple random sampling the members of the population were numbered and a number of them were selected using random numbers by replacing them. Therefore each sample unit can only appear once in the sample. So the researcher chose simple random sampling for this study to get the appropriate sample and to maintain the standard of the study.

3.5 Sample size

10 participants with cerebral palsy were selected. The small sample size (10) was selected due to limited time. The study has its own limitation constructed by limited time scale and as a result by the sample size. Small sample size was corrected by an increase in the stringency to measure the outcome. “A large sample is more likely to be representative of the population than a smaller one and secondly small sample size are corrected by and increases in the stringency with which the analysis is conducted”. The samples were selected through some inclusion and exclusion criteria which were given below:-

3.5 a Inclusion criteria

- Participants with a primary diagnosis of spastic diplegic cerebral palsy. Because according to Condie (1993) to improve the gait of patients with spastic diplegia, the Ankle Foot Orthosis (AFO) is designed and used to prevent or eliminate an equines, valgus or varus position.
- Who have been wearing clinically prescribed AFO for at least six months or more. Because according to Aaran (2004) general progress is not seen before six month of using AFO.
- Age range is 3 to 12 years.
- Participants who use solid ankle type of AFO because Russel and Volpe (2008) stated that the solid ankle type of AFO allows an increased late stance ankle moment that is reflected weight bearing area of stance, which may provide an increase in gait stability in a typical patient who has spastic diplegia and a classic scissor or crouch gait with exaggerated stance phase knee flexion, increased hip adduction and internal rotation.
- Able to walk individually with AFO or by bare foot.
- Children with intact cognition. Because child with cognitive perceptual disorder as they might not be followed the instructions.
- Those whose parents voluntarily agreed to let their child to be include in research study.

3.5 b Exclusion criteria:

- Children with undiagnosed cerebral palsy. Because if undiagnosed child was in the study then other conditions child may mix up and influenced the study.
- Children with other type of cerebral palsy such as athetoid, ataxic, flaccid.
- Excessive spastic or flaccid tone.
- Unable to walk or who able to walk with assistance.

3.6 Pilot study

Before the researcher could undertake final study, the researcher performed a pilot study because this helped the researcher to refine the data collection plan (Depoy 1998). The aim of this pilot study was to find out the way to do this research, for example, selecting the type of cerebral palsy children who mainly use the AFO, type of AFO that have been used, the appropriate use of measurement tools. Researcher selected two weeks for pilot study and visited the Pediatric Unit and Orthotic and Prosthetic department of CRP and consulted with the relevant physiotherapist and orthotists to identify the type of cerebral palsy children , the type of AFO which are most use in case CP children. After finishing the pilot study the researcher informed that spastic type of cerebral palsy children mostly use the AFO and solid type of AFO is mostly prescribed by the Physiotherapists and orthotists.The importance of pilot study is "The efficiency, validity and effectiveness of the intervention can be then evaluated." (Ritson and Scott, 1996).

3.7 Ethical issues

The ethical guideline of WHO and BMRC was strictly followed. A research proposal was submitted to the local review committee to verify and kind permission and an interview was conducted by local review committee. After the proposal was approved to carry on with the study the researcher had moved the study. Then the researcher have to collected the approval to carry out with the study from departmental head of physiotherapy department (see appendix) in accordance with Supervisor, Course coordinator and In-charge of Pediatric Unit and Orthotics and Prosthetics Department of CRP. To intervention of the participant, researcher took permission from participant's carer, before that every participant's carer were informed about the aim and objective of the study. The researcher has ensured the confidentiality of all participants like, it was ensured that, the actual name of participants will be hidden from others. Anonymity was ensured throughout, with the use of identification numbers for each participant (such as P-1, P-2………). It was be explained to all the participants that their personal identity will be kept confidential, their name and address would not be written except, for a social number or a pseudonym. All the information about participants will be kept in a locker. It was explained that there would be no potential or any other risk to them resulting from participation in the research. The researcher was explained about participant's right to them. The raw data destroyed after the completion of the research and all the data on computer file were deleted. Finally the study was reviewed and approved by the authorities.

3.8 Informed consent

The carers of the participant were informed verbally about the title, aims and purpose of the research project. They have received a clear description of the study and aware that the research is the part of the study process; they would take part as volunteer. Before participating in the study the researcher had provided them a written consent form to sign, responsible physiotherapist sign as a witness. The researcher had also signed in the consent form. The carer of the participant informed clearly that their information might be published but their personal identity would be kept confidential. In addition it was explained that there would be no direct benefit as a participant in the study but there might be some changes in service delivery system of physiotherapy and using AFO to the cerebral palsy children, which might be helpful for their children in future. The carers of the participants were informed also that they have the right to withdraw consent and discontinue participation at any time without any prejudice.

3.9 Data collection tools

3.9. a 10 Meter walking Test

The ten-meter walk test is a measure of walking speed. Form, digital stopwatch, measuring tape, masking tape, quiet hallway or open space at least 14 meters long is required for this procedure. A measured course indoors is established with a length of 14 meters. Lines are drawn with tape at 0 meters, 2 meters, 12 meters and 14 meters. With the participant seated, measure the participant's resting heart rate and blood pressure. Give the participant the following information: "You are going to walk a distance of about 40 feet. Have the participant proceed to the start line (0 meters). Before the 1st trial, tell the participant "you will walk at a comfortable pace to the chair. When the researcher and the participant are ready, say "Ready and Go". If the participant starts too early, have them start again. Start the stop watch when the participant's first foot crosses the plane of the 2 meter line and Stop the stop watch when the participant's first foot crosses the plane of the 12 meter line. Have the participant continue walking until he/she reaches the chair after the 14 meter line. Record (in seconds to the hundredths) the time it took for the participant to walk the ten meter. Distance between the 2 meter line and the 12 meter line. Have the participant rest, if needed, in the chair at the 14 meter line. Immediately take the participant's pulse and blood pressure when he/she is sitting in the chair. Record assistive device, type of AFO (if appropriate) on the form (Dunkan, 2007).

3.9 b A tape measure

A tape measure will be used to measure the length of the distance.

3.9 c Stop Watch

A stopwatch will be used to measure time. The stop watch will be started when the participant started to walk through 10 meter distance and the toes of the leading foot crosses the 2-meter mark and Stop timing when the toes of the leading foot crosses the 8-meter mark.

3.9 d Velocity of walking

Velocity of walking can be measured by dividing the total walking distance by total time. (Meter/min).

3.9 e Stride length

It is the distance between two successive placements of the same foot. Stride length can be also measured by dividing the total walking distance by total steps. (Meter/step).

3.9 f Step length

It is the distance between two successive placements of the same foot.

