CALIFORNIA STATE UNIVERSITY, NORTHRIDGE

The Effects of Aquatic Exercise on Gait Parameters in Children with Cerebral Palsy

A thesis submitted in partial fulfillment of the requirements

For the degree of Masters of Science

In Kinesiology

By

Robert D. De La Cruz

May, 2012

The thesis of Robert De La Cruz is approved:

Mai Narasaki Jara, MS	Date
Konstantinos Vrongistinos, Ph.D.	Date
Taeyou Jung, Ph.D., ATC, CAPE, Chair	Date

California State University, Northridge

DEDICATION

To my mom & dad,

Who has courageously given me the strength for my education

To my family,

Who have always encouraged nothing but the best results

To my friends,

Who have made this process all that more enjoyable

ACKNOWLEGDEMENTS

I would gratefully like to acknowledge my committee members for their knowledge and unique expertise. A special thanks to Dr. Jung, my committee chair, for believing that I could thrive in this field, and providing continuous support. Dr. Vrongistinos for his knowledge in biomechanics and optimism. Mai Narasaki Jara for challenging and providing her expertise in aquatic exercise.

This project was made possible by the contributions of colleagues, staff, community members of the Center of Achievement, and the individuals who participated in this study. I would like to thank Jennifer O'Connor, Leora Gabay, Michelle Borja, Sabrina Anostasis, Ashley Kokawa, Amber Hubbard, and Michael Lee who gave so generously of their time and support.

As a student associate I would like to thank all the students whom I have learned from because they allowed me to teach them. To them I am most grateful. A teacher is not successful without his students. Thank you for contributing to my continued success.

TABLE OF CONTENTS

Abstract

The Effects on Gait Outcomes of Aquatic Exercise in

Children with Cerebral Palsy

By

Robert De La Cruz

Masters of Science in Kinesiology

BACKGROUND: Cerebral palsy (CP) is defined as a group of disorders of the development of movement and posture, causing activity limitation that are attributed to non-progressive disturbances occurred in the developing fetal or infant brain (Gage, 2004). CP is known as one of the most common childhood disabilities with an incidence of about 2-3 per 1,000 live births each year (Chang et al., 2010). In most cases of CP, gait and balance play a key role in participating in activities of daily living and other physical activities. The effects of exercise programs on land have been well documented; however, there are very few studies that involved aquatic intervention in the CP population. Aquatic exercise is gradually gaining popularity among the CP rehabilitation field and has been viewed to be beneficial for children with neuromuscular impairments such as CP (Kelly & Darrah, 2005). Water properties can establish an intervention protocol that can help children with CP improve balance and gait function in a supportive environment. The unique quality of buoyancy can reduce joint impact and support postural control (Kelly &

Darrah, 2005). Buoyancy enables initiation of independent movement possibilities that are less likely to be achieved on land-based exercise (Fragala-Pinkham et al., 2008). Water resistance can aid children with CP and improve muscular strength (Hutzler et al., 1998). Warm water temperatures have been known to be effective for decreasing muscle tone while exercising in the water (Getz et al. 2007). Few studies have examined the effects of aquatic exercise on gait and balance in children with CP.

OBJECTIVE: To examine the gait outcomes of children with CP after 6-week aquatic exercise program.

SETTING: All data collection and intervention procedures was held at the Center of Achievement, California State University, Northridge (CSUN).

PARTICIPANTS: A total of 4 children was recruited from local schools in the greater Los Angeles ares. Inclusion criteria are: a) diagnosis of spastic diplegic or hemiplegic CP, b) age between 7-17 years old, c) medical clearance for adapted exercise or aquatic exercise, d) ability to walk independently with or without an assistive device, e) Gross Motor Function Classification System (GMFCS) levels I-III, f) ability to follow verbal instructions and communicate in English, g) ability to participate in a exercise program in and out of the water for up to 30-40 minutes.

INTERVENTION: The children participated in an aquatic exercise program in a 40-minute session, three times per week for 6 consecutive weeks. The aquatic exercise program consists of warm-up, gait and balance exercises, and cool-down.

MEASURES: The participants were measured on kinemtaic gait parameters (hip flexion and extension, knee flexion and extension, and ankle plantar-flexion and dorsi-flexion) and spatial-temportal gait variables (% stance and swing phase, velocity, cadence, step width and stride length).

RESULTS: There were no trends among participants as a whole. However, individal trends for improvement in kinematic and spatial-temporal variables was observed for each participant.

CONCLUSION: Although there were no systematic changes whithin the group after the 6-week intervention, individal changes in ankle, knee, and hip range of motion presented individual improvements based on each particpant's deviation in gait pattern in which trends for improvemts display that group aquatic exercise is a useful mode of exercise to maintain and improve gait paramerters in children with CP.

INTRODUCTION:

Cerebral Palsy (CP)

DEFINITION & ETIOLOGY:

Cerebral palsy (CP), widely referred to “Little’s Disease” named after William John Little in the end of the 19^{th} Century, is defined as a group of disorders of the development of movement and posture. CP is a disorder that causes activity limitations and is attributed to non-progressive disturbances that occurred in the developing fetal or infant brain (Gage, 2004). CP is also known as one of the most common childhood disabilities, with an incidence of about 2-3 per 1,000 live births each year (Cogher et al., 1992). Causes of CP are unknown and its risk factors can be identified as complications before (prenatal) and during (perinatal) birth, up to the first 6 years (postnatal) of life (Panteliadis&Strassburg, 2004). Among all the risk factors associated with CP, prenatal risk factors are responsible for the majority of CP cases (Panteliadis&Strassburg, 2004). Panteliadis and Strassburg (2004) state that prenatal risk factors include complications that cause damage to the developing brain such as congenital brain malformation, chromosomal defects, congenital infections, familial predisposition to CP, maternal drug or alcohol abuse, maternal mental retardation, maternal hyperthyroidism or epilepsy, incompetent cervix and or third trimester bleeding. According to Hinhcliffe (2003), motor disorders of cerebral palsy are often accompanied by disturbances of sensation, cognition, communication, perception, behavior, and or by seizures that ultimately limit an individual with CP in various motor capabilities.

CLASSIFICATION:

CP is divided into four major classifications to describe different movement impairments: spastic (muscle spasm), ataxic (tremors), athetoid or dyskinetic (mixed muscle tone), and hypotonic (limp musculature). When a child is diagnosed with CP, motor function is observed to have one or a combination of these different characteristics. According to Cogher et al. (1992), spastic cerebral palsy is the most common type, occurring in 75% of all cases. The affected area of the body can be identified as hemiplegia (one side), diplegia (lower extremities), monoplegia (one single limb), triplegia (three limbs) and quadriplegia (all four limbs).

Knowing what motor functions children with CP are able to perform is an important part to implementing a successful treatment protocol. A test to measure motor function in children with CP is called the Gross Motor Function Measure (GMFM). The GMFM is a validated instrument that enables comprehensive quantitative evaluation of changes in motor function in children with CP (Panteliadis&Strassburg, 2004). The GMFM tests activities and positions in lying, rolling, sitting, crawling, kneeling, standing, walking, running, and jumping skills. Each child is classified into different levels depending on the severity of the children's mobility called the Gross Motor Function Classification System (GMFCS). The GMFCS consists of levels I through V and classifies children with CP and their ability to ambulate. According to Gage (2004), level I describes the mildest case of CP, where the child is able to ambulate without any restrictions, and level V, indicates when a child with CP is completely immobile. To assess and distinguish mobility options, a child with CP is classified using the GMFCS. Once parents and primary physicians know what functional limitations the child possess, treatment options can be implemented according to functional mobility from their GMFM scores.

MOTOR FUNCTION:

Locomotion is defined as someone who walks with or without an assistive device and is able to utilize transportation with a manual or motorized wheelchair (Lepage et al., 1998). In children with CP, irregular posture, spasticity, and weakness all contribute to functional limitations associated with gait. Typical walking patterns associated with CP include “jump knee”, “crouch”, “true equinus”, “apparent equinus”, “recurvatum”, and “stiff knee” gait (Chambers, 2001). These typical gait patterns are usually accompanied by fixed flexion contractures and or hyperextension of the hip, knee, and ankle that limit a child with CP to walk efficiently (O'Byrne et al., 1998 & Chambers, 2001). According to Wu et al. (2010), spasticity is a common impairment that interferes with motor function that is characterized by increased tone with a tendency to flexor spasm along with a flexed posture. Active co-contraction of the leg muscles is generated and spasticity occurs before the first step during walking takes place.

TREATMENT:

Surgery or less invasive treatments such as the use of orthotics are immediate solutions to treating gait deviations in CP. However, a surgical solution known as Selective Dorsal Rhizotomy (SDR) for spasticity, has been known to have complications due to surgically incising a nerve root not associated with spasticity (Gage, J.R., 2004). Additionally, orthotics, primarily prescribed by a physician, are not readily available for the general public and hinder treatment options for children with CP. A treatment option that may help promote participation, activity, and physical fitness in children with CP is exercise. Exercise is a more resourceful type of treatment option to improving gait with children with neuromuscular disorders because it can be done without any restrictions (Gage, J.R., 2004). There have been various intervention studies that incorporate land based exercise to help with gait deviations in children with CP (Verschuren et al., 2007, Blundell et al., 2003, Lee et al., 2008, Eeek et al., 2008, Scholtes et al., 2010, & Unger et al., 2006). The need for other forms of rehabilitation should be explored so that the CP population can incorporate an exercise intervention that will have a consistent protocol to improving gait in children with CP.

LITERATURE REVIEW:

CP &GAIT:

Typical gait patterns in children with CP include jump knee, crouch, true equinus, apparent equinus, recurvatum, and stiff knee gait (Chambers, H.G., 2001). These gait patterns are usually accompanied by involvement at the hip, knee, and ankle. Davids et al. (2004) and Winters et al. (2010) uses various gait abnormalities in children with CP through the use of quantitative gait analysis, using 3-dimentional high-speed motion picture cameras or VICON system. This method of gait analysis has been used to record various gait parameters during walking interventions. Davids et al. (2004) and Winter et al. (2010) investigated the gait outcome after strengthening exercise in children with CP. Both studies have identified various mechanisms to understand pathological gait in children with CP and monitored progression after gait interventions. David's et al. (2004) also utilized this quantitative analysis to identify characteristics of common gait abnormalities associated with the knee in children with CP. Whereas Winter's et al. (2010) took advantage of this instrument to classify participants into subsequent groups based on kinematic variables made in three major joints of the lower extremity (ankle, knee and hip). Although Davids et al. (2004) and Winters et al. (2010) show the use motion analysis system to classify gait associated in children with CP, research on interventions that can help improve gait deviations in children with CP were not addressed in these studies.

CP & MUSCLE CONTRACTURE:

Children with CP experience muscle contractures that cause movements in walking to be stiff and floppy (Gage, J.R., 2004). Contractures have been a major concern in treating children with CP. Orthopedic treatments has been suggested to treat various contractures in children with CP. With more severe cases of contractures, Gage (2004) refers to a sequence of the “diving or birthday syndromes” in which the child has an operation every birthday following a yearlong of therapy. Consequently, Gage (2006) states that following the periods of therapy and each surgical procedure, the child may end up in excessive morbidity and permanent weakness, becoming less mobile than when the child was first treated.

Less invasive treatments such as using orthotics and or walking aides have shown to improve gait in children with CP (Balaban et al., 2007). Studies have shown that using devices increases participation and maximizes performance in various activities of daily living in children with CP (Balaban et al., 2007 & Park et al., 2001). Orthotics, such as Hinged Ankle Foot Orthosis(AFO), has shown to normalize ankle motion during dorsiflexion range and improve walking speed, stride length, and single support time, and decrease double support time in children with CP (Balaban et al., 2007). Walking aids, such a posterior walkers, has been shown to be more suitable for facilitating an upright posture during walking in children with CP (Park et al., 2001). However, using these devices may not solve the deviation in gait that children with CP possess, but rather help with the abnormal deviations in gait children with CP experience. Although these devices have been shown to improve posture for children with CP, they do not promote independent walking that may result in a less active child when participating in different activities and sports.

CP &SPASTICITY:

Spasticity hinders children with CP during walking and engaging in physical activity. Ensegerg et al. (2000) and Chambers et al. (2001) documented mechanisms associated with spasticity in gait patterns with ambulatory children with CP. Enseberg et al. (2000) found that spasticity occurs when the ankle is in plantar-flexed position during the gait cycle. Whereas Chambers et al. (2001) concluded that spasiticity involves abnormal knee motion that is related to dynamic conditions during muscle shortening or muscle contraction. Selective Dorsal Rhizotomy (SDR), a surgical procedure that selectively severs problematic nerve roots in the spinal cord, and injection of botulinum toxin type A (botox) to the muscle, are procedures used for treating spasticity (Steinbok, 2001 &Davids et al., 2004). However, literature reveals that administering botox or incising a nerve root might do more damage than good for the use of treatment of spasticity in CP (Gage, 2004). Botox may have to be administered multiple times to decrease the effects of spasticity, and for others, it may only be temporary relief from spasticity. Additionally, incising of a nerve root may have adverse side effects if there were to be any complications. For example, permanent paralysis of the legs and bladder, permanent impotence, sensory loss and or numbness in the legs, wound infection and or leakage of the spinal fluid through the wound are risks that should be taken into account when deciding to do the procedure (Panteliadis&Strassburg, 2004). Rather than taking risks to help improve gait, other forms of treatment should be implemented so that spasticity does not limit mobility and activity in children with CP.

CP &MUSCLE WEAKNESS:

Muscle weakness is another limiting factor that limits mobility, participation, and activity in children with CP. Many studies have incorporated land-based exercise interventions to improve motor function in children with CP (Verschuren et al., 2007, Blundell et al., 2003, Lee et al., 2008, Eeeket al., 2008, Scholtes et al., 2010, & Unger et al., 2006). Interventions on land have emphasized variations in strength training as an exercise regimen to increase strength and a wide range of functional motor skill activities. Lee et al. (2008) have shown therapeutic effects of strengthening exercise on gait function, such as increased muscle strength without significant adverse effects or increase in muscle tone in children with CP. Lee at al. (2008) emphasized home exercise programs twice a week and a small group session once a week with a physiotherapist which consisted of easy to heavy load and sets of ten repetitions for each muscle group. Whereas, Eek et al. (2008) showed that strengthening programs have a positive effect on ambulation, such as ability to balance on one leg, negotiating obstacles and climbing stairs that may promote independence in children with CP. Eek et al. (2008) used a strengthening program targeting the muscles groups of the lower limbs that consists of warm up stretching exercises, squat to stand, lateral step up, stair walk up and down, isotonic exercise of lower limb muscles, isokinetic exercise utilizing a bicycle, and a cool down exercise for five consecutive weeks. Although the studies had different exercise protocols, both studies demonstrated positive outcomes in gait with children with CP such as increased muscle strength and stride length.

CP & MOBILITY:

Mobility is described as the ability to move from place to place, participation with their family and peers, and the ability to function optimally in everyday life (Bludell et al., 2003). Various strength exercises, such as functional strength training interventions, have increased mobility during physical activity and help promote a healthier lifestyle in children with CP (Verschuren et al., 2007 &Bludell et al., 2003). Verschurem et al. (2007) developed a functional based exercise program that were task specific that included running and changing direction, step-ups, and negotiating stairs repeatedly, as well as muscle strengthening exercises in circuit training format. The 12-month follow up concluded that participation in an exercise program maintains fitness levels and enhances health related quality of life in children with CP. Blundell et al. (2003) uses a 4-week circuit-training program task specific to lower limb strength and functional performance in children with CP. Following the intervention, eight weeks after documented all improvements in strength function performance and functional motor performance was maintained. Follow-up tests concluded participation in functional strength related exercise had positive results in maintaining physical activity.

