Effectiveness of the AmTryke® Therapeutic Tricycle as an Intervention for Children with Hemiplegic Cerebral Palsy: A Pilot Study

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The United Cerebral Palsy Foundation (UCPF) has estimated that 10,000 new cases of cerebral palsy (CP) are diagnosed each year and the number of new cases of CP has increased 25% over the last decade (United Cerebral Palsy Research and Education Foundation, 2005). Cerebral palsy commonly presents as motor impairments affecting one side of the body, which is referred to as hemiplegia (Wiklund & Uvebrant, 1991). Due to the incidence and associated deficits of CP, it is important to develop research on new therapeutic interventions. Current interventions used include (a) functional interventions (Van der Weel, Van der Weel, & Lee, 1991, Volman, Wijnroks, & Vermeer, 2002a; Lewis, 2003), (b) constraint induced interventions (Gordon, Charles, & Wolf, 2005), and (c) bilateral movement interventions (Hung, Charles, and Gordon, 2004; Utley & Steenbergen, 2006).

One intervention being employed is the AmTryke® therapeutic tricycle. The design of the AmTryke® allows for a combination of, (a) functional interventions, (b) constraint induced interventions, and (c) bilateral movement interventions, and it also creates a child-friendly context which may result in increased social participation and increased motivation to participate in therapy; however, there is limited research on the effectiveness of the AmTryke®. Based upon current information regarding the integration of the above interventions, the authors hypothesize that the AmTryke® may be an effective intervention for improving motor function and social participation for children with hemiplegic CP.

Literature Review

Current Interventions

Constraint-Induced Movement Therapy (CIMT) involves applying a restraint to the

uninvolved upper extremity in order to force the use of the affected upper extremity. CIMT is based on two different principles: Mass practice of therapeutic tasks and forced-use of the affected limb through use of a constraint (Hoare, Carey, Imms, & Wasiak, 2007). Many children with CP have damage to areas of the brain that influence bilateral coordination, or the ability to use both hands together during a task (Charles and Gordon, 2006). In addition, bilateral movement therapy allows for practice of bilateral movements and has been shown to improve abnormal upper extremity patterns, increase bilateral use and function, and create fluidity between the limbs during functional tasks (Hung, Charles, and Gordon, 2004; Utley and Sugden, 1998; Sugden and Utley, 1995; Volman, Wijnroks, and Vermeer, 2002b).

Rhythmic limb movement, such as riding a bike or arm cycling, is another form of bilateral training. It has been found that bilateral lower limb cycling has resulted in improvements in hemiparetic lower limb function. (Fujiwara, Liu, and Chino, 2003; Pountney and Williams, 2007). Due to the similarity in the neural responses and modulation of motor control in the upper and lower extremity during rhythmic movement (Brooke, McIlroy, Stains, Angerilli, & Peritore, 1999; Zehr, Collins, Frigon, & Hoogenboom, 2003; Zehr, Hesketh, & Chua, 2001; Zehr & Kido, 2001), it can be suggested that upper extremity rhythmic movement may have similar positive effects on the function of the hemiparetic upper extremity.

The AmTryke®

The AmTryke® therapeutic tricycle was developed for children with disabilities and includes many unique features, such as foot cups, adjustable length foot plates, different seating systems, various hand wraps, push bars, a knee separator, and the ability to be sized for different children. The AmTryke® can be hand and/or foot powered (AMBUCS™, n.d.).

The AMBUCS™ organization offers the AmTryke® to children with disabilities. AMBUCS™ literature (n.d.) proposes that the AmTryke® builds stamina, endurance, and strength for children that exhibit low-tone or weakness, as well as allows the children to have fun. The AMBUCS™ literature (n.d.) also suggests that use of the therapeutic tricycle on a daily basis leads to an increase in the amount of therapy the child receives without receiving treatment from a licensed professional. This use would take place with friends and family, therefore resulting in increased social participation. In the opinion of AMBUCS™, the AmTryke® promotes motor coordination, independence, and self-esteem. Although the AmTryke® is being used with many children across the country, there is limited research on the effectiveness of the AmTryke®.