3.9 g Cadene

1Cadene is measured by counting total steps per minute. (Steps/min)

3.10 Data collection procedure

In order to evaluate the effects of the AFO intervention, the following assessments were used: velocity of walking, stride length, step length & cadence. These assessments were completed in two sessions: I) walking by barefoot followed by II) walking with AFOs. Between these two sessions the child was allowed rest for approximately 30 min. The clinical studies were performed by more than one session e.g. for 10 participants the researcher used 10 different days. For each study, the participant performed one condition (walking by bare foot) And then the second condition (walking with AFO) .The sequence of condition performance (braced or bare foot walking) was decided by the researcher because it has no impact on the measurement as the results were compared within the same subject. Participants who were able to walk independently for at least 10 meter with or without AFO were instructed to walk in a straight line on an indoor route. Participants were asked to walk at their usual, self-preferred, comfortable speed. The walking time was measured by stop watch by both conditions. Comparisons between barefoot and braced walking conditions for each participant were for the above spatiotemporal parameters (Duncan, 2007)

3.11 Data analysis

In order to ensure that the research have some values, the meaning of collected data has to be presented in ways that other research workers can understand. In other words the researcher has to make sense of the results. As the result came from an experiment in this research,. data analysis was done with statistical analysis (Hicks1999, p.13). Statistical analysis is concerned with the organization and interpretation of data according to well-defined, systemic and mathematical procedures and rules. Thus, to compare the effectiveness of Ankle Foot Orthoses in improving walking speed among cerebral palsy children, the result should be analyzed by statistical test called inferential statistics. By using inferential statistics the researcher could inference the to the target population.

For this experimental study used one group for two condition and condition A was used as experimental group (walking with AFO) and condition B is used as control group (walking by bare foot) and results from both condition are compared for difference. Data was analyzed manually and parametric related "t" test was performed using ratio data system. Because according to Hicks (1999, p.150), the related 't' test is used when one group of subjects takes part in both of two condition and the result from the two condition are then compared for differences.

So the related't' test is especially suitable for 'before and after' type design. At the time of calculating the related't' test, the't' value represents a significant difference between the results from both condition.

The ‘t’ formula which was being used in this study is given below:

Formula of related’ test:

$$t = \frac{\sum d}{\sqrt{\frac{N \sum d^2 - (\sum d)^2}{N - 1}}}$$

Here,

$\sum d$= the total of the difference

$(\sum d)^2$ = the total of difference, squared

$\sum d^2$= the total of squared differences

N= number of subject, or pair of matched subjects

$\sqrt{}$= The square root of the final calculation of everything under the square root sign

Table - 1 presented at a glance of subject, which was used for both Condition.

Childs No.	Age (years)	Sex	How long have the child used the AFO?	Duration of AFO used(hour/day)	Type of Cerebral Palsy
1.	7.6	M	3yrs	2 (hour/day)	Spastic diplegic
2.	5.9	F	1yrs 5months	1.5 (hour/day)	Spastic diplegic
3.	6.8	M	2yrs	3 (hour/day)	Spastic diplegic
4.	9	M	8months	2.5 (hour/day)	Spastic diplegic
5.	12	M	2yrs 3months	5 (hour/day)	Spastic diplegic
6.	12	F	1yr	3.5(hour/day)	Spastic diplegic
7.	10	F	1yrs 5months	4 (hour/day)	Spastic diplegic
8.	8.6	M	2yrs	2.5(hour/day)	Spastic diplegic
9.	7.5	F	7months	3(hour/day)	Spastic diplegic
10.	8.3	M	1yrs 9months	4.5(hour/day)	Spastic diplegic

3.12 Significant level

In order to find out the significance of the study, the researcher calculated the p value. According to Hicks (1999, p.87) 'The p value in an experiment is called the significant level'. The p values (appendix) refer the probability of the results for this experimental study. The word probability refers to the accuracy of the findings. A p value of <0.05 was accepted as significant result for health service research (Bowling1997, p.150). If the p value is equal or smaller than the significant levels, the results are said to be significant.

Calculating the degree of freedom from the formula:

Degrees of freedom (df) = (N-1)

=10-1

=9

Table 2-Level of significance for one tailed hypothesis:

Df	0.1	.05	.025	.01	.005	.0005
9	1.383	1.833	2.262	2.821	3.250	4.781

The table is showing bellow the data of child's performance according to simple scoring scale.

Table-3 Mean Score of the Childs performance (velocity of walking meter/minute).

Children no	Condition A (AFO)	Condition B (Bare foot)	Variation (A-B)=d	d^2
1.	21.52	18.52	3	9
2.	8.33	8.33	0	0
3.	16.62	15.62	1	1
4.	27.88	23.88	4	16
5.	17.64	19.64	-2	4
6.	9.14	5.14	4	16
7.	23.44	23.44	0	0
8.	18.83	16.83	2	4
9.	19.00	16.00	3	9
10.	37.84	35.84	2	4
N=10	$\sum A=200.24$	$\sum B=183.21$	$(\sum d)=17$	$\sum d^2=63$

To test the hypothesis related' test and mean difference were compared.

Formula of related' test

$$t = \frac{\sum d}{\sqrt{\frac{N \sum d^2 - (\sum d)^2}{N-1}}}$$

$$= \frac{17}{\sqrt{\frac{630-289}{9}}}$$

=2.76

Following this way, the data was analyzed and calculated the stride length, step length and cadence and find out the'‘t' value. For further inquiry see in the appendix for next proceeding in significance improvement in case of stride length, step length and cadence while the participants were walking with or without AFO.

3.13 Limitations

- There are some limitations in the study which was not possible to overcome; it was necessary to design the study within the situation. The limitations were:
- The amount of participants was very small in relation to the other quantitive study because the researcher strictly followed the inclusion and exclusion criteria. There were only 10 participants involved in this study. Small number of samples inclusion may be affected the external validity of the study and the results might not be representative of the population.

- The researcher had limited resource during experiment while Abel et al. (1998) had used three dimensional gait analysis to analyze all temporal and kinematic data. In other research reflective markers were placed on specific anatomical land marks and cameras recorded the three-dimensional spatial location of each markers as the subject walked at his or her freely chosen speed. Brehm et al. (2008) had used a breath by breath gas analysis system for the assessment of oxygen consumption for their research but the researcher do not had the opportunity.

- The result of the study cannot be generalized to the whole population of spastic diplegic cerebral palsy children in Bangladesh as the samples were collected only from the CRP. Many organizations in Bangladesh are working in pediatric condition and they provide the children AFO. But others institution those are provide AFO is not selected in this study.

- The latest recent literature especially the recently issued journals were not accessible. Because there were only few study completed in this area. So some of the latest information was not able to be included in the literature part.

