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The Benefits of Riding an Adaptive Tricycle for Toddlers with Cerebral Palsy

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Introduction

Children diagnosed with cerebral palsy (CP) typically present with coordination, postural control, and motor impairments that can drastically affect their quality of life. Children with cerebral palsy may have neglect unilaterally or have difficulty using both upper extremities to perform bimanual coordination tasks. Children generally are not diagnosed with CP until twelve months of age due to physicians caution in ensuring an appropriate diagnosis.[1] Cerebral palsy is the leading cause of childhood disability and represents the most frequent diagnosis of children who receive physical therapy.[2] Physical therapists play a central role in helping manage cerebral palsy by gearing the child's therapy towards function and movement, thus enabling optimal use of the child's potential.

Current research supports the use of functional intervention for children with cerebral palsy.[3] When compared to the normalization of movement method common to physical therapy, functional intervention demonstrates higher scores on outcome measures such as the Gross Motor Function Measure. Taub et al.[4] showed that constraint-induced movement therapy improved motor impairments and function following three weeks of treatment. Emphasizing the use of the more involved extremity allows the child to utilize both extremities in order to improve their quality of movement. Hung et al.[5] performed a study with directed tasks which demonstrated a positive correlation between speed and coordination. These results show that children in functional environments can improve their coordination bimanually. With directed tasks, a correlation between speed and coordination may allow children with cerebral palsy to perform bimanual tasks more efficiently.[5] Children with cerebral palsy who practice a whole task approach with bimanual training, also show changes in the mapping of their motor control and increased cortical excitability.[6] This evidence demonstrates the importance of emphasizing functional activities during treatment to improve coordination and motor abilities.

Fowler et al.[7] demonstrated that cycling incorporates bimanual training in a functional setting to improve coordination, postural control, gross motor function, and cardiovascular fitness in children with cerebral palsy. Cycling has also shown trends of providing benefits that help combat deconditioning that often occurs in children with CP due to their decreased capacity to participate in play and other activities.[8] Cycling strengthen the musculature of the hips, knees, and ankles, while also improving cardiopulmonary fitness in the individual. Although research is limited on the use of cycling as an intervention for children with CP, benefits have been found to include improvements in locomotion endurance, gross motor function, and muscle strengthening.[8] Cycling may also promote motor coordination, independence, and self-esteem.[9] These improvements have also been found in children with severe physical disabilities.[8] Cycling is considered a relatively safe and effective intervention for this population because there is little dependence on balance, coordination, and motor control which decreases injury and fall risk.[8]

With this evidence, AmTryke, a national non-profit service organization dedicated to creating mobility and independence for people with disabilities, has developed adaptive tricycles to be utilized by children with cerebral palsy to improve their coordination, motor function, and postural control.[9]AmTryke specifically developed tricycles to incorporate aspects of bimanual tasks, cycling, and constraint-induced therapy as a way to improve the mobility of children with CP. The foot and hand pedals aid in bimanual movements, the straps that can be applied to the hands and feet incorporate constraint-induced movement principles, and the act of riding a tricycle is functional for a toddler.[9] Arndorfer et al.[9] performed a study using AmTryke tricycles to discover how this treatment would impact the gross motor function of children ages seven to thirteen with cerebral palsy. The researchers did find positive trends in the reduction of time taken to complete specified upper extremity tasks and saw improvements in functional task completion and range of motion with the use of the Gross Motor Function Measure. This study also incorporated parents' perceptions through the use of a questionnaire and all of the parents included saw improvements of their child's ability to function at home.

The research on cycling interventions for children with cerebral palsy is limited. It is unclear how an early intervention cycling treatment would impact growth and development of toddlers, as many of the studies do not focus on this population. Instead, the studies have been performed on older children. Arndorfer et al.[9] discussed the need for a more consistent riding time as well as the use of more standardized functional measures for assessing bimanual coordination. Additional research on the use of adaptive tricycles for children with cerebral palsy will help determine the degree of evidence for positive outcomes in the function status of children with cerebral palsy.

Methods

Purpose/Recruitment

The purpose of this current study was to determine if similar results as seen in the study by Arndorferet al[9] could be seen in a younger population of children with cerebral palsy and to expand on the outcome measures used in determining the benefits of cycling in this population. To recruit participants, a flier describing the study was given to local pediatricians and pediatric physical therapy offices within the Lynchburg community. Additional fliers were provided to therapists and student physical therapists to hand out to families of potential participants.

Interested families were instructed to contact the faculty advisor by phone or email. Once contacted, the faculty advisor described the study and answered any questions. Participants were screened by the faculty advisor over the phone or via email to determine if they met the inclusion criteria for the study. The study was also discussed in more detail at this time to ensure that potential participants were fully aware of the time commitment.

Participants

Participants were included if they met the following inclusion criteria: between the ages of two and four years old, an established diagnosis of cerebral palsy, and available transportation to and from the Lynchburg College Health Sciences Building. If the child met the inclusion criteria and the family wanted to participate, the faculty advisor arranged a meeting with the guardian and child at their convenience at the Lynchburg College Health Sciences Building to begin baseline data collection. At the initial meeting, the faculty advisor reviewed the Informed Consent Agreement, the Child's Assent form, Riding Log, and Consent to Record form with the guardian to address all components of the study. Each participant was assigned a unique numerical identifier. This unique identifier was used on the Data Collection form, the Riding Log, the PEDI, and the GMFM-66. The faculty advisor kept a list of the names and assigned numerical identifiers in a locked filing cabinet. The screening form was used to record this information.

Baseline Measurements

Following the recruitment and signing of the Informed Consent Agreement for Guardians and the Child's Assent form, guardians of children with cerebral palsy completed The Pediatric

Evaluation of Disability Inventory (PEDI). This is a questionnaire regarding the level of assistance a child needs to perform activities of daily living (ADLs). Guardians were also encouraged to enlist in the Amtryke Riders Club (www.amtrykeridersclub.org). For a period of two to five weeks, the researchers collected baseline information on the children included in the study. Children were randomly assigned to either a two, three or five week minimum baseline period. A minimum of three measurement sessions occurred throughout the baseline period to determine the stability of certain measures. Measurements also occurred at the start of each intervention period, week 4, week 8, and four weeks following the conclusion of the intervention. Outcome measures in all measurement sessions included: goniometric measurement of passive elbow flexion/extension, knee flexion/extension and ankle dorsiflexion/plantarflexion, the modified Ashworth Scale of the upper and lower extremities, limb circumference, the grasping and visual motor integration sections of the Peabody Developmental Motor Scale (PDMS-2*)* and the Gross Motor Function Measure (GMFM-66). A data collection form was used to record goniometric measurements and ratings using the modified Ashworth Scale. All measurement sessions occurred at the Lynchburg College Health Sciences Building.

At the beginning of the baseline period, each child was measured and fit for an Amtryke. They were given the opportunity to ride the tricycles during the baseline sessions in order to get acquainted with the tricycle. If at any point during this period, or any other time throughout the study, the child was resistant to the tricycle or their parents did not wish for them to partake in the study because they did not feel that their child was enjoying the tricycle, the child was allowed to withdrawal from the study without any consequences. Once baseline was completed, implementation of the intervention period began. No children withdrew from the study.

Intervention

The intervention period took place over eight weeks. The children and their guardians were given an appropriately sized AmTryke to take home. Each participant’s family was encouraged to have their child on the bike, riding with the least amount of assistance necessary, for sessions that last approximately 30 minutes for a minimum of three times a week. The amount of time spent with the child pedaling the tricycle and the amount of assistance provided by the parent was recorded in the parent’s riding log. Ambucs provided each child with a pedometer for the bicycle. This will be used to triangulate the information on the Riding Log.

