RESEARCH ARTICLE

THE EFFECTS OF FUNCTIONAL THERAPY ON MOTOR DEVELOPMENT IN CHILDREN WITH CEREBRAL PALSY

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Abstract

Objective

Cerebral palsy (CP) is one of the most common causes of activity limitation in children. Although the central nervous system (CNS) lesion, causing the disorder of posture and movement, is not progressive, the manifestations of the lesion however may change over time. The purpose of this study was to determine the effects of a functional therapy program on motor abilities of children with cerebral palsy.

Materials & Methods

In the year 2007, in a pre- and post design study, fifteen children, diagnosed with CP at the physiotherapy clinic of Zahedan University of Medical Sciences were recruited using simple non - probability sampling by consulting the child neurologist. Before and after intervention, subjects were classified with Gross Motor Function Classification System (GMFCS) to assess gross motor function with the Gross Motor Function Measure (GMFM). Muscle tonicity was graded, based on the Modified Ashworth Scale (MAS). A 24 session functional physical therapy program which lasted 12 weeks, twice per week, and 90min per session was carried out.

Results

Fifteen children with CP (12 boys and 3 girls) aged 21.87±13.37 months were enrolled in this study; six of them were diplegic, 7 hemiplegic, and 2 quadriplegic. After treatment, muscle tonicity decreased from 1.93±0.59 to 0.87±0.64 ($P<0.0001$). The subjects' GMFM scores increased significantly from 30.52±28.99 to 49.27±26.9 ($P<0.0001$).

Conclusion

The results showed that a functional therapy program may be effective in increasing gross motor function and improving daily activities in children with cerebral palsy, thereby decreasing parent and nursing dependency following this program.

Keywords: Cerebral palsy, Functional therapy, Gross Motor Function Measure (GMFM), Modified Ashworth Scale, Gross Motor Function Classification System (GMFCS)

Introduction

Cerebral palsy (CP) is a disorder of posture and movement that occurs secondary to the immature brain damage before, during, or after birth (1). The severity of limitation

in gross motor function among children with CP, the most common physical disability is highly variable (2). It represents the most frequent diagnosis of children who receive physical therapy (3). Despite the static nature of the brain damage in CP, the clinical manifestations of the disorder may change as the child grows older. Although movement demands increase with age, the child's motor abilities may not change quickly enough to meet these demands (1). CP is characterized by decreased functional abilities, delayed motor development, and impaired muscle tone and movement patterns (1). The reported incidence in the general population ranges from 0.6 to 4.2 cases per 1000 live births, depending on the source (4). The incidence of CP is 2 to 2.5 cases per 1000 live births in developing countries.

Children with CP typically receive physical therapy to facilitate motor development and to enhance their independence in motor skills, self-care, play, and leisure activities (6). Over the years, many systems of treatment with different strategies have been developed, all aiming at achievement of the highest degree of independence in children with CP (6). Ahl et al evaluated functional therapy for children with CP and reported significant improvements in both gross motor function and social function after treatment (7). Tieman et al examined the capability and performance of children with CP and documented evidence that there are differences in performance across settings in children with CP and similar capabilities, and suggested that physical therapists should examine performance in the settings (8). Ketelaar et al compared the motor abilities of children with CP receiving functional therapy with a control group whose therapy was based on the principle of normalization of the quality of movement and although they found no significant difference between the two groups in terms of basic gross motor abilities, more improvements were found in functional skills in daily situations in the functional therapy group compared to the other group (6). Jansen et al presented a review of the literature on parental participation in physical therapy for children with physical disabilities, demonstrating that the child's potential in terms of daily functioning developed when their parents participate in physical therapy (9).

According to studies, the purpose of treatment is to help the individual to maximize his or her potential (6). To achieve this goal, therapeutic approaches emphasize two principles; quality of movement and functional activities. Neurophysiological approaches such as Neurodevolpmental treatment and the Vojta method focus on the first principle, eliciting and establishing normal patterns of movements through sensorimotor experience (10,11); the effectiveness of neurophysiological approaches has been questioned by numerous publications (10,12). Recently, the focus of assessment and intervention strategies is on functional approaches (6), in which context, physical therapy emphasizes the interaction between the individuals, the task and the environment as a basis for the child to learn. Children actively seek effective solutions to problems that arise in situations which they desire to master (13). Therefore the functional approach is based on an active aspect of motor learning rather than passive one, by which subjects learn to solve their problems actively, rather than repeatedly practicing normal patterns of movement (6); Using this approach, both parents and caregivers can participate to achieve the required functional goals (7). The purpose of this study was to determine the effects of a functional therapy program on the motor abilities of children with CP. We hypothesized that motor abilities would improve following functional physical therapy.