The purpose of this study was to examine the effectiveness of the AmTryke® therapeutic tricycle as an intervention for children with hemiplegic CP. It was hoped hypothesized that, by riding the AmTryke®, the participants would demonstrate improvements in physical and functional contexts as a result of the multiple intervention strategies and techniques that are incorporated in the AmTryke®. As there is little or no research to date on the effectiveness of the AmTryke® regarding the population of children using it in therapy, the researchers also hoped to contribute to this limited body of knowledge and support the use of the AmTryke® in therapy.

Methods

Participants

Participants in this study were recruited by contacting pediatric therapists in the Omaha area. Participants needed to satisfy the following criteria: They needed to fit the AM-12 model AmTryke® therapeutic tricycle, which is suitable for heights from 36”- 42” and leg length (measured from hip to floor) of 17.5”- 24” (AMBUCS™, n.d.); they must not have owned nor

had any prior experience with the AmTryke®; and they must have been diagnosed by a physician as having hemiplegic cerebral palsy, which results in a greater deficit and movement of one upper extremity in comparison to the other. Participants were excluded if the degree of involvement in each individual child associated with CP inhibited the individuals' ability to tolerate a minimum of one-half hour (broken up as needed) of intervention per day. The experimental group consisted of 5 participants (2 female, 3 male, with a mean age of 10.2 years, and range of 6 years). Participant characteristics are outlined in Table 1.

	Gender	Age	Involvement
Participant #1	Male	7 years, 2 months, 4 days	R. side hemiplegia
Participant #2	Female	12 years, 5 months, 11 days	Quadriplegic CP, greater involvement on L. side
Participant #3	Male	12 years, 5 months, 11 days	Quadriplegic CP, greater involvement on L. side
Participant #4	Male	13 years, 9 days	R. side hemiplegia
Participant #5	Female	7 years, 8 months, 18 days	L. side hemiplegia

Table 1 – Participant characteristics

Measurements

Information was collected via the Pediatric Evaluation of Disability Inventory (PEDI), goniometry measurements, and two other tasks. The PEDI examines functional tasks through a parent questionnaire. Range of motion measurements were taken to assess overall gains in upper extremity movements. Two other tasks were chosen as measures of client factors that were most likely to change with intervention. The tasks included timed bilateral movement of a box of 64 crayons and timed unilateral placement of three Beanie Babies™ into a basket with the affected hand.

Pediatric Evaluation of Disability Inventory. The PEDI is a standardized tool that assesses performance in functional capabilities in the domains of self-care, mobility, and social

functions (Haley, Coster, Ludlow, Haltiwanger, & Andrellos, 1992). It is standardized for children ages 6 months to 7.5 years, but can be used with older children if their functional abilities fall below that expected of 7.5 year olds without disabilities (Haley et al., 1992). The PEDI can be completed by parents or a therapist who is knowledgeable about the child. The Functional Skills Scales measures functional capability in daily functional activities. The Caregiver Assistance Scale measures the extent to which caregivers provide assistance in order for the child to accomplish daily functional activities. The Modifications Scale measures the level and use of environmental modifications in order for the child to accomplish daily functional abilities (Haley et al., 1992). The PEDI was given before the intermittent intervention phase and after the consistent phase. Internal consistency reliability coefficients for all scales of the PEDI range from 0.95-0.99, indicating excellent internal consistency (Haley et al., 1992). Sundberg reported the consistency of PEDI scores between therapists and the family respondents for the Functional Skills Scale to be 0.95, for the Caregiver Assistance Scale to be 0.96, and for the Modifications Scale to be 0.91 (as cited in Haley et al., 1992).

Range of motion. In order to record the children's range of motion (ROM), a goniometer was used to measure shoulder flexion, elbow flexion, and elbow extension following a standard format (Killingsworth & Pedretti, 2006).

Timed bilateral movement task. This measurement was designed to provide the children with a task that required them to coordinate both of their upper extremities to complete a task. The materials consisted of a box of 64 crayons and a 24" by 16" piece of paper with three targets. One target was placed at midline, one at a 45 degree angle to the left, and one at a 45 degree angle to the right. The targets were placed at a distance that was equal to the length of the child's forearm. The object of the task was for the child to use both hands to grasp the box of

crayons and place it at each of the targets; the child was timed and the targets were measured for accuracy.