CP & EXERCISE:

Various studies have also focused on enhancing muscle weakness to improve gait function such as gait speed in children with CP (Lee et al., 2008, Eek et al., 2008, Scholtes et al., 2010, & Unger et al., 2006). Eek et al. (2008) investigated the influence of strength related exercises on gait outcomes in children with CP. The 8-week training period consists of an exercise protocol of three times a week with a physiotherapist and twice per week at home. The sessions consisted of a low intensity warm up, individualized programs with strength training exercises, followed by stretching exercises, which concluded a more efficient gait that increased power during push off and making the push off phase of gait easier for the ankle plantar-flexors to push off actively in children with CP (Eek et al. (2008). In addition, this study showed a significant increases in stride length and plantar-flexor generating power during push off, as well as improved stability during the stance phase in walking. Lee et al. (2008) developed a 5-week strengthening program targeting the muscle groups of the lower limbs 3 times per week and the duration of 60 minutes each session. The program had subjects perform stretching exercise during warm up, squat to stand, lateral step up, stair stepping, isotonic exercise of lower limb muscles, isokinetic exercise utilizing a bicycle, and then followed by a cool down similar to the warm up. The experimental group had a significant increase in gait speed and stride length, single limb support, and maximal hip flexion during walking. This study concluded that strength is an important aspect of normal motor control that is deficient in patients with CP. Although both studies had unique individualized exercise protocols to improve strength, both studies did not have the same results in improving gait velocity in children with CP. Lee et al. (2008) had an increase in gait speed in his study, whereas Eek et al. (2008) had no change in velocity in children with CP.

Other strength related interventions focus on a more functional task related exercise to investigate its effects on mobility in children with CP (Blundell et al., 2003, Scholtes et al., 2010, & Liao et al., 2007). Blundell et al. (2003) established functional exercises such as step ups, sit to stand, leg presses, and treadmill walking to determine an increase in functional movement pattern in children with CP .Scholets et al. (2010) followed three functional exercise protocols for the lower extremity with weighted vests that consists of sit to stand, lateral step up, and half knee rise to improve mobility in children with CP. Whereas, Liao et al. (2007) emphasized loaded sit to stand exercise and utilized weighted vests to add resistance for progression. All functional task specific intervention studies concluded that an increase in isometric strength following training. However, Blundell et al. had gains in improvement in mobility and ambulation in children with CP due to functional performance that was maintained over time. Scholtes et al. (2010) concluded that the exercise protocol projected in this study increased isometric muscle strength of the knee and hip, but improvements in mobility did not carry over due to lack of supporting elements related to balance and coordination. Liao et al. (2007) emphasized functional strengthening exercises in loaded sit to stand exercise alone, but did not incorporate elements in improving gait function in children with CP. Overall, specific task related interventions to improve gait should be established when finding a proper exercise protocol for children with CP.

CP &AQUATIC EXERCISE:

An alternative intervention that addresses the factors that limit mobility and improve gait in children with CP is aquatic exercise. Aquatic exercise can be used for children with CP and address posture, spasticity, and muscle weakness. Aquatic exercise has been viewed to be beneficial for children with neuromuscular impairments such as CP (Kelly &Darrah, 2005). There are very few aquatic interventions in literature for children with CP to improve gait function. Due to various properties of water, aquatic exercise can establish a proper intervention protocol that will improve gait function in children with CP. Kelly &Darrah (2006) report that exercise in the water appeals to children with CP because of the unique quality of buoyancy of water that reduces joint loading and impact, and decreases the negative influences of poor balance and postural control. Buoyancy enables initiation of independent movement possibilities that are less likely to be achieved on land-based exercise. Water property such as viscous drag may help with strengthening weakened limbs that child with CP experience. Gage (2004) states, strengthening exercises may exacerbate spasticity and limit motor function when doing exercises. Warm temperatures used in aquatic setting have been known to generate therapeutic properties that decrease muscle tone (Getz et al. 2007). In addition, the resistive forces of buoyancy and viscous drag permit a variety of aerobic and strengthening activities that can be easily be modified to help accommodate the limited range of motor abilities in children with CP.

Interventions in an aquatic setting have increased physical competence and social acceptance in children with CP (Getz et al. 2007). The use of the Pediatric evaluation of disability inventory (PEDI) and the Aquatic independence measure (AIM) to evaluate functional performance in self-care, mobility and social function and to assess the children's level of skill acquisition in the aquatic environment was used. Getz et al. (2007) states that children who participate in the aquatic exercise program may initiate multiple social interactions, provide greater sensory stimulation and feedback, as well as commence independence in children with CP. However, this study does not express gait outcomes or functional related activities that children with CP lack. Self-assurance in children with CP and physical competence allows a stepping-stone to improving gait in children with CP. Competence gained in an aquatic setting may transfer over to walking on land and may improve mobility and physical activity in children with CP.

Others studies investigate that aquatic based exercise for children with CP can improve gait function (Fragala-Pinkham et al., 2008, &Hutzler et al., 1998). Posture, spasticity, and muscle weakness are three primary reasons why children with CP are less engaged in physical activity and participation (Fragala-Pinkham et al., 2008). Although land based exercise have shown to improve gait function in children with CP, the use of an aquatic setting may be more beneficial for children with CP. Due to water's unique properties, aquatic exercise can greatly help to improve gait function in children with CP by eliminating the factors that hinders physical activity in children with CP. Other studies incorporate aquatic exercise and children with CP that have shown positive effects on vital capacity, muscle strength, and motor skill (Fragala-Pinkham et al., 2008, &Hutzler et al., 1998). However, further research is needed to find the effects of aquatic exercise and investigate gait outcomes to improve gait function in children with CP.

By using an aquatic exercise intervention, gait associated with spatiotemporal and kinematic variables can be improved in children with CP due to a proper aquatic gait-training regimen. Properties of water can help to aid in creating a proper exercise protocol that can address mobility limitations to improve gait variables in children with CP. With gait improvements due to aquatic exercise, children with CP will be able to walk more efficiently with greater velocity and increasing stride and step length, as well as increasing how much children with CP are able to ambulate. Furthermore, children with CP will have a greater range of motion on their lower extremities as a result of improved contracture. With the use of aquatic exercise to improve gait, children with CP are able to walk with a more efficient gait pattern other than typical gait abnormalities they experience.

The aquatic setting is suitable for children with CP to improving gait and can also be adapted to other disabilities other than CP. Provide scientific evidence to the CP population that aquatic exercise can improve gait deviation in children with CP and treating other neuromuscular disorders that can improve gait deviations. Additionally, present clinicians with evidence based research on aquatic exercise interventions in children with CP and other neurological disorders so that clinicians are able to incorporate and encourage the use aquatic exercise program to their rehabilitation regimen. Overall, exercise and physical activity is beneficial for children with and without disability to promote overall health. The use of an aquatic environment is an alternative source to getting children with disabilities physically active to prevent obesity and other complications associated with inactivity.

There is little research that focuses on the effectiveness of aquatic exercise in improving gait parameters in children with CP. Recent studies that incorporate aquatic exercise have measured respiratory function, increased participation, and physical activity (Getz et al. 2007, Fragala-Pinkham et al., 2008, &Hutzler et al., 1998). Aquatic therapy has grown popularity in the rehabilitation field to treat many neuromuscular disorders. (Fragala-Pinkham et al., 2008). The unique properties of water such as buoyancy and viscous drag help to create an exercise environment suitable for the CP population. Buoyancy properties allow children with CP to move freely in the water by decreasing excessive stress on their joints associated with gravity (Fragala-Pinkham et al., 2008). Viscous drag creates resistance that can be used to implement various exercise intensities (Fragala-Pinkham et al., 2008). Aquatic exercise can be used to keep children with CP physically active as well as help improve functional limitation due to their disability (Fragala-Pinkham et al., 2008). The use of an aquatic setting will not only give children with CP an environment that is different from the usual land based exercise, but can open a new dimension that children with CP have not experienced before. This may help children with CP be motivated in participating in an exercise program as well as be more independent due to buoyancy properties that an aquatic setting can offer.

Gait abnormalities in children with CP have been a primary concern that hinders participation and physical activity in the CP population (Gage, J.R., 2004). Due to motor limitation that is associated with contracture, spasticity, and weakness, children with CP experience a much slower gait speed as well as cadence to compensate with their abnormalities in gait. Children with CP have less stride and step length as well as single support time due to lack of coordination and balance associated with CP. Additionally, contracture in children with CP hinders movement through a full range of motion in various joint angles of the lower extremity. Decreased ankle range of motion is the primary reasons that children with CP are unable to walk efficiently. Toe walking is the most common type of gait that children with CP experience. By using an aquatic exercise regimen, its unique properties can establish a proper exercise regimen and improve spatiotemporal and kinematic variables in children with CP. Therefore, the purpose of this study is to investigate the effects of a 6-week aquatic exercise program in improving gait parameters in children with CP.

METHODS

Participants

Children will be recruited from local elementary schools in the city of Northridge. All participants will have to be ambulatory children with mild form of CP, GMFCS level I-III. All participants should obtain a medical clearance form from their primary care physicians prior to participation in this group aquatic exercise (Appendix A).

Inclusion criteria are: a) diagnosis of spastic diplegic or hemiplegic CP, b) age between 7-17 years old, c) medical clearance for adapted exercise or aquatic exercise, d) ability to walk independently with or without an assistive device, e) Gross Motor Function Classification System (GMFCS) levels I-III, f) ability to follow verbal instructions and communicate in English, g) ability to participate in a exercise program in and out of the water for up to 30-40 minutes.

Exclusion Criteria are: a) nstable seizures, b) medical/surgical treatment for spasticity 6 months prior to the study (Botox or Selective Dorsal Rhizotomy), and c) current participation in aquatic therapy.

Setting

The study took place at the Center of Achievement (COA) at California State University, Northridge. The aquatic intervention was held in the main therapy pool where the water depth was 1.5 meters and the temperature was maintained at 35 degree Celsius (95 degree Fahrenheit). Data collection using 3-Dimensional gait analysis took place in the expansion room of the COA. Multiple data measurements were used to test joint range of motion of the hip, knee, and ankle. In addition to velocity, cadence, stance and swing phase, and step width and stride length. At a total of 4 multiple data measurements were taken at week 0 (pre intervention), week 3 (mid intervention), week 6 (post intervention), and week 7 (follow-up intervention).

Instrumentation

The study used the VICON Bonita System (VICON, Oxford, UK, 2010),using 7 high-speed infrared cameras that I captured each participant's walking. VICON Nexus computer softwarewas also used to analyze and measure data received from participant's walking.

Intervention Protocol

Participants exercised in an aquatic group exercise setting following baseline data collection. The aquatic group exercise was instructed by a researcher on the pool deck where he/she lead the various exercises. Certified lifeguard ensured children's safety in the water as well asresearch assistance whom will behelping the children with each exercise. A total of 18 sessions occurred, 3 times a week, for a total of 40 minutes.

The aquatic group exercise began with a 10' minute warm-up that consisted of water adjustment and stretching as the moveable pool floor was adjusted. All children were to stand or sit in the middle of the pool while lifeguard adjusted the pool floor to ranges of children's chest to waist level. Exercises consists of 10 minutes of warm-up (water adjustment and stretching),10 minutes of gait training (forward/backward walking, sidesteping, toe-walking, and heel-to-toe walking), 10 minutes of balance training (wide-to-narrow stance, tandem standing, and one-leg standing), and 10 minutes of cool down (group play and modified fun game). All gait and balance exercises were modified to mimic various games/sports to help keep children's attention span on specific exercises performed.

Data Outcome Measrues

The participants were measured on kinemtaic gait parameters (hip flexion and extension, knee flexion and extension, and ankle plantar-flexion and dorsi-flexion) and spatial-temportal gait variables (% stance and swing phase, velocity, cadence, step width and stride length) .

Data Collection Procedures

During Initial data collection, all participants submitted medical clearance obtained from their primary physician before their participation in this study. Data collection procedures were approved by CSUN Institutional Review Board . Each parent and guardian reviewed and signed the informed concent form while the child reads and signs the child accent form. During pre, mid, post, and follow-up data collection, all participants were ask to change into bicycle shorts or tightly fit clothing. Reseacher attached reflective markers to the lower extremity bony landmarks. Static data were captured as the participants stand still in the middle of a 10-meter walkway. Gait trials will then be captured as the participants will be asked to walk a 10-meter walkway 3 times at a comfortable walking speed and 3 times at their maximum velocity (30-second rest periods between trials and 2-minute rest period between comfortable and maximum walking speed tests).

Human Subjects Review

The Human Subjects protocol was approved by the Standing Advisory Committee for the Protection of Human Subjects (SACPHS) at California State University, Northridge.

RESULTS

The purpose of this study was to investigate the effects of aquatic exercise on gait parameters in children with Cerebral Palsy (CP). Kinematic (hip, knee, and ankle) and spatial-temporal (stance and swing phase, cadence, velocity, step width, step length, and stride length) variables were measured in this study. The outcomes of kinematic and spatial-temporal measures were analyzed independently using the Polygon software. Descriptive statistics were used to illustrate the main results of this study. Visual analysis of bar graphs was used to depict any main changes in trends.

Four participants from local elementary schools in the city of Northridge were recruited for this study. Two participants with mild spastic hemiplegia CP with Gross Motor Classification System (GMFCS) levels of I (participants 2 and 3), and two participants with mild spastic diplegic CP with GMFCS level of II-III (participants 1 and 4) completed the 6-week aquatic intervention; thereafter, 7-week follow-up was then analyzed. Data analysis was conducted on the affected side of the spastic hemiplegic CP and the most affected side of the spastic diplegic CP participants. Anthropometric data of all participants is listed in detail in Table 1.

It was hypothesized that there would be trends for improvement in all kinematic measurements variables; sagittal hip, knee, and ankle range of motion. It was also hypothesized that there would be trends for improvement in all spatial-temporal measurement variables; cadence, velocity, stance and swing phase, step width, step length, step time, stride length, and stride time. The results of each participant are described individually.

Table 1 Participant anthropometric/physical characteristics information

Participants	1	2	3	4
Age (yrs.)	10	14	7	10
Height (mm.)	1397	1550	1275	1322
Weight (kg.)	60	39.6	28	29
Gender	Female	Female	Female	Male
CP Dx./GMFCS	Diplegic/II	Hemi/I	Hemi/I	Diplegic/II

Participant 1

Participant 1 was a 10 year old girl with mild spastic diplegia, GMFCS level II-III. According to her physical therapist, left side was mostly affected with walking characteristics of crouch and left slap foot gait. Participant was also diagnosed with a secondary physical disability of developmental delay and had a medical history that consists of a fractured tibia and femur 6 years prior to this study.

There were no systematic changes in hip and knee kinematics observed throughout gait cycle (Figure 1 & Figure 2). However, sudden ankle plantar-flexion was observed in participant's kinematic baseline (pre intervention) during initial contact of gait cycle (Figure 3). Mid, and post intervention displays a smooth transition in plantar-flexion during initial contact and maintains its effect at follow-up intervention.

At baseline, stance phase showed an increasing trend throughout the study and adversely effects swing phase of the participant's gait cycle(Figure 4). Initial stance phase was at 55% and increases to 57% (4%) during mid-intervention,58% (5% from baseline) during post-intervention, and 62%(13% from baseline) during follow-up intervention.