The researchers made sure primary safety precautions were met by providing each child with a properly fitted helmet and educating the child and caregivers on the importance of bike safety. In order to ensure as little harm as possible in the event that the child may fall off of the tricycle, the researchers made sure that primary safety precautions were met. These safety precautions included: educating the caregivers on the importance of wearing a helmet, fastening the seat belt, guarding the child while they climb on or off of the tricycle and using proper body mechanics while placing the child on or off of the Amtryke. The children were asked to place their hands on the hand-pedals and feet on the feet pedals. If a child was unable to maintain this position during riding, a velcro strap was applied to either their hands or feet. An adult was instructed to remain within arms-distance on either side of the tricycle as the child rode independently. For a child who was unable to ride independently, the adult was allowed to propel the tricycle via a push-bar on the back of the AmTryke.

If the child was unable to climb on the AmTryke independently, the researchers demonstrated proper body mechanics for the caregivers to use while placing the child onto or removing them off of the Amtryke. The children continued their regular therapeutic services in addition to the intervention in this study. These services were documented on the data collection form and monitored for any changes during the course of the study. Possible benefits to the children included improved strength and endurance, improved limb function and mobility, an increased motivation to play and be active, and an improved quality of life. Parents could potentially benefit from the improvement in quality of life their child may receive from this intervention.

After the follow-up period ended, the families kept the AmTryke if desired. If they did not wish to continue with the riding program, it was suggested that they return the AmTryke to Wheels on the James so that another child may benefit from tricycle riding.

Participant Descriptions

Participant One

Participant one was a two year old girl with a diagnosis of cerebral palsy. At baseline, she presented with mild to moderate increase in muscle tone for bilateral knee flexors, ankle plantarflexors, biceps, and shoulder extensors. Her range of motion was within functional limits except for a few restrictions with bilateral ankle dorsiflexion and popliteal angle measurements (see graph for values). Her baseline Peabody quotient for the Grasping and Visual-Motor Integration sections was 8% placing her in the sixteenth percentile for her age group. Her gross motor skills for lying and rolling fell within the 94%-96% for her age group, according to the Gross Motor Function Measure (GMFM-66). Her gross motor skills for sitting fell within the 35%-43% for her age group, according to the GMFM-66. For crawling and kneeling, her gross motor skills fell within 7% for her age group, according to the GMFM-66. Throughout the intervention period, she received physical therapy once a week and early intervention services once a month.

Participant Two

Participant two was a three year old girl with a diagnosis of cerebral palsy. She presented with greater involvement on her left side as compared to the right. At baseline, she presented with varying tone with greater involvement of the left upper and lower extremities. Her range of motion was within normal limits with the exception of her popliteal angle and ankle dorsiflexion on the left (see graph for values). Her baseline Peabody quotient for the Grasping and Visual-Motor Integration sections was 43 placing her in the less than 1 percentile for her age group. Her gross motor skills for lying and rolling fell within the 35% of her age group, according to the GMFM-66. Her past medical history included: history of seizures, cortical-visual impairment, and traumatic brain injury (TBI). She received both physical and occupational therapy services throughout the intervention period.

Participant Three

Participant three was a three year five month old girl with spastic hemiplegia and a GMFCS Level I. She presented with right-sided hemiparesis and wore an ankle foot orthotic (AFO) on the right foot. At baseline, she presented with increased muscle tone in elbow flexors and extensors, pronators, and ankle plantarflexors. Her range of motion was within normal limits with the exception of her popliteal angle and shoulder flexion on the right (see graph for details). Her baseline Peabody quotient for the Grasping and Visual-Motor Integration sections fell within 79, placing her in the 8^{th} percentile for her age group. Her gross motor skills for walking, running, and jumping fell within the 60^{th} percentile for her age group, according to the GMFM-66. Her past medical history included: TBI, seizures, and microcephaly. Throughout the intervention period, she received speech, physical, and occupational therapy services.

Participant Four

Participant four was a 40-month-old girl, diagnosed with spastic hemiplegia in 2010 and a GMFCS Level I. She presented with left-sided hemiparesis and wore an AFO and a wrist splint on the left side. At baseline, the subject presented with mild to moderate increase in muscle tone for both her upper and lower extremities on the left side. Range of motion was within normal limits with the exception of popliteal angle, ankle dorsiflexion, and wrist supination (see graph for values). Baseline Peabody quotient for the Grasping and Visual-Motor Integration sections fell between 94 and 97, placing her in the 35%-42% for her age group. Her gross motor skills for walking, running and jumping fell within the 67%-69% for her age group, according to the GMFM-66. Past medical history included seizures that began in July of 2011, with her most recent one in June of 2012. Throughout the intervention period, the participant received speech, physical, and occupational therapy in an outpatient setting. The subject received each service once a week for 60 minutes per session.

Results

Data Analysis

The data was collected and analyzed for each participant. Measurements of ROM, tone, limb circumference, GMFM-66, and Peabody scores were recorded in table format and plotted on graphs. Visual analysis was used to compare the results of each measurement for each participant to determine the effectiveness of the use of Amytrke tricycles on bimanual tasks, motor tasks, and ROM. Quotients were obtained for the GMFM-66 as well as the grasping and visual-motor integration sections of the Peabody to determine the degree of improvement of an objective outcome measure, after the completion of the intervention period. The scores of the subjects in the study were compared to the norm based on their age group.

Table 1. Baseline and follow-up data for child #1.

Left LE ROM	Popliteal Angle	60°	60°	60°	62°	70°	70°
	Ankle Dorsiflexion	-10°	-10°	-10°	-5°	5°	5°
Right LE ROM	Popliteal Angle	50°	55°	58°	55°	65°	65°
	Ankle Dorsiflexion	-10°	-10°	-8°	-6°	5°	5°
Left Modified Ashworth Scores	Shoulder Extensors	2	2	2	2	1	1
	Elbow Flexors	2	2	2	2	1	1
	Wrist Supinators	2	2	1	1	0	0
	Knee Flexors	2	2	2	2	1	1
	Ankle Plantarflexors	3	3	3	3	3	3
Right Modified Ashworth Scores	Shoulder Extensors	2	2	2	2	0	0
	Elbow Flexors	2	2	2	2	1	1

	Knee Flexors Ankle Plantarflexors	2 3	2 2	2 2	2 3	1 2	1 2
GMFM-66 Percentiles	Lying & Rolling Sitting Crawling & Kneeling	96% 35% 7%	96% 35% 7%	94% 43% 7%	94% 43% 7%	94% 45% 7%	94% 45% 7%
PDMS-2 Quotients		8%	8%	8%	8%%	21%	21%
		Visit 1	Visit 2	Visit 3	Visit 4	Visit 5	Visit 6
		Baseline			**Follow-up**		

Table 2. Baseline and follow-up data for child #2.

Left LE ROM	Popliteal Angle Ankle Dorsiflexion	44° 10°	65° 10°	55° 12°	50° 15°	65° 18°
Left Modified Ashworth Scores	Shoulder Flexors Elbow Flexors Elbow Extensors Wrist Flexors Finger Flexors Knee Extensors Ankle Plantarflexors	2 2 2 2 2 2 2	1+ 2 1+ 1 1 0 2	1+ 1+ 2 1 0 1 2	1 1+ 1+ 1 0 1 1	1 1+ 1 1 0 1 1
	Elbow Flexors Elbow Extensors Finger Flexors	0 0 0	1 1 1	1 0 1	0 1 0	0 0 0
GMFM-66 Percentiles	Lying & Rolling	27%	33%	35%	33%	35%
PDMS-2 Quotients		1%	1%	1%	1%	1%
		Visit 1	Visit 2	Visit 3	Visit 4	Visit 5
		Baseline			**Follow-up**	

Table 3. Baseline and follow-up data for child #3.