CHAPTER – IV: RESULTS

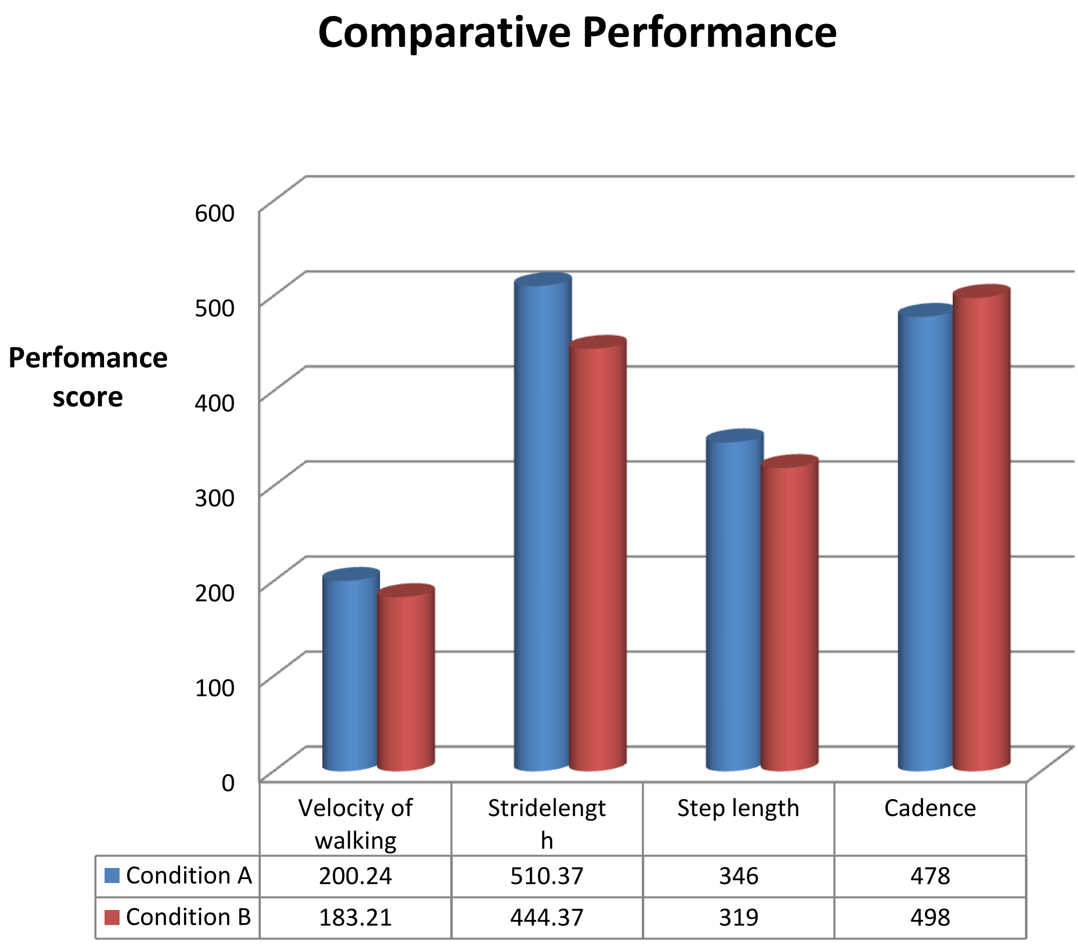
4.1 Results

Here, according to the Hicks (1999, p. 260) there are some critical values for the independent ‘t’ test. These values has given a range between the 1.383 to 4.781.the first one refers to 10%, second one 5%, third one 2.5%, fourth 1%fiftho.5% and the sixth .05% significant level. When “t” value is equal to or larger than the associated critical “t” value the result is significant.

Here “t” value is larger than 2.262 and lesser than 2.821.Therefore it used the critical value of 2.262. The value was associated with a probability level of 0.025 (one tailed) and .05(two tailed) hypothesis. As this research focused on effectiveness of Ankle Foot Orthosis in improving walking speed among cerebral palsy children, therefore it was a one tailed hypothesis. In the similar way the researcher have calculated the stride length, step length and cadence and find out the‘t’ value. For further inquiry see in the appendix for next proceeding in significance improvement in case of stride length, step length and cadence.

Table - 4 Variables in the study showing statistically significant or not significant at the following level of significance:

Variables	"t" value	P value less than	Significant	Not significant
Velocity of walking	2.762	0.025	Significant	……… ……
Stride length	3.160	0.01	Significant	……… ……
Step length	2.726	0.025	Significant	……… ……
Cadence	1.356	0.10	……… ……	Not Significant



The graph is showing the changes of child’s performance when they walked with AFO and walked by bare foot (in case of all the gait parameters)

Figure - 1: Comparative performance (Walking speed)

4.2 Interpreting the result

4.2.a Velocity of walking

The ‘t’ value of velocity of walking is 2.762. The mean score for condition (walking with AFO) was found 200.24 where condition B (walking by bare foot) was found 183.21.So condition A was larger than condition B. Using related ‘t’ test on the data of velocity of walking ($t=2.762$, $df=9$, $p<0.025$) the result was found to be significant for one tailed hypothesis. The ‘t’ has an associated probability level of less than 2.5%, which means that the probability of random error is less than 2.5 in 100.Therefore this study can say that the result is significant in case of velocity of walking. So this result suggests that there is more significant improvement in velocity of walking with AFO than walking by bare foot in case of cerebral palsy children.

The graph is showing the changes of child’s performance when they walked with AFO and walked by bare foot