Velocity displays a decreasing trend throughout the study (Figure 5). At baseline, velocity was at 1.37m/s and decreases to .84m/s (39%) at mid-intervention, .75m/s (45% from baseline) during post-intervention, and.66m/s (52% from baseline) at 7-week follow-up. Cadence (steps/minute) also had a decrease trend throughout the study (Figure 6). At baseline, cadence was at 189 s/m and decreases to 131s/m (39%) at mid intervention, 136m/s (28% from baseline) during post-intervention, and 105m/s (44% from baseline) 7-week follow-up.

Step width diminished an increasing trend throughout the study (Figure 7). At baseline, step width was at .2m and increases in step width of .26m (30%) during mid-intervention,.27m (35% from baseline) during post-intervention, and.34m(70% from baseline) during follow-up intervention. However, stride length had a decreasing trend throughout the study (Figure 8). At baseline, stride length was at .91m and decreases to.75m (17%) during mid-intervention,.68m (25% from baseline) during post-intervention, and .74m(18% from baseline) during follow-up intervention.

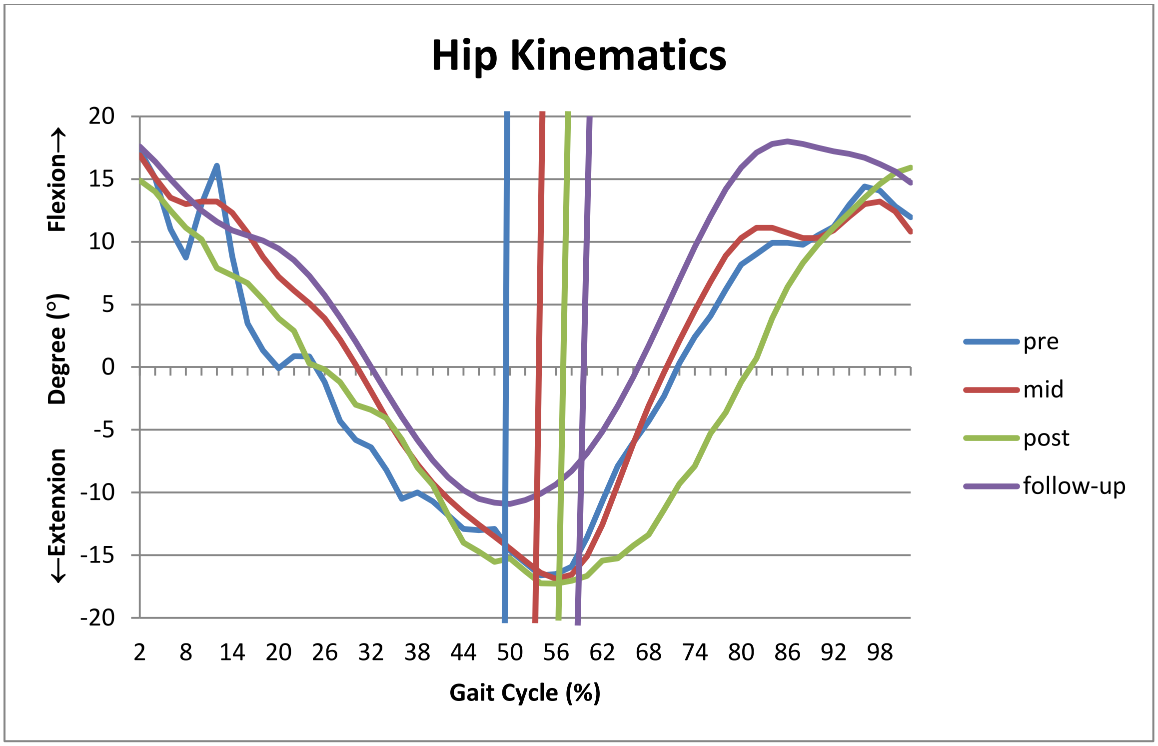

Figure 1. Hip kinematics for particpant 1.

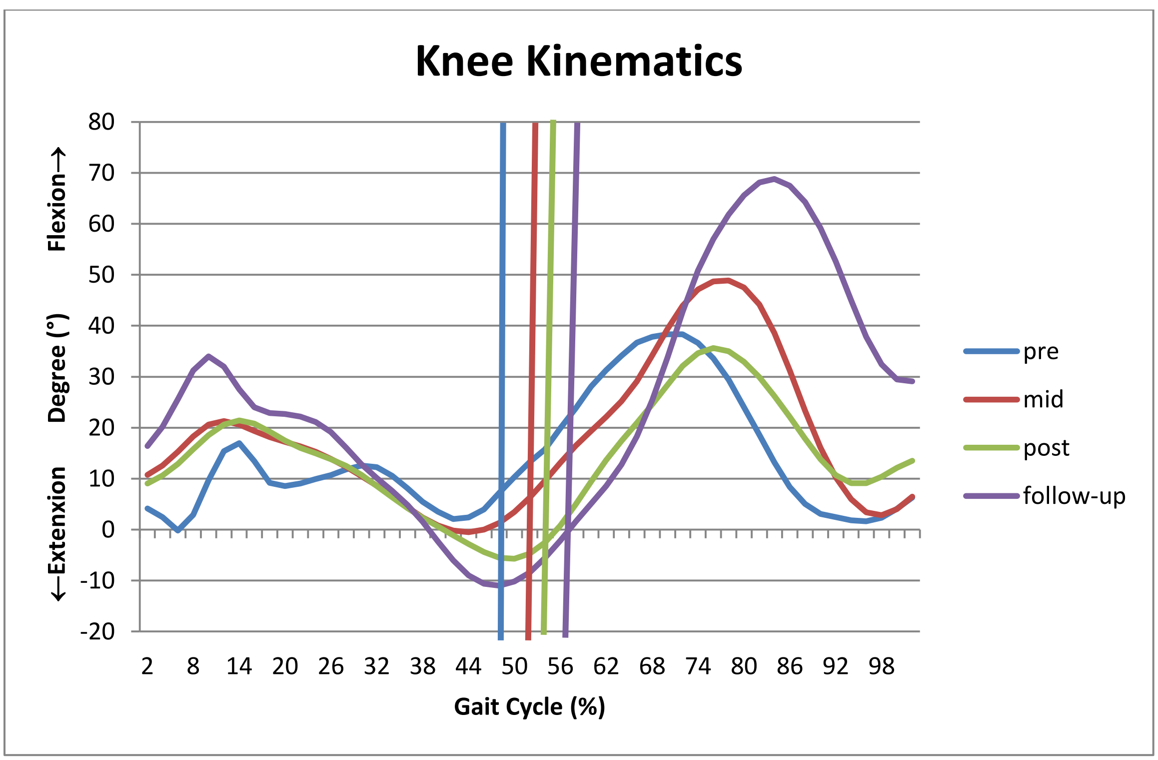

Figure2. Knee kinematics for particpant 1.

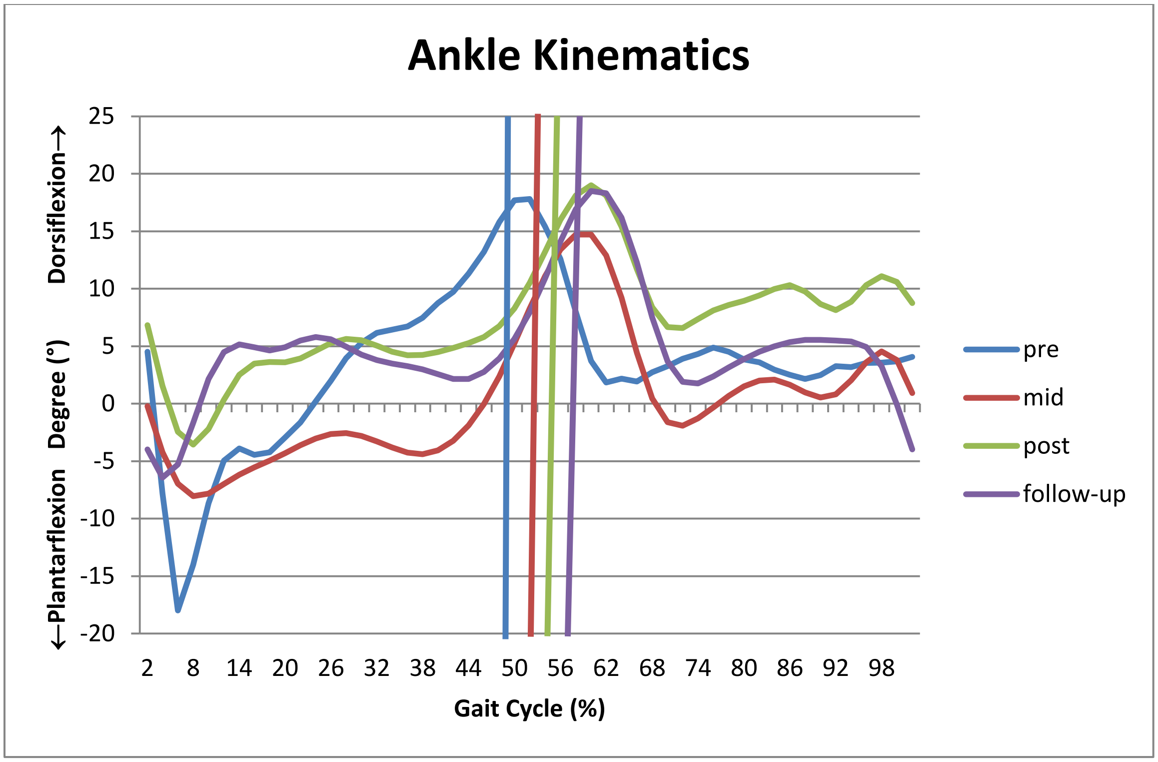

Figure 3. Ankle kinematics for particpant 1.

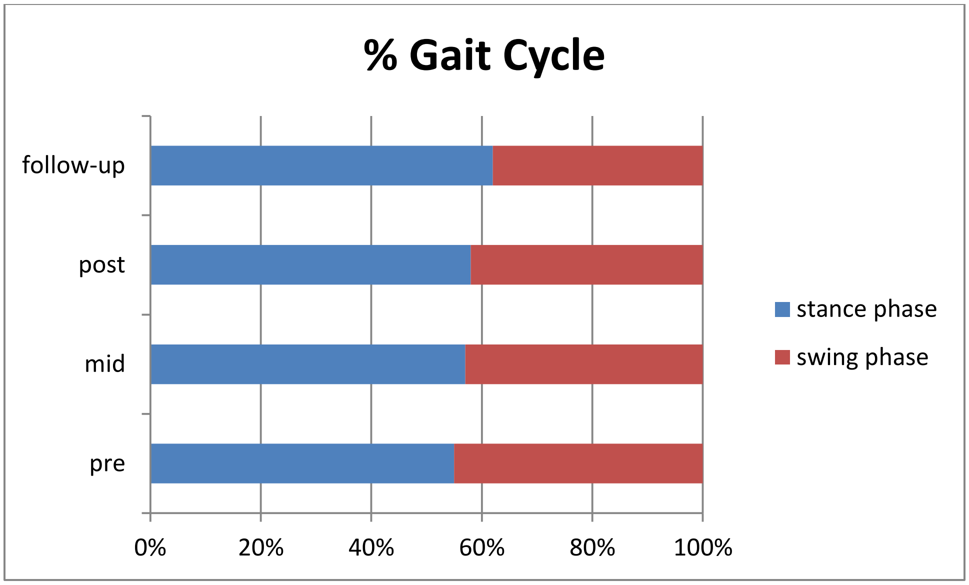

Figure 4. Stance and swing % for particpant 1.

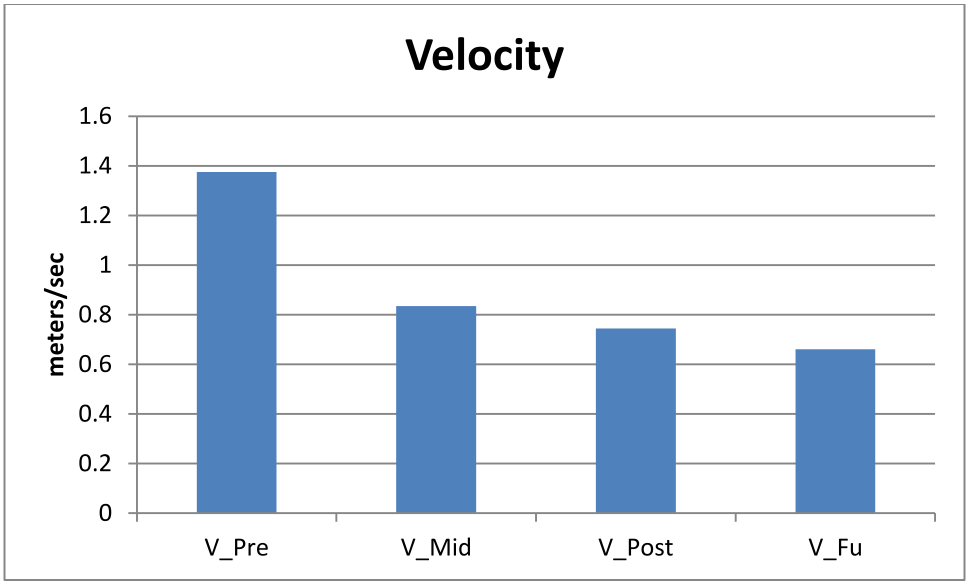

Figure 5. Velocity for particpant 1.

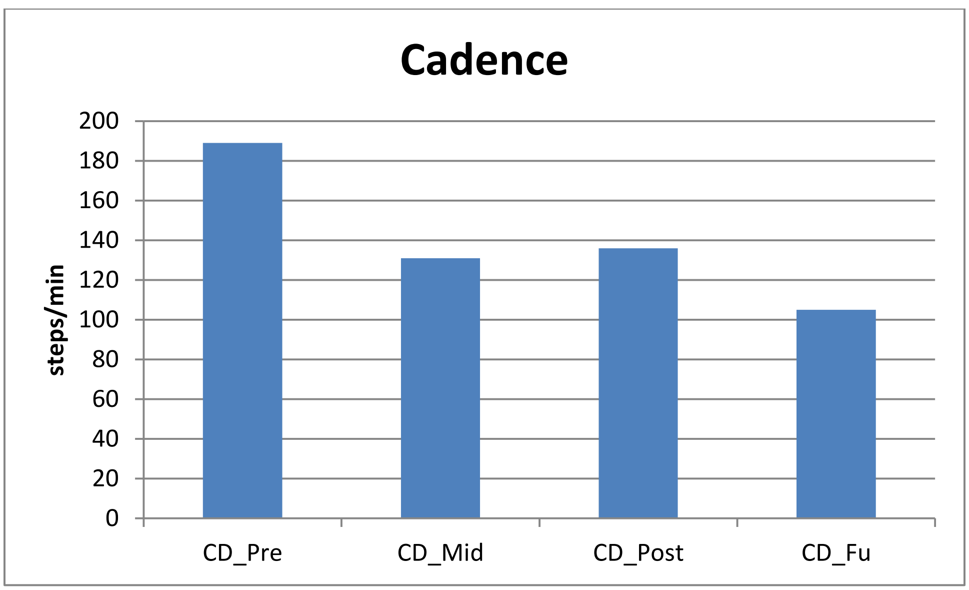

Figure 6. Cadence for particpant 1.