Left LE ROM	Popliteal Angle Ankle Dorsiflexion	0° WFL	0° WFL	0° WFL	0° WFL
Right LE ROM	Popliteal Angle Ankle Dorsiflexion (knee extended) Ankle Dorsiflexion (knee flexed)	35° 0° 10°	40° 0° 20°	30° 10° 20°	25° 10° 12°
Right UE ROM	Shoulder Flexion Supination	150° 70°	150° 70°	150° 75°	150° 85°

Right Modified Ashworth Scores	Shoulder Extensors Elbow Flexors Knee Flexors Ankle Plantarflexors Wrist Pronators	1+ 2 1 2 2	1+ 2 1+ 2 2	1+ 1+ 2 2 1+	1+ 1+ 1+ 1+ 1+
GMFM-66 Percentiles	Walking, Running, & Jumping	58%	60%	85%	89%
PDMS-2 Quotients		2%	5%	5%	5%
		Visit 1	Visit 2	Visit 3	Visit 4
		Baseline			**Follow-up**

Table 4. Baseline and follow-up data for child #4.

Left LE ROM	Popliteal Angle Ankle Dorsiflexion (knee extended) Ankle Dorsiflexion (knee flexed) Wrist supination Shoulder flexion	-20° -4° Neutral 70° 140°	-25° -5° -10° 70° 140°	-35° -5° -15° 70° 150°	0° -6° -10° 85° 180°	0° 10° 15° 90° 180°
Circumference	Left calf/Right calf Left Quad/Right Quad 2" up from mid patella 4" up from mid patella	8.75"/9" 11"/12" 13.5"/13.5"	9"/9.5" 11"/12.5" 12.5"/13.5"		9.5"/9.5" 11"/11.5" 13"/12.75"	9.5"/9.5" 11.5"/12" 12"/13"
Left Modified Ashworth Scores	Shoulder Extensors Elbow Flexors Wrist Pronators Knee Flexors Ankle Plantarflexors Hip Adductors	1+ 2 2 1+ 2 1+	1+ 2 2 1+ 2 1+	0 1+ 2 1+ 2 0	0 1+ 1+ 1+ 2 0	0 1+ 1+ 0 1+ 0
GMFM-66 Percentiles	Walking/Running/Jumping	67%	69%	67%	76.3%	84.7%
PDMS-2 Quotients		42%	35%	38%	35%	35%
		Visit 1	Visit 2	Visit 3	Visit 4	Visit 5
		Baseline			**Follow-up**	

Discussion

Child 1

At baseline (see Table 1), child one presented with bilateral hamstring and plantarflexor tightness. Tone was also increased bilaterally in the following muscle groups; shoulder extensors, elbow flexors, knee flexors and ankle plantarflexors. Increased tone was also noted in the child's left supinators. After the intervention period, the child's left popliteal angle increased from 60 degrees to 70 degrees, while the right popliteal angle increased from 50 degrees to 65 degrees. Both left and right ankle dorsiflexion improved from -10 degrees to 5 degrees. An improvement from a 2 to a 1 on the Modified Ashworth scale was noted for left shoulder extensors, left elbow flexors, and bilateral knee flexors. An improvement from a 2 to a 0 on the Modified Ashworth scale was noted for right shoulder extensors, right elbow flexors, and left wrist supinators. The child's tone in the left ankle plantarflexors improved from a 3 to a 2 on the Modified Ashworth scale. Following the intervention period, the child made improvements with fine motor skills as indicated by an increase in PDMS-2 scores from 79% at baseline to 88% at the end of the intervention period. The child continued to favor using her right hand when performing tasks, but pincer grasp and object manipulation were improved significantly; thus leading to an improvement in many fine motor skills such as stacking blocks and imitating specific brush strokes with a marker. An overall decrease in muscle tone throughout the upper extremity following the intervention may have been the source of this improved fine motor control. There was no significant increase in lying and rolling or crawling and kneeling scores on the GMFM-66 following the intervention, but sitting scores improved from 35% to 43% on the GMFM-66. Most notably, the child was able to maintain unsupported sitting while reaching for and manipulating objects with bilateral upper extremity. The ability to do so may have stemmed from improved lower extremity range of motion, as well as improved muscle tone in both lower and upper extremities. Though it was not tested, core control may have also been improved with tricycle riding. Peddling the tricycle with both arms and legs may have strengthened core musculature allowing the child to maintain a more stable sitting posture without the need for arm support.

Child 2

At baseline (see Table 2), child two presented with increased hamstring and plantarflexor tightness on the left side. Muscle tone was increased on the left side in the following muscle groups; shoulder flexors, wrist flexors, knee extensors, and ankle plantarflexors. Muscle tone was also increased bilaterally in the following muscle groups; elbow flexors, elbow extensors, and finger flexors. At 8 weeks, the child's left popliteal angle improved from an average of 55 degrees at baseline to 65 degrees. Results were inconsistent, however, as the child's impairments seemed to be consistent with her emotional status on a day to day basis. The child's left dorsiflexion, however, did improve from an average of 13 degrees at baseline to 18 degrees after 8 weeks of intervention. Muscle tone improved from a 2 to a 1+ on the Modified Ashworth scale for left elbow flexors. Tone also improved from a 2 to a 1 for the following muscle groups on the left side; shoulder flexors, elbow extensors, wrist flexors, knee extensors and ankle plantarflexors. Tone improved from a 1 to a 0 for bilateral finger flexors as well as right elbow flexors and extensors. As noted by GMFM-66 scores, lying and rolling was slightly improved from a 27% to a 35% for the child's age group. The child was able to consistently roll over her left side whereas she was unable to roll to either direction at baseline. The child had also improved in her ability to pull herself into sitting from a lying position as long as the therapist provided something for her to pull on. Head support also seemed to be improved following the intervention period. This may have been a result of the child being curious as to where she was while being pushed along on the tricycle. The child's emotional status, and therefore her participation with the therapists, was improved following the intervention period; it is unclear whether the tricycle riding had any influence on her emotional status or whether other factors improved her outlook.

Child 3
At baseline(see Table 3), child three exhibited increased hamstring tightness, plantarflexor tightness, and increased tone in bilateral upper extremities primarily in the elbow flexors and extensors on the right side. At final data collection, right ankle plantarflexor tone improved from a modified Ashworth score of 2 to a 1+. Wrist extension improved from a 1+ to a 0 and pronators improved from a 2 to a 1+. Girth measurements showed the left quadriceps increased by one inch compared to the right when measured two inches above the knee. Circumferential measures did not show a significant change from baseline to final measurements. When functional fine and gross motor skills were assessed, the patient exhibited left-sided dominance in single and bimanual tasks. After the course of eight weeks, the child demonstrated improvements in functional tasks in both the upper and lower extremities. Bimanual tasks such as reciprocal gait, stair negotiation as well as stepping over a knee-high barrier also demonstrated improvement. Visual motor tasks also improved including: building a ten cube tower, copying a circle and a cross, and building a train with the blocks. The child's GMFM-66 score improved from a baseline average of 59% to 85% at six weeks and 89% in eight weeks. When observed, the subject exhibited improvements in transitioning objects from the right and left hand with increased fluidity and limited hesitation. The mother of the child reported that initially the child required assistance to maneuver the tricycle 100% of the time. At eight weeks, the child only required occasional nudging 25% of the time and was able to maneuver the tricycle twenty feet independently on a flat, asphalt surface.

Child 4
At baseline(see Table 4) , child four demonstrated tightness in the hamstrings, plantarflexors, and supinators. The subject exhibited increased tone in plantarflexors, elbow flexors, elbow extensors, and pronators on the left side. Girth measurements two inches above the knee showed a one and a half inch difference, with right side greater than the left. At two inches below the popliteal fossa, the child exhibited a half inch difference with the right side greater. After eight weeks of riding the tricycle, the child showed significant improvements on the GMFM-66 score from 68% at baseline

to 76% at six weeks. The subject's major improvements were seen primarily with bilateral utilization of the lower extremities. The child was able to lead with the right and left lower extremities when stepping over objects and required minimal assistance to ascend stairs with a reciprocal gait pattern. While holding a rail, the child was able to perform stair negotiation with contact guard and a reciprocal gait pattern. The child exhibited improvement with stair negotiation as demonstrated with an increased willingness to participate because at baseline the child refused to attempt stairs without minimal to moderate assistance.

