Evaluation of the functional effects of a course of Bobath therapy in children with cerebral palsy: a preliminary study

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This study aimed to evaluate functional effects of Bobath therapy in children with cerebral palsy (CP). Fifteen children with a diagnosis of CP were recruited (9 males, 6 females; mean age 7 years 4 months, SD 2 years 8 months; age range 2 to 12 years). Types of motor disorder were as follows: spastic quadriplegia (n=9); spastic diplegia (n=4); athetoid quadriplegia (n=1), and ataxia (n=1). Participants were distributed across the following Gross Motor Function Classification levels: level I, n=1; level II, n=4; level III, n=5; level IV, n=4; and level V, n=1. Children awaiting orthopaedic intervention were excluded. A repeated measures design was used with participants tested with the Gross Motor Function Measure (GMFM) and Pediatric Evaluation of Disability Inventory (PEDI) at 6-weekly intervals (baseline, before and after Bobath therapy, and follow-up). As the data were of ordinal type, non-parametric statistics were used, i.e. Wilcoxon's test. Participants showed a significant improvement in scores in the following areas following Bobath therapy compared with the periods before and after Bobath therapy: GMFM total score (p=0.009); GMFM goal total (p=0.001); PEDI self care skills (p=0.036); and PEDI caregiver assistance total score (p=0.012). This demonstrates that in this population, gains were made in motor function and self care following a course of Bobath therapy.

At present it is difficult to demonstrate the effects of physiotherapy in children with cerebral palsy (CP). This is because of different motor disorders, a variety of treatment approaches which lack clear description, and a lack of suitable validated evaluative tools. Hur (1995) reviewed 37 studies of therapeutic interventions for children with CP and reported that the majority of the studies had small samples, were poorly controlled, and some lacked rigour in both experimental design and analysis. Of the seven studies using a comparative design, only two showed a significant treatment effect.

However specific factors associated with physiotherapy have been shown to have a positive impact on the outcome of treatment. For example, the use of specific measurable goals in treatment rather than general aims may be associated with increased motor skill acquisition (Bower and McClellan 1992, Bower et al. 1996). Providing weekly rather than monthly therapy (Mayo 1991) and daily rather than weekly or fortnightly therapy (Bower et al. 1996) may accelerate the acquisition of motor skills. However, this is not supported by other work by Bower and colleagues (2001) where the use of goals did not appear to affect outcome and more intensive daily treatment only produced a limited and temporary improvement. Stretching tight muscle, regular change of position, provision of appropriate equipment, and encouraging mobility have all been shown to prevent or slow down the deterioration of secondary deformities (Watt et al. 1986, Tardieu et al. 1988, Myhr and von Wendt 1991, Chad et al. 1999). Treatment strategies involving both parents and children have been shown to be most effective in achieving an enhanced developmental outcome (Barrera et al. 1986, Shonkoff and Hauser-Cram 1987, Short et al. 1989).

One therapy approach most widely used within the UK for children with CP is Bobath therapy (Bobath and Bobath 1984). The Bobath concept emphasizes observation and analysis of the client's current functional skill performance (Mayston et al. 1997) and the identification of clear therapy goals. The aims of treatment are to influence muscle tone and improve postural alignment by specific handling techniques, and then to work for better active participation and practice of specific, relevant, functional skills (Mayston 2001a,b). Bobath therapy is considered to be appropriate for treating any motor control disorder within the CP spectrum (Mayston 1992). Treatment programmes within the Bobath concept are goal focused (Mayston 2001b). The Bobath approach centres on the likely potential for secondary deformities and how these may be prevented. Parent/carer education is one of the main elements of the intervention which is intended to facilitate the parent–child relationship, enable the parent to handle/assist with their child's difficulties, and give an intensive period for practice of activities (Bly 1991, Mayston 1992).

As the Bobath concept initially followed a developmental approach it soon became known as 'neurodevelopmental therapy' (NDT). As it has evolved independently in different countries some slight differences of interpretation have occurred. In this paper, if a treatment is cited which shows a different approach to what is usually encompassed by the Bobath approach, this is stated in the text.

Despite the widespread use of Bobath therapy there has been a lack of rigorous research into its clinical effectiveness (Royeen and DeGangi 1992). Ottenbacher and coworkers (1986) conducted a meta-analysis of studies which investigated the effects of NDT in paediatric populations. Their

report showed that clients receiving NDT or a combination of NDT and other interventions performed better than 62% of participants receiving other treatment modalities, although the effect size was perceived to be small. Some other small studies have also shown that NDT may be of benefit (Laskas 1985, Kluzik et al. 1990, De Gangi 1994, Jonsdottir et al. 1997). However, Royeen and DeGangi (1992) reviewed 19 studies investigating the effects of NDT, and found many to have inconclusive results. There were similar problems with sample size, with lack of suitable validated measures, and in the experimental design – a problem common to research into all types of therapy for children with CP.

More studies investigating the efficacy of specific interventions are needed which use appropriate experimental designs (Royeen and De Gangi 1992, Hur 1995). The purpose of the present study was to investigate the effects of a 6-week block of Bobath therapy on the function of children with CP. This length of therapy reflects current practice for children at the Bobath Centres in Glasgow and Cardiff, and for some children local to the London Bobath Centre. Children are also seen at all three centres for 2-week therapy blocks. This represents the first phase of a larger study.

The dependent variable was change in function as measured by standardized tests: the Gross Motor Function Measure (GMFM; Russell et al. 1993) and the Pediatric Evaluation of Disability Inventory (PEDI; Haley et al. 1992). The independent variable was the Bobath therapy course. It was hypothesized that the test scores would demonstrate differences before and after the Bobath course of therapy.

Method

EXPERIMENTAL DESIGN

A repeated measures design was used with assessment carried out at 6-weekly intervals: at baseline, before Bobath treatment, after Bobath treatment, and at follow-up. In this pilot study, the children acted as their own controls. The amount of local therapy received by the children was not altered, but was recorded by the parents. A convenience sample was used. Ethical approval was given by the Ethical Practices Subcommittee at the Royal Free Hospital, Hampstead, London.

PARTICIPANTS

Inclusion criteria were: a diagnosis of CP (irrespective of the type or distribution), age 2 to 12 years, and referral to a UK Bobath Centre (London, Cardiff, or Glasgow) for a 6-week course of therapy. Exclusion criteria were: receipt of medical procedures likely to affect motor function such as botulinum toxin injections or orthopaedic surgery, and a Gross Motor Function Classification (GMFCS; Palisano et al. 1997) of level V. The GMFCS classifies children with CP into five levels according to motor ability with particular reference to sitting ability and independent mobility. Children classified as Level V are unable to maintain antigravity head and trunk postures in prone and sitting positions and require adult assistance to roll. They are usually transported but may achieve self-mobility using a powered wheelchair with extensive adaptations. In initial sensitivity studies of the GMFM, children at Level V showed least change over time (Russell et al. 1989). Children at Level V can usually only attempt a limited number of test items resulting in fewer degrees of freedom for change. Performance when tested with the GMFM is often affected by their health status (Bower et al. 2001). Therefore, it was decided to exclude this group from the trial due to the possible reduced sensitivity of the test in this population.