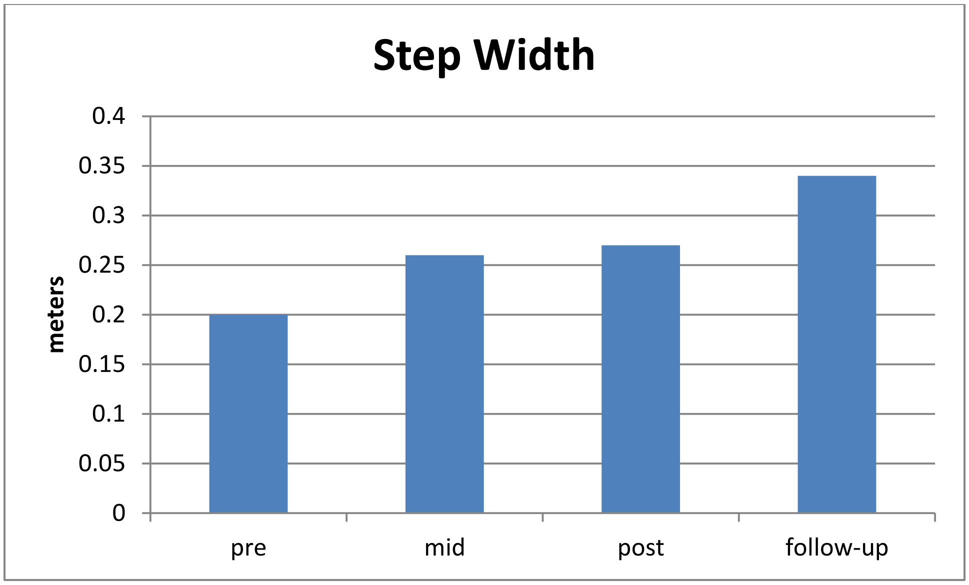

Figure 7. Step width for particpant 1.

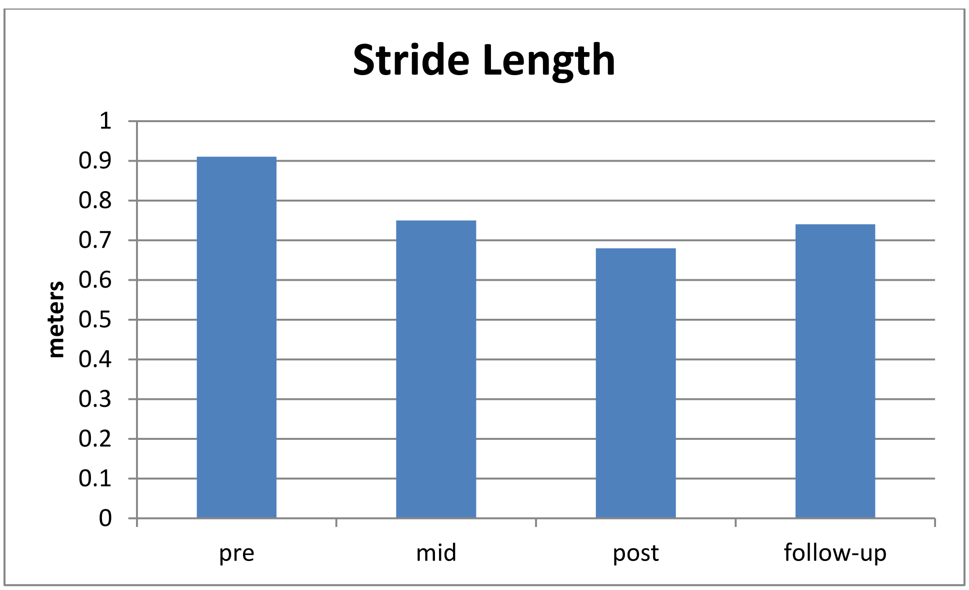

Figure 8. Stride length for particpant 1.

Participant 2

Participant 2 was a 14 year old girl with left sided mild spastic hemiplegia; GMFCS level I and experiences walking characteristics of left toe walking. Participant's medical history consisted of tibial osteotomy of the left lower extremity 6 years prior to this study.

At baseline, hip kinematic graph during pre-intervention displayed an early and excessive hip flexion that occurs during terminal stance and pre-swing phase of participant's gait cycle (Figure 9). Hip flexion was then decreased and occurs later during mid and post intervention. However, hip flexion did not retain its effect during follow-up intervention. There were no other systematic changes in knee and ankle kinematics observed throughout gait cycle (Figure 10 & Figure 11).

Stance and swing phase, velocity, cadence, and stride length showed fluctuation throughout intervention (Figure 12 – Figure 14 & Figure 16). However, step width show a decreasing trend pre and mid- intervention at .17m to.1m (41%) post intervention, and retaining its effect at .12m (29% from baseline) follow-up (Figure 15).

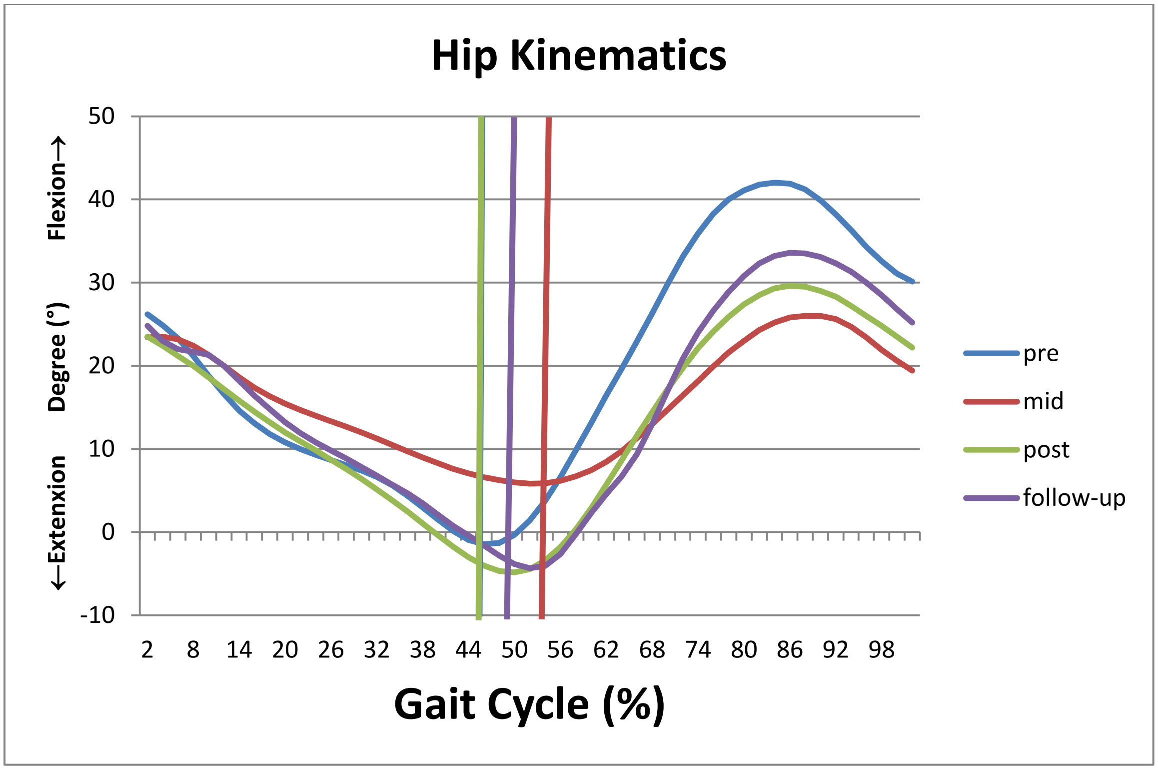

Figure 9. Hip kinematic for participant 2.

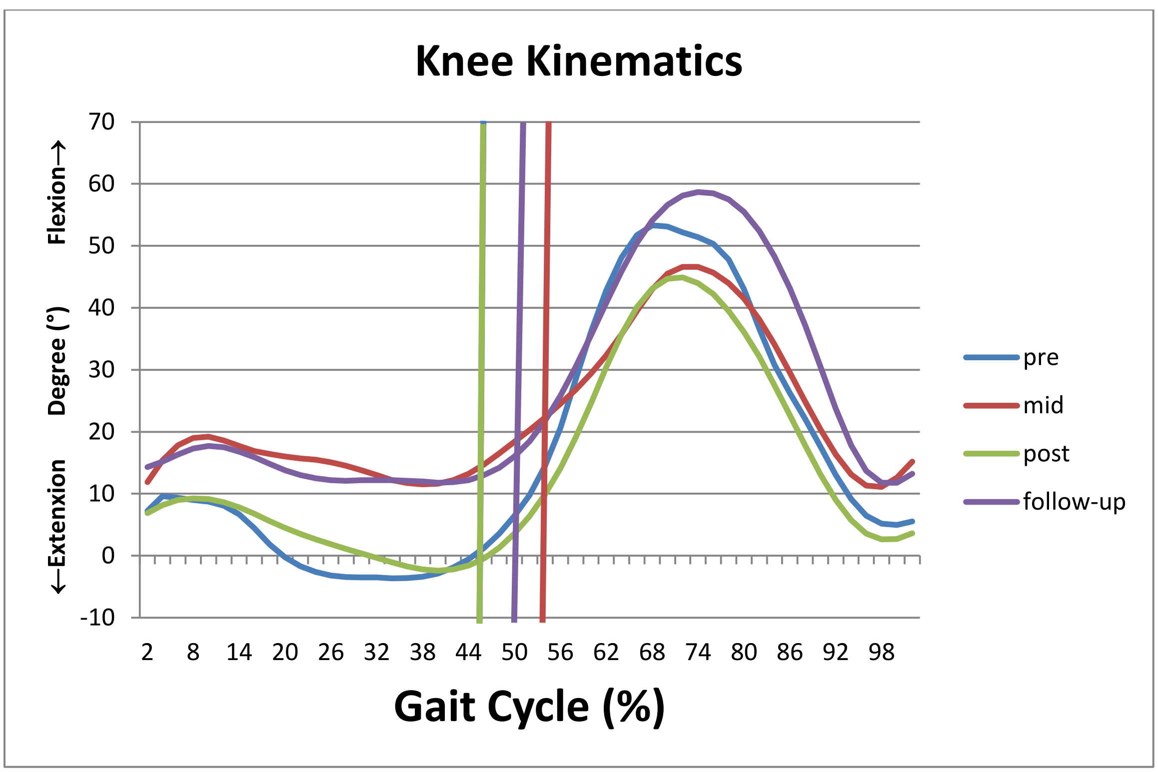

Figure 10. Knee kinematic for participant 2.

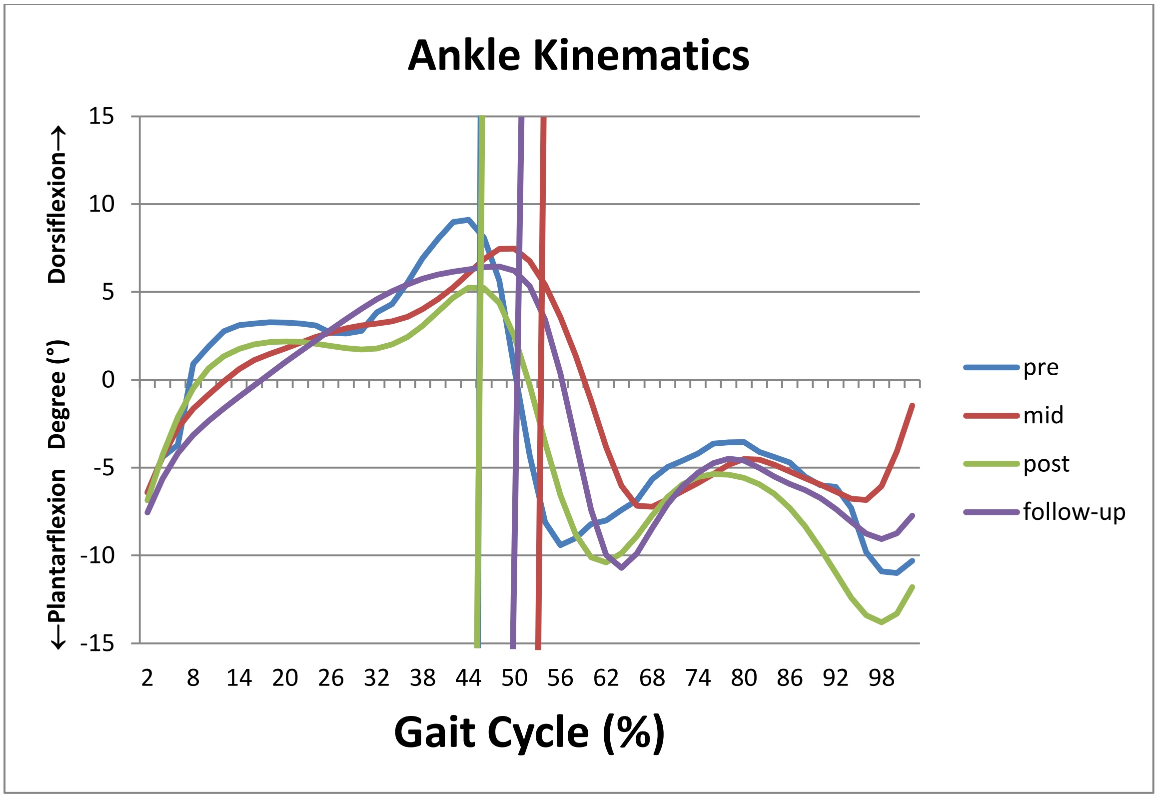

Figure 11. Ankle kinematics for participant 2.

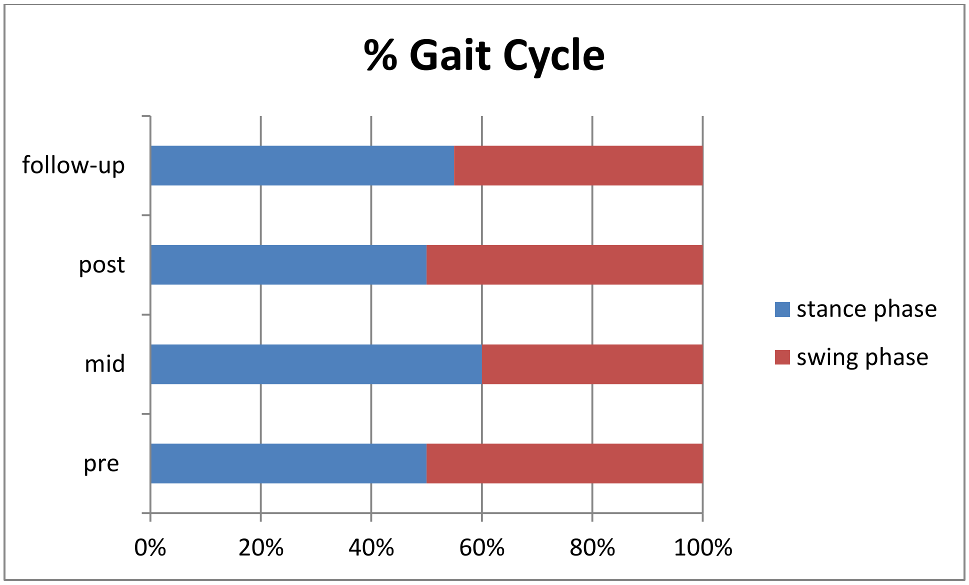

Figure 12. Stance and swing% for participant 2.