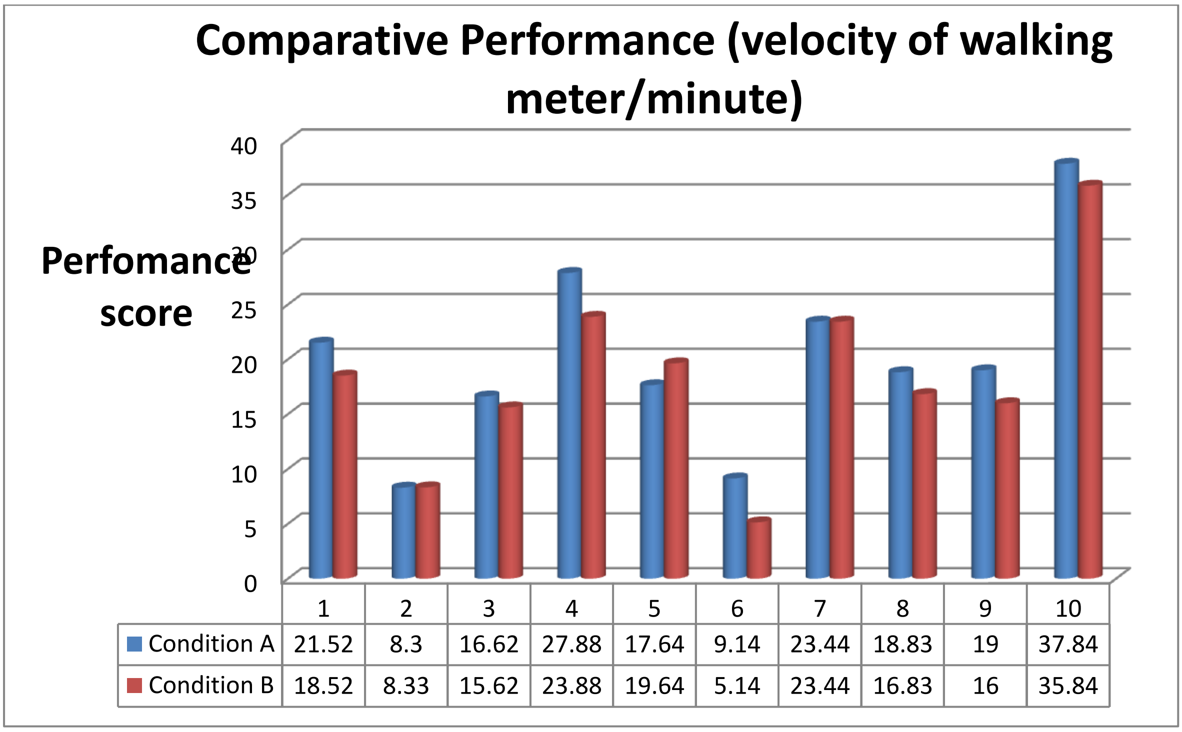
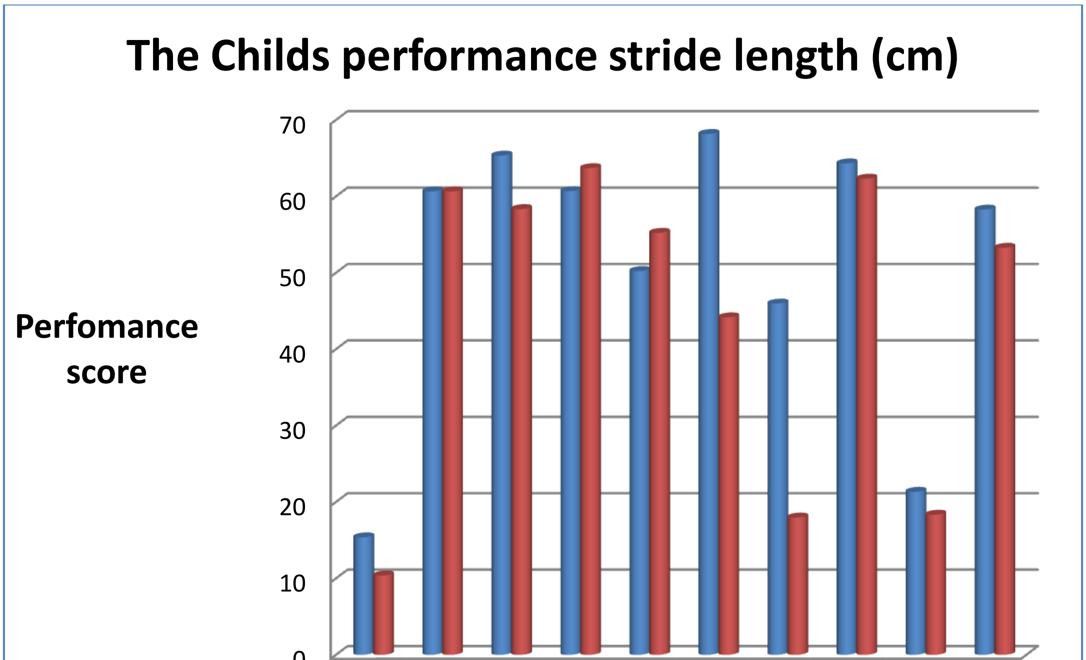


Figure – 2: Comparative performance (velocity of walking meter/minute)

4.2.b Stride length

The 't' value of stride length is 3.160. The mean score for condition A (walking with AFO) was found 510.37 where condition B (walking by bare foot) was found 444.37. So condition A was larger than condition B. Using related't' test on the data of stride length (t=3.160, df=9, $p<0.01$) the result was found to be significant for one tailed hypothesis. The 't' has an associated probability level of less than 1%, which means that the probability of random error is less than 1 in 100.Therefore this study can say that the result is significant in case of stride length. So this result suggests that there is more significant improvement in stride length during walking with AFO than walking by bare foot in case of cerebral palsy children.



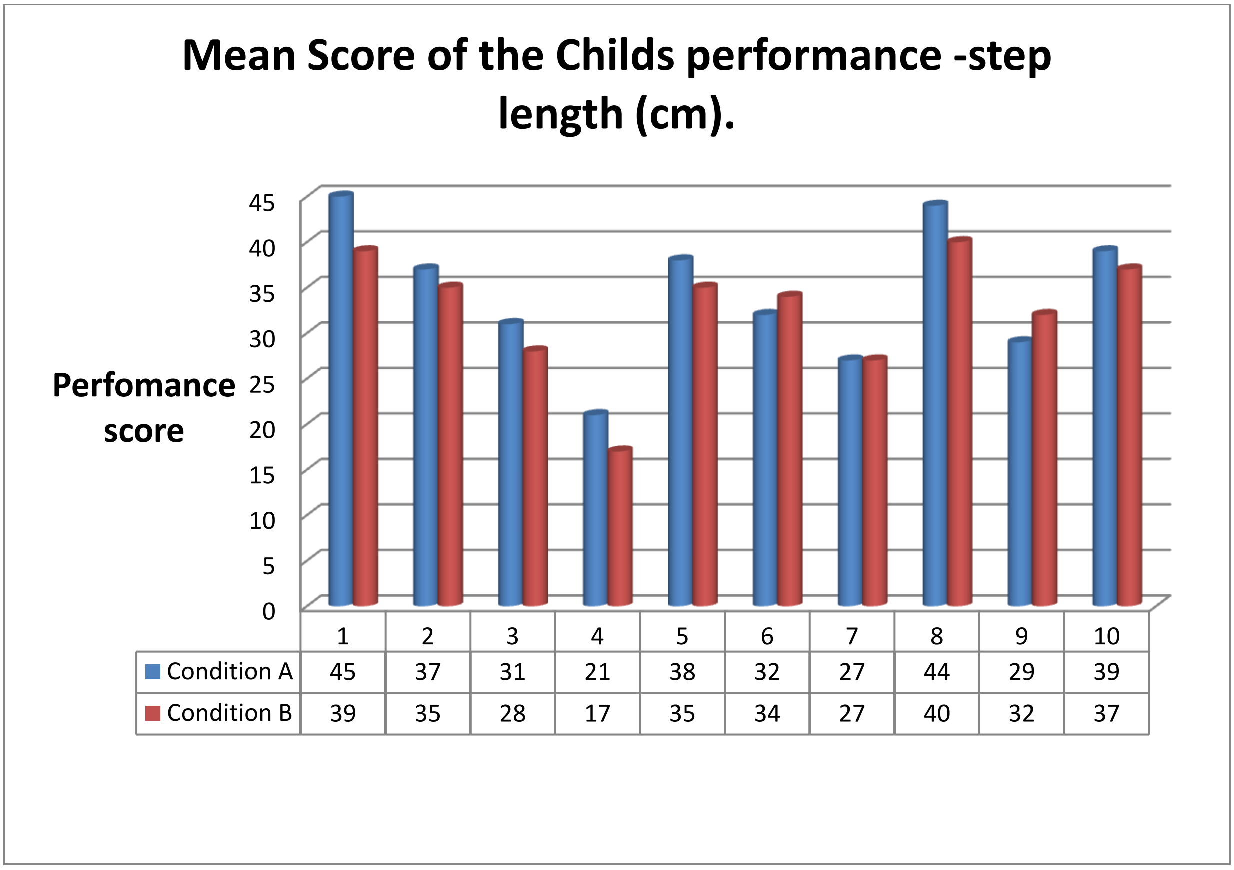
	1	2	3	4	5	6	7	8	9	10
Condition A	15.38	60.66	65.34	60.69	50.23	68.17	45.97	64.32	21.34	58.27
Condition B	10.38	60.66	58.34	63.69	55.23	44.17	17.97	62.32	18.34	53.27

The graph is showing the changes of child's performance when they walked with AFO and walked by bare foot.

