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Effectiveness of Neuro-Developmental Treatment (Bobath Concept) on postural control and balance in Cerebral Palsied children

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Abstract.
BACKGROUND AND OBJECTIVE: The aim of this study was to show the effects of an 8-week Neurodevelopmental Treatment based posture and balance training on postural control and balance in diparetic and hemiparetic Cerebral Palsied children (CPC).
METHODS: Fifteen CPC (aged 5–15 yrs) were recruited from Denizli Yağmur Çocukları Rehabilitation Centre. Gross Motor Function Classification System, Gross Motor Function Measure, 1-Min Walking Test, Modified Timed Up and Go Test, Paediatric Balance Scale, Functional Independence Measure for Children and Seated Postural Control Measure were used for assessment before and after treatment. An 8-week NDT based posture and balance training was applied to the CPC in one session (60-min) 2 days in a week.
RESULTS: After the treatment program, all participants showed statistically significant improvements in terms of gross motor function ($p < 0.05$). They also showed statistically significant improvements about balance abilities and independence in terms of daily living activities ($p < 0.05$). Seated Postural Control Measure scores increased after the treatment program ($p < 0.05$).
CONCLUSIONS: The results of this study indicate that an 8-week Neurodevelopmental Treatment based posture and balance training is an effective approach in order to improve functional motor level and functional independency by improving postural control and balance in diparetic and hemiparetic CPC.

Keywords: Cerebral palsy, postural control, balance, Bobath Concept

1. Introduction

Cerebral Palsy (CP) is a clinical process that effects child's neurological development; characterized by bad muscle tone and posture, lack of movement and balance; going with sensitive, cognitive, perceptual problems and epileptic seizures, causes from several factors in prenatal, perinatal or postnatal term [1,2].

Normal posture is necessary for both the development of new motor skills and success of current motor skills. The balance creates the background for these movements. One of tasks of the central nervous system is making possible movements that require high-level skills by providing the control of posture and balance. Reciprocal innervation of muscles working reverse each other, is not the only way using for coordination. The synergist muscle groups contract for fixation in the adjacent joints at the same time. Sometimes antagonist muscles must contract with agonist muscle. This mechanism is especially used for proximal joint stabilisation during the distal movements and it's named as "co-contraction". Reciprocal innervation and cocontraction mechanisms are very important neurophysiological to provide balance and to regulate postural tone during normal movements. But these mech-

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anisms do not work properly in cerebral palsied children (CPC). CPC have some difficulties in providing postural control and balance, because of living without these mechanisms. Thus, CPC cannot achieve essential motor skills and get dependent to their families in daily living activities [2].

Managing the complicated process of CP, the physical therapy and rehabilitation is used to be an effective method for years. Neuro-Developmental Treatment (NDT), also known as Bobath Concept, was developed by physical therapist Berta Bobath and her neurologist husband Karel Bobath to use for treating movement disorders in young and adult people. Since the year 1940, NDT was developed based on the researches about brain functions and neurophysiology, and NDT is a common physical therapy approach today. Providing purposive neuromotor and postural control is aimed within NDT. The main objective of NDT is improving children to the maximum independence level as much as possible within the age and ability limits. Treatment sessions are planned for a certain function and the patient's active participation is prompted as much as possible. Physical therapist helps and guides less as much as the child accomplishes the postural and motor requirements [2,3]. NDT provides normal movement experience in CPC and has 3 cardinal principles; facilitation, stimulation and communication. It is known that NDT has positive effects on postural control and balance defects with the methods based on these 3 principles.

The aim of this study is to assess the effects of an 8-week NDT based posture and balance training on postural control and balance in CPC.

2. Material and methods

This study was done between February 2015 and December 2015 in Denizli Yağmur Çocukları Special Education and Rehabilitation Centre with permission. Informed Consent Forms were taken from all the parents. The study was approved by Pamukkale University Non-invasive Clinical Research Ethics Committee in 13.01.2015 with the number 60116787-020/4199. Declaration of Helsinki was complied during the study.

2.1. Participants

Fifteen children were included in the study according to the inclusion criteria.