Materials & Methods

This was a single group interventional study with a pre- and post design. The subjects were treated with a functional physical therapy protocol. The purpose of study was explained for child's parents, following which a 24 supervised session exercise program lasting 12 weeks, twice per week/90 min per session was conducted at the Razmejo-Moghadam Physiotherapy Clinic, Zahedan University of Medical Sciences, Zahedan, Iran, in 2007. Before and after intervention, treatment outcomes were measured. Parents gave their written voluntary informed consent before initiation of the study.

Participants

We recruited 15 children with CP (6 diplegic, 7 hemiplegic, and 2 quadriplegic) from the physiotherapy clinic of Zahedan University of Medical Sciences through simple non-probability sampling. Children were selected based on following inclusion criteria;

age less than 12 years, mild or moderate severity of involvement, and a confirmed CP diagnosis by a child neurologist). Children were excluded if they failed to complete the treatment program or used other therapies, received dorsal rhizotomy surgery, intrathecal baclofen, or botulinum toxin injections in the lower limbs prior to study recruitment. Data were collected using questionnaires, observation and examination.

Outcome Measures

Tonicity assessing

Quadriceps muscle tonicity was graded on an ordinal scale from zero to 5 based on the Modified Ashworth Scale (table 1), a common clinical tool for assessing muscle tonicity (14,15).

Gross motor function classification

Subjects were classified by age and severity of motor disability using the Gross Motor Function Classification System (GMFCS) (16). The GMFCS is based on the concepts of abilities and limitations in gross motor function and is analogous to the staging and grading systems used in medicine to describe cancer. We believe this approach for classification could enhance communication among professionals and families with respect to utilization of rehabilitation services, the creation of databases and registries, and comparison and generalization the results of program evaluations and clinical research. The GMFCS is designed for children with CP, aged ≤12 years. The system has 5 levels that are based on differences in self-initiated movement, particularly sitting and walking. The results of nominal group process and Delphi survey consensus methods, involving 48 experts, provided evidence of content and construct validity of GMFCS data, with 5 levels which represent differences in gross motor function, meaningful to children's daily lives (16); level I is the highest one and level V is the lowest.

The GMFCS was used to classify child's gross motor function, by determining which of the 5 levels best correspond to the child's abilities and limitations in gross motor function at home, in school, and in community settings; the description for each level is broad and is not intended to describe all aspects of gross motor function; for each level, separate descriptions are provided for children in the following age groups: Less than 2 years, 2 to 4 years, 4 to 6 years, and 6 to 12 years. Distinctions among GMFCS levels are based on functional limitations, need for assistive mobility devices (walkers, crutches, canes) or wheeled mobility, and quality of movement in lesser extents. The GMFCS scores are ordinal, with no assumption for (or when) the distances between levels are equal or the children with CP are equally distributed among the 5 levels. Inter-rater reliability of obtained GMFCS data has been examined by Palisano et al (16), and Wood and Rosenbaum (17), who reported an inter-rater reliability value of 0.93 between 2 raters independently classified 85 children at 4 ages from a blinded chart review.