Figure - 3: Comparative performance (stride length, cm)

4.2.c Step length

The 't' value of stride length is 2.726. The mean score for condition A (walking with AFO) was found 346 where condition B (walking by bare foot) was found 319. So condition A was larger than condition B. Using related 't' test on the data of stride length (t=2.726, df=9, p<0.025) the result was found to be significant for one tailed hypothesis. The 't' has an associated probability level of less than 2.5%, which means that the probability of random error is less than 2.5 in 100.Therefore this study can say that the result is significant in case of stride length. So this result suggests that there is more significant improvement in stride length during walking with AFO than walking by bare foot in case of cerebral palsy children.

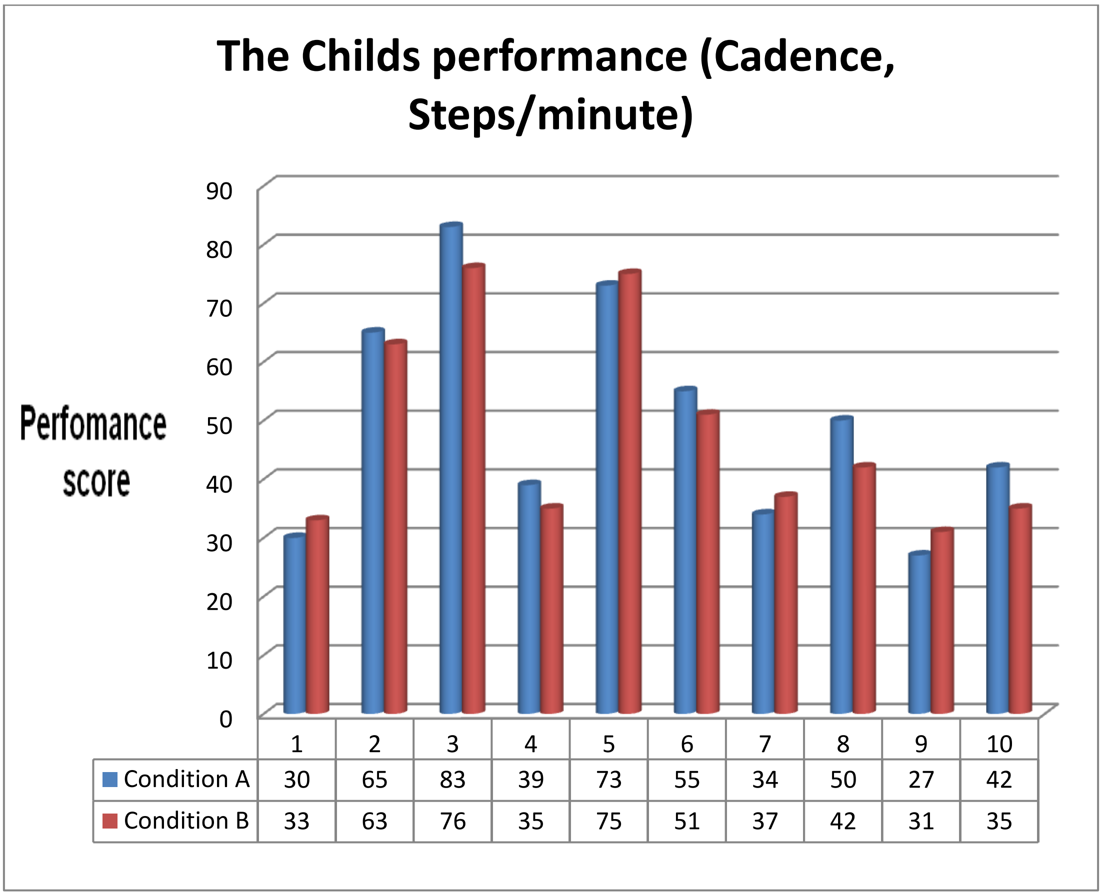


The graph is showing the changes of child's performance when they walked with AFO and walked by bare foot.

Figure - 4: Comparative performance (step length, cm)

4.2.d Cadence

The 't' value of cadence is 1.356. The mean score for condition A (walking with AFO) was found 498 where condition B (walking by bare foot) was found 478. So condition A was larger than condition B. Using related 't' test on the data of cadence (t=1.356, df=9,) the result was found not to be significant for one tailed hypothesis. So this result suggests that there is no significant improvement in cadence during walking with AFO than walking by bare foot in case of cerebral palsy children.



The graph is showing the changes of child's performance when they walked with AFO and walked by bare foot.

Figure - 5: Comparative performance (cadence,steps/minute)

Walking speed is related with gait spatiotemporal parameters such as velocity of walking, stride length and cadence. When cadence, that means how many steps occurred per minute is decreased the stride length (distance between the two opposite steps) is increased.

In this study the researcher found that between three gait parameters velocity of walking ($p<0.025$) and stride length ($p<0.01$) has shown the significant result and the result of cadence ($p<0.1$) is no more significant. But as the researcher discussed earlier that when cadence is decreased the stride length is increased and ultimately the walking speed is increased. So it can be suggested that when velocity of walking and stride length is increased in condition A (walking with AFO) and decreased in condition B (walking by bare foot), the walking speed would be increased in cerebral palsy children during walking with AFO. Therefore the experimental hypothesis has been supported and the null hypothesis has rejected.

CHAPTER – V: DISCUSSION

The purpose of this study was to evaluate the effect of ankle foot orthoses in improving walking speed among cerebral palsy children to determine this, the researcher assessed clinically prescribed AFO on the temporal spatial parameters of gait in participants with CP especially spastic diplegic cerebral palsy children. Walking speed is directly related with velocity of walking & velocity is the product of stride length, step length and cadence. The researcher found a statistical significant increase in velocity ($p<0.025$), stride length ($p<0.01$), step length ($p<0.025$), & a small but not statistically significant, decrease in cadence. The researcher studied on 10 spastic diplegic cerebral palsy children and their mean age is 8.9 yrs, they have used solid type of AFO for 2 yrs, their mean time for using AFO is 2.5 hours per day and they can walk independently with or without AFO.

White et al. (2002) did a retrospective study in between 1995 to1999 on 700 patients (mean age 9 yrs) who had a primary diagnosis of spastic diplegic cerebral palsy they all were clinically prescribed hinged or solid AFO. Their statistical analysis indicated that temporal & spatial gait parameters of velocity, stride length and step length were significantly increase ($p<0.001$) with the use of AFOs versus barefoot walking. Cadence was the only parameter found not to be significant.

Abel et al. (1998) studied on 35 subjects (mean age 8.7 yrs) who were spastic diplegic children & used fixed bilateral AFOs & analysis of gait by bare foot and with AFOs occurred on the same day. As compared between the use of an AFO during gait, with the bare foot condition, produced an increase in velocity ($p<0.001$), stride length ($p<0.001$) single support time ($p<0.002$), a decrease in double support time ($p<0.001$) & no changes in cadence.