2.1.1. Inclusion criteria

- Accepting whose child's participation in the study (by parents and/or their legal representatives)
- CP diagnosed
- Ages between 5–15
- Clinical types diparesis and hemiparesis
- Cooperative
- Walking independently or at least with a walking aid (Gross Motor Function Classification System (GMFCS) Level I, II or III)

2.1.2. Exclusion criteria

- Different diagnosis from CP
- Different clinical types of CP
- Children who cannot walk independently or at least with a walking aid (GMFCS Level IV or V)
- To be not attended the assessments or the therapy sessions regularly. But all the participants were attended every session properly.

2.2. Measurements

Participants' first name, surname, gender, age, height, weight, Body Mass Index (BMI), CP's clinical type, limb involvement, number of brothers, presence of disabled brother, medical histories, using of walking aids, surgical operation history and NDT history were saved in registration forms.

GMFCS and Gross Motor Function Measure-88 (GMFM-88) were used to assess gross motor functions. GMFCS was developed to provide a simple method for classifying children with CP aged 18 years or less on the basis of functional abilities and limitations. The GMFCS includes five levels and four age bands. Distinctions between levels represent differences in gross motor function that are thought to be meaningful in the daily lives of children with CP [4]. GMFM-88 is used to measure changes in gross motor function in children with CP and has been commonly used by researchers. The GMFM-88 consists of 88 items in five dimensions: lying and rolling (GMFM-A); sitting (GMFM-B); crawling and kneeling (GMFM-C); standing (GMFM-D); and walking, running and jumping (GMFM-E). The GMFM-88 comprises 88 items, of which only seven were not found to be at the level of activities and participation of the International Classification of Functioning, Disability and Health (ICF) [5]. Functional Independence Measure for Children (WeeFIM) was used to assess functional independence levels. WeeFIM is an 18-item, 7-level ordinal scale instrument that measures a child's consistent performance in essential daily functional skills. Three main domains (self-care, mobility, and cognition) are assessed by interviewing or by observing a child's performance of a task to criterion standards. WeeFIM is categorized into 2 main functional streams: "Dependent" (i.e., requires helper: scores 1–5) and "Independent" (i.e., requires no helper: scores 6–7). Scores 1 (total assistance) and 2 (maximal assistance) belonged to the "Complete Dependence" category. Scores 3 (moderate assistance), 4 (minimal contact assistance), and 5 (supervision or set-up) belonged to the "Modified Dependence" category. Scores 6 (modified independence) and 7 (complete independence) belonged to the "Independent" category [6].

Balance skills were evaluated with 1 Minute Walking Test (1MWT), Modified Timed Up and Go Test (MTUGT), and Paediatric Balance Scale (PBS). For 1MWT, one assessor explained the protocol to each subject before the test, demonstrated one lap of the track and gave the order to start and stop. A second assessor recorded the total distance walked. During testing children wore their own comfortable clothing, shoes and splints (as appropriate), and used their walking aid/s as appropriate. On each occasion participants were asked to complete two 1-min walks using the following procedure: following a 5 min seated rest, children stood at a starting point inside the outline of an oval 20 m level track (track width 30 cm at both venues). They were given the following instruction: 'Once you are given the instruction to start, you should walk as fast as possible around the track for 1 min, until you are asked to stop. You are not allowed to run'. Distance was calculated to the nearest metre using markings on the track. During the test children were informed after 30 s had elapsed and again when 10 s remained. A 10 min seated rest was given between tests [7].

For MTUGT, the following instructions were delivered to the subject slowly and clearly: "This test is to see how you can stand up, walk, and touch the star, then come back to sit down. The stopwatch (of cell phone) is to time you." Subjects wore their regular footwear or orthosis, and were allowed to use walking aid, but were not allowed to be assisted by another person during the performance of the test. There was no time limit for the performance of the test, and they may stop and take rest (but not sit down) if they needed to do so. Instructions given were "After I say 'go,' stand up, walk up to and touch the star, and then come back and sit down. Remember to wait until I say 'go.' This is not a race; you must walk and not run, and I will time you. Don't forget to touch the star, come back and sit down." Timing was started as the child left the seat, rather than on the instruction "go" and stopped as the subject's bottom touched the seat, in order to measure "movement time" only. A practice trial was given to the subject. Thereafter, the test was conducted thrice and respective time was recorded. The time was measured in seconds. The mean of three values was documented and used for analysis. The investigator sat on a chair in clear view of the subject. Subjects were tested in small groups. Every completed MTUGT was scored and noted. The same investigator conducted all the testing procedures for the study [8].