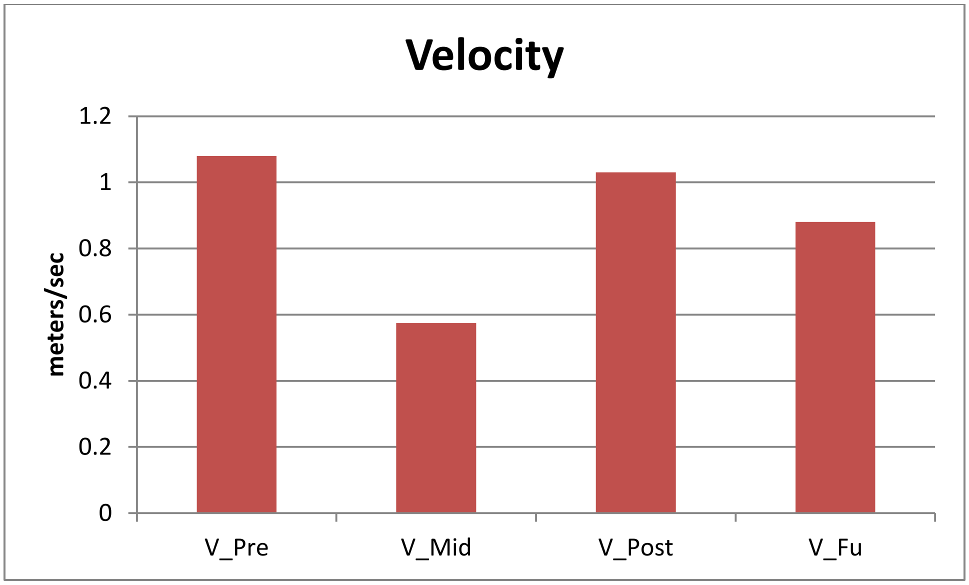

Figure 13. Velocityfor participant 2.

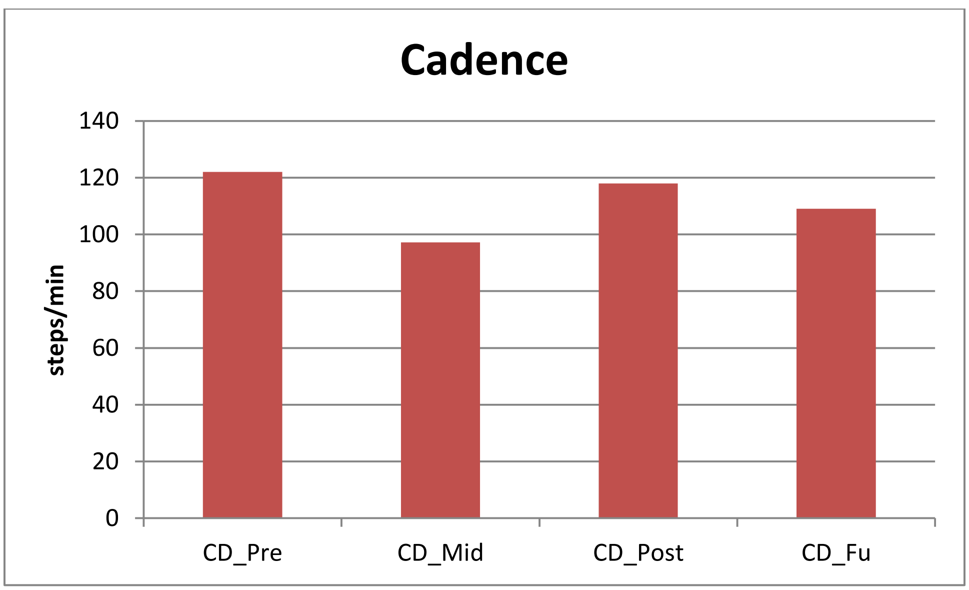

Figure 14. Cadencefor participant 2.

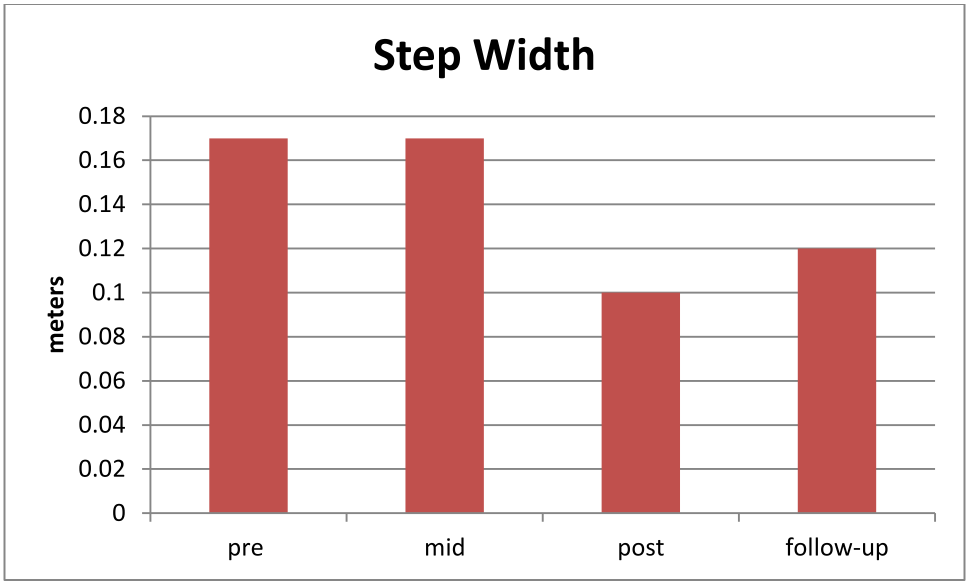

Figure 15. Step widthfor participant 2.

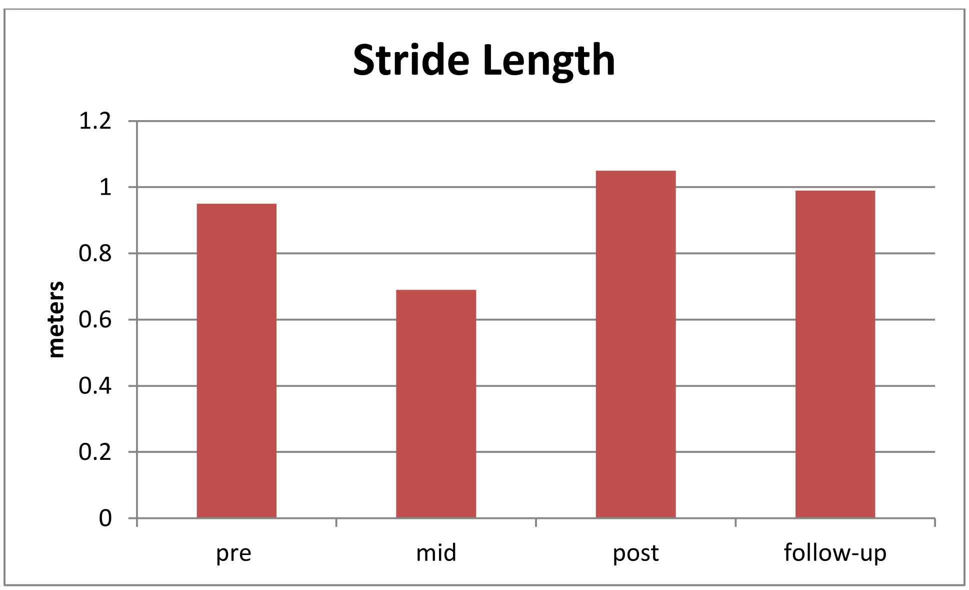

Figure 16. Stride length for participant 2.

Participant 3

Participant 3 was a 7 year old girl with left sided mild hemiplegia, GMFCS level I and experiences walking characteristics mild hemiplegic gait. Participant's secondary diagnosis was asthma and had no other related medical history.

At baseline (pre-intervention), hip, knee, and ankle kinematic displays an early and excessive hip extension, knee flexion, and limited plantar flexion during terminal stance and pre-swing of participant's gait cycle (Figure 17-19). However, after mid and post intervention, hip extension, knee flexion decreased but did not retain its effects 7 weeks follow-up intervention. Additionally, plantar flexion increases mid and post intervention but did not retain its effect during 7-week follow-up.

Stance phase showed increasing trend throughout the study and adversely effects swing phase of the participant's gait cycle (Figure 20). At baseline, stance phase was at 56% and increase to 64% (14%) during mid-intervention, 68% (21% from baseline) during post-intervention, and a slight decrease from mid-intervention to follow-up intervention but still show an increasing trend from baseline at 62% (10%) stance phase.

Velocity decreased progressively from .92m/s to .7m/s (24%)pre to post intervention, however increased follow-up intervention to .81m/s (Figure 21). Cadence also decreased progressively from 113s/m to 97s/m (15%) pre to post intervention, however increased during follow-up intervention to 107s/m (Figure 22).

Step width decreased from .13m to .05m (58%) pre to post intervention (Figure 23). However, step width did not retain its effect during follow-up intervention and increasing to .17m (30%). There was no systematic change in stride length (Figure 24).

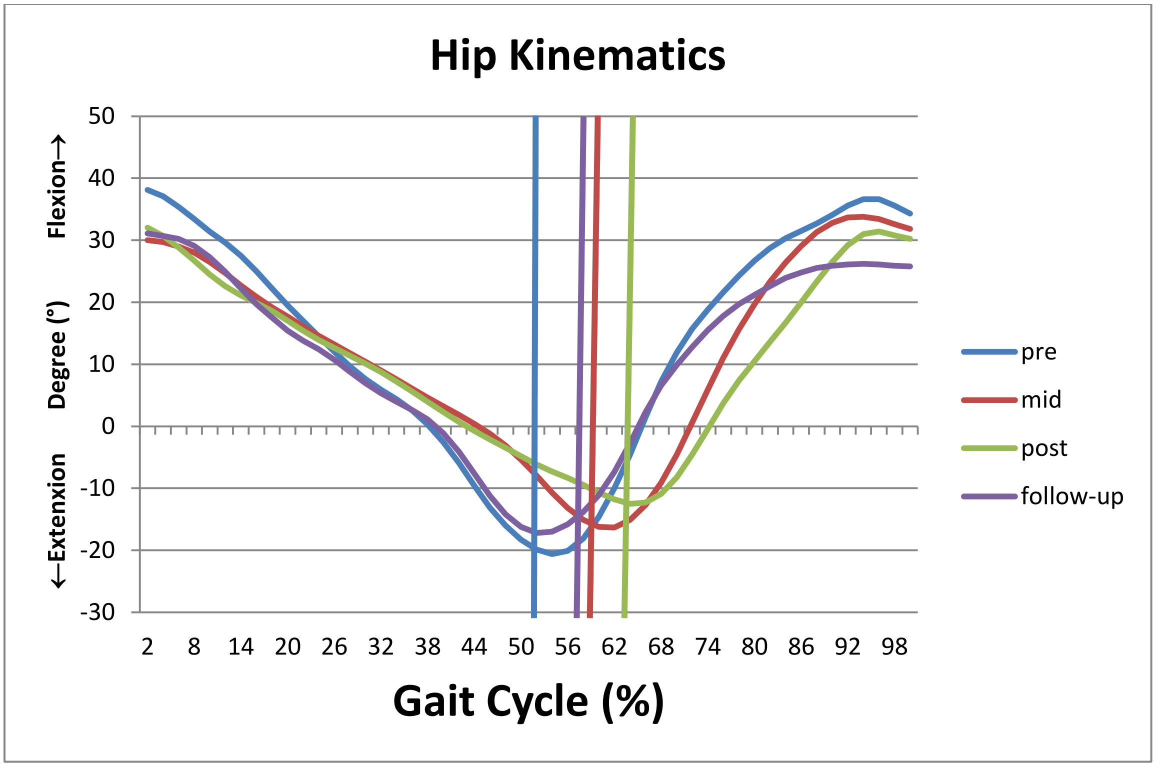

Figure 17. Hip kinematics for participant 3.

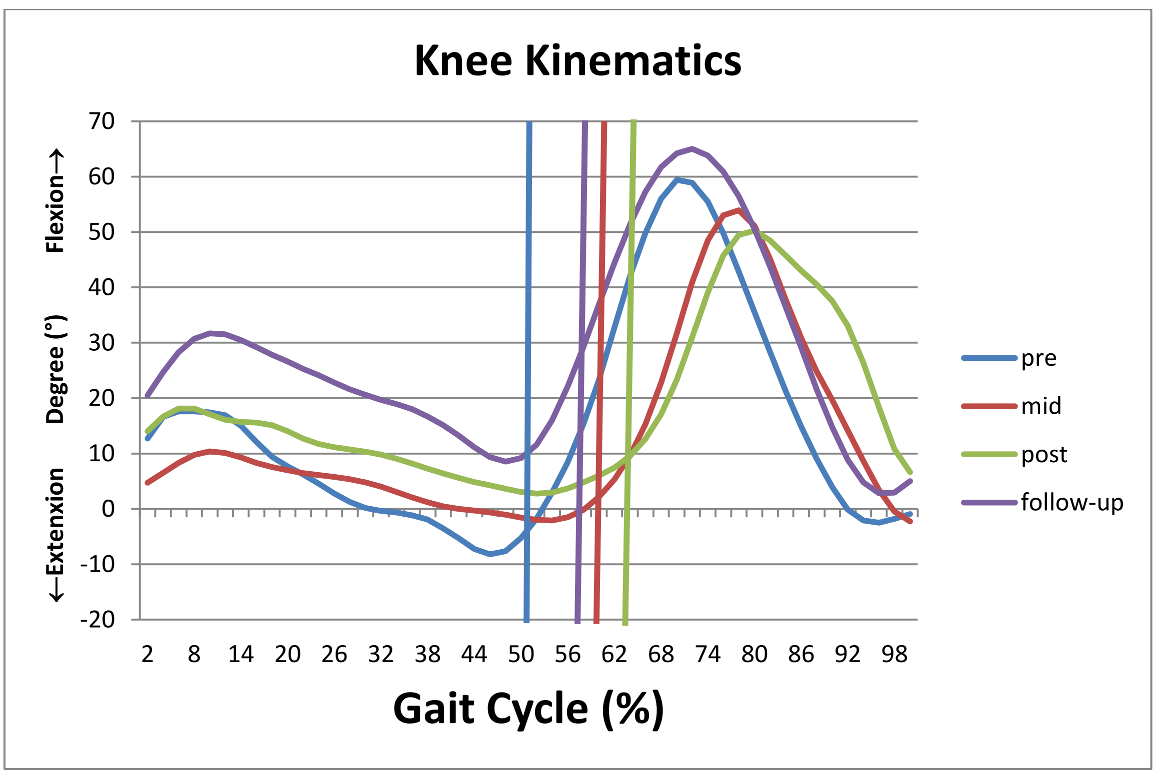

Figure 18. Knee kinematics for participant 3.

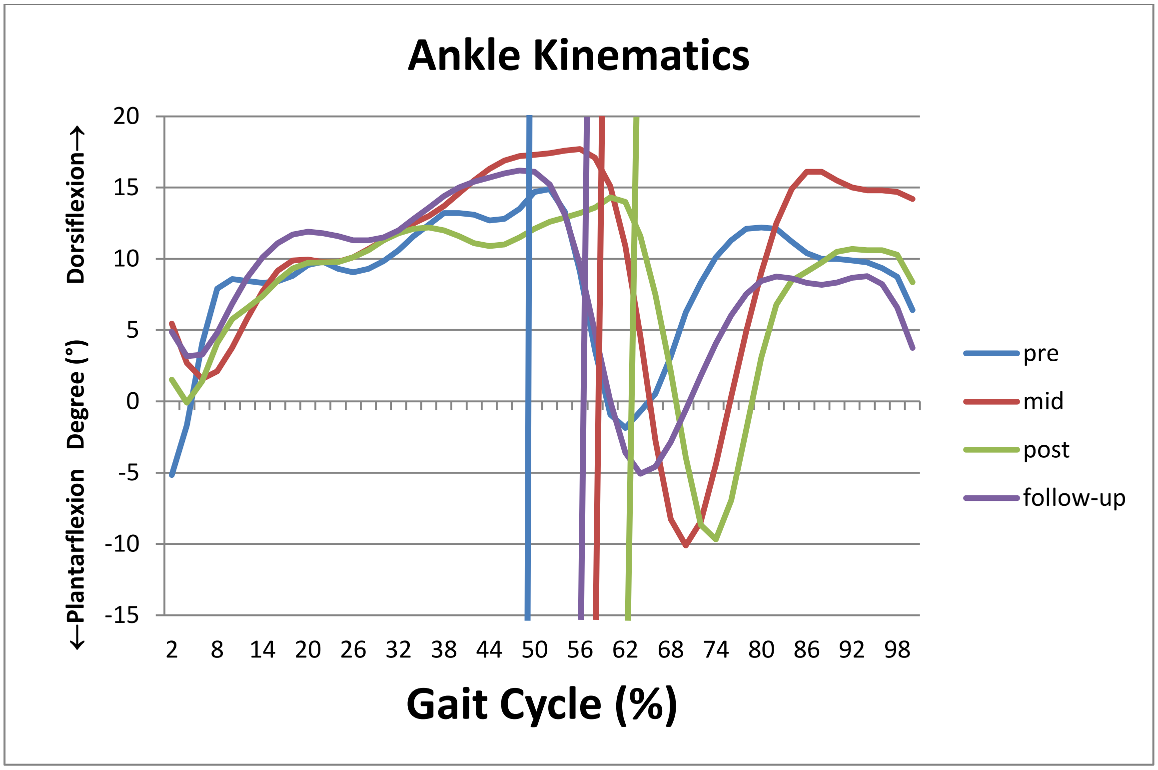

Figure 19. Ankle kinematics for participant 3.