Timed unilateral placement task. This measurement was designed to see how the children performed when using only their affected extremity. The materials consisted of three Beanie Babies™ and a basket that was 24.5 cm long x 20 cm wide x 11 cm deep. The basket was placed at the edge of the table on the side of the child's effected extremity at a distance equal to the length of the forearm and the child was timed while placing the Beanie Babies™ in the basket.

Questionnaire. A parental questionnaire, developed by the investigators, was completed following the conclusion of the intervention phase. Parents were asked to determine the children's ability to complete functional tasks and participate in social settings. The questionnaire consisted of five questions and was based on a five point Likert scale.

Inter-rater reliability. Two researchers were recruited as assessors to evaluate the measurements. In order to determine inter-rater reliability for the goniometry measures, the timed bilateral task, and the timed unilateral task, the researchers assessed a pilot subject prior to the study. The measurements obtained for the three different assessments were evaluated to assure that there were no significant differences. At least 90% inter-rater agreement was achieved. During the study, all measurements were taken in the child's home and by the same researcher to provide consistency.

Procedures

Each child participated in a baseline, intermittent intervention, and intervention phase. Baseline was established over 5 consecutive days. During the baseline phase, the researchers gathered data for each measurement tool and the parents completed the PEDI. The intermittent intervention phase was initiated the week following the completion of the baseline phase. It

lasted 4 weeks and involved inconsistent riding. Each parent recorded the amount of time their children rode the AmTryke®. One day a week during this phase, the researchers assessed range of motion, the timed bilateral movement task, and the timed unilateral placement task for each child in their home.

The intervention phase, which lasted 8 weeks, was initiated after the intermittent intervention phase and a 2 week period of no riding. Each child was asked to ride for 30 minutes a day. Parents recorded the actual time of riding and in what setting the children rode the AmTryke® each day. During the last 4 weeks of the intervention phase, the researchers conducted data collection with each of the measurement tools on each child. The PEDI and the parental questionnaire were completed at the end of this phase.

Range of motion. Range of motion was assessed with the child sitting at a table in a chair with a supportive back. Shoulder flexion, elbow extension, and elbow flexion were taken for both the right and left upper extremities utilizing a goniometer. If the child could not supinate his/her forearm, elbow extension was measured from a pronated position.

Timed bilateral movement task. In order to complete the bilateral movement task, the child was seated in front of the middle of the paper and as close to the table as possible, maintaining the same distance for each measurement for the duration of the study. The child was asked to grasp the box with both hands and place at each of the targets. Timing started when the researcher released her hands from the box, and this was repeated for each target. The times for the placement on each target were summed and reported as one score.

Timed unilateral placement task. In order to complete the unilateral placement task, the child was seated in a chair at a table. For the right hand, the basket was placed flush with the edge of the table to the right of midline, at a distance that was equal to the length of the child's

right forearm. Three Beanie Babies™ were chosen by the child and placed at midline on the table. The child was asked to place the Beanie Babies™ one at a time and as fast as possible into the basket only using the right hand. The researcher started the timer when the child touched the first Beanie Baby™ and was stopped when the child released the third Beanie Baby™ into the basket.

Data Analysis

The data collected from the bilateral task, unilateral task, and goniometry measurements were plotted onto graphs and placed in charts. Visual analysis was used to discern trends within the data collection phases. The Statistical Program for Social Sciences (SPSS) software was used to complete non-parametric testing to determine if the changes in the participants' performance showed statistical significance.

Standardized analysis. The Pediatric Evaluation of Disabilities Inventory (PEDI) was not scored and analyzed according to standard scoring procedures because the scores were compared independently for each subject. The researchers identified changes within specific items of the PEDI for each participant in order to assess specifically where the change occurred.

Discussion

Outcomes

The time taken by each participant to complete the unilateral task is presented in Figure 1. The overall trend showed that the participants demonstrated improvement by decreasing the time taken to complete the unilateral task with his/her affected hand. Figure 2 represents the time taken to complete the bilateral task. This figure demonstrates that each participant, with the exception of Child #3, exhibited a decrease in the amount of time taken to complete the task.