PBS, a modification of Berg's Balance Scale, was developed as a balance measure for school-age children with mild to moderate motor impairments. PBS is easy to administer, does not require specialized equipment, and can be completed in 20 minutes. A 0 to 4 grading scale provides a quantitative and qualitative measure of performance. An overall numeric score is obtained at the conclusion of testing [9].

Lastly, postural control skills were evaluated with Seated Postural Control Measure (SPCM). SPCM is a 34-item, criterion-referenced, evaluative measure and was developed by a team of clinicians and researchers at Sunny Hill Health Centre for Children. The SPCM was designed to measure specific aspects of postural alignment and functional movement that are expected to change as a result of adaptive seating intervention [10].

2.3. Treatment

Individual NDT programs were applied participants by a specialist physiotherapist who has 3 years of experience in NDT, for 8 weeks in one session (60 min.) 2 days in a week. Participants were assessed twice (before and after the NDT programs) and obtained data were saved.

NDT programs were planned specially for each patient according to their needs. Besides the NDT programs generally contain:

- Vestibular and proprioceptive training on balance board
- Vestibular and proprioceptive training on exercise balls in different sizes
- Dynamic balance training in sitting, kneeling and standing position (eyes open and closed)
- Balance exercises in front of the mirror
- Standing on one foot for improving the proprioceptive input (eyes open and closed)

- Balance training on the trampoline
- Sensory stimulation for foot soles with various materials
- Weight bearing exercises in sitting, crawling, kneeling and standing position
- Functional reaching and ball throwing-keeping exercises in various positions
- Multi-task trainings
- Walking trainings in different types
- Climbing up & stepping down the stairs (supported-unsupported, symmetric, reciprocal etc.) [2].

2.4. Statistical analysis

Power analysis results is estimated to be 15 people working at the 95% confidence reached 90% power. Data were analysed using the Statistical Package for Social Science (v21.0). Continuous variables are expressed as mean ± standard deviation and median (minimum – maximum values), while categorical variables were expressed as numbers and percentages. In dependent group comparisons, Paired Samples t Test was used when parametric test assumptions are provided, and Wilcoxon Signed Rank Test was used when parametric test assumptions are not provided. Marginal Homogenity test was used for to examine before – after treatment difference for categorical variables. The p values below 0.05 were considered statistically significant.

3. Results

3.1. Demographic data

Fifteen CP diagnosed children ages between 5–15, clinical types diparesis or hemiparesis, cooperative and walk independently or at least with a walking aid (GMFCS Level I, II or III) were included in the study. Seven children were girls, and eight children were boys. Demographic data are summarized in Table 1.

All participants' cognitive skills were available to understand all the directions and all participants were cooperative. Four of participants were using walking aid and thirteen of them had surgical operation history. Eight of participants' limb involvement were diparesis and seven of theirs were hemiparesis.

3.2. Gross Motor Function Classification System

CPC's before and after treatment gross motor function levels based on GMFCS are given as numeric and as percentage in Table 2. Before treatment; 3 of CPC were in Level-I and after treatment there were no changes; 8 of CPC were in Level-II and after treatment 7 of them raised up to Level-I; 4 of CPC were in Level-III and after treatment 3 of them raised up to Level-II. These changes were statistically significant ($p < 0.05$) according to the marginal homogeneity test. In this case, NDT improved the gross motor function levels of CPC.

Table 1
Demographic data

Data	X ± SD	Median	Min-Max
Age (months)	120.4 ± 31.69	123	60–176
Height (cm)	133 ± 18.87	133	105–170
Wight (kg)	30.8 ± 12.82	30	17–65
BMI (kg/cm^2)	16.75 ± 2.99	16.33	10.88–22.49
Total received NDT before (months)	106.73 ± 28.56	109	52–153

BMI: Body Mass Index.

Table 2
Gross Motor Function Classification System

GMFCS	BT n (%)	AT n (%)
Level I	3 (20%)	10 (66.7%)
Level II	8 (53.3%)	4 (26.7%)
Level III	4 (26.7%)	1 (6.7%)

BT: Before Treatment; AT: After Treatment; Marginal Homogeneity Test: $p < 0.05$.

3.3. Sitting skill levels

All CPC's sitting skill levels were evaluated by SPCM. Fourteen of participants were suitable with "keeps position, doesn't move" option and one of participants was suitable with "shifts his/her body anterior" option.