Limitations

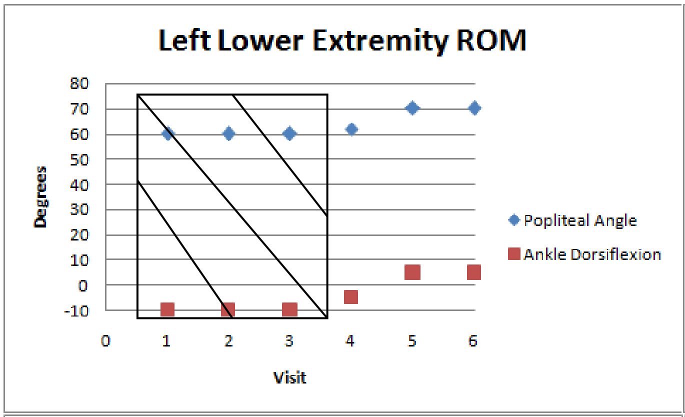
Limitations of the pilot study included: scheduling of the participants, variations in physical therapy services, changes in the lifestyle of the child including school changes, and the child's utilization of orthotics. During the study, it was difficult to record measurements at the same time for each participant due to scheduling conflicts with the families of the participants and the DPT coursework. Other limitations included: number of participants, variety of symptoms of each participant and the weather for the child to ride to tricycle on a regular basis during the intervention. Data of this study was collected in the cooler fall months, and some parents reported the subject not getting outside to ride as often due to the weather.

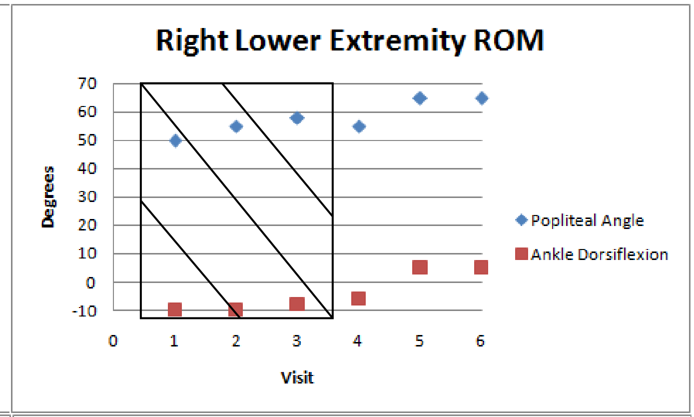
Conclusion

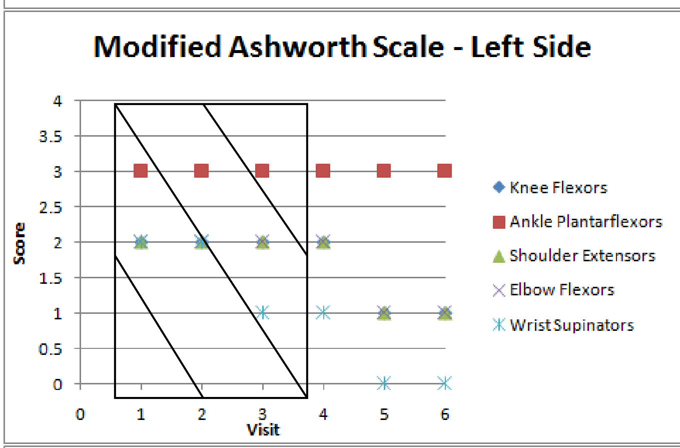
In conclusion, based off of the findings of this pilot study, it appears that the utilization of adaptive tricycles for toddlers with cerebral palsy has the potential to be a successful treatment for the participants of our study. ROM, GMFM-66 and Peabody scores improved after the eight week intervention period for the participants. Additional research is required to determine the lasting effects that the utilization of adaptive tricycles have on tone, bimanual tasks, and functional tasks for toddlers with cerebral palsy.

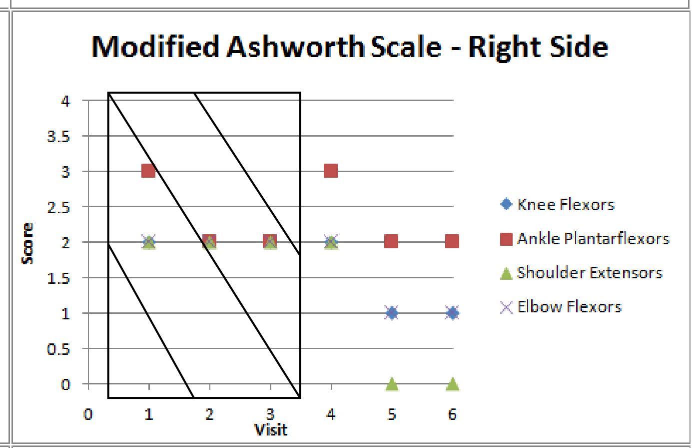
Appendix Data Charts for Subjects 1-4

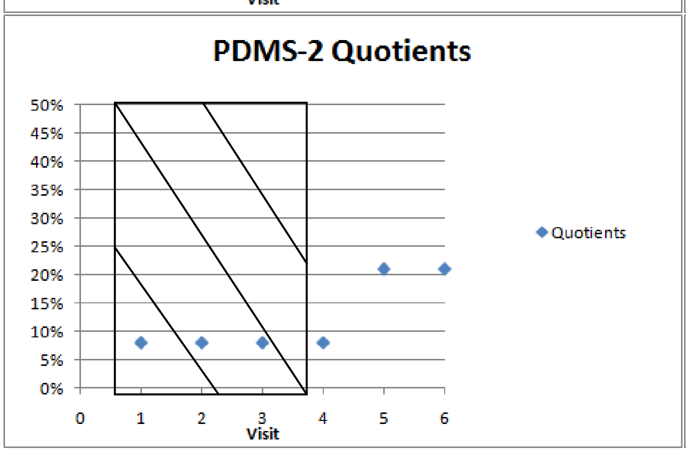
Subject 1 Data Plots (shaded box indicates baseline measurements)