MEASURES

Three standardized validated measures of function were used: The GMFM which assesses gross motor abilities of children with CP in five dimensions: (1) Lie and Roll, (2) Sit, (3) Crawl and Kneel, (4) Stand, and (5) Walk, Run, and Jump (Russell et al. 1989, 1993). In children with CP, the GMFM has been shown to be sensitive to change during periods of therapy (Bower et al. 1992, 1996; Steinbok et al. 1997). Individual dimension and total percentage scores can be calculated representing how many and to what extent items are achieved. McLaughlin and colleagues (1998) suggested that there might be a difference in level of difficulty of items in different parts of the range of the GMFM scores with the upper range being less sensitive to change. The scale is ordinal and differences between scores are not intended to represent equal differences of ability. Therefore, it was decided also to use the Gross Motor Function Measure-66 (GMFM-66).

The GMFM-66 is a new method of scoring using only 66 test items that have been arranged in order of item difficulty (Russell et al. 2000). This allows an interval score to be calculated representative of the overall level of motor ability of the child. It does not entail separate testing but can be calculated from the GMFM scores. The scale does, however, appear to be less sensitive than the GMFM in detecting change in children over 5 years of age and many items have been removed from the Lying and Sitting dimensions making it potentially less sensitive to change for the more severely involved child.

The PEDI assesses mobility, self care, and social function. Functional skills and caregiver assistance (physical assistance typically required of the caregiver) scales were used (Haley et al. 1992). The PEDI is completed on parent interview. It has been shown to be sensitive to differences between children with differing distributions of CP and to changes following surgery and therapy (Bloom and Nazar 1994, Dudgeon et al. 1994).

These standardized measures do have some limitations. The GMFM and PEDI only measure certain aspects of function and do not purport to measure how a child performs a task such as speed, coordination, and fluency of movement, which may be relevant skills for the child with CP (Wright et al. 1998). Although the GMFM is aimed at the broad range of ability of children with CP, floor and ceiling effects can affect the sensitivity of the GMFM. If a child is already performing at near 100% or baseline, there are limited degrees of freedom for change (Russell et al. 2000, Stanley et al. 2000). The same phenomenon is acknowledged to be true of the PEDI by the original authors (Haley et al. 1992). To obtain a maximum score on the GMFM, the child must attempt as many items as possible. If a child can achieve an item at a higher maturational level such as crawling, they may be reluctant to attempt an item at a lower level such as creeping in prone. Therefore, children may function at a higher level, but achieve a lower or similar score due to refusal or poor attempts at lower level items (Nordmark et al. 2000). Despite these limitations, these standardized measures are currently considered the best available for children with CP and complementary to each other as they measure different aspects of function (Ketelaar and Vermeer 1998).

Parent and therapist questionnaires were designed for this

study (see Appendix I) requesting information on what, if any, changes they perceived to have taken place in the child's motor, self care, and social skills. No suitable standardized questionnaire could be identified for this purpose. The questionnaires were administered to identify any correlation between parents' and therapists' perceptions of change, to determine whether any association existed between these perceived changes and the results of standardized testing, and to determine whether changes might have occurred in areas outside the remit of the standardized tests.

PROCEDURE

Informed written consent was obtained from the parents. Children received their baseline assessment (GMFM and PEDI) and parents were asked to record local therapy sessions received over the first 12 weeks of the trial. This was to give an indication of the type and quantity of local therapy during the baseline and intervention periods. At 6 weeks the next assessment took place and a parent questionnaire was administered asking if any changes were perceived by the parent to have taken place in the child's function during the baseline period. Bobath therapy began and the treating therapist was asked to set a minimum of three short-term treatment goals in agreement with the family. Treatment sessions lasted 75 minutes and participants attended three times per week (expected attendance being 16 sessions, as the first and last were used for testing). At 12 weeks, (the end of the intervention period), the third assessment took place and questionnaires were administered to the parents and treating therapist regarding perceived changes in function. A final assessment took place at 18 weeks (Fig. 1).

All therapists had several years paediatric experience before attending an 8-week paediatric Bobath course and had then worked in a Bobath Centre in the UK treating children with CP, for between 2 and 20 years (mean 6.4 years). Two therapists were Bobath tutors (qualified to teach a paediatric Bobath course) and three therapists had almost completed their tutor training. During this trial, physiotherapy was the main therapy applied, but additional therapists (e.g. occupational or speech and language) were present for some sessions.

It was not possible to have the same therapist assessing every child due to the geographical spread of the Centres (London, Glasgow, and Cardiff) and limited funding for the study. Therefore, assessment was carried out by designated therapists from the centre where the participant was being treated, but who were not themselves involved in treatment. Therapists received training and practice in using the PEDI and GMFM. Therapists using the GMFM were tested for reliability by a video assessment and attained a Kappa of >0.8 (considered by the authors to be good reliability). No such procedure is available for the PEDI. Masking was not attempted. Additional funding required for running an interrater reliability study were not available for this project.

DATA ANALYSIS

In addition to individual dimension scores for the GMFM, the following scores were analyzed: GMFM total, GMFM goal total,[1] GMFM non-goal total,[2] and GMFM-66 scores. As well as individual PEDI domain scores, total scores for functional skills and caregiver assistance were calculated.[3] As the data were ordinal and would not follow a normal distribution, non-parametric statistics (Wilcoxon's test) were used: to see if there was a significant difference between any pair of test scores collected at different times: 0 and 6 weeks; 6 and 12 weeks; and 12 and 18 weeks. Probability for statistical significance was set at $p<0.05$.

Results

Twenty participants with a diagnosis of CP were recruited (12 males, 8 females; range 2 to 12 years), but five could not be followed up due to: illness during trial ($n=2$); botulinum toxin injections during trial ($n=1$); failure to attend a majority of treatment sessions ($n=1$); and communication difficulties causing the child distress during measurement procedures ($n=1$). These participants were not included in data analysis on an intention to treat basis. Analysis was concerned with change over time. These children received a maximum of one (or in one child) two tests before Bobath intervention. There were, therefore, no meaningful data to add to the final analysis. Therefore, fifteen children were studied (9 males, 6 females; mean age 7 years 4 months, SD 2 years 8 months; range 2 to 12 years). Characteristics of all participants are shown in Table I.