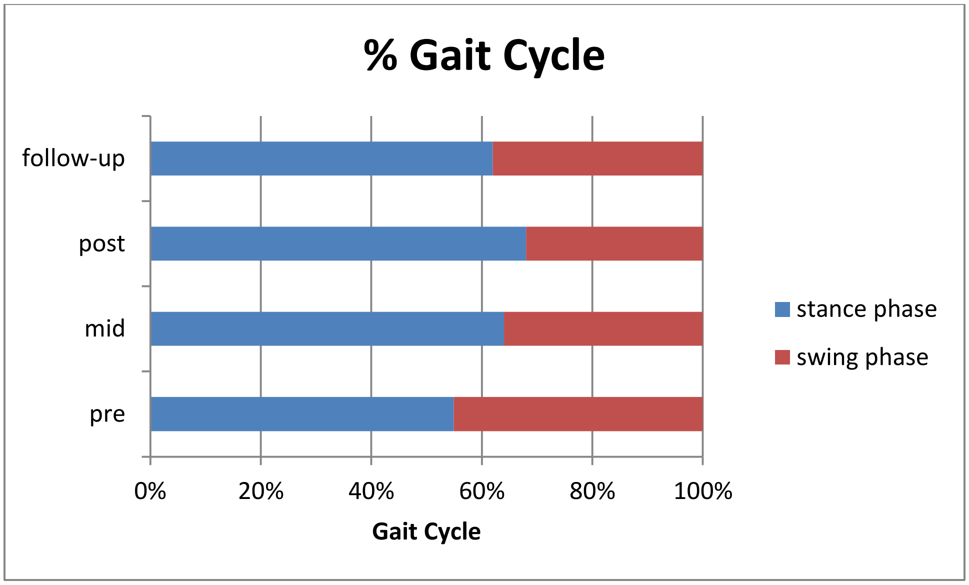

Figure 20. Stance & swing % for participant 3.

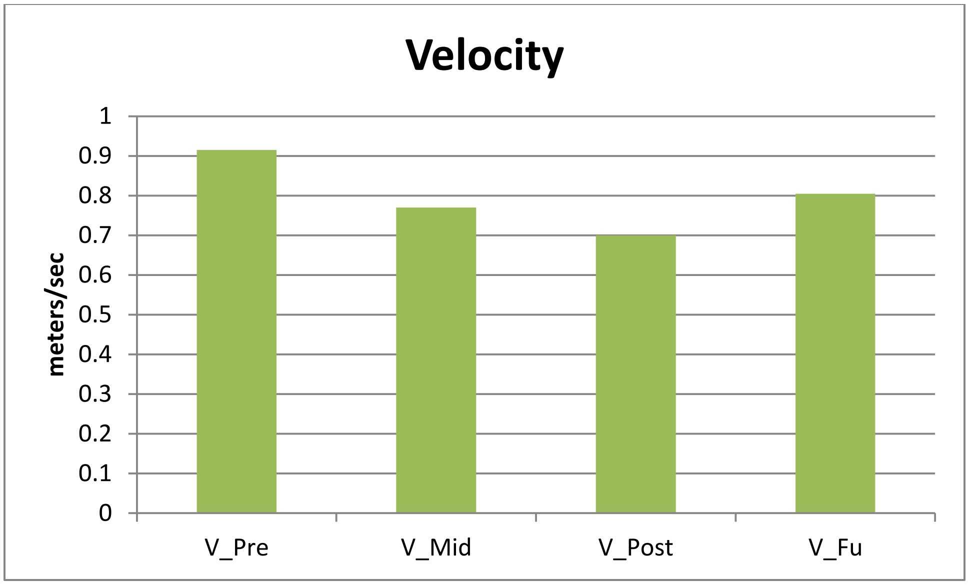

Figure 21. Velocity for participant 3.

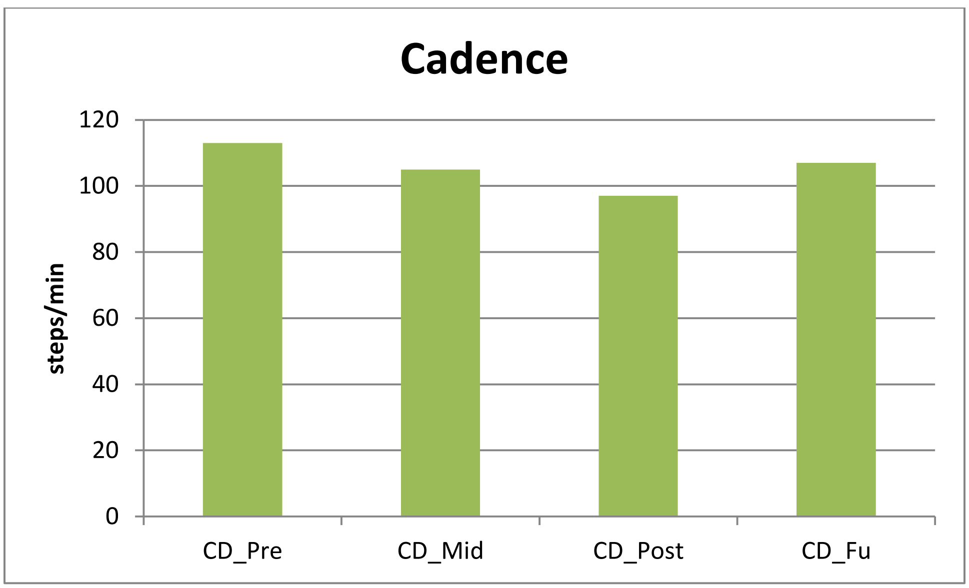

Figure 22. Cadence for participant 3.

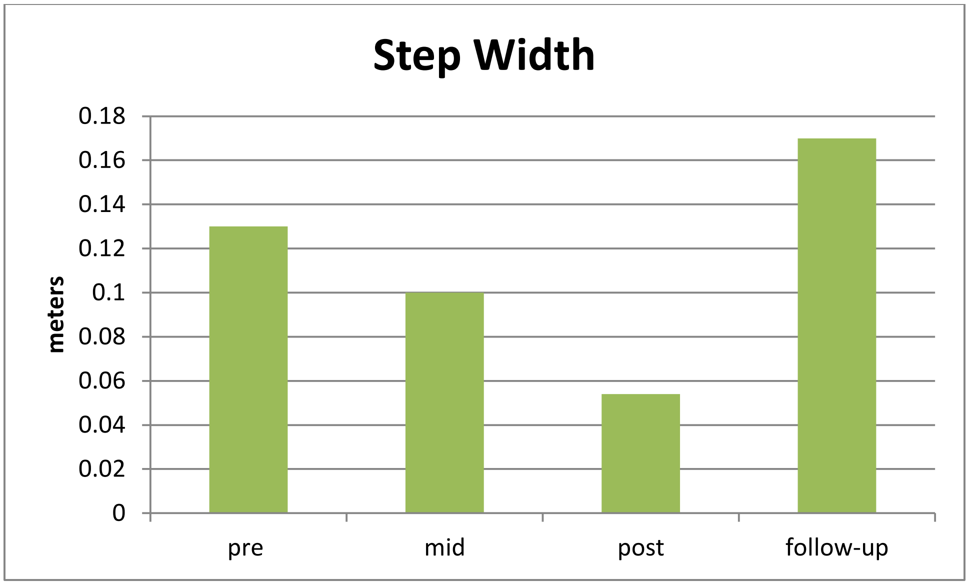

Figure 23. Step widthfor participant 3.

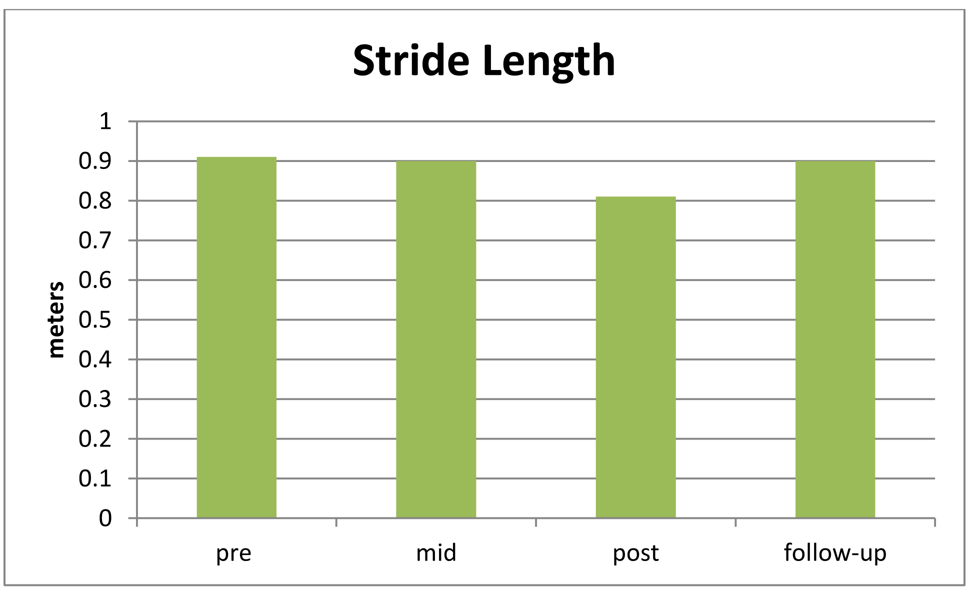

Figure 24. Stride lengthfor participant 3.

Participant 4

Participant 4 was a 10 year old boy with mild spastic diplegia, GMFCS level II-III. According to participant's physical therapist, left side was mostly affected and experiences walking characteristics of equinus and stiff knee gait. Participant's medical history consisted of left femoral osteotomy, bilateral tibialostetomy, bilateral hamstring lengthening, and bilateral adductor tenotomy, all within 3 years prior to this study.

There were no systematic changes in hip kinematics for participant 4 (Figure 25). At baseline, knee kinematics displayed an increase in knee flexion during initial swing and mid swing from pre to mid intervention and continues to maintain effect through follow-up intervention (Figure 26). Ankle kinematics displayed a reduction of unwanted plantar flexion from pre to mid intervention during pre-swing and initial swing and continued to maintain its effect through post intervention (Figure 27). However, during follow-up intervention, plantar-flexion excessively increased more than baseline data collection.

Stance and swing phases, velocity, cadence, and stride length showed fluctuation throughout the intervention (Figure 28 – Figure 30 & Figure 32). However, step width had an increasing trend from mid through follow-up intervention (Figure 31). At mid-intervention, step width was at .08m and increases to.12m (9% from mid-intervention) during post-intervention, and.13m (18% from mid-intervention) during post-intervention.

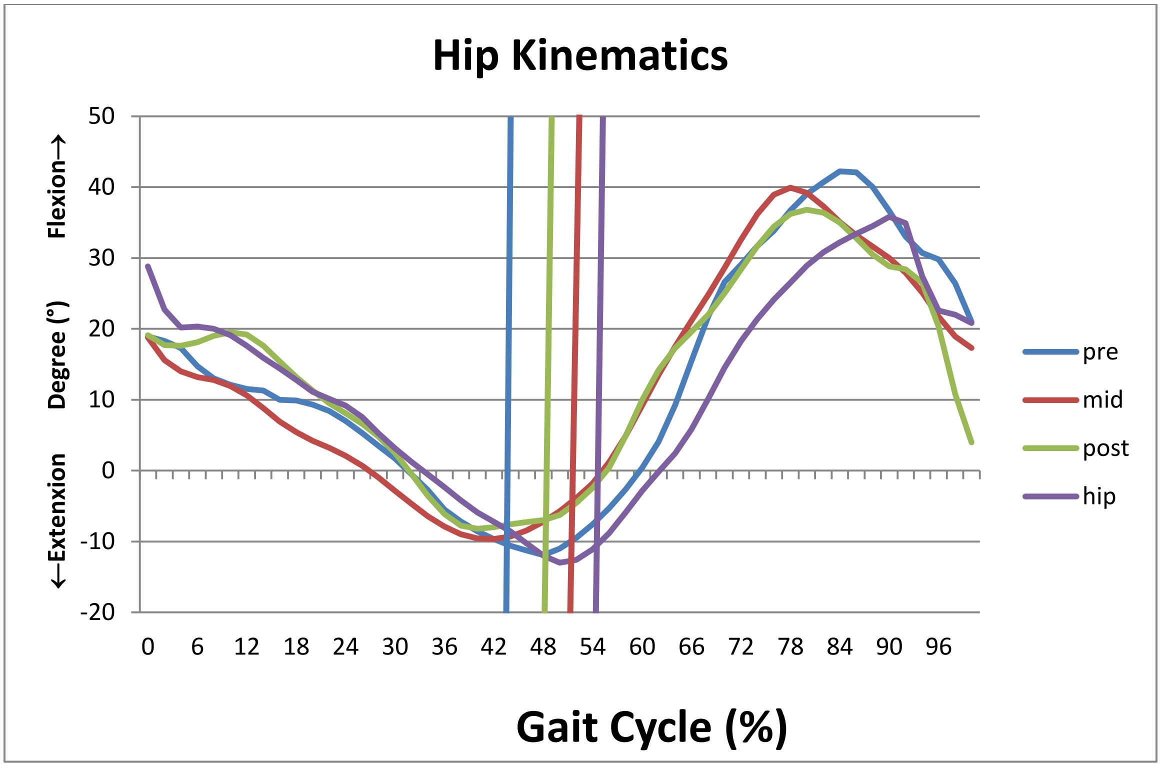

Figure 25. Hip kinematics for participant 4.