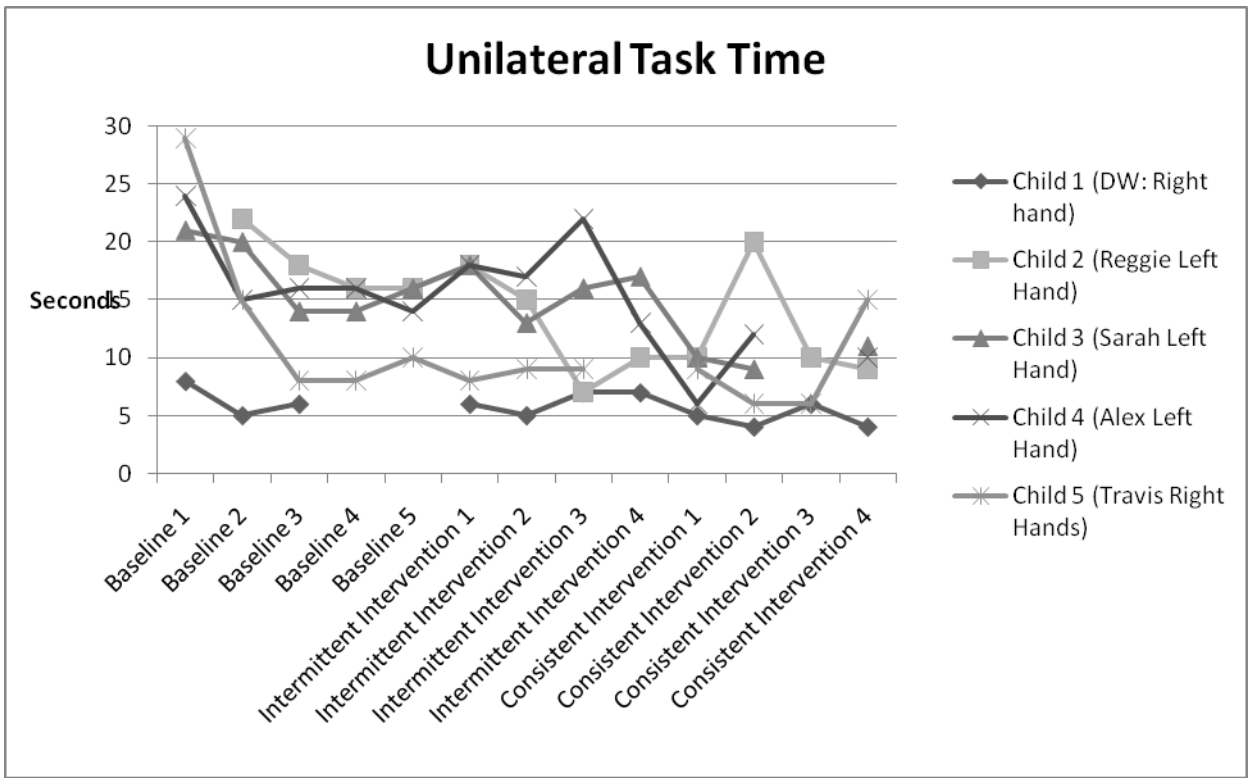

Figure 1 – Unilateral task time

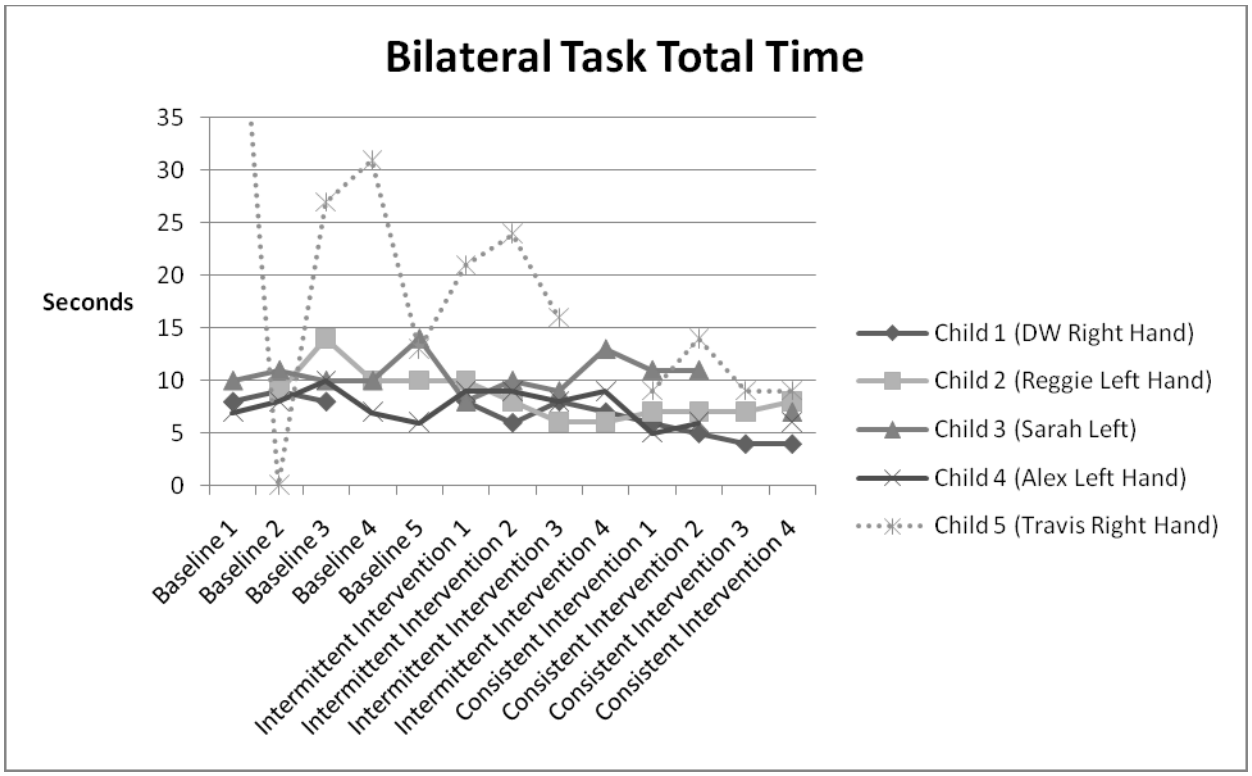

Figure 2 – Bilateral task time

Table 2 outlines the accuracy of the participants while completing the bilateral task.

Bilateral Task Accuracy (cm)	Left			Middle			Right		
	Average Baseline Phase	Average Intermittent Phase	Average Intervention Phase	Average Baseline Phase	Average Intermittent Phase	Average Intervention Phase	Average Baseline Phase	Average Intermittent Phase	Average Intervention Phase
Child 1	4.233	5.6	6.025	3.266	3.05	2.475	3.033	3.05	4.725
Child 2	5.72	4.4	3.8	3.78	4.7	2.65	4	5.5	4.3
Child 3	2.1	1.625	2.5	1.52	1.55	1.6	1.7	1.325	2.067
Child 4	1.12	1.275	1	0.84	1	1.13	0.76	0.7	1.43
Child 5	1.72	1.133	2.15	2.88	2	3.225	2.06	2.7	2.625

Table 2 – Bilateral task accuracy

For each target (left, middle, and right), a measurement was taken to determine which corner was the farthest away from the designated target, and an average of these distances was calculated to determine each participant's accuracy. Table 3 outlines each participant's progression in terms of range of motion.