Gross motor function measure

The GMFM (18) is a standardized, criterion-referenced test designed to measure changes in gross motor function of children with CP. Evidence of the reliability and validity of GMFM scores has been reported. (18-22). The test consists of 88 items grouped into 5 gross motor function dimensions; lying and rolling (17 items), sitting (20 items), crawling and kneeling (14 items), standing (13 items), and walking, running, and jumping (24 items). The 88 items of the GMFM are measured by child observation and scored on a 4-point ordinal scale (0=does not initiate, 1=initiates <10% of activity, 2=partially completes 10% to <100% of activity, and 3=completes activity). Scores for each dimension are expressed as a percentage of the maximum score for that dimension. The total score is obtained by averaging the percentage scores across the 5 dimensions. The GMFM is administered following standardized procedures, including encouraging the child's best possible effort for each item attempted (23), in a setting without environmental interferences, e.g. the GMFM manual (18) states that the floor should be a smooth and have a firm surface. The assigned score represents the child's best effort over a maximum of 3 trials. The GMFM items are used to represent capability, administered only by the therapist, not by the parent report. The entire GMFM was administered without mobility aids or orthoses. If the child typically used mobility aids or orthoses, standing and walking items were administered for a second time with the typical mobility aids or orthoses. For

consistency among children and test items, the obtained scores without the use of mobility aids or orthoses were used to represent capability.

Intervention

After training, the functional physical therapy program was administered. Functional physical therapy is directed at promoting functional skills instead of movement normalization. Because each child has different problems in performing functional skills in different ages, intervention is dependent on age and 4 combinations of the functional physical therapy program. Hence it was scheduled for 4 age groups, on the physical and social demands of child. The therapy model consists of stages which lead to a task-specific individual therapy plan to master in important functional skills. Priorities were established by parents and children, after collection of general information about the physical and social environments and also specific information about the child's problems in the functional motor activities performance. In the next stage, the selected problems were analysed separately. Individual factors, related to the functional skill, such as specific impairments, functional limitations, and motivational aspects and also constraints and possible support from the environment (both physical and social) in which the skill was problematic were determined. Many therapists analysed which subsystems constrain the performance of the task, and also which of them can be altered through intervention. When the constraints were analysed, long-term goals (related directly to the selected problematic activities) were divided into less complex short-term goals, related to the long-term goals. For example, a child falls often when walking on an uneven surface. His parents run a farm, and he likes to walk in the stables. Poor ability to stand on one leg and the uneven surfaces in and around the stables, are the main factors related to his falling. Walking in and around the stables without falling is formulated as the long-term goal. Goals such as the child steps over a doorstep without holding on the doorpost or kicks a ball without falling when standing on a mat are short-term goals; an evaluation date was established for each goal.

In the implementation stage, the short-term goals were practiced in various natural settings. Repetitive practicing took place in situations resembling the problematic situation as closely as was possible, i.e. practice took place in natural situations, mostly at home or outdoors, or maybe in the therapy room when the desired situation could be simulated. The therapist and parents discussed how, when, and where to practice, and they also discussed the amount of assistance, the reduction of assistance, the most practical time of day for practicing each specific skill, and the related skill setting needed for the child to practice. On specified dates, goals were evaluated by parents, child, and the therapist. The main features of the functional approach were; establishment of functional goals, repetitive practice of the problematic motor abilities in functional situations and in a meaningful environment, active role of the child (the child must find solutions for motor problems), and active involvement of parents in all stages of the program (e.g., goal setting, decision making, implementation in daily life, evaluation of goals).

Sample size estimation

The required sample size was determined, assuming a type I error probability of 5 percent, a type II error probability of 10 percent, and 15 percent dropout based on the expected change in the clinical measures of gross motor function.

Data Analysis

Data were analyzed using SPSS 15 (SPSS Inc, Chicago, Illinios). Kolmogorov-Smirnov test for normality was performed for all outcome variables. For parametric data paired t- tests and for non-parametric data, Wilcoxon tests were used for comparison between pre- and post treatment test results, and a p-value less than 0.05 was considered statistically different.

Results

A total of 15 children based on the inclusion criteria were enrolled in the study. Information on sample characteristics, including sex, age, type and distribution of CP, etiology, previous rehabilitation, medication, and surgery are listed in Table 2.

Before treatment, the majority of children (n=5, 33.3%)

were found to be at GMFMS level IV, and after treatment, the majority (n=6, 40%) were at GMFMS level III. Table 3 shows the GMFMS levels of participants before and after intervention; before and after intervention, mean and standard deviation of study variables, p-values of within group comparisons and confidence intervals are shown in table 4.

Paired t-tests revealed significant difference between pre- and post test results, with increases in scores of lying and rolling, sitting, crawling and kneeling, standing, and walking, running, and jumping scores and also total GMFM scores (P<0.0001). Wilcoxon tests also identified significant difference within groups regarding muscle tonicity (P<0.00001) (Table 4).