3.4. Comparison of before-after tests

Comparison of participants' balance skills and functional independence levels before and after treatment are given in Table 3. All of the results were statistically significant ($p < 0.05$). This has led to the development of walking and balance skills and independence of daily activities in children with CP at the end of the treatment period.

Statistics about participants' postural control skills before and after treatment according to SPCM Alignment and Function parameters are given in Table 4. Changing's in Alignment and Function parameters were statistically significant ($p < 0.05$). However, after

Table 3
Comparison of balance skills and functional independence levels before and after treatment

Assessment method		X ± SD	Median	Min-Max	p
1MWT (m)	BT	43.86 ± 19.89	45	5–70	0.0001α
	AT	55.06 ± 19.13	57	16–76	
MTUGT (sec)	BT	18.73 ± 23.82	11	7–102	0.001β
	AT	9.60 ± 5.61	7	5–28	
PBS	BT	47.2 ± 9.65	51	22–56	0.001α
	AT	52.33 ± 5.20	55	38–56	
WeeFIM	BT	112.1 ± 13.34	114	85–126	0.001α
	AT	118.3 ± 9.03	120	96–126	

BT: Before Treatment; AT: After Treatment; α: Paired Samples t Test: $p < 0.05$; β: Wilcoxon Signed Rank Test: $p < 0.05$.

Table 4
Comparison of postural control skills before and after treatment

Postural assessment		X ± SD	Median	Min-Max	P
Alignment	BT	71.66 ± 4.04	72	60–77	0.0001α
	AT	81.53 ± 5.24	83	66–87	
Function	BT	45.8 ± 1.27	45.7	44–48	0.0001β
	AT	48 ± 0	48	48–48	

BT: Before Treatment; AT: After Treatment; α: Paired Samples t Test: $p < 0.05$; β: Wilcoxon Signed Rank Test: $p < 0.05$.

Table 5
Comparison of gross motor function levels before and after treatment

Gross motor function levels		X. ± SD	Median	Min-Max	p
GMFM-88-D	BT	83.8 ± 13.25	87	62–100	0.0001α
	AT	94.26 ± 6.76	97	79–100	
GMFM-88-E	BT	79.93 ± 17.28	85	54–100	0.0001α
	AT	88.6 ± 12.25	94	69–100	
GMFM-88	BT	92.2 ± 6.21	94	81–100	0.0001α
	AT	96.53 ± 3.68	99	90–100	

BT: Before Treatment; AT: After Treatment; α: Paired t Test: $p < 0.05$.

the treatment program all participants got full points from Function tests. Thus, this parameter's standard deviation was zero. After the NDT procedure, CPC's body alignment and upper extremity functions have improved.

Statistics about participants' gross motor function skills before and after treatment according to GMFM-88 are given in Table 5. Changing's in GMFM-88-D (standing) and GMFM-88-E (walking) sections and GMFM-88 total points were statistically significant ($p < 0.05$). Thus, it was determined that NDT increased gross motor functions in CPC. Before and after treatment participants' GMFM-88-A, GMFM-88-B and GMFM-88-C points were full, thus this sections weren't added to statistics.

4. Discussion

CPC have some limitations about postural control in static and dynamic tasks like sitting, standing and walking [11]. Particularly delay in independent sitting which is the first milestone of postural control is an early sign of normal motor development deficiency in CPC [12]. Impairments in sitting postural control can effect a child's motor development significantly and can limit eventual independent movement [13,14].

Trahan and Malouin [15] applied NDT to 50 spastic CPC (quadriplegia ($n = 24$), hemiplegia ($n = 16$), and diplegia ($n = 10$)) aged between 12 and 79 months and assessed participants' gross motor function skills by GMFM-88. After 8-month treatment period, improving in CPC's gross motor function skills were significant [15]. Although the number of patients with quadriplegia was high in Trahan and Malouin's study, CPC's gross motor functions were developed in parallel with the present study. This was probably due to the length of the treatment.

Bower and McLellan [16] recruited 30 spastic CPC ages between 18 months – 8 years from four different centres and separated them as control and intervention group. Then applied NDT for 6 months to intervention group and nothing for control group. They found no statistically significant difference between groups in the assessment made by GMFM-88 [16]. The reason for not achieving a significant difference with this 6-month NDT in this study is that the treatment effect of the children included in the study in their centres is different, so some of them are better at starting treatment and some are behind. At the beginning of the study, children with poor motor function skills and development status were prevented from getting significant outcomes.