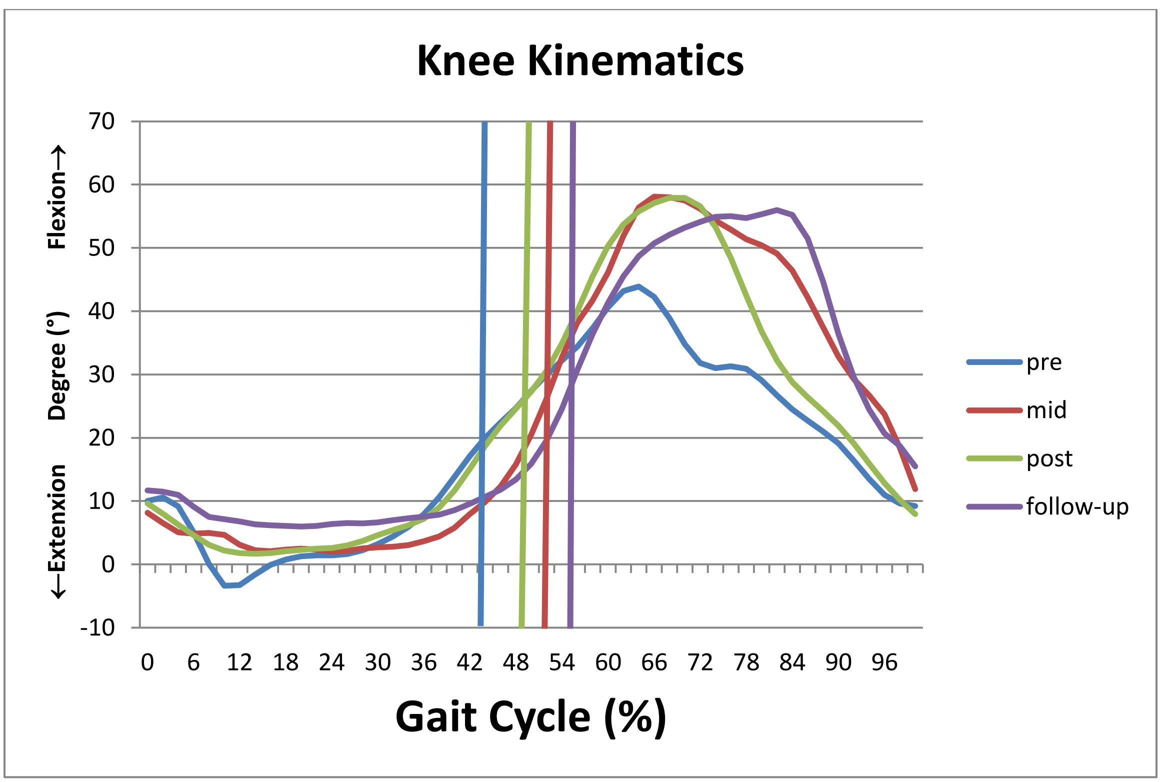

Figure 26. Knee kinematics for participant 4.

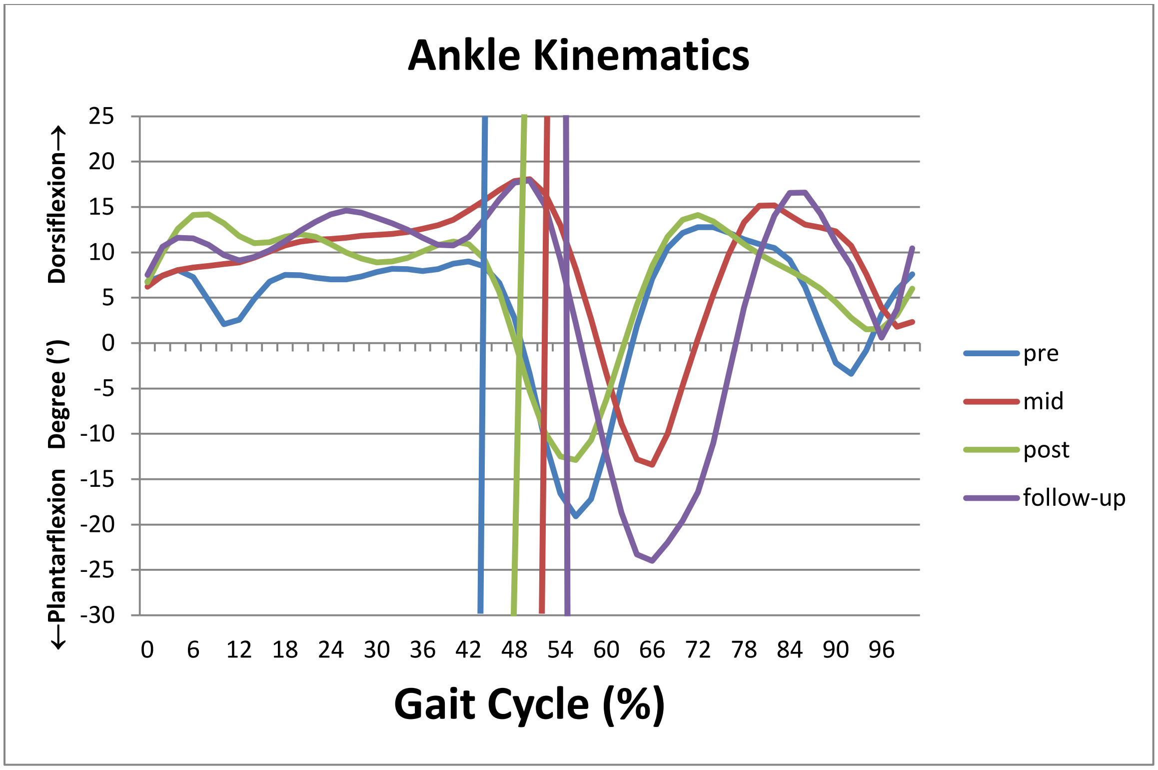

Figure 27. Ankle kinematics for participant 4.

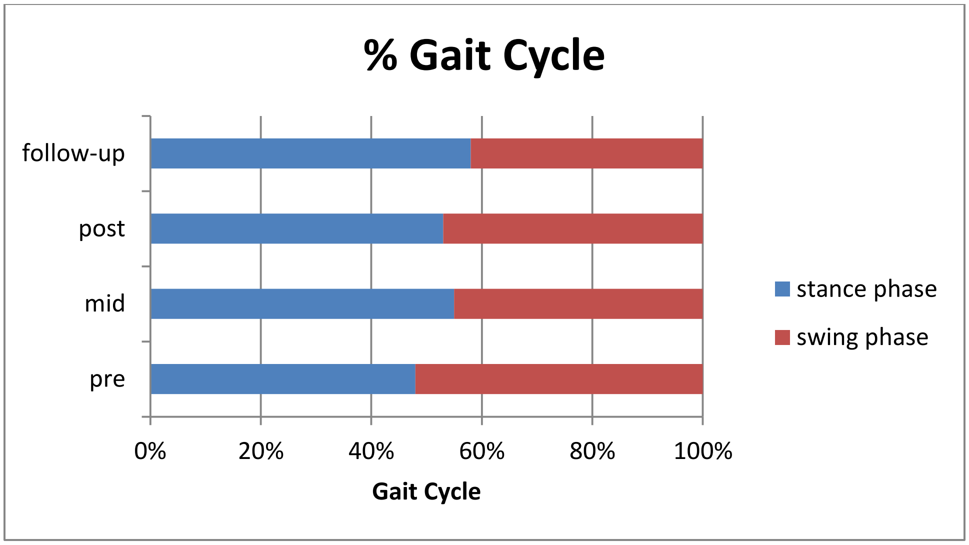

Figure 28. Stance & swing % for participant 4.

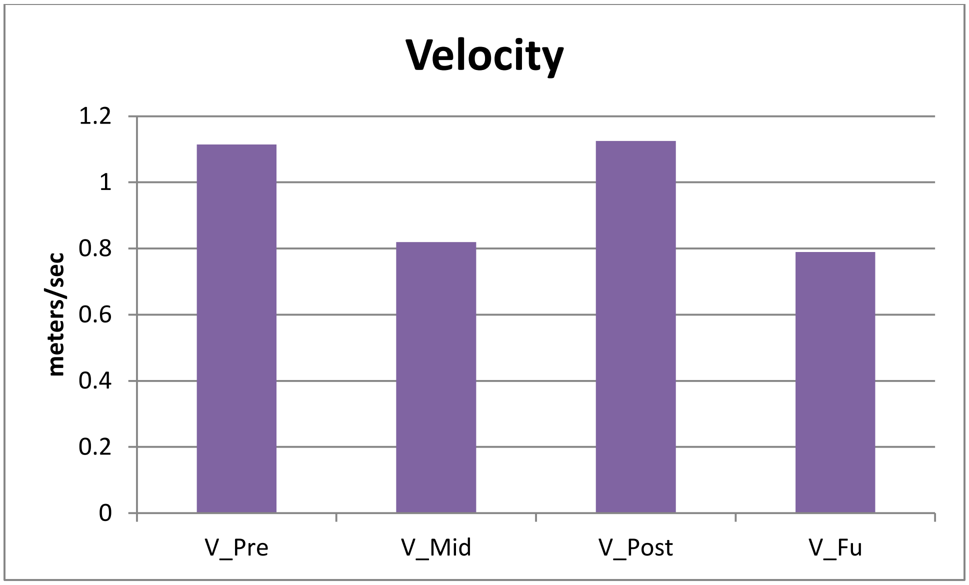

Figure 29. Velocity for participant 4.

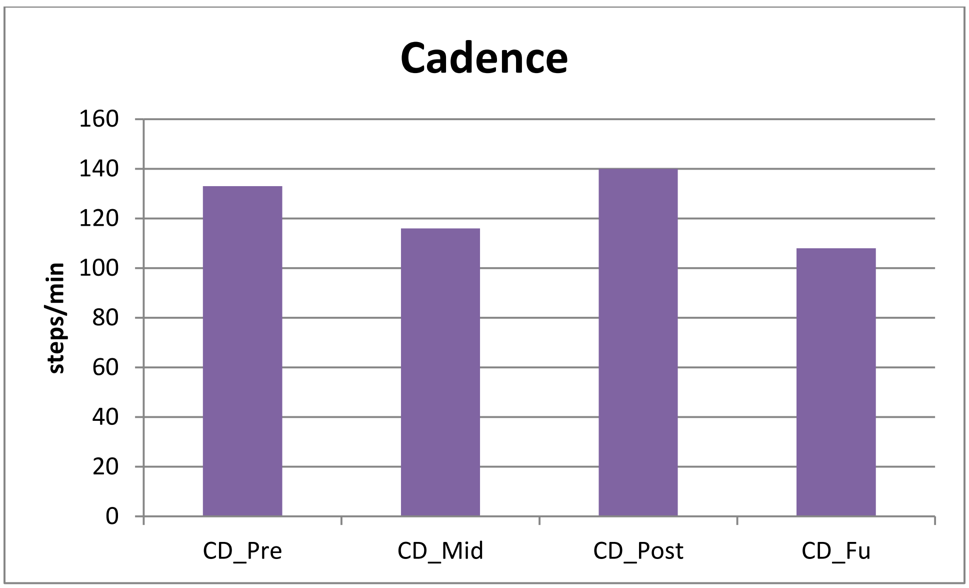

Figure 30. Cadence for participant 4.

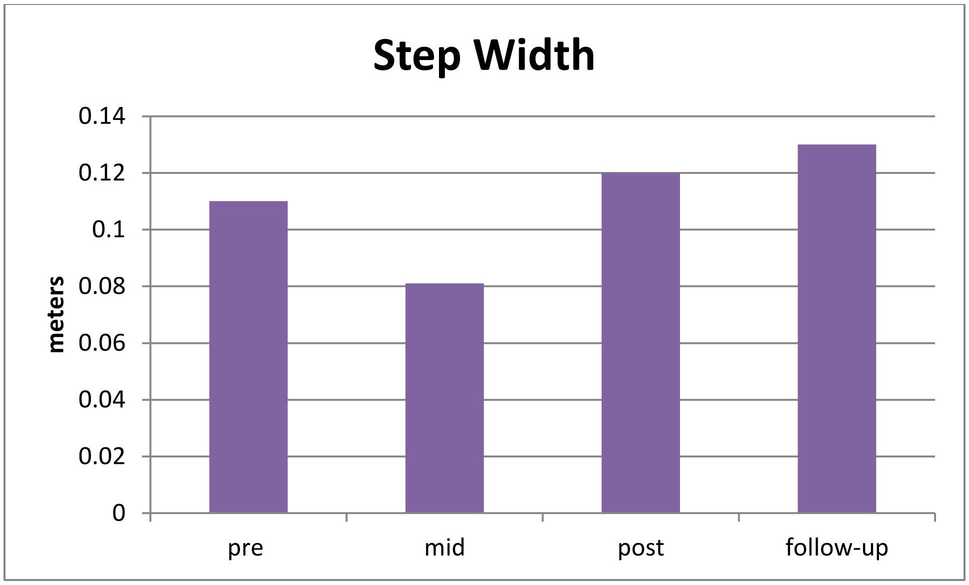

Figure 31. Step width for participant 4.

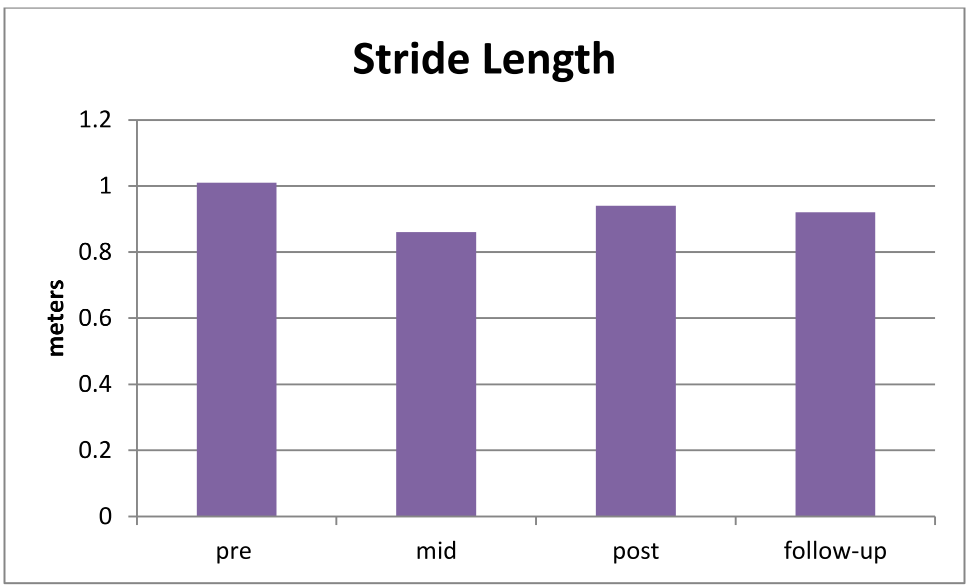

Figure 32. Stride length for participant 4.

DISCUSSION

The purpose of this study was to investigate the effects of a 6-week aquatic group exercise program on gait outcomes in children with CP. It was hypothesized that the 6-week aquatic intervention would improve hip knee and ankle kinematics as well as spatial temporal variables (velocity, cadence, stance and swing phase, stride length, and step width).

Participant 1 revealed no characteristics of crouch gait in hip joint during this study. However, slap foot was noticeable during participant's pre-intervention evaluation. Slap foot typically occurs when the person's pretibial muscles (particularly the anterior tibialas) are weak and the individual does not have the strength to control the slowing down effect of plantar flexors during initial contact and loading response at the beginning of the gait cycle (Perry, J. &Burnfeild, 2010). Aquatic exercise may have increased in strength of the participant's anterior tibalis muscle due to a smoother heel rocker transition in plantar flexion during initial contact at mid intervention and was maintained throughout post and 7-week follow up intervention (Figure 3).

Although velocity decreased in accordance to his/her step length decreasing, participant 1 displayed wider steps when walking and emphasizing on a much wider base of support (Figure 7). Eek et al. (2008) suggested that increase of base of support during walking increases stability in stance phase during gait cycle and makes it easier for the ankle plantar flexors to push off actively. Our findings indicate that aquatic exercise can help facilitate how to walk properly with an appropriate base of support which helps with his/her slap foot during initial contact. In addition, Liao et al. (2007) states that the benefit of a muscle strengthening program on gait speed depends on the targeting specific muscles, in which this present study was not specifically designed for. The present study targeted walking ability as a whole and concentrated on walking ability for each individual. Although there was no test that the participant was cognitively aware of their walking ability, the decrease in velocity with a much wider base of support during walking can be assumed that the participant was a lot more careful in her walking throughout the intervention.