Table 1. Modified Ashworth Scale

0	No increase in muscle tone
1	Slight increase in tone, manifested by a catch and release or by minimal resistance at the end of the range of motion when the affected part(s) is moved in flexion or extension
2	Slight increase in muscle tone, manifested by a catch, followed by minimal resistance throughout the remainder (less than half) of the range of motion
3	More marked increase in muscle tone through most of the range of motion, but affected part(s) easily moved.
4	Considerable increase in muscle tone, passive movement difficult
5	Affected part(s) rigid in flexion or extension

Table 2. Characteristics of the samples

	Variable	No
Sex	Female	3
	male	12
Age	Birth to 2 years	10
	2-4 years	4
	4-6 years	1
	6-12 years	0
Distribution of CP	Hemiplegic	7
	Diplegic	6
	Quadriplegic	2
Accompanied problems	Maternal infection	2
	Difficult labor	4
	Seizures	6
	Prematurity	2
	Rh incompatibility	1
Prior rehabilitation		10
Medication	Pirastam	8
	Baclofen	3
	Disport	1
	Other	3
Surgery		0
Total		15

Table 3. GMFMS levels of participants before and after intervention

		Pre treat		Post treat	
		No	Percentage	No	Percentage
GMFMS	I	-	-	4	26.7
	II	2	13.3	3	20
	III	4	26.7	6	40
	IV	5	33.3	2	13.3
	V	4	26.7	-	-
Total		15	100	15	100

Table 4. Within group comparisons of study variables

Outcome measures	Before	After	P value*	CI**
Lying and Rolling	46.67±32.9***	71.1±24.1	0.0001	-33.99_-14.89
Sitting	42.33±33.26	67.44±27.52	0.0001	-34.57_-15.65
Crawling and Kneeling	32.38±33.39	50±32.41	0.0001	-24.8_-10.4
Standing	18.63±28.35	36.4±32.5	0.0001	-25.76_-9.79
Walking, Running, and Jumping	12.59±26.25	21.39±33.04	0.012	-15.38_-2.21
GMFM Total	30.52±28.99	49.27±26.9	0.0001	-13.76_-8.1
Muscle Tonicity	1.93±0.59	0.87±0.64	0.0001	0.92-1.21

* Statistical different at P<0.05.

**Confidence Interval.

***Values are Mean ± Standard Deviation.

Discussion

The results demonstrated that functional physical therapy improves motor abilities of children with CP. All dimensions of gross motor function including lying and rolling, sitting, crawling and kneeling, standing, and walking, running, and jumping, measured by the GMFM were significantly improved following functional physical therapy. The results also indicated that differences in GMFMS levels between pre- and post treatment are clinically meaningful. The main goal of therapeutic intervention in working with children with neurologic dysfunction is to improve function; since brain damage occurs in a developing motor system, the primary emphasis of physical therapy intervention is to foster motor development and functional motor skills learning (1). The functional approach has some advantages, and being more structural functional. It facilitates better cooperation between children, parents and therapists, who know which skills should be improved. This approach prompts better participation of parents and higher motivation of parents and children, and

is enjoyable for children. It provides better insight into the problematic skills of the children, making therapeutic goals clearer, and hence improvements are more apparent (6).

Children with neurologic dysfunction may exhibit delays in motor development and impairments in muscle tone, sensation, range of motion, strength, and coordination. These children are at risk for musculoskeletal deformities and contractures and often are prone to developing limitations in performing functional activities. Functional limitations in transfers, locomotion, manipulation, and daily living activities may result from impairments (1).

Ahl et al evaluated functional training for children with CP, and their findings, in line with those of our study, demonstrated that gross motor function and performance of daily activities, including social function, improved significantly, following treatment, although a decrease in caregiver assistance related to the children's mobility was noted; parents' perception of family-centeredness improved in all GMFM domains. Furthermore, the children's preschool assistants felt more competent in their care of the children (7).