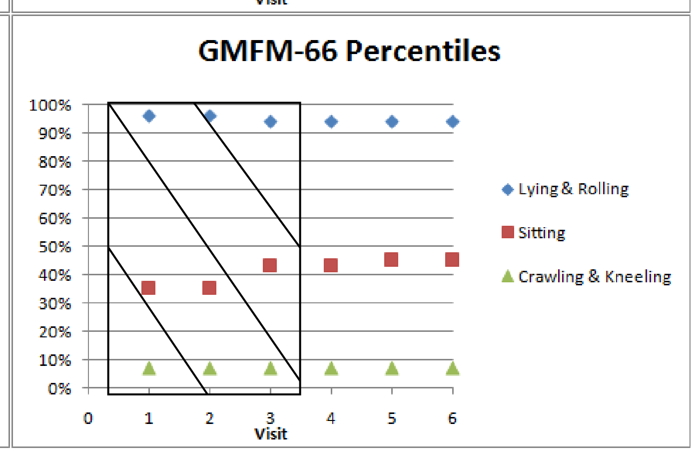




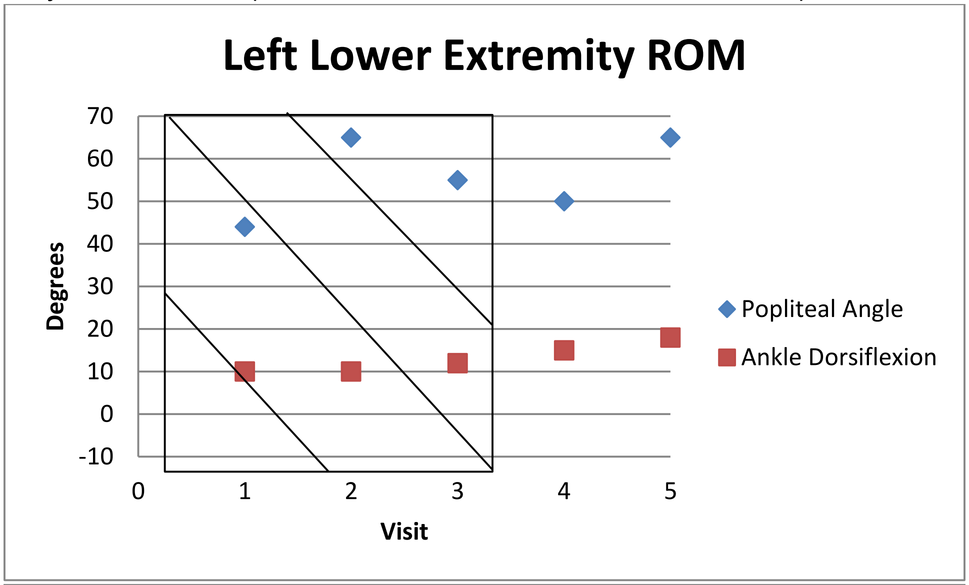


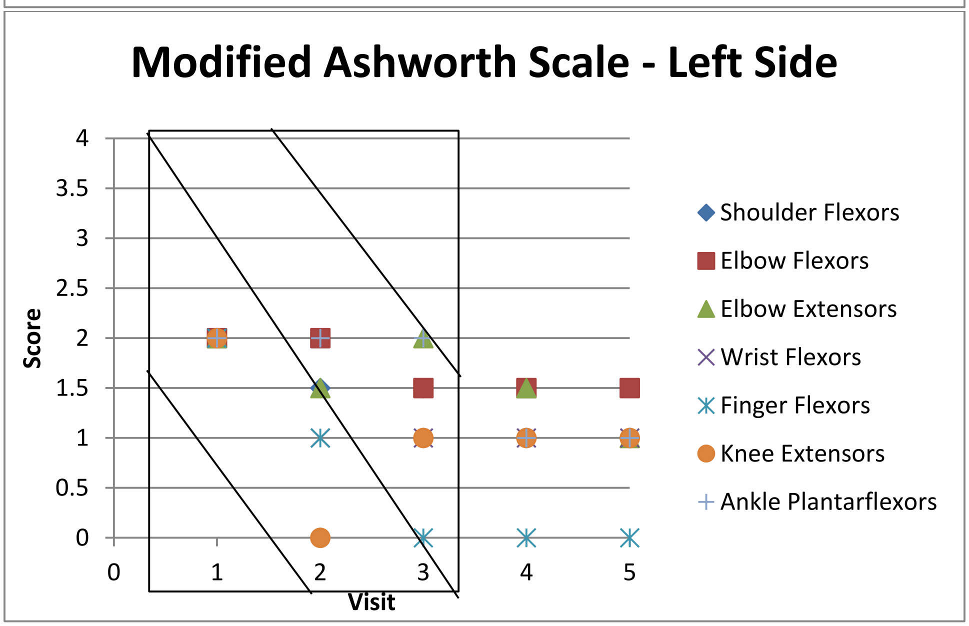


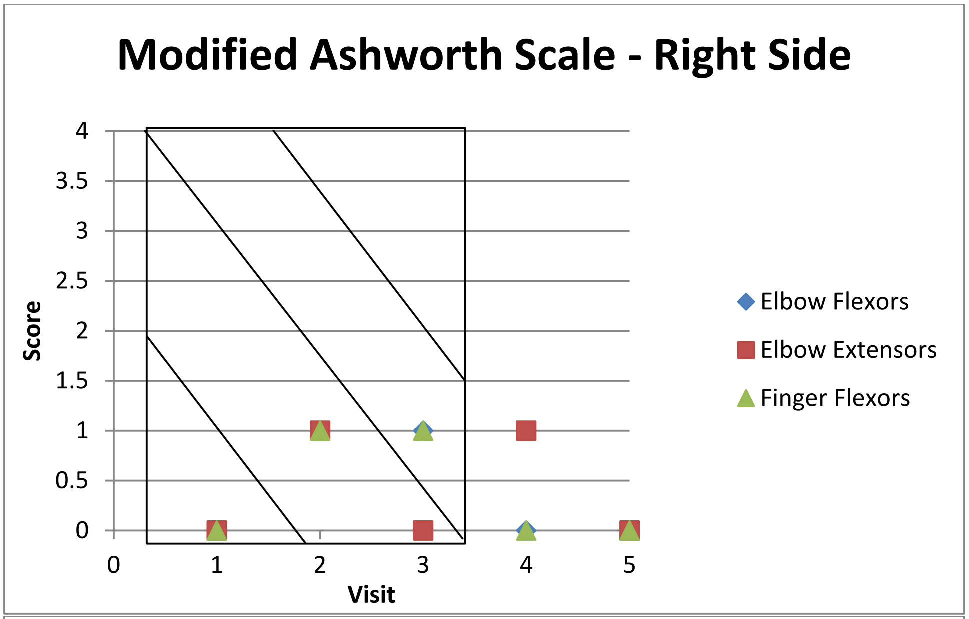


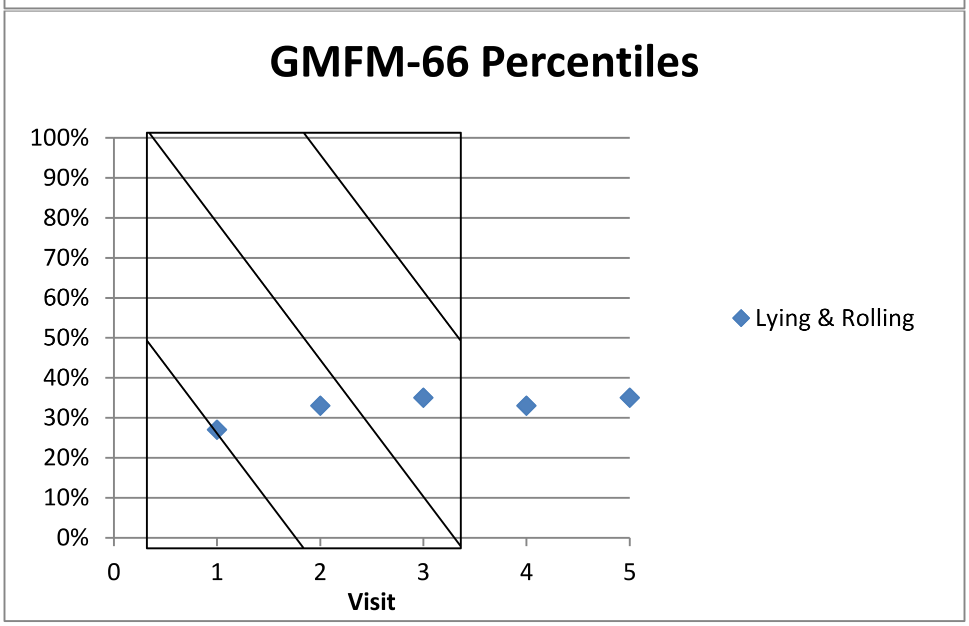


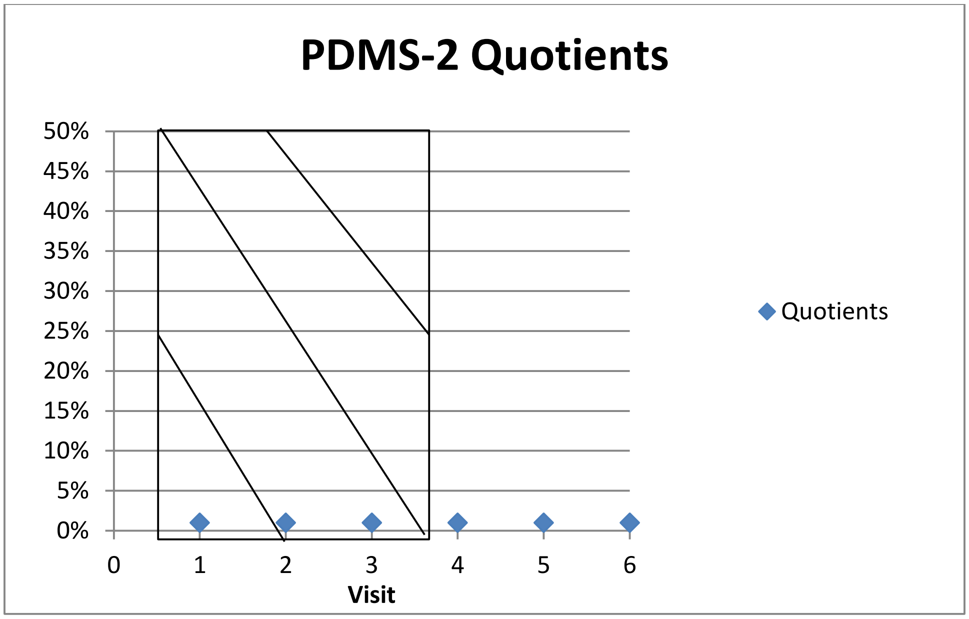
Subject 2 Data Plots (shaded box indicates baseline measurements)