Brehm et al. (2008) did a study on 172 cerebral palsy children out of them 97 were diplegic children & the speed of walking was 9% faster ($p<0.001$) in comparing walking with AFO & walking by bare foot. They also reported that, the use of an AFO significantly reduced the energy cost of walking (6% lower) in comparing with bare foot walking.

Buckon et al. (2001), did a study among thirty children (21 male, 9 female, mean age 9 yrs 4 months; age range 4to18 yrs) with spastic diplegic cerebral palsy and reported that stride step length were significantly increased (p=0.0001) & cadence significantly decreased (p<0.002) in comparing with where velocity was unchanged.

Franceschini et al. (2007) had completed a study entitled effects of an Ankle Foot orthoses on spatiotemporal parameters and energy cost of hemiparatic gait & found that the orthoses led to a significant increase in the self selected speed (p<0.001) & a significant reduction in energy cost of walking (p,0.01). They also reported that the reduction in energy cost of gait with the orthoses detected by the biomechanical effectiveness of the AFO.

Smith et al. (2009) did a study where fifteen children (mean age 7.5yrs) with spastic diplegic cerebral palsy who were able to walk independently with or without AFOs found that significant increase in stride length and walking speed & significant decrease in cadence in comparing with walking with AFO & walking by bare foot.

Hayek et al. (2007) had done a research on the effect of community prescribed ankle foot orthoses in gait parameters among the children with spastic cerebral palsy where they had used 10 meter walking test to measure the gait parameters & the result showed that stride length with AFOs was 17.4% long compared to bare foot (p<0.001) & walking velocity improved by 17.8% (p<0.001) & cadence was unchanged.

CHAPTER – VI: CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Cerebral palsy is the most common condition that is responsible for the child disability. Lower extremity orthoses such as ankle foot orthoses (AFOs) are often prescribed for ambulatory children with CP as a treatment modality to reduce gait abnormalities and related limitation in physical mobility and also acts on the lower leg to support an ankle and foot and is used in the treatment of spastic diplegic CP to reduce in proximal muscle tone, correction, prevention delaying of contracture develop facilitation of functional or ambulation as well as effectiveness of the therapeutic programme.

Ankle Foot Orthosis are typically prescribed to prevent deformity, support normal joint alignment and mechanics, provide variable range of motion when appropriate and facilitate function. When wearing Ankle Foot Orthosis, statistically significant increases in stride length, step length and velocity were noted compared with bare foot walking. Cadence is the only one parameters which is not found to be significant. This experimental study demonstrates that Ankle Foot Orthosis in our population provide clinical improvements in the temporal and spatial parameters of gait listed above.

As velocity is the product of stride length, step length and cadence, the increase in stride length and step length but not cadence resulted in an increase in velocity for cerebral palsy population. White et al. (2002) illustrated that the cause of this increase in step length and stride length is because the AFO provides increased stability to the ankle that allows for longer step and stride length. They also theorize that placing a mass at the end of the limb results in longer step and stride lengths. . Brawn (2007) discusses that physiotherapist often prescribe AFO which helps to maximize child function, adapt to limitation in life as much as possible and allow them to participate fully in his or her schooling programme that can facilitate independence of this client group in their activities of daily living.

From this research the researcher wished to explore the effectiveness of ankle foot orthosis in improving walking speed among cerebral palsy children so that their schooling and other functional activities will perform properly and more efficiently.

6.2 Recommendations

- Many organization of Bangladesh working with cerebral palsy children and they provide AFO for their clint. In this study participants Are not selected from the other organization. If researcher include the study participants from the other organization those are provide AFO, then it will be easy to generalize the result. So, further study is recommended to identify the study population not only the CRP.

- In this study children spastic diplegic CP are selected. Researcher also recommended, to cunuct study selecting participants from different condition such like- hemiplegic CP, in case of functional gait outcome, foot drop, club feet, GBS, ALS to find out the effect of AFO.

- In this stidy only solid type of AFO is used as intervention but other type of AFO like hinged AFO, Posterior Leaf Spring (PLS) AFO, dynamic AFO (DAFO) can be used for further research.

- The amount of participant is very small in relation to the other quantitive study. There were only 10 participants involved in this study. So, further study should conduct with increase number of participants so that the external validity of the study can generalize the wider population of cerebral palsy.

- The researcher only measure the spatiotemporal parameters of gait cycle to explore the walking speed. Franceschini et al. (2007) had done a research where the cardio respiratory parameters were also analyzed: ventilation prr minute (VE), heart rate (HR), respiratory rate (RR) and oxygen uptake and the energy consumption. So further study is recommended to investigate to investigate those parameters to get the outcomes more valid.

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Appendix

সম্মতি পত্র

এই অধ্যয়ন“সেরিব্রাল পালসি শিশুদের হাটার গতি উŸনতিতে এঙেকল ফুট অর্থোসিস এর কার্যকারিতার প্রভাব ” বিষয়ক গবেষনা।

গবেষক ফেরদৌসি মাহিন ঢাকা বিশ্ববিদ্যালয়ের চিকিৎসা অনুষদের অর্ন্তভুক্ত বাংলাদেশ হেল্থ প্রফেশন্স ইনস্টিটিউটের ৪র্থ প্রফেশনাল বি এস সি ইন ফিজিওথেরাপি এর ছাত্রী এবং এই গবেষনা তার অধ্যয়নের অংশ। অংশগ্রহন কারীকে নিম্নলিখিত তথ্য সমূহ জানার পর এই গবেষনায় অংশ গ্রহণ করার জন্য অনুরোধ করা হচ্ছে।

এই অধ্যয়নের লক্ষ্য হল, সেরিব্রাল পালসি শিশুদের হাটার গতি উননতিতে এঙেকল ফুট অর্থোসিস এর কার্যকারিতার ফলাফল বের করা। এই গবেষনা সফল ভাবে শেষ হলে, যে সকল রোগিরা এঙেকল ফুট অর্থোসিস ব্যাবহার করে, তারা তাদের কার্যাবলি আরও সফল ভাবে করতে পারবে। এ গবেষনার ফলাফল ফিজিওথেরাপিষ্ট গণের এঙেকল ফুট অর্থোসিস ব্যাবহারের বিধান দিতে সাহায্য করবে।

আপনার সন্তান দশ মিটার হাঁটার পরিক্ষায় অংশ গ্রহণের মাধ্যমে এই গবেষনায় অংশ গ্রহণ করবে। অংশগ্রহণকারীগণদের নিজস্ব পছন্দনীয়, আরামদায়ক গতিতে খালি পায়ে এবং এঙকেল ফুট অর্থোসিস পরে হাটার জন্য বলা হবে ।

গবেষক অঙিগকারাবদ্ধ যে, এ গবেষনা আপনার সন্তানের কোনরকম ক্ষতির কারন হবে না । আপনার যেকোন মুহূর্তে সম্মতি প্রত্যাহার এবং গবেষণায় অংশগ্রহণে অনিয়মিত হবার ব্যাপারে সম্পূর্ণ অধিকার রয়েছে ।এ গবেষনা পত্র প্রকাশ কালে অংশগ্রহনকারীর পরিচয় ও অন্যান্য তথ্য সমূহ গোপনীয়তার সাথে রক্ষা করা হবে।

আমি .... ঘোষনা দিচ্ছি যে, উপোরক্ত সকল তথ্য জানার পর আমার সন্তানকে এই গবেষনায় অংশ গ্রহণ কারানোর ইচ্ছা পোষন করছি।

অংশগ্রহণকারীর স্বাক্ষর: তারিখ:

সাক্ষীর স্বাক্ষর: তারিখ:

গবেষকের স্বাক্ষর : তারিখ:

Inform Consent

The study entitled "Effectiveness of Ankle Foot Orthosis in improving walking speed in cerebral palsy children." The researcher, Ferdausi Maheen is a student of 4th professional B. Sc. in Physiotherapy of Bangladesh Health Profession Institute (BHPI) under Medicine faculty of University of Dhaka and it is a part of her study. The participants are requested to participate in the study after informing the following.