No children had hemiplegia, which is representative of

[1]Goal total: determined by observing in which dimension(s) the treating Bobath therapist had set goals at onset of therapy and assigning those dimension(s) as the goal total score (if more than one dimension is highlighted, an average score is calculated).
[2]Non-goal total: an average score calculated from all dimensions not assigned as goal areas.
[3]Calculation of total scores are not suggested in the manual, but as this test was thought to be less sensitive over a period of a few weeks, it was thought this might maximize the chance of seeing any change in scores that occurred.

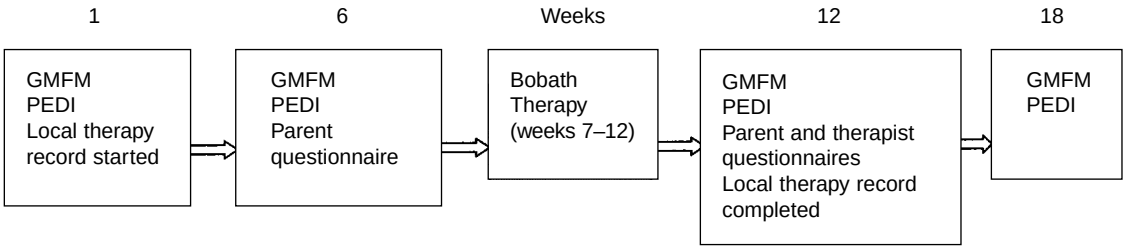

Figure 1: *Flow chart of study design showing timing of assessments and intervention.*

the population of children referred to Bobath Centres, where most children have more complex disabilities. Two children who were thought to be Level IV at the recruitment stage were, on more detailed appraisal at initial testing, reclassified as level V. The intention had been to exclude children at Level V (see method section), but as data collection for these children had begun, it was decided that they would be included in the final analysis. One of these participants completed the trial and one could not be followed up.

Fifty-seven GMFMs and 53 PEDIs were completed (of a possible 60 each). Complete data were available for nine children and partial sets for the remaining six, but this was sufficient for

Table I: Characteristics of all children recruited

Child	*Sex*	*Age (y:m)*	*GMFCS level*	*Motor disorder*	*Additional Impairment*				
					Learning difficulties	*Hearing*	*Visual*	*Communication*	*Contractures*
1	M	4:4	I	Sp Di					
2	M	2:9	II	Sp Di					
3[a]	F	5:10	III	Sp Di					
4	M	6:11	III	Sp Di			+		
5	F	8:8	III	Sp Di					
6	F	12	II	Sp quad					+
7	M	4:3	III	Sp quad			+		
8	F	4:9	III	Sp quad			+	+	
9	M	10:9	III	Sp quad					+
10[a]	M	2:10	IV	Sp quad				+	
11	M	5:8	IV	Sp quad	+			+	+
12	M	7:3	IV	Sp quad				+	
13	F	7:10	IV	Sp quad					
14	M	8:6	IV	Sp quad					
15[a]	M	8:10	IV	Sp quad			+		+
16	M	6:4	V	Sp quad	+		+	+	+
17	F	10:10	II	Ath quad		+	+	+	
18[a]	F	6:9	V	Ath quad	+			+	+
19	F	8:11	II	Ataxia		+		+	
20[a]	F	6:10	III	Ataxia	+			+	

[a]Withdrawn from trial. Sp Di, spastic diplegia; Sp quad, spastic quadriplegia; Ath quad, athetoid quadriplegia.

Table II: Therapy sessions during baseline and intervention periods

Child	*Bobath sessions Max=16*	*Number of local therapy sessions*							
		Baseline period				*Bobath intervention*			
		PT	*OT*	*SLT*	*Other*	*PT*	*OT*	*SLT*	*Other*
1	14	5	1			2			
2	13		Not recorded				Not recorded		
4	15		6		6				3
5	15	6			13	6			15
6	16		Not recorded				Not recorded		
7	16	3					1		
8	12	3	1		13				10
9	6		Not recorded				Not recorded		
11	16	1	1	1	1				
12	15		Not recorded				Not recorded		
13	16	3	3	2	1				3
14	14		Not recorded				Not recorded		
16	11	5	2		2				
19	14	12				12			
17	16	1		6	4		Not recorded		

PT, physiotherapy; OT, occupational therapy; SLT, speech and language therapy; Other: riding, hydrotherapy, swimming, group, or home programme.

statistical analysis. Missing data were largely from the final test at 18 weeks, 6 weeks after Bobath therapy had finished, where some children failed to return for final testing or parental time was limited for completion of the PEDI. GMFM scores were affected by illness on one occasion. The mother of child 12 commented that he was recovering from influenza at his final test when his scores decreased and she did not think this reflected his usual performance.

Bobath treatment attendance was good for the majority of participants. Eight parents recorded local therapy sessions. During the Bobath intervention, local therapy remained consistent or was less regular (Table II).

GOALS

Fifty-three goals were set. Of these, 40 were achieved (75%), seven were not achieved, and the results for six goals were not recorded. Examples of goals set include: (1) 'to be able to sit with supervision unsupported on a bench with both hands down for 10 seconds'; (2) 'to be able to put tops and trousers and socks on in correct sequence without instruction or assistance'; (3) 'to be able to walk up a flight of steps independently (in Bobath Centre) holding on to both rails, stepping alternately with right and left foot'.

A large proportion of the goals set by the therapists were within areas covered by the GMFM or PEDI, such as activities related to sitting, self care, and so on, although therapists were not asked to consider this when setting their goals. Some were potentially within more than one GMFM dimension or both a GMFM dimension and PEDI domain. Other goals did not fall within the remit of either measure, for example 'be able to roll with arms extended above shoulder level, from supine to prone'; 'improve passive range of hip abduction'; 'fill in a

Table III: Goals set related to test dimensions and domains

Child	*Total number of goals*	*Goals in GMFM dimension or PEDI domain*	*Goals achieved*	*Number of other goals*	*Goals achieved*
1	3	Walk and Mobility[a]	+	1	+
		Social	+		
2	3	Stand and Walk[a]	+	2	++
4	3	Stand	+		
		Walk and Mobility[a]	+		
		Self care	+		
5	5	Sit	+	2	+–
		Stand	+		
		Walk and Mobility[a]	+		
6	3	Lying and Sitting[a]	+	1	+
		Self care	–		
7	3	Walk	+		
		Self care	+		
		Mobility	+		
8	3	Sit	+	1	+
		Sit	–		
9	3	Sit	–	1	+
		Stand	–		
11	3	Sit	+	1	+
		Sit	+		
12	3	Sit	+	1	NR
		Self care	–		
13	7	Sit	+	2	+ NR
		Sit	NR		
		Crawl	+		
		Self care	+		
		Mobility	+		
14	4	Sit	NR	2	+ NR
		Stand and Mobility[a]	+		
16	4	Lying	+	1	+
		Sit	+		
		Self care	+		
17	3	Stand	–	2	++
19	3	Stand and Self care[a]	+	1	+
		Walk and Mobility[a]	NR		

[a]Goals that fell into more than one dimension/domain. + achieved; – not achieved; NR, result not recorded.

missing part on pre-drawn picture' and so on, so neither standardized test could be expected to demonstrate whether these were achieved.