Ketelaar et al investigated the motor abilities of child's with spastic CP receiving functional physical therapy, with a focus on practicing functional activities; they compared their subjects with children in a reference group whose physical therapy was based on the principle of movement quality normalization, aiming to assess whether the child's motor abilities in functional physical therapy group improved more than those of the children in the reference group. They found that the groups' improvements in basic gross motor abilities, measured by the GMFM in a standardized environment, did not differ. When examining functional skills in daily situations, as measured by the PEDI, children in the functional physical therapy group improved more than those in the reference one (6).

Furthermore, for improving function in children with CP, other therapeutic approaches have also been considered; dynamic splints made from Lycra are thought to reduce abnormal tone and involuntary movements, increase proximal stability, and improve upper-limb movements in children with CP (24). However, they are associated with significant practical problems, as they are difficult to put on and are often uncomfortable (25). Nicholson et al assessed upper limb function and movement in children with CP, after wearing the Lycra garment, for at least 6 hours a day for 6 weeks, and suggested that the functional benefit of Lycra garments for children with CP is mainly due to improvements in proximal stability, but this should be weighed against the inconvenience and loss of independence (26).

Several investigators (27-30) have reported positive results in functional areas following botulinium toxin A injections. Mall et al (27) and Heinen et al (30) evaluated the effect of botulinium toxin A treatment on function in children with CP and adductor muscle spasm. Mall and colleagues (27) used the GMFM to measure the treatment effect, and reported significant improvement in gross motor function in GMFM total scores; it was further noted that patients with moderate impairment of gross motor function, defined as those who met the criteria for levels III and IV in the GMFCS, derive the greatest benefit from treatment; those at level III could walk with an assistive device, but had some outdoor limitations, whereas children who meet the criteria for level IV were self-mobile in wheelchairs. Hence ambulatory subjects in the Mall study by Mall and colleagues (27) were limited by the need for an assistive device, while non ambulatory ones were independently mobile in wheelchairs, and were found to derive the greatest effect, or benefit, from botulinium toxin A injections. Fehlings et al (29) also reported an increase in upper extremity function in a sample of children with hemiplegia, measured with a standardized tool known as the Quality of Upper Extremity Skills Test (QUEST). In addition to their findings in upper-extremity function, Denislic and Meh (28) also reported improved foot posture (70% - 90% improvement, measured using a modified Physician Rating Scale [PRS]). Although many studies have focused on functions of body systems, these studies have reported positive effects of botulinium toxin A on patient's activity or limitations. The effects of botulinium toxin A on daily life and functional abilities considered very carefully since it is of fundamental importance to the individual (31).

A few research studies showed that spastic hypertonicity

limits a patient's ability in moving quickly, since activation of stretch reflex is velocity dependent. Bobath suggests that "Weakness of muscles may not be real, but relative to the opposition of spastic antagonists" and proposed that normalization of muscle tone should be a priority of treatment (32). In line with Bobath's approach, Tsorlakis et al also emphasized on the effectiveness of neurodevelopmental treatment and the need for intensive application of the treatment on gross motor function of children with CP (33). The Bobath neurodevelopmental treatment approach advised against the use of resistive exercise, as proponents felt that increased effort would increase spasticity. On the contrary, Fowler et al examined the premise that the performance of exercises with maximum efforts will increase spasticity in people with CP; their results do not support the premise that exercises with maximum efforts increase spasticity in people with CP (34). Akbari et al determined effects of a strengthening exercise protocol in treatment of quadriceps and gasterosoleous muscles tonicity in hemiparetic patients, despite differing opinions on the side effects of strengthening exercises; contrary to current views, their results support the effectiveness of lower limb muscle strength training in reducing the spasticity in addition to improving muscle strength in the chronic stages of rehabilitation following stroke. (35, 36).

To mention our limitations, although GMFM provides a lot of data, it is complex and very time-consuming for the staff. Another limitation has been the interpretation of the GMFM total score. Children with different skills and abilities within and between dimensions can get the same total score. A further limitation is that scores of children functioning in the middle of the scale have greater potential to change than scores of children whose initial assessment is either very low or very high because there are more items in the middle of the scale than at the extremes.

In conclusion our findings show that the functional physical therapy program may be effective in improving motor abilities, daily activities, and decreasing muscle tonicity of children with CP. All dimensions of gross motor function and also GMFMS levels were significantly improved following functional physical therapy.

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