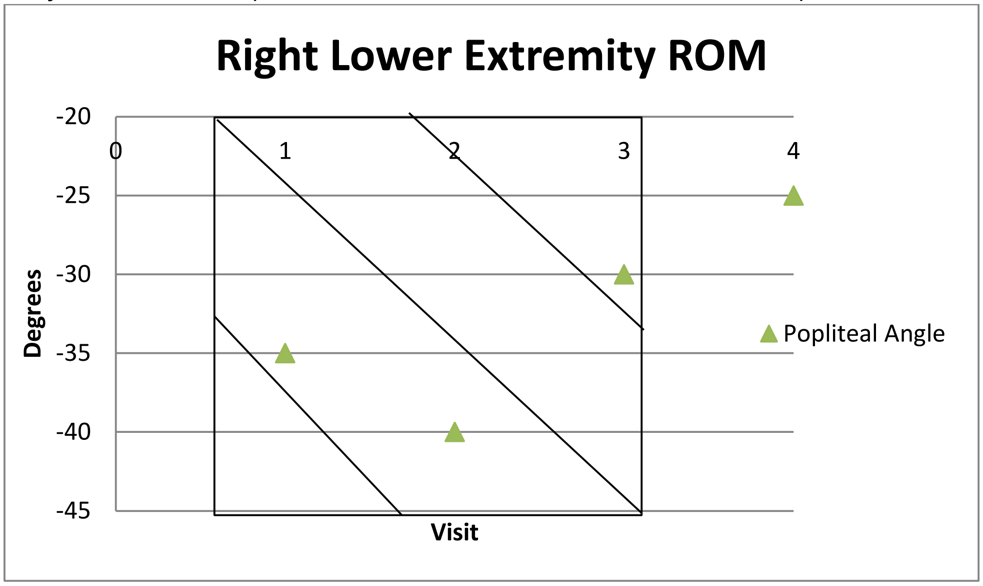


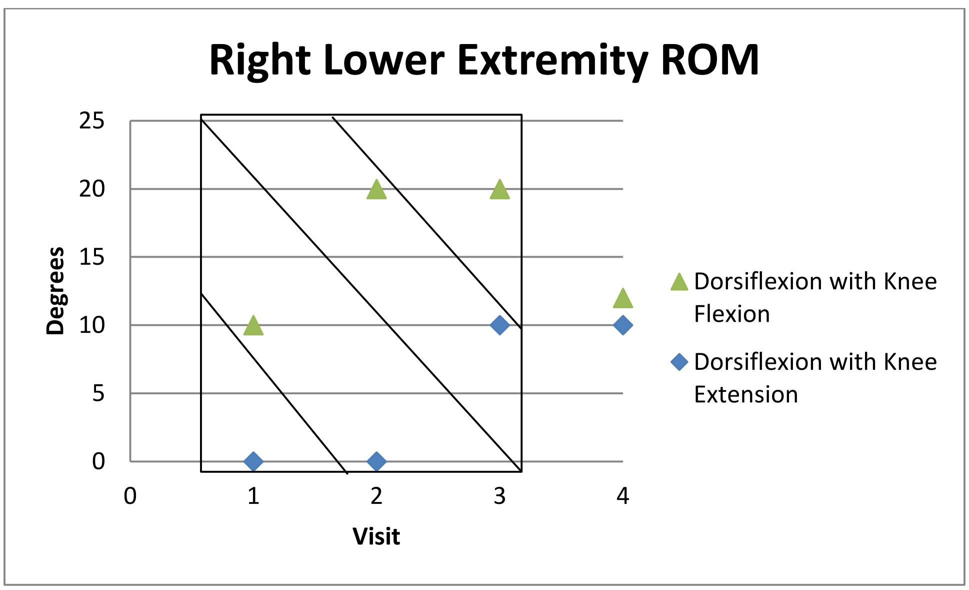

Modified Ashworth Scale - Right Side
Score
4
3.5
3
2.5
2
1.5
1
0.5
0
0
1
2
3
4
5
Visit
Elbow Flexors
Elbow Extensors
Finger Flexors

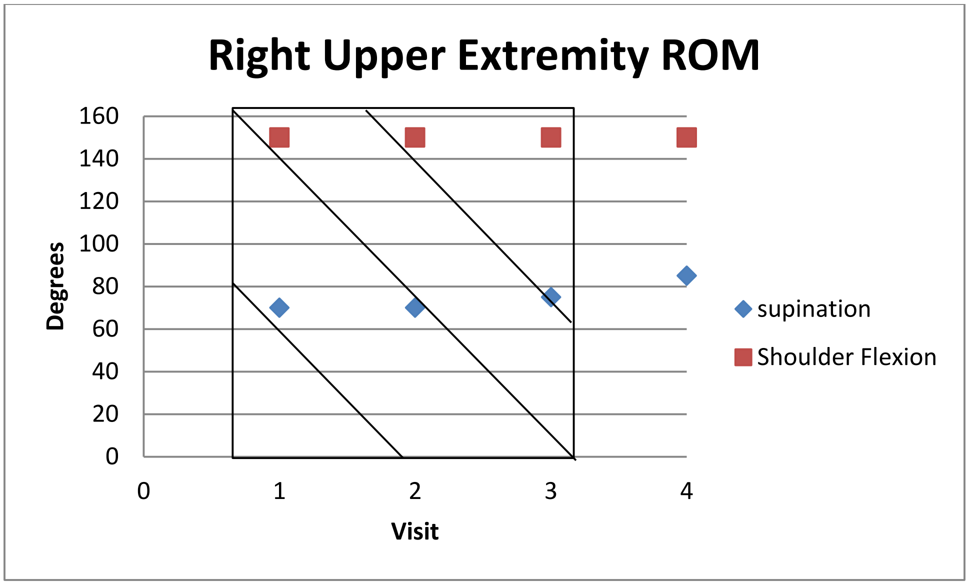

GMFM-66 Percentiles
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
1
2
3
4
5
Visit
Lying & Rolling