Although therapists were encouraged to set specific functional measurable goals, some were less specific than required or related to equipment assessment rather than attainment of a specific skill (see goal 3 in section on individual participant results 4 and 17). Setting specific goals over a short intervention period is a challenge within this population. It was recognized that therapists required more training in this skill to maintain goal-setting standards.

Comparing the GMFM goal and non-goal totals for the group as a whole can indicate whether targeting the therapy had any impact on outcome within this sample (see GMFM results section below). Comparisons of individual test scores and the achievement or non-achievement of specific goals are more difficult to interpret, as there is not always a direct relation between the goal and specific test items. Table III shows the number of goals set for each child, whether the goals fell within a dimension or domain of the tests, and whether the treating therapist considered the goals to have been achieved.

GROSS MOTOR FUNCTION MEASURE (GMFM) RESULTS

Significant improvements in score following Bobath therapy were seen in the GMFM total scores ($p=0.009$) and goal total scores ($p=0.001$). There was no significant improvement in the non-goal total scores ($p=0.196$). Significant improvements following Bobath therapy were also seen within Walking ($p=0.010$) and Crawling ($p=0.050$) dimensions and reached nearly significant levels in Lying ($p=0.066$; Table IV). GMFM-66 scores also showed a significant improvement following intervention ($p=0.03$).

Table IV: Gross Motor Function Measure – Wilcoxon's signed rank tests ($n=15$)

Dimension and Total scores	*Wilcoxon's signed rank tests*		
	Test 2–1	*Test 3–2*	*Test 4–3*
	Baseline	*Bobath intervention*	*Follow-up*
Lying	0.645 (z=–0.460)	0.066 (z =–1.963)	0.670 (z =–0.426)
Sitting	0.262 (z =–1.121)	0.259 (z =–1.128)	0.670 (z =–0.426)
Crawling	0.068 (z =–1.823)	0.050[a] (z =–1.958)	0.786 (z =–0.271)
Standing	0.075 (z =–1.782)	0.507 (z =–0.664)	0.440 (z =–0.772)
Walking	0.720 (z =–0.358)	0.010[a] (z =–2.580)	0.735 (z =–0.338)
GMFM total	0.609 (z =–0.609)	0.009[a] (z =–2.605)	0.248 (z =–1.156)
Goal total	0.281 (z =–1.079)	0.001[a] (z =–3.408)	0.505 (z =–0.667)
Non-goal total	0.875 (z =–0.875)	0.196 (z =–1.293)	0.767 (z =–0.296)
GMFM-66	0.65 (z =–0.454)	0.030[a] (z =–2.166)	0.515 (z =–0.652)

[a]Scores reaching statistically significant levels.

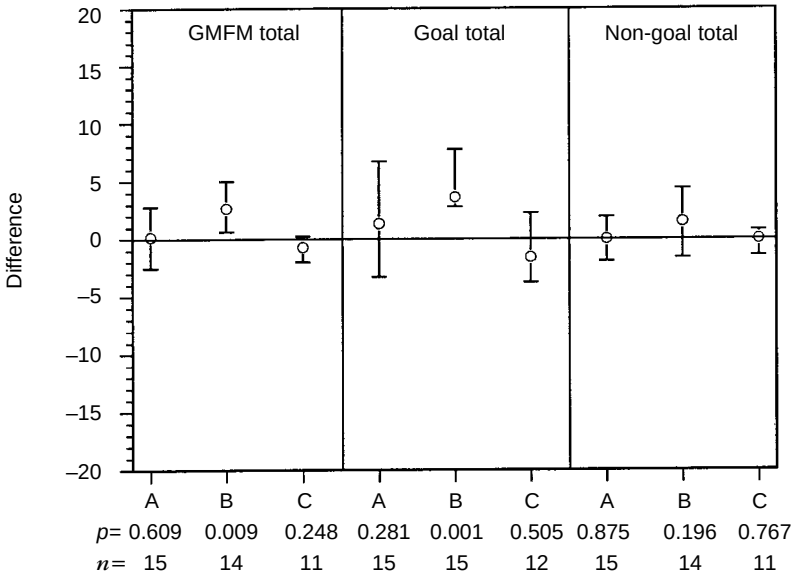

Figure 2: *Median and quartiles of intertest difference scores for GMFM goal and non-goal totals. A, baseline (test 2–test 1); B, Bobath therapy (test 3–test 2); C, follow-up (test 4–test 3).*

This is also illustrated in Figure 2, which presents intertest differences for the total scores, expressed as median differences, 25th and 75th centiles of the distribution.

No significant treatment effects were seen in the scores for sitting (p=0.259) or standing (p=0.507) dimensions. The children did show an overall improvement in score in these areas from the beginning of the study to the end, but this appeared to be unrelated to the Bobath therapy. Table V shows mean values for GMFM scores.

Due to the heterogeneity of this group of children, which is consistent with the variety of functional ability seen within children with CP, the SDs are very large. For example, some children were unable to achieve a score on any items within the walking dimension whereas other children achieved a score of up to 88%. SDs are, therefore, not very helpful in interpreting the data.

PEDIATRIC EVALUATION OF DISABILITY INVENTORY (PEDI) RESULTS

Significant improvements occurred in scores following Bobath therapy in the following domains: functional skills – self care

Table V: Gross Motor Function Measure – Group Mean Values (SD) (n=15)

Dimension	*Test 1*	*Test 2*		*Test 3*	*Test 4*
Lying	83.06 (18.88)	83.08 (20.48)	B[a]	86.46 (15.76)	86.11 (19.13)
Sitting	70.91 (34.72)	73.02 (36.43)		74.83 (34.75)	75.14 (34.11)
Crawl/kneeling	61.47 (46.58)	59.96 (46.78)	O	63.21 (45.78)	62.99 (46.92)
Standing	42.31 (35.52)	47.86 (36.40)	B	49.79 (39.00)	48.49 (37.60)
Walking	29.75 (31.92)	29.16 (29.75)		33.79 (34.04)	34.95 (34.09)
Total	57.80 (31.76)	58.56 (32.67)	A	61.20 (32.19)	60.80 (32.50)
Goal total	47.22 (25.44)	48.77 (25.88)	T	55.80 (25.78)	55.16 (25.23)
Non goal total	62.64 (37.68)	62.74 (38.59)		63.73 (37.67)	64.10 (38.69)
GMFM-66	54.71 (13.99)	55.09 (14.72)	H	56.94 (14.40)	55.59 (13.97)

[a] Denotes 6-week period of Bobath intervention.