	Shoulder Flexion			Elbow Flexion			Elbow Extension		
	Baseline	Intermittent	Consistent	Baseline	Intermittent	Consistent	Baseline	Intermittent	Consistent
Child 1	133.33	133	132.5	130	136.75	137.75	-5.67	-11	-4
Child 2	97.25	101.25	113	103.33	115	126.25	-13.75	-10.75	-25
Child 3	106.6	109.25	110	137.4	154.25	149	-83.4	-88	-94
Child 4	112	117.75	132	134.6	144	144.67	-55	-51.25	-42
Child 5	142.4	156.33	153.75	149	146.33	144.75	-7	-9.67	-13

Table 3 – Range of motion

The measurements taken at each data collection were averaged for each respective phase. Non-parametric statistical tests were used to analyze the data presented in Figures 1 and 2 as well as Tables 2 and 3. The results of the parent questionnaires were also analyzed with this statistical program. Results of the tests did not reveal any statistically significant differences.

PEDI. Child #1 demonstrated improvement in the raw scores in the areas of self-care (functional skills) and the amount of caregiver assistance required for self-care, including

preparing toothbrush with toothpaste, brushing hair, washing and drying his face thoroughly, assisting with fasteners, zipping and unzipping, and putting on and removing pants. Child #2 demonstrated improvement in the raw scores in the areas of social function (social skills) and the amount of caregiver assistance required for social function, including removing pants (including unfastening), putting on socks, taking self to the bathroom, and getting in and out of the car (including opening and closing the door). By the end of the consistent intervention phase, Child #2 required less caregiver assistance for dressing her lower body, bladder management, chair/toilet transfers, and participating with peers in play activities. Child #3 exhibited improvements in the raw scores in the areas of self-care (functional skill) and social function (social skill), including removing t-shirts and sweaters, assisting with fasteners, removing socks and unfastened shoes, assisting with clothing management during toileting, washing self thoroughly, and using a knife to butter bread and cut soft foods, among others.

Child #4 demonstrated improvement in the raw scores in the areas of self-care (functional skill) and social function (functional skill), including increased capability included putting on a t-shirt or sweater, assisting with fasteners, taking off pants, and managing clothes before and after toileting. Child #5 exhibited improvement in the raw scores in all domains, including self-care (functional skill); mobility (functional skill); social function (functional skill); and caregiver assistance in the areas of self-care, mobility, and social function. Areas in which Child #5 was scored as being incapable to being scored as capable included snapping and unsnapping, buttoning and unbuttoning, washing and drying face thoroughly, and brushing/combing hair, among others. Child #5 also required less caregiver assistance to groom and dress his lower body and get in and out of the tub at the end of the consistent intervention phase.

Parent questionnaire. The parent questionnaire measured the subjective feedback of the parents (according to a Likert scale) regarding their opinions concerning their children's progress following the use of the AmTryke® therapeutic tricycle. According to the responses given for Child #1, he demonstrated moderate improvement in completing functional tasks at home, little improvement in participating in social contexts, large improvement in moving his involved arm, large improvement in completing tasks using both hands, and large improvement in completing tasks faster. The responses given by the parents of Child #2 indicated moderate improvement in completing functional tasks at home, little improvement in participating in social contexts, large improvement in demonstrating greater movement with her involved arm, little improvement in completing tasks using both hands, and moderate improvement in completing tasks faster. Child #2's parents also commented that, following the completion of the study, they noticed exceptional improvement in their child's endurance and large improvement in her appetite.

Child #3's parents reported little improvement in completing functional tasks at home, moderate improvement in participating in social contexts, little improvement in demonstrating greater movement with her involved arm, little improvement in completing tasks using both hands, and moderate improvement in completing tasks faster. The responses given for Child #4 indicated little improvement in completing functional tasks at home, moderate improvement in participating in social contexts, little improvement in demonstrating greater movement of his involved arm, little improvement in completing tasks using both hands, and moderate improvement in completing tasks faster.

Child #5's parent reported moderate improvement in completing functional tasks at home, large improvement in participating in social contexts, large improvement in demonstrating greater movement with his involved arm, moderate improvement in completing tasks using both

hands, and moderate improvement in completing tasks faster. According to the parent, Child #5 had progressed from completely ignoring his affected arm to beginning to use it as a "helper hand" and to assist what the other arm was doing during tasks.

Parent logs. Each child's parents were required to keep a log of the amount of time the children spent riding the AmTryke® throughout the course of the study. They were also asked to record the context in which their child rode the AmTryke®. Child #1 rode sporadically at the on-set of the study, but during the intermittent intervention phase, he rode for 15 to 30 minutes 5-6 days per week. By the end of the consistent intervention phase, Child #1 was able to ride for approximately 25-30 minutes per day for about 4-5 days per week.