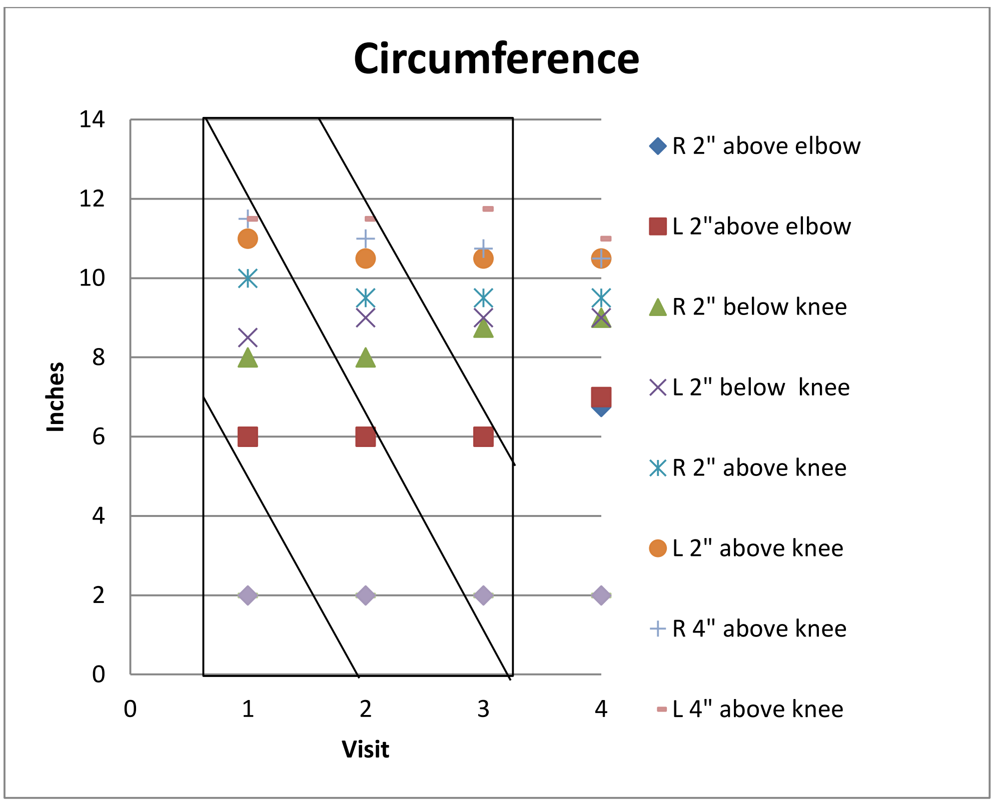

PDMS-2 Quotients
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
0
1
2
3
4
5
6
Visit
Quotients

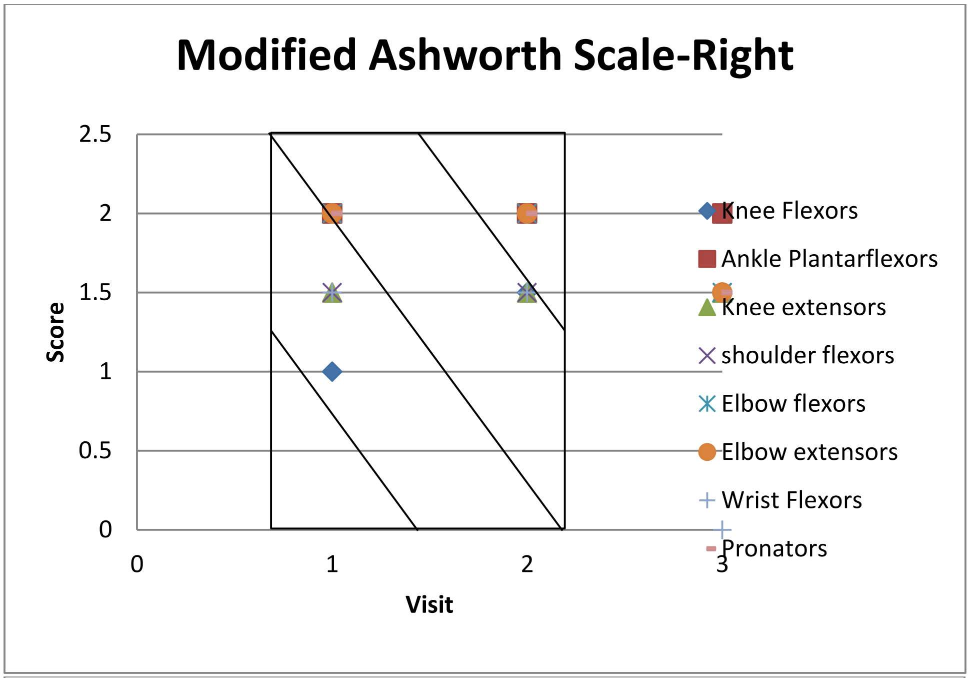
Subject 3 Data Plots (shaded box indicates baseline measurements)

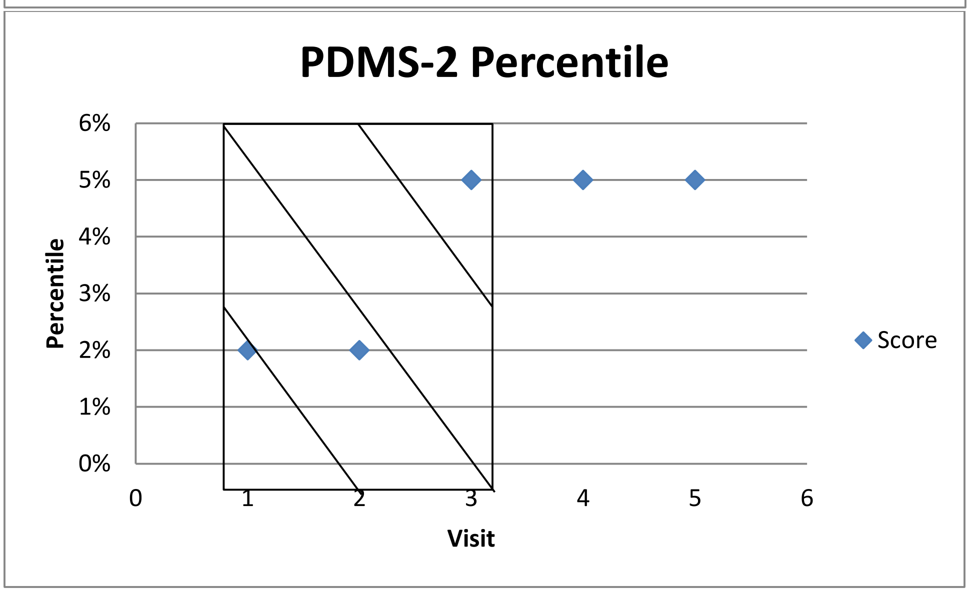


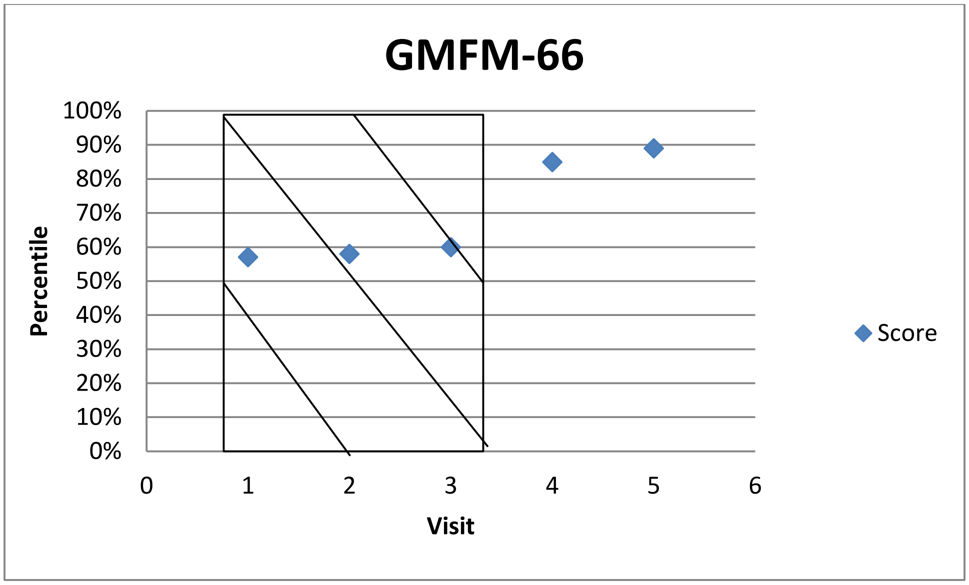



Right Upper Extremity ROM
Degrees
160
140
120
100
80
60
40
20
0
0
1
2
3
4
Visit
supination
Shoulder Flexion