The aim of the study is to see the effectiveness of Ankle Foot Orthosis (AFO) in improving walking speed in cerebral palsy children. If the study can be completed successfully, the patients who use AFO will be more benefitted in their functional activities. The findings of the study will help the physiotherapists in prescribing AFO.

Your son/daughter will participate in the study with performing a 10 meter walking test. .Participants will be asked to walk at their self -preffered, comfortable speed by bare foot and with AFO.

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

I………………………………… declare, that I am giving my consent to participate my son/daughter in the study after being informed about all the above information in details.

Sign of the participant ….………………………………… Date-

Sign of the witness …………………………………..… Date-

Sign of the researcher …………………………………... Date-

QUESTIONNAIER

1. Name:--
2. Age:---
3. Sex:--
4. How long have you used the AFO : Month / Year…………….
5. Duration of using AFO : Hour / Day…………………………..
6. Pattern of walking: Independently or with minimum assistance………………………………………………………
7. Type of cerebral palsy………………………………………….
8. Type of AFO:…………………………………………………..
9. Velocity of walking:
    - During walking by bare foot……..………… Meter/min
    - During walking with AFO………………….. Meter/min
10. Stride length:
    - During walking by bare foot……..………… meter/step
    - During walking with AFO………………….. meter/step
11. Step length:
    - During walking by bare foot……..………… cm
    - During walking with AFO………………….. cm
12. Cadence :
    - During walking by bare foot……..………… steps/minute
    - During walking with AFO………………….. steps/minute

Table-5 Mean Score of the Childs performance stride length (cm).

To test the hypothesis related'‘t' test and mean difference were compared.

Children no	Condition A (Walking with AFO)	Condition B (Walking by Bare Foot)	Variation A-B=d	d^2
1.	15.38	10.38	5	25
2.	60.66	60.66	0	0
3.	65.34	58.34	7	49
4.	60.69	63.69	-3	9
5.	50.23	55.23	-5	25
6.	68.17	44.17	24	576
7.	45.97	17.97	28	784
8.	64.32	62.32	2	4
9.	21.34	18.34	3	9
10.	58.27	53.27	5	25
N=10	∑A=510.37	∑B=444.37	(∑d)=89	$\sum d^2$ =1506

Formula of related'‘t' test:

$$t = \frac{\sum d}{\sqrt{\frac{N\sum d^2 - (\sum d)^2}{N-1}}}$$

$$= \frac{89}{\sqrt{\frac{15060 - 7921}{9}}}$$

=3.160

Table-6 Mean Score of the Childs performance -step length (cm).

To test the hypothesis related't' test and mean difference were compared.

Formula of related't' test

Children no	Condition A (Walking with AFO)	Condition B (Walking by Bare Foot)	Variation A-B=d	d^2
1.	45	39	6	36
2.	37	35	2	4
3.	31	28	3	9
4.	21	17	4	16
5.	38	35	3	9
6.	32	34	-2	4
7.	27	27	0	0
8.	44	40	4	16
9.	29	32	-3	9
10.	39	37	2	4
N=10	∑A=346	∑B=319	(∑d)=22	$\sum d^2=107$

$$t = \frac{\sum d}{\sqrt{\frac{N\sum d^2 - (\sum d)^2}{N-1}}}$$

$$= \frac{22}{\sqrt{\frac{1070-484}{9}}}$$

=2.726

Table-7 Mean Score of the Childs performance (Cadence, Steps/minute).

To test the hypothesis related't' test and mean difference were compared.

Children no	Condition A (Walking with AFO)	Condition B (Walking by Bare Foot)	Variation A-B=d	d^2
1.	30	33	-3	9
2.	65	63	2	4
3.	83	76	7	49
4.	39	35	4	16
5.	73	75	-2	4
6.	55	51	4	6
7.	34	37	-3	9
8.	50	42	8	64
9.	27	31	-4	16
10.	42	35	7	49
N=10	∑A=498	∑B=478	(∑d)=20	$\sum d^2=236$

Formula of related't' test:

$$t = \frac{\sum d}{\sqrt{\frac{N\sum d^2 - (\sum d)^2}{N-1}}}$$

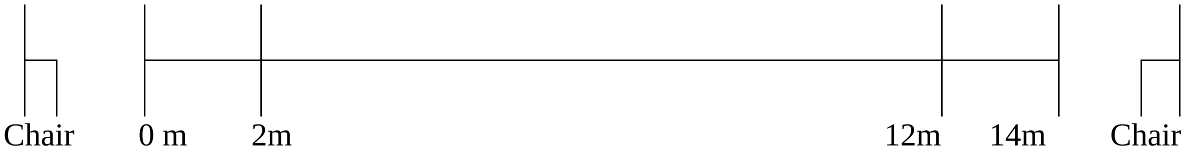
$$= \frac{20}{\sqrt{\frac{2360-400}{9}}}$$

=1.356

10-Meter walking Test

1. A measured course indoors is established with a length of 14 meters. Lines are drawn

with tape at 0 meters, 2 meters, 12 meters and 14 meters.



2. With the participant seated, measure the participant's resting heart rate and blood pressure.

3. Give the participant the following information: "You are going to walk a distance of about 40 feet.

4. Have the participant proceed to the start line (0 meters). Before the 1st trial, tell the participant "you will walk at a comfortable pace to the chair.

5. When you and the participant are ready, say "Ready and Go". If the participant starts too early, have them start again.

6. START THE STOPWATCH when the participant's first foot crosses the plane of the 2 meter line and STOP THE STOPWATCH when the participant's first foot crosses the plane of the 12 meter line. Have the participant continue walking until he/she reaches the chair after the 14 meter line.

7. Record (in seconds to the hundredths) the time it took for the participant to walk the ten meter. Distance between the 2 meter line and the 12 meter line.

8. Have the participant rest, if needed, in the chair at the 14 meter line.

9. Immediately take the participant's pulse and blood pressure when he/she is sitting in the chair.

To

The Head of the Physiotherapy Department,

Center for the Rehabilitation of the Paralyzed (CRP),

Savar, Dhaka-1343.

Subject: Prayer for seeking permission to collect data to conduct a research study.