Table VI: Pediatric Evaluation of Disability Inventory – Wilcoxon's Signed Rank tests (n=15)

Domain & Total Scores		*Wilcoxon's Signed Rank tests*		
		Test 2–1 Baseline	*Test 3–2 Bobath intervention*	*Test 4–3 Follow-up*
Functional skills	Self care	0.359 (z=–0.918)	0.031[a] (z= –2.158)	0.753 (z =–0.314)
	Mobility	0.17 (z =–2.397)	0.678 (z=–0.415)	0.080 (z =–1.753)
	Social function	0.388 (z =–0.863)	0.141 (z=–1.471)	0.498 (z =–0.677)
	Total	0.116 (z =–1.572)	0.064 (z=–1.852)	0.086 (z =–1.718)
Caregiver Assistance	Self care	0.814 (z =–0.235)	0.036[a] (z=–2.100)	0.043[a] (z =–2.028)
	Mobility	0.021[a] (z =–2.312)	0.015[a] (z=–2.429)	1.000 (z =–0.000)
	Social function	0.449 (z =–0.756)	0.326 (z=–0.981)	1.000 (z =–0.000)
	Total	0.101 (z =–1.642)	0.012[a] (z=–2.510)	0.110 (z =–1.599)

[a] Scores reaching statistically significant levels.

Table VII: Pediatric Evaluation of Disability Inventory – group mean values (SD) (n=15)

Domain	*Test 1*	*Test 2*		*Test 3*	*Test 4*
Skills					
Self care	61.17 (16.01)	60.60 (17.96)	B[a]	62.40 (17.82)	62.94 (16.98)
Mobility	60.06 (17.83)	61.53 (19.14)		63.28 (19.57)	65.52 (18.22)
Social function	70.34 (17.41)	70.70 (20.21)	O	73.27 (18.53)	74.37 (17.86)
Total Skills	191.58 (44.67)	192.83 (51.91)	B	198.96 (51.74)	202.84 (48.73)
Caregiver assistance			A		
Self care	58.84 (17.40)	55.63 (24.61)	T	56.42 (24.94)	61.26 (17.66)
Mobility	61.24 (18.34)	62.21 (16.98)		64.48 (17.82)	64.72 (19.33)
Social function	71.31 (24.88)	71.31 (24.25)	H	72.30 (22.96)	71.76 (22.70)
Total Caregiver	191.40 (55.48)	189.15 (62.12)		193.21 (62.60)	197.75 (55.77)

[a] Denotes 6-week period of Bobath intervention.

(p=0.031); caregiver assistance – self care (p=0.036); caregiver assistance – mobility (p=0.015), and caregiver assistance – total (p=0.012; Table VI). In other domains, mean scores improved over the whole course of the trial, but did not show a significant improvement after Bobath therapy (Table VII). The clearest difference between the results of the different trial periods was apparent for, functional skills – self care and caregiver assistance – total; both the baseline and follow-up period showed no significant improvements, whereas there was a significant improvement after Bobath therapy. Improvement was not seen within the social function domain of the PEDI. This is not unexpected as only a small proportion of this group of children were either seen by a speech and language therapist during their therapy or had goals set in this area (n=3). Also, the test has been recognized to be less sensitive and have less reliability within this domain (Haley et al. 1991), so it may not have been sufficiently sensitive to detect changes likely to occur in this population over a 6-week period.

Significant improvements occurred within domains of the PEDI within which goals had been set. Seven children had goals set within the self care domain and significant improvements occurred in self care skills (p=0.031) and the level of caregiver assistance required (p=0.036). The majority of these children had goals set for dressing skills and showed improvements in functional skills items for: dressing (n=7); washing/drying (n=4); tooth brushing (n=2); and nose care (n=1); and in caregiver assistance items for: dressing (n=5); eating/drinking (n=3); grooming (n=1); and bathing (n=3). Seven participants had goals set within caregiver assistance – mobility and a significant improvement occurred in this domain (p=0.015). Goals set related to transfers, indoor and outdoor locomotion, and stairs; improvements occurred in transfers (n=7), stairs (n=1), and outdoor locomotion (n=1).

AGE BANDS AND ABILITY LEVELS

When the group was divided into different age bands (2 to 6 years, n=7; and 7 to 12 years, n=8), the younger group showed a significant improvement following Bobath therapy in the GMFM Walking dimension (p=0.043), PEDI total functional skills (p=0.028); and PEDI total caregiver assistance (p=0.043) whereas the scores for the older group were not significant (Fig. 3). Both groups showed a significant improvement in their GMFM goal total scores following intervention (younger group p=0.018; older group p=0.012). When the group were divided into different GMFCS levels (levels I to III, n=10; levels IV and V, n=5), both groups showed a significant improvement following intervention in their goal total scores (levels I to III, p=0.005; levels IV and V, p=0.043), but the more functionally able group (levels I to III) showed the most significant improvement. Levels I to III also showed a significant improvement in PEDI total functional skills following intervention (p=0.047) and in PEDI total caregiver assistance (p=0.022), whereas the scores for levels IV and V were not significant.

PARENT AND THERAPIST QUESTIONNAIRES

Of the 10 parents who completed both questionnaires, eight reported more positive changes occurring in the 6 weeks after the Bobath therapy than in the 6 weeks preceding it. Examples of perceived changes included: 'he can undress quicker'; 'he can get out of the bath'; 'the biggest improvement is in sitting – he is sitting straighter at his lower back and keeping his head up for longer'; 'initiating trying to wipe herself after toileting'.

Examples of therapist comments included: 'able to open a door towards himself, i.e. take steps backwards'; 'gained almost full range of supination in the left arm'; 'able to remove top clothes, shoes and socks'; 'using top lip to take food off spoon'.

There was a large degree of overlap between the changes reported by the therapists and those of the parents and the results of standardized tests for individual children (Table VIII and individual participant results). Many areas of improvement mentioned by parents and therapists fell outside of the remit of the tests. For example, 'actively extending wrist when approaching an object to pick it up'; 'he has reduced the amount of pushing he does when in his chair'; and 'stepping is better – bigger steps with less scissoring' (see Appendix I).