Child #2 rode the AmTryke® on a fairly consistent basis throughout the entire study period, riding approximately 30 minutes per day, 5 days of the week. She completed most of her riding at school, often in a social context with peers and others at the school. She rode it during P.E. class, in the hallway while "racing" friends, and even at recess. Child #2 often received positive remarks from peers and teachers while riding the AmTryke® at school. Both Child #3 and Child #4 rode the AmTryke® therapeutic tricycle for about 20-30 minutes per day, 3-4 days per week. This riding time was consistent throughout the duration of the study. At the onset of the study, Child #5 rode the AmTryke® outdoors in the neighbor's driveway for approximately 35 minutes per day. Child #5 rode only sporadically during the inconsistent phase. For the consistent intervention phase, Child #5 rode the AmTryke® 7 days a week, 30-45 minutes per day.

Major Findings and Relation to Previous Literature

The purpose of the study was to examine the effectiveness of the AmTryke® therapeutic tricycle as an intervention used in occupational and physical therapy for increasing the use of the

affected upper extremity of children suffering from hemiplegic cerebral palsy. The authors had hypothesized that the research would produce significant findings; however, no significance was found in the study. Despite this, the findings of the study did show trends in decreased time taken to complete both the unilateral and bilateral tasks. Also, each child showed an increase in range of motion in at least one of the ranges measured. Each child also showed improved function in at least one section of the PEDI from pre-test to post-test, and all parents felt that their children had made improvements in function as evidenced on the parental questionnaire.

Despite this study's inability to show significant results, the AmTryke® should not be discounted as a beneficial intervention for children with hemiplegic CP. It provides children with affected extremities the opportunity to ride a bicycle, something which they might not have been able to do before. This study also found that by parent report, the children did show improvement, even if not significant. Occupational and physical therapy students should be educated on the concepts behind the use of the AmTryke® and that it can provide potential benefit when used as an intervention for children with hemiplegic CP. Furthermore, there is previous literature that may support the use of the AmTryke® as an intervention for children with hemiplegic CP. Volman, Wijnroks, and Vermeer (2002) suggest that "Treatment of children with spastic hemiparesis should focus on practicing functionally relevant skills (actions) instead of practicing meaningless movements" (p.689). The AmTryke® is an age-appropriate occupation and requires children with hemiplegic CP to use purposeful and functionally relevant movements, all while incorporating the affected extremity. Along with making the child use functional movements, it also allows the child to engage in play, which has proven difficult for some children with CP and often leads to unsuccessful peer interactions (Richardson, 2002; Rigby & Gaik, 2007).

Limitations

Psychometric properties of the unilateral and bilateral assessments were not established, nor were they piloted with each participant prior to commencing the study. The reliance on parent report for the completion of the PEDI and the questionnaire is an additional limitation, as the parents were not blinded to the intervention. Also, the short length of the consistent intervention period may be why significant change was not found. Future studies could benefit from a longer consistent riding phase. The small convenience sample, which consisted of participants from the same geographic location, limits the generalizability of the study. In addition, two of the participants did not truly fit the required diagnosis of hemiplegic cerebral palsy. Future studies need to include participants on the basis of strict inclusion and exclusion criteria in order to gain a more representative sample of hemiplegic cerebral palsy.

Implications for Future Research

The researchers suggest that future studies delineate and quantify the specific motor gains that are correlated with the use of the AmTryke®. In addition, studies that include functional assessments, such as the Functional Independence Measure (FIM) or the Assessment of Motor and Process Skills (AMPS), would aid in determining the efficacy of the AmTryke® therapeutic tricycle in contributing to functional gains in daily living skills. Future investigation is needed to determine the long term effects of the AmTryke® on motor and daily functioning. Additional studies that utilize single-subject designs with longer intervention periods and more consistent riding times would contribute to understanding the efficacy of the AmTryke®. Future research for the development of protocols for riding and safety parameters is recommended.

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