Sir,

With due respect and humble submission to state that I am a student of 4thprofessional B.Sc. in physiotherapy at Bangladesh Health Professions Institute (B.H.P.I). In 4th year we have to do a researches project for the partial fulfillment of the requirements for the degree of B.Sc. in Physiotherapy. My dissertation title is "Effectiveness of Ankle Foot Orthosis in improving walking speed among cerebral palsy children." The aim of my study is to investigate the effectiveness of Ankle Foot Orthosis in improving walking speed in cerebral palsy children. It is a quantitative experimental research. I have chosen Pediatric Unite and Orthotic and Prosthetic department to collect required data. Now I am looking for your kind approval to start my research project and data collection. I would like to assure that anything of my research project will not harmful for the participant.

So, I therefore pray and hope that you would be kind enough to grant me the permission to do this study successfully in your department.

Yours faithfully,

Ferdausi Maheen
4th professional B. Sc. in physiotherapy of B.H.P.I.
Savar, Dhaka
Date:

To

The Coordinator,

William & Marie Taylor School,

The inclusive School of CRP,

Savar, Dhaka-1343.

Subject: Prayer for seeking permission to collect data to conduct a research study.

Sir,

With due respect and humble submission to state that I am a student of 4th professional B.Sc. in physiotherapy at Bangladesh Health Professions Institute (B.H.P.I). In 4th year we have to do a researches project for the partial fulfillment of the requirements for the degree of B.Sc. in Physiotherapy. My dissertation title is “Effectiveness of Ankle Foot Orthosis in improving walking speed among cerebral palsy children.” The aim of my study is to investigate the effectiveness of Ankle Foot Orthosis in improving walking speed in cerebral palsy children. It is a quantitative experimental research. I have chosen Pediatric Unite, Orthotic and Prosthetic department & William & Marie Taylor School to collect required data. Now I am looking for your kind approval to start my data collection. I would like to assure that anything of my research project will not harmful for the participant.

So, I therefore pray and hope that you would be kind enough to grant me the permission to collect the data and will help me to conduct a successful study as part of my course.

Yours faithfully,

Ferdausi Maheen

4th professional B. Sc. in physiotherapy of B.H.P.I.

Savar, Dhaka

Date:

To

The In-Charge,

Orthotic and Prosthetic Department,

Center for the Rehabilitation of the Paralyzed (CRP),

Savar, Dhaka-1343.

Subject: Prayer for seeking permission to collect data to conduct a research study.

Sir,

With due respect and humble submission to state that I am a student of 4th professional B.Sc. in physiotherapy at Bangladesh Health Professions Institute (B.H.P.I). In 4th year we have to do a researches project for the partial fulfillment of the requirements for the degree of B.Sc. in Physiotherapy. My dissertation title is "Effectiveness of Ankle Foot Orthosis in improving walking speed among cerebral palsy children." The aim of my study is to investigate the effectiveness of Ankle Foot Orthosis in improving walking speed in cerebral palsy children. It is a quantitative experimental research. I have chosen Pediatric Unite and Orthotic and Prosthetic department to collect required data. Now I am looking for your kind approval to start my data collection. I would like to assure that anything of my research project will not harmful for the participant.

So, I therefore pray and hope that you would be kind enough to grant me the permission to collect the data and will help me to conduct a successful study as part of my course.

Yours faithfully,

Ferdausi Maheen
4th professional B. Sc. in physiotherapy of B.H.P.I.
Savar, Dhaka
Date:

To

The In-Charge,

Pediatric Unit,

Center for the Rehabilitation of the Paralyzed (CRP),

Savar, Dhaka-1343.

Subject: Prayer for seeking permission to collect data to conduct a research study.

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With due respect and humble submission to state that I am a student of 4th professional B.Sc. in physiotherapy at Bangladesh Health Professions Institute (B.H.P.I). In 4th year we have to do a researches project for the partial fulfillment of the requirements for the degree of B.Sc. in Physiotherapy. My dissertation title is "Effectiveness of Ankle Foot Orthosis in improving walking speed among cerebral palsy children." The aim of my study is to investigate the effectiveness of Ankle Foot Orthosis in improving walking speed in cerebral palsy children. It is a quantitative experimental research. I have chosen Pediatric Unite and Orthotic and Prosthetic department to collect required data. Now I am looking for your kind approval to start my data collection. I would like to assure that anything of my research project will not harmful for the participant.

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Ferdausi Maheen

4th professional B. Sc. in physiotherapy of B.H.P.I.

Savar, Dhaka

Date:

Table A2.5 Critical values of *t* (related and unrelated *t* tests) at various levels of probability. For your *t* value to be significant at a particular probability level, it should be *equal* to or *larger than* critical values associated with the df in your study (Reproduced from Lindley DV, Scott WF (1984) New Cambridge Elementary Statistical Tables, 10th edn. Cambridge University Press, with permission.)

	Level of significance for one-tailed test					
	.10	.05	.025	.01	.005	.0005
	Level of significance for two-tailed test					
df	.20	.10	.05	.02	.01	.001
1	3.078	6.314	12.706	31.821	63.657	636.619
2	1.886	2.920	4.303	6.965	9.925	31.598
3	1.638	2.353	3.182	4.541	5.841	12.941
4	1.533	2.132	2.776	3.747	4.604	8.610
5	1.476	2.015	2.571	3.365	4.032	6.859
6	1.440	1.943	2.447	3.143	3.707	5.959
7	1.415	1.895	2.365	2.998	3.499	5.405
8	1.397	1.860	2.306	2.896	3.355	5.041
9	1.383	1.833	2.262	2.821	3.250	4.781
10	1.372	1.812	2.228	2.764	3.169	4.587
11	1.363	1.796	2.201	2.718	3.106	4.437
12	1.356	1.782	2.179	2.681	3.055	4.318
13	1.350	1.771	2.160	2.650	3.012	4.221
14	1.345	1.761	2.145	2.624	2.977	4.140
15	1.341	1.753	2.131	2.602	2.947	4.073
16	1.337	1.746	2.120	2.583	2.921	4.015
17	1.333	1.740	2.110	2.567	2.898	3.965
18	1.330	1.734	2.101	2.552	2.878	3.922
19	1.328	1.729	2.093	2.539	2.861	3.883
20	1.325	1.725	2.086	2.528	2.845	3.850
21	1.323	1.721	2.080	2.518	2.831	3.819
22	1.321	1.717	2.074	2.508	2.819	3.792
23	1.319	1.714	2.069	2.500	2.807	3.767
24	1.318	1.711	2.064	2.492	2.797	3.745
25	1.316	1.708	2.060	2.485	2.787	3.725
26	1.315	1.706	2.056	2.479	2.779	3.707
27	1.314	1.703	2.052	2.473	2.771	3.690
28	1.313	1.701	2.048	2.467	2.763	3.674
29	1.311	1.699	2.045	2.462	2.756	3.659
30	1.310	1.697	2.042	2.457	2.750	3.646
40	1.303	1.684	2.021	2.423	2.704	3.551
60	1.296	1.671	2.000	2.390	2.660	3.460
120	1.289	1.658	1.980	2.358	2.617	3.373
	1.282	1.645	1.960	2.326	2.576	3.291

NB When there is no exact df use the next lowest number, except for very large dfs (well over 120), when you should use the infinity row. This is marked