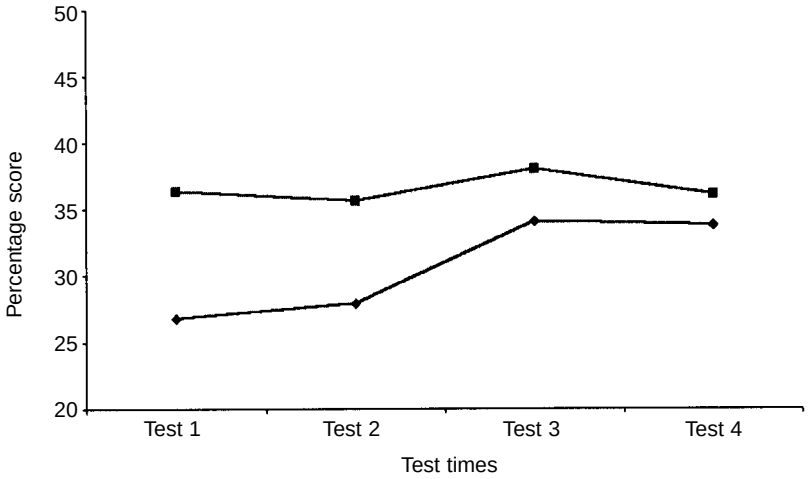

Figure 3: *GMFM Walking dimension: group mean values for age bands ◆, 2 to 6 years (n=7); and ■, 7 to 12 years (n=8).*

Table VIII: Areas of perceived improvement by parents and therapists and test results

Child	*Areas of perceived improvements after intervention*		*Results of test dimensions and domains Intervention compared to baseline*	
	Parent	*Therapist*	*GMFM*	*PEDI*
1	Standing		Standing↑	
	Walking	Walking	Walking↑	Mobility↑
	Dressing	Dressing		Self care =
2	Standing	Standing	Standing =	
	Walking	Walking	Walking↑	
	Dressing	Dressing		Self care ↑
	two-handed play	two-handed play		Social function ↑
4	Standing	Standing	Standing ↓	
	Walking	Walking	Walking ↑	Mobility ↑
	Dressing	Dressing		Self care =
5		Sit	Sitting ↑	
		Stand	Standing =	
	Walking	Walking	Walking =	
6	Sitting	Sitting	Sitting = remained at 100%	
	Stand		Standing ↓	
	Walk		Walking ↓	
	Dressing	Dressing		Self care CG ↑
7	Standing	Standing	Standing ↓	
	Transfers	Walking	Walking ↑	Mobility skills ↑
	Dressing	Dressing		Self care ↑
8	Lying		Lying =remained at 100%	
		Sitting	Sitting =	
	Standing	Standing	Standing ↓	
	Walking	Walking	Walking ↑	
	Dressing	Dressing		Self care =
	Hand skills & speech	Hand skills & speech		Social function ↑
9		Sitting	Sitting ↓	
	Standing		Standing ↑	
11	Lying	Lying	Lying ↑	
	Sitting	Sitting	Sitting ↑	
	Kneeling		Kneeling remained at 0%	
	Standing	Standing	Standing remained at 0%	
	Walking		Walking remained at 0%	
	Dressing	Dressing		Self care insufficient data
	Speech	Speech		Social function insufficient data
12	Lying	No questionnaire	Lying ↑	
	Sitting	completed	Sitting ↑	
	Walking		Walking remained at 0%	
	Dressing			Self care =
13	Lying	Lying	Lying =	
	Sitting	Sitting	Sitting =	
	Kneeling	Kneeling	Kneeling ↑	
	Standing	Standing	Standing ↑	
	Walking	Transfers	Walking =	Mobility =
	Dress & wash	Dressing		Self care ↑
14		Lying	Lying ↑	
	Sitting	Sitting	Sitting ↑	
		Standing	Standing =	
	Dressing	Dressing		PEDI self care *insufficient data*
16	Sitting	Sitting	Sitting ↓	
	Dressing, Eat/drink			
		Eat/drink		Self care ↑
17		Stand	Standing ↑	
	Stairs	Walk & Stairs	Walking ↑	Mobility =
19	Sitting	Sitting	Sitting ↓	
	Standing	Standing	Standing =	
	Walking	Walking	Walking ↑	
	Dressing	Dressing		Self care ↑
		Hand function		

Parents and therapists perceived improvements have been grouped into areas, e.g. sitting, hand function etc. Changes in test scores have been given for all domains/dimensions which appear to relate to these 'areas'. However, specific skills cited as being improved did not always fall within remit of either test or correspond to any test items. ↑, score improved; ↓, score deteriorated; =, score remained same or continued improving at same rate.

EXAMPLES OF INDIVIDUAL PARTICIPANT RESULTS

Child 4

Child 4 had spastic diplegia, was aged 6 years 11 months and classified Level III on the GMFCS; he had an alternating strabismus. Goals of therapy were as follows: (1) to be able to walk independently up a flight of stairs (at Bobath Centre) holding on to both rails, stepping alternately with right and left feet – achieved; (2) to be able to fold clothes while undressing independently sitting on the bench with only verbal prompts if needed – achieved; (3)to be able to take 10 steps slowly once within last week – achieved.

GMFM scores showed improvement in the lying and walking dimensions after intervention. Improved item scores, which appeared related to stairs and stepping, included ability to walk downstairs using alternating feet, to jump, and to kick a ball without falling. Throughout testing, the participant achieved the item: 'walk up four steps alternating feet holding onto one rail', but from the choice of goal 1, it is apparent that initially a full flight could not be managed. This is not tested within the GMFM. PEDI total scores improved, largely due to improved mobility domain scores, including walking over uneven surfaces and requiring less assistance for bath transfers. The parent perceived the following changes: 'able to walk upstairs using two handrails' and 'with little supervision able to undress and fold clothes'. The therapist's reported changes were: 'able to slow down walking', 'improved independent standing with feet flat', and 'better grasp of the concepts needed to fold clothes and to put them on the right way round'.

Child 17

Child 17, aged 10 years 10 months had choreoathetosis, was Level II on the GMFCS, had strabismus, severe hearing loss, and a cochlear implant. Goals of therapy were: (1) to be able to stand still independently, with head centered for a count of 10 seconds – able to stand still, however, head in middle for less than 10 seconds at a time; (2) to be able to make the 'f' sound in isolation and to discriminate auditorally between 'f', 'p', 's', and 't' in isolation and in initial positions in words – achieved; (3) to assess whether sitting posture was improved by the use of a saddle chair. The ability to maintain a good sitting posture while using her computer, was measured by the treating therapist comparing photographs of sitting in the usual seating system and the saddle chair – achieved.