Participant 2 had tibial osteotomy, where surgical procedure takes place when the distal end of tibia and is severed on the lateral (open wedge osteotomy) or medial (closing wedge osteotomy) of the tibia to realign the angles of the lower leg. Participant's tibialosteotomy 6 years prior to this study have decreased alignment in the frontal view. However, this present study looked at sagittal plane kinematics. The participant's regular standing stance favored the right side due to pain and weakness on the participant's contracted plantar-flexed left foot. Favoring all of her weight onto the right side, the left foot is plantar flexed during her regular standing posture as well as during walking. Perry et al. (2010) states, individuals with muscle weakness can modify the timing of muscle action to avoid threatening postures and induce protective alignment during stance. An increased plantar flexion may have had an exaggerated hip and knee flexion during mid-swing of the gait cycle for the foot to clear during mid-swing, which is demonstrated in her kinematic graphs (Figure 9 & Figure 10). The added flexion can carry over into terminal swing but would not persist as the limb approached the floor, in which this participant experiences. Our outcomes indicate that hip and knee flexion decreased and was retained post intervention. However, 7-week follow-up, hip flexion and knee flexion increased over time. This present study illustrates that aquatic exercises have improved walking ability by possibly strengthening the participant's hamstrings that might have countered the rapid hip and knee flexion during mid-swing.

All other spatial-temporal variables measured for participant 2 displayed fluctuations throughout the intervention except for a decreasing trend in step width. In this particular case, the participant's age had passed the participant's growth spurt. Although maturation may improve a child's developmental growth, it may also affect it adversely. Development not only affects treatment of these children but also may complicate measurement of treatment outcomes. Therefore, there were no trends in the participant's spatial temporal variables due to her development. However, the participant presented a trend in decreasing the step width pre to post intervention and retaining its effects (Figure 15). In contrast to participant 1 and their increase in step width, participant 2 showed a decrease in their base of support in their walking indicating an effect of improving their balance while walking. Narrowing base of support can imply an improvement in balance systems in deviated walking which shows in this present study.

Participant 3, after baseline data, display normal ranges in hip, knee, and ankle kinematics at mid to post intervention (Figure 17-19). However, the changes did not retain during follow-up intervention. In this case, aquatic exercise may have increased gains in muscular strength in all muscle groups that assists in a person’s walking ability. It appears that the participant developed an effective way of clearing the leg during the swing phase by decreasing hip extension, knee flexion, and increasing plantar flexion. Additionally, typical gait cycle consists of 60% stance phase and 40% swing phase.

Participant 3 displayed an increase in stance phase during the gait cycle and reached ranges of typical gait cycle phases (Figure 20). However, the participant did not retain its effect during follow-up intervention.

Participant 4 showed an excessive plantar flexion during pre to initial swing possibly due to his jump knee and equinus gait in which the participant experiences muscle tone and spasticity. The participant's foot did not seem generate enough strength to clear the ground and into dorsiflexion (Figure 27). Equinus gait can be observed as initial swing that causes tripping as advancement of the limb is delayed. Perry et al. (2010) states that if the foot cannot reach its forward position to receive the advancing body weight, the subject will fall. With an increase in plantar flexion during swing phase, excess knee flexion would have to occur for the whole leg to propel through the swing phase of the gait cycle. Overall, aquatic exercise has contributed to an increase in strength of the anterior tibialas muscle. Thus, decreasing the amount of plantar flexion used to clear the ground, and decreasing the amount of knee flexion used during pre to initial swing phase. In addition, parents of this participant stated that the participant did not rely on assistive device on transportation and was able to walk with decreased fall incidences.

CONCLUSION

Aquatic therapists and clinicians in rehabilitation can use our findings when utilizing an aquatic exercise program for populations with CP or other similar neurological disorders. Clinicians are encouraged to incorporate the use of aquatic exercise program to their gait rehabilitation regimen for children with CP. Overall, exercise and physical activity are beneficial for children with and without disability to promote health. The use of an aquatic environment can be an alternative source to getting children with disabilities more physically active, which can prevent obesity and other complications associated with inactivity. Due to the nature of this preliminary case study, we suggest that future studies should involve a randomized control study with a larger sample size. In addition, Gross Motor Function Measure (GMFM) can be used to correlate gait outcomes in future studies.

In summary, our case study outcomes suggest that group aquatic exercise can be beneficial for children with mild to moderate CP. Our findings also suggest that the effects of aquatic exercise may vary from individual to individual considering the large variability of physical conditions among children with CP. Clinicians can take such individualizing into consideration as they develop aquatic exercise programs for children with CP.

REFERENCES

Balaban, B. , Yasar, E. , Dal, U. , Yazicioglu, K. , Mohur, H. , et al. (2007). The effect of hinged ankle-foot orthosis on gait and energy expenditure in spastic hemiplegic cerebral palsy. Disability & Rehabilitation, 29(2), 139-144.

Blundell, S. , Shepherd, R. , Dean, C. , Adams, R. , & Cahill, B. (2003). Functional strength training in cerebral palsy: A pilot study of a group circuit training class for children aged 4-8 years. Clin Rehabil, 17(1), 48.

Chambers, H. (2001). Treatment of functional limitations at the knee in ambulatory children with cerebral palsy. Eur J Neurol, 8 Suppl 5, 59.

Cogher, L. , Savage, E. , & Smith, M.F. (1992). Cerebral Palsy: the Child and Young Person. Cambridge, University Press.

Davids, J. , Ounpuu, S. , DeLuca, P. , & Davis, R. (2004). Optimization of walking ability of children with cerebral palsy. Instr Course Lect, 53, 511.

Eek, M. , Tranberg, R. , Zügner, R. , Alkema, K. , & Beckung, E. (2008). Muscle strength training to improve gait function in children with cerebral palsy. Dev Med Child Neurol, 50(10), 759.

Engsberg, J.R. , Ross, S. , Olree, K. , & Park, T. (2000). Ankle spasticity and strength in children with spastic diplegic cerebral palsy. Deveopmental Med & Child Neurology, 42, 42-47.

Fragala-Pinkham, M. , Haley, S. , & O'neil, M. (2008). Group aquatic exercise for children with disabilities. Developmental Medicine & Childe Neurology, 50, 822-827.

Gage, J.R. (2004). The Treatments of Gait Problems in Cerebral Palsy. St. Paul, Minnesota. Mac Keith Press.

Hinhcliffe, A. (2003). Children with Cerebral Palsy: A Manual for Therapists, Parents and Community Workers. ITDG Publishing.

Hutzler, Y. , Chacham, A., Bergman, U. , & Szeinber, A. (1998). Effects of a movement and swimming program on vital capacity and water orientation skills of children with cerebral palsy. Developmental Medicine & Child Neurology, 40, 176-181.

Kelly, M. & Darrah, J. (2005). Aquatic exercise for children with cerebral palsy. Developmental Medicine & Child Neurology, 47(12), 838-842.

Lee, J. , Sung, I. , & Yoo, J. (2008). Therapeutic effects of strengthening exercise on gait function of cerebral palsy. Disabil Rehabil, 30(19), 1439.

LePage, C. , Noreau, L. , & Bernard, P.M. (1998). Association between characteristics of locomotion and accomplishment of life habits in children with cerebral palsy. Physical Therapy, 78, 458.

Liao, H. , Liu, Y. , Liu, W. , & Lin, Y. (2007). Effectiveness of loaded sit-to-stand resistance exrcise for children with mild spastic deplegia: A randomized clinical trial. Arch Phys Med Regabil, 88, 25-30.

Lin, C. , Guo, L. , Su, F. , Chou, Y. , & Cherng, R. (2000). Common abnormal kinetic patterns of the knee in gait in spastic diplegia of cerebral palsy. Gait Posture, 11(3), 224.

O'Byrne, J. , Jenkinson, A. , & O'Brien, T. (1998). Quantitative analysis and classification of gait patterns in cerebral palsy using a three-dimensional motion analyzer. J Child Neurol, 13(3), 101.

Panteliadis, C.P. , & Strassburg, H.M. , (2004). Cerebral Palsy: Principles and Management. Stuttgart, New York. Georg Thieme Verlog.

Park, E. , Park, C. , & Kim, J. (2001). Comparison of anterior and posterior walkers with respect to gait parameters and energy expenditure of children with spastic diplegic cerebral palsy. Yonsei Med J, 42(2), 180.

Scholtes, V. , Becher, J. , Comuth, A. , Dekkers, H. , Van Dijk, L. , et al. (2010). Effectiveness of functional progressive resistance exercise strength training on muscle strength and mobility in children with cerebral palsy: A randomized controlled trial. Dev Med Child Neurol, 52(6), e107.

Steinbok, P. (2001). Outcomes after selective dorsal rhizotomy for spastic cerebral palsy. Child's Nerv Syst, 17: 1-18.

Unger, M. , Faure, M. , & Frieg, A. (2006). Strength training in adolescent learners with cerebral palsy: A randomized controlled trial. Clinical Rehabilitation, 20(6), 469-477.

Verschuren, O. , Ketelaar, M. , Gorter, J. , Helders, P. , Uiterwaal, C. , et al. (2007). Exercise training program in children and adolescents with cerebral palsy: A randomized controlled trial. Arch Pediatr Adolesc Med, 161(11), 1075.

Winters, T.F. , Gage, J.R. , & Hicks, R. (2010). Gait pattern in spastic hemiplegia in children and young adults. J. Bone Joint Surg Am, 69(3), 437.

Woollacott, M. , & Shumway-Cook, A. (2005). Postural dysfunction during standing and walking in children with cerebral palsy: What are the underlying problems and what new therapies might improve balance. Neural Plasticity, 12(2-3), 211-219.

Wu, Y. , Ren, Y. , Goldsmith, A. , Gaebler, D. , Liu, S. , et al. (2010). Characterization of spasticity in cerebral palsy: Dependence of catch angle on velocity. Developmental Medicine & Child Neurology, 52(6), 563-569.

APPENDIX A

MEDICAL RELEASE FORM

Name of Client: ____ DOB__________

(Print) Last Name First Name

To: Attending Physician

The Center of Achievement for the Physically Disabled is designing an exercise program for your patient. The program may include exercises for improved muscular strength, range of motion, cardiovascular endurance, posture and balance.

The Center of Achievement requests that you provide any medical information, which would affect the selection of activities. All medical records will be handled in strict confidence. Thank you for your assistance.**Please complete items I, II, & III below as applicable:**

I. Primary Physical Disability:

____

Secondary Medical Diagnosis: ____

II. Client is **medically cleared** for the following program(s):

❑ **Land Based Exercise**	❑ **Aquatic Based Exercise**	❑ **Both Land Based & Aquatic**	❑ **None**

Patient **IS NOT CLEARED**for the following exercises:**LAND BASED EXERCISE PROGRAM**	Patient **IS NOT CLEARED** for the following exercises**:**AQUATIC BASED EXERCISE PROGRAM
❑ No Strength Training Exercises	❑ No Strength Training Exercises
❑ No Partial Weight Bearing (i.e. tilt table)	❑ No Assistive Weight Bearing
❑ No Stretching Exercises Active/Passive	❑ No Stretching Exercises Active/Passive
❑ No Cardiovascular Exercise	❑ No Cardiovascular Exercise
	❑ No Submersion
	❑ No Deep Water Exercise

III. Please give a brief explanation for above restrictions and/or your recommendations.(Example Max Working Heart Rate)____**Physician's Signature:** ____, **M.D. Date:** ___________ **Print Name**: ________________________________**Phone:** (___)_____________ **FAX:** (___)________

18111 Nordhoff Street, Northridge, CA 91330-8287
Phone (818) 677-2182 Fax (818) 677-3246

Reviewed by _________

APPENDIX B

California State University, Northridge

CHILD ASSENT TO BE IN A HUMAN RESEARCH PROJECT

Effects of Aquatic Exercise on Gait and Balance in Children with Cerebral Palsy

This paper explains a research project. The people doing the research would like your help, but they want you to know exactly what this means. Participating in this project is your choice. Please read about the project below. Feel free to ask questions about anything that you do not understand before deciding if you want to participate. A person connected to the research will be around to answer your questions.

Informal Title of the study – How water exercise can help you walk and stand better

Formal Title: Effects of Aquatic Exercise on Gait and Balance in Children with Cerebral Palsy

RESEARCH TEAM

Name and Title of Researcher: Robert De La Cruz, Graduate Teaching Assistant

Department: Kinesiology

Telephone Number: (818) 677-2182

Name and Title of Faculty Advisor:Dr. Taeyou Jung

Department: Kinesiology

Telephone Number: (818) 677-2182

Study Location(s): Center of Achievement through Adapted Physical Activity, California State University, Northridge

YOU ARE HERE BECAUSE….

We want to study how water exercise can help you walk and stand better. We want to see if you would like to be in our study.

WHY ARE THEY DOING THIS PROJECT?

Dr. Jung, Mr. De La Cruz, and some other researchers are doing this research project to learn more about how the pool exercises might help you stand and walk better.

WHAT WILL HAPPEN IN THE PROJECT?

These things will happen if you want to be in the study:

1.) When you say yes to help us, you will be asked to do exercises at home or in the pool 3 times a week for 12 weeks. Before and after the 12 weeks of exercise, you will be tested for standing and walking.

2.) When you come to our center for our study, you will be asked to stand still on a square metal plate for the standing test and walk on a path a few times for the walking test. We will tell you more about what to do when you get to the center.

3.) When you are doing the standing test, you will wear a safety vest to make sure you do not fall. You will be asked to stand still on the metal plate while you are given directions such as closing your eyes or moving your body from side-to-side. During some of the tests, the plate that you are standing on might wobble. The computer will trace how your body moves while you are trying to stand still. You will be able to sit down and rest after each test.

4.) When you are tested for walking, you will be asked to change into tight fitting bike shorts. We will measure how tall you are, how much you weigh, and how you're your legs are. Shiny stickers will be put on your skin. You will be asked to walk on a path a few times while the cameras record your walking. You will be able to sit down to rest after each time you walk.

5.) If you are told to exercise in the pool, you will workout for 40-minutes in the water 3 times a week for 12 weeks. You will do some stretching, walking, standing exercises, and fun games. A teacher and a lifeguard will be there to help you.

6.) If you are told to exercise at home, you will workout for 40-minutes at home with your parent/guardian 3 times a week for 12 weeks. You will do some stretching, walking, standing exercises, and fun games with your parent/guardian.

You might feel bored, tired, thirsty, and pain in your legs and/or chest. Before you do any of the exercise, your doctor will need to say that it is okay for you to exercise. You will have breaks to rest will be asked to drink plenty of water to keep you from being thirsty.

IF YOU HAVE ANY QUESTIONS

You can ask questions any time. You can ask now or you can ask later. You can talk to the researchers, your family or someone else in charge. It is important that you know what is going on.

DO YOU WANT TO BE IN THE PROJECT?

No

You do not have to be in the study. No one will be upset with you if you don't want to do this. If you don't want to be in this study, or if you want to skip a question that is hard or confusing, that's fine. Just tell the researchers and they won't get upset.

Yes

If you want to be in the study sign your name below. You can say yes now and say no later. It is up to you to decide.

______________________________ ____________________ ____________

Signature of Child Age Date

______________________________ ____________

Signature of Researcher Date

______________________________ ____________

Signature of Individual Obtaining Assent Date

If different from researcher