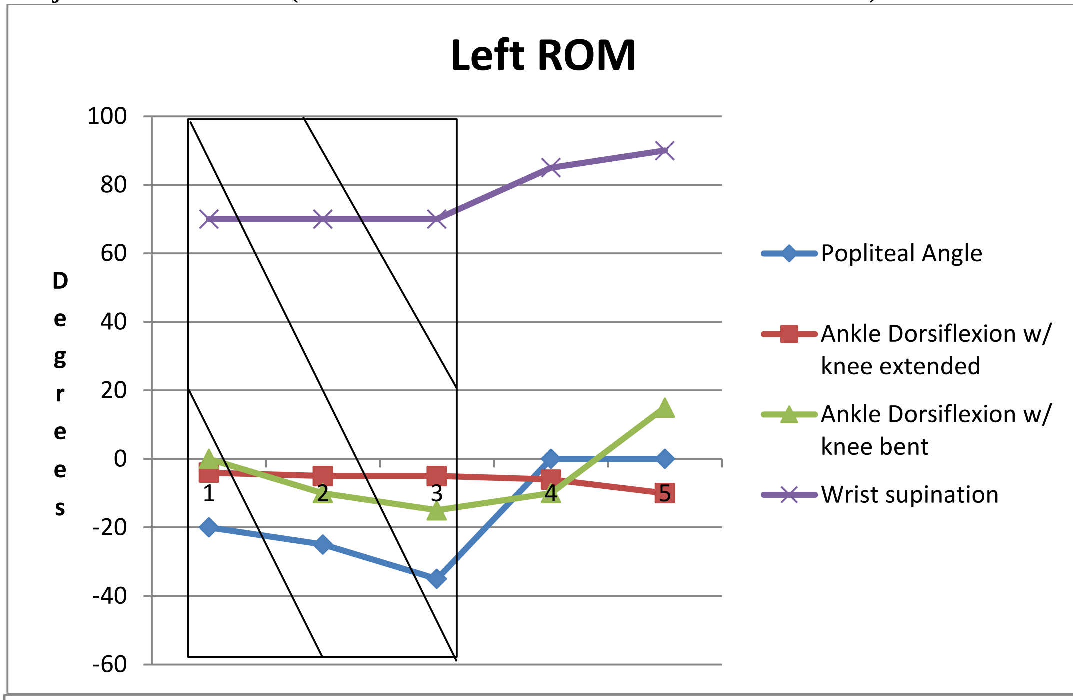

Circumference
Inches
14
12
10
8
6
4
2
0
0
1
2
3
4
Visit
R 2" above elbow
L 2"above elbow
R 2" below knee
L 2" below knee
R 2" above knee
L 2" above knee
R 4" above knee
L 4" above knee

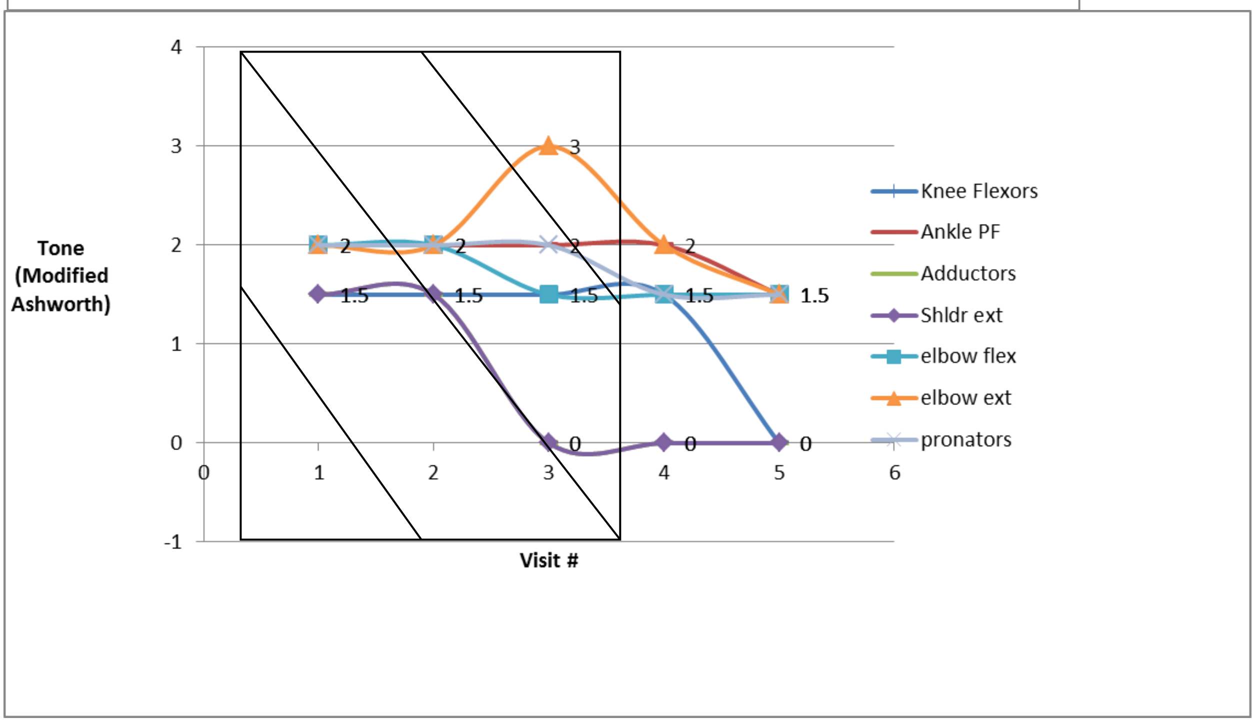

Modified Ashworth Scale-Right
2.5
2
1.5
1
0.5
0
Score
0
1
2
3
Visit
Knee Flexors
Ankle Plantarflexors
Knee extensors
shoulder flexors
Elbow flexors
Elbow extensors
Wrist Flexors
Pronators

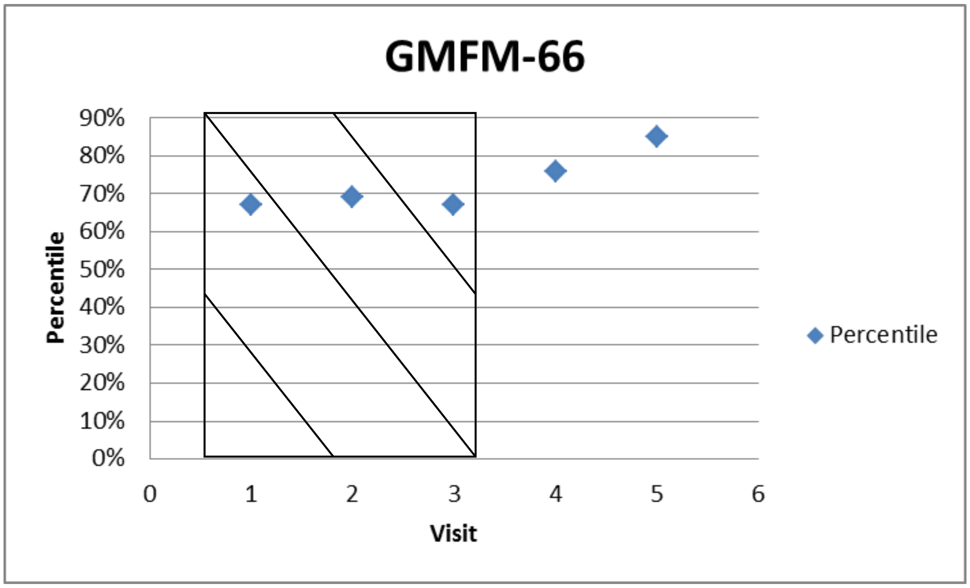

PDMS-2 Percentile
6%
5%
4%
3%
2%
1%
0%
Percentile
0
1
2
3
4
5
6
Visit
Score


GMFM-66
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentile
0
1
2
3
4
5
6
Visit
Score

Subject 4 Data Points (shaded box indicates baseline measurements)






GMFM-66
Percentile
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
1
2
3
4
5
6
Visit
Percentile

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