After Bobath intervention, improvements were seen within the GMFM Crawling, Standing, and Walking dimensions, compared with the baseline period. Specific items showing an improved score which might relate to the goal regarding standing balance, were lifting the left foot in standing for over 3 seconds lowering from standing to sitting with arms free and walking 10 steps along a 1.8 cm line. PEDI scores remained largely the same. The parent completed a questionnaire after intervention reporting no changes, but reported verbally that stair climbing had improved. The therapist reported these changes: 'able to go up/down stairs holding onto one banister', 'able to step into a skirt while holding the shoulders of a helper', and 'able to pick something off the floor without knees touching'.

Discussion

In this study of a small number of participants, a significant improvement in gross motor function was seen over the 6-week Bobath intervention period, compared with the pre- and post-treatment scores. This effect might be anticipated as the Bobath concept focuses on preparing for, working within, and gaining new functional skills (Mayston 2001b). It is also concerned with how a child performs movement, as this has implications for the efficiency of the movement and prevention of secondary deformities, which in turn affects the potential for achieving more functional skills in the future (Mayston 1992).

The most significant result was seen in the GMFM goal totals. No significant change was seen in the non-goal total score, which suggests that changes were achieved in the goal areas where therapy was concentrated. In addition, attainment of specific goals appeared be linked to improvements in related test item scores and in comments made by parents and therapists (see individual participant result: 4). This provides some support for the study by Bower and coworkers (1996) where the use of goals enhanced treatment outcome over a treatment period of 2 weeks. It differs from the pilot study by Bower and McClellan (1992) where the differences in scores between the goal and non-goal totals were less apparent. However, in both this present study and that of Bower and McClellan (1992), small populations of participants were used and inevitably there will be considerable diversity in their population characteristics. Also, there was a difference in the time periods of treatment (2 versus 6 weeks). In another randomized controlled trial by Bower and coworkers (2001), minimal benefit was observed from the use of goals and more intensive daily treatment. However, this trial featured a very different intervention period (6 months), a slightly higher intensity of treatment (5 hours per week versus 3 hours 45 minutes per week) and involved varied types of physiotherapy, so making direct comparisons difficult.

Significant improvements occurred in PEDI scores following Bobath therapy. Actual skill level only showed improvement in the self care domain, but less caregiver assistance was required for both self care and mobility. The Bobath concept emphasizes the importance of providing opportunities to practice relevant skills and giving time to parent education regarding how they may best assist their child and how one can progress to reducing the level of hands-on assistance (Mayston 2001b).

A few studies investigating the effects of NDT have either used a similar intervention period of a few weeks and/or have investigated motor function. In a randomized controlled trial by Carlsen (1975), individuals were assigned to a control group ($n=6$) and an NDT group ($n=6$), which received 2 hours of therapy per week over 6 weeks. This is a very similar intervention time to the present study. The outcome measures concerned motor development: the Bayley and Denver Developmental Motor Scales. The group receiving NDT improved to a statistically significant level compared with the control group, which supports the findings of this study. However, it is important to be aware that the Bayley and Denver Scales were primarily designed to be discriminatory rather than evaluative, which may affect the validity of the results. Jonsdottir (1997) and Kluzik (1990) and their respective colleagues both investigated the effects of NDT on reaching tasks in children with CP, using kinematic and video analysis. Jonsdottir and colleagues (1997) found NDT to be significantly more effective than practice alone in improving postural alignment during reaching. Kluzik and coworkers (1990) found that reaching was significantly

faster and smoother following one session of NDT. Although the participant numbers were small ($n=8$ and $n=5$ respectively), they may provide some support for the findings of the present study, in that NDT appears to improve motor function, although the current study looked at a wider range of motor skills and used different outcome measures.

Law and colleagues (1997) conducted a cross-over trial of 50 children with CP, comparing the effects of a regular occupational therapy programme versus intensive NDT plus upper-limb casting. The occupational therapy programme was aimed at improving specific functional skills, whereas NDT aimed to improve impairment and quality of movement, but was not described as directly addressing function. No significant difference was found between the two groups in hand function or quality of upper-extremity function, although both groups improved over the course of the trial. To maximize motor learning, therapy needs to be task related and include meaningful functional goals (Dean and Shepherd 1997, Carr and Shepherd 2000, Dean et al. 2000). Therefore, the effectiveness of the NDT programme may have been influenced by a lack of focus on function. It is questionable from the description of the therapy, whether it can be considered to truly reflect the nature of NDT. As early as the 1960s, Bobath recognized the importance of 'teaching skilled motor patterns for everyday life and self-help' (Bobath 1963). By the 1980s, treatment 'incorporated systematic preparation for specific functions' and the children were treated in 'functional situations' (Bobath and Bobath 1984). Working for meaningful functional goals and giving opportunities for the practice of such skills is central to the Bobath concept (Mayston 2001b). In the present study, Bobath therapy was focused on the improvement of function and resulted in functional gains. As the study by Law and coworkers (1997) only had one measurement at baseline before intervention started, it is not possible to determine whether improvements occurred due to normal maturation and/or therapeutic input. Therefore it is difficult to make comparisons with the current study.

In a randomized controlled trial by Palmer and colleagues (1988), 48 infants with spastic diplegia were assigned to receive 12 months of NDT or 6 months of NDT preceded by 6 months of infant stimulation. The NDT was aimed at improving righting and equilibrium responses. Outcome measures included the Bayley Motor Scale (1993) and observation of defined motor skills. The group receiving infant stimulation performed significantly better than those receiving only NDT. Over the course of the trial, the NDT group reduced in their Bayley Motor scores although they did make some gains in specified motor skills. This does not appear to support the findings of the current study where motor function improved after Bobath intervention. The NDT protocol of Palmer and coworkers (1988) appears very narrow, especially as NDT has been recognized to have a much broader remit since the 1970s and early 1980s. The Bobath concept recognizes the importance of improving quality of movement, counteracting the development of secondary deformities and the importance of parent training (Bryce 1976). It also addresses issues of sensory dysfunction and works for specific functions (Bobath and Bobath, 1984). As mentioned before, the Bayley Motor Scale was primarily designed to discriminate from normative values, and not intended for evaluative purposes, which may affect the validity of the results. There was also a suggestion that the NDT group may have been more neurologically involved.

More research is needed using up-to-date standardized outcome measures with clear descriptions of the interventions and population characteristics. This should allow more direct comparison between studies, facilitate replication of studies, and build up of evidence regarding the efficacy of NDT.

DIFFERENT AGE AND ABILITY LEVELS

Despite a small sample, differences were discernible between the younger and older children. Although both age bands improved in GMFM goal total scores following intervention compared with baseline and follow-up periods, younger children also made significant improvements in the GMFM Walking dimension, PEDI total functional skills, and total caregiver assistance, whereas the older group did not. This could be expected as many children with CP start to plateau in their achievement of motor skills at about 7 years of age and can lose walking skills as they go through their growth spurts at 10 to 12 years (Palisano et al. 1997).

Differences were also apparent when dividing the group by GMFCS levels into a group containing levels I to III (more functionally able) and another containing levels IV and V (less functionally able). Both ability groups showed a significant improvement in GMFM goal total score following Bobath intervention, with the higher ability having a more significant result, and only the higher ability group showed a significant improvement in PEDI scores. This demonstrates the difference in potential for change within different levels of functional ability (Palisano et al. 1997). Further research regarding the sensitivity of the GMFM and PEDI to change in different ability groups and following different interventions seems to be warranted.

OUTCOME MEASURES

Although the GMFM and PEDI are considered among the best available standardized measures for children with CP (Ketelaar and Vermeer 1998) they have limitations. Their content areas although broad did not include all the functional changes perceived to have taken place in children, by parents and therapists. There was little change in the GMFM Standing dimension scores, despite two-thirds of therapists and parents reporting perceived improvements after Bobath therapy, including standing for a longer time, and being more extended at hips and knees when standing. Within the GMFM, posture in standing and length of time standing beyond 20 seconds are not measured. Any such improvements would not be detected as they fall outside of the content area of the test.

Floor and ceiling effects of the GMFM and PEDI tests, can affect their sensitivity to detect changes in children with CP resulting from therapy. Change was not detected in the Sitting dimension of the GMFM, although this area was mentioned as one of the goal areas for nine participants. Positive changes were reported after therapy by all therapists and all but two parents. Several reasons could account for no changes being recorded on standardized testing. First it is possible that no overall change took place in this area within this population of children, despite the reports of therapists and parents to the contrary. They may have had bias due to having expectations, after setting goals. Second, some children were reported to have an improvement in a skill or quality of sitting not tested

by the GMFM, such as reaching while bench sitting. Third, and most importantly, Sitting was the dimension where the largest number of participants started with a score of >95 leaving a smaller degree of freedom for change (n=8 at baseline). All these children were in the higher GMFCS ability levels (II to III). In a study which assessed the Sitting dimension of the GMFM in children with spastic diplegia, those assessed as having mild to moderate impairment also had very high initial scores of between 87 and 100% (Brogren et al. 2001). This demonstrates the 'ceiling effect' of the GMFM (Russell et al. 2000, Stanley et al. 2000). Another possibility is that there may have been a Type II error, that is, a change occurred in sitting function, which was not detected by the standardized measures used in this study.

Another feature of the GMFM affecting the sensitivity of the test, is the necessity of attempting a maximum number of GMFM test items despite their maturational level, to achieve the best score. This was demonstrated by child 2, who was very reluctant to attempt the easier items particularly those on the floor, as he could function well when up against gravity in standing (maximum score in lying was 53% whereas standing was 82%). This can result in data showing declining scores suggesting a reduction in abilities, whereas the child has developed more advanced motor skills.

The GMFM and PEDI are considered to be complementary to each other, because they test different aspects of function. For example, regarding ability on stairs, the GMFM tests whether a child can walk up/down four steps alternating feet with or without the use of a handrail, whereas the PEDI tests whether the child can crawl or walk up/down a flight of stairs, their speed ascending/descending stairs, and the amount of assistance that they require. Throughout testing on the PEDI, child 4 was scored as 'fully independent on stairs' and remained 'slow for age'. Child 4 improved on the GMFM in his ability to alternate his feet on stairs. This demonstrates that the tests cover different aspects of function, but also how one test may only cover certain aspects of a specific skill. This has implications for the responsiveness of the tests. It could be assumed that as a child achieved the same score on repeated administrations of a test, their abilities had remained the same. However, they may have changed in other aspects of specific skills. It is, therefore, important to be aware of the specific content of test items when attempting to interpret different test scores.

Despite the characteristics of the GMFM and PEDI, which may affect their sensitivity, changes were detected in this study resulting from a short period of intervention. These tests cover a broad range of tasks and remain the most appropriate measures of overall function in children with CP.

Conclusion

Within this population sample, children improved significantly in gross motor and self care skills and required a lower level of caregiver assistance for mobility and self care, as measured on the GMFM and PEDI, following a 6-week course of Bobath therapy. Most improvements occurred within areas in which therapy goals were set. As the children acted as their own control individuals in this study, no control group was studied. This together with the small sample size does limit the power of the results. For the planned second phase of the study, participants will be stratified into age bands and GMFCS levels, and randomized into one of two groups: a treatment group as described in this study; and a control group which will be measured at the same time intervals with no Bobath therapy being instigated. If the results of the current study can be confirmed in the proposed larger randomized controlled trial, then it may provide useful information to empower parents, therapists, and purchasers in choosing appropriate therapy.

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Knox Appendix I: First/second parent/therapist questionnaire

Name of Child:_____ **Subject No.** ___ **Name of Parent:** _____
Date:_____

In the last __ week(s, have your child's abilities changed in any way?
Changes may be positive or negative, or none may have taken place. They may include learning new activities, doing activities more quickly/slowly, being more/less consistent requiring more/less help from a carer or special equipment. Changes may also include the time your child tolerates being in a position, the ease or difficulty with which you can move them; changes in their ability to balance or get in or out of a position and in the distance and speed with which your child moves.

ACTIVITIES	**ANY CHANGE?**			In what way did your child change?	**How significant was this change for you and your child?**
	Yes	No	Don't know		*Circle a number on the scale below, where **0=very negative** and **5=very positive***
1.Un/Dressing					0 1 2 3 4 5
2.Toiletting					0 1 2 3 4 5
3.Grooming -teeth nose care, hair brushing, etc.					0 1 2 3 4 5
4.Bathing					0 1 2 3 4 5
5.Drinking					0 1 2 3 4 5
6.Eating					0 1 2 3 4 5
7. Overall mobility *(is it easier/harder to move limbs and/or carry child)*					0 1 2 3 4 5
8.Lying & Rolling					0 1 2 3 4 5
9.Sitting					0 1 2 3 4 5
10.Crawling & kneeling					0 1 2 3 4 5
11.Standing					0 1 2 3 4 5
12.Walking					0 1 2 3 4 5
13.Communication: Expression (Ability to express feelings or needs, choose activities, use switches)					0 1 2 3 4 5
14.Communication: Level of Understanding (e.g. understanding words/pictures/symbols, being able to wait for something)					0 1 2 3 4 5
15.PLAY: Interaction (e.g. child able to make choices, direct play participate in pretend play)					0 1 2 3 4 5
16.PLAY: Practical Ability (e.g. using hands differently, playing with new or different toys, looking at toys, can be left in position to play)					0 1 2 3 4 5

What were the 3 most important changes that occurred during the last 6 weeks? Please place them in order of importance, with number 1 being the most important.

1_____

2 _____

3 _____