Gross motor function level of participants increased in present study. This means NDT based posture and balance training is effective on gross motor functions in a short period of 8 weeks.

In Harbourne et al.'s study [17], fifteen typically developing infants were followed longitudinally during sitting development to use as a comparison on postural control variables, and thirty-five infants with risk factors and delays in achieving sitting were recruited for the study. Infants with delays were randomly assigned to either a home program group, or a perceptual-motor intervention group. After the 8 weeks of treatment process data obtained from GMFM-88 and Centre of Pressure device showed that the results were in favour of the intervention group [17]. In Harbourne et al.'s study, similar to present study, 8-week of NDT program which was applied by specialist physiotherapist improved the gross motor functions and balance of CPC.

Ketelaar and Vermeer [18] included 55 spastic CPC (median age = 57 months, average = 55 months, range = 24–87 months; n = 32 with hemiplegia, n = 11 with diplegia, n = 12 with quadriplegia) to their study and separated the children in two groups. They applied classic physiotherapy one of these groups and NDT for the other one. The groups were assessed with GMFM-88 and Paediatric Evaluation of Disability Inventory in the 6^{th}, 12^{th} and 18^{th} months. There were no differences according to GMFM-88, but there were statistically significant differences according to Paediatric Evaluation of Disability Inventory in favour of NDT group [18]. The reason for not achieving a significant difference with this 6-month NDT in terms of the GMFM-88 is that the children recruited for the study have poor motor function skills and development status compared to the children in the present study at the beginning of the study. The children's GMFCS level was at least 3, so this means all of the children in the present study could walk. This has increased the opportunity to benefit from NDT of these children. The situation that there were statistically significant differences according to Paediatric Evaluation of Disability Inventory in favour of NDT group, is also consistent with the improvement of daily living activities and gross motor functions of CPC in the present study.

In the present study, after treatment mean scores of 1MWT, MTUGT, PBS and WeeFIM changed positively compared before treatment mean scores. In that case, NDT based posture and balance training improved gait and balance skills and independence level in daily living activities of CPC.

Jonsdottir and Fetters [19] applied NDT to spastic CPC in intervention group, and made participants in control group play computer games in sitting position. After treatment period they found no significant changing in the assessment made by Modified Postural Assessment Scale [19]. Kluzik et al. [20], applied NDT to 5 spastic CPC ages between 7–12 years for 4 weeks. They assessed CPC's upper extremity movement skills and speeds by video kinematic analysis, and after treatment they found significant increase in upper extremity movement skills and speeds [20]. In the present study, SPCM-Alignment and SPCM-Function parameters were improved after NDT program. Eight-week NDT based posture and balance training improved postural control skills and upper extremity functions in sitting position of CPC. Although these two studies showed similarity to the present study in terms of their results, there was no more related study to the present study in the literature. Butler and Darrah [21] made a systematic review researching the effects of NDT on CPC. They investigated evidence-based studies about this topic and found that NDT improves postural control and balance in CPC [21]. Carlsen [22] made a study with 12 CPC ages between 1–5 years, and applied NDT to intervention group for 6 weeks. CPC's before and after treatment motor development ages defined by Bayley Scales of Infant and Toddler Development. They found significant improvements in motor development ages in intervention group [22]. In this study, after treatment mean scores of GMFM-88-D, GMFM-88-E and GMFM-88 increased. In that case, NDT based posture and balance training improved CPC's gross motor function skills and related to this it also improved postural control and balance skills. These two studies indicate that there is an increase in postural control, balance and motor development stages in CPC as well as in the present study. This supports the development of postural control, balance and gross motor functions in the present study.

Limitations of this study:

- There was no control group to compare the result of treatments.
- Evaluator was not double blind to the study.

5. Conclusion

Eight-week NDT based posture and balance training applied to diparetic and hemiparetic CPC improved their functional motor level with together postural control skills, thus independence levels in daily living activities. Improving in CPC's balance made them walk safer and faster.

It is very important that clinicians and researchers working with diparetic and hemiparetic CPC should focus more intensively on NDT programs to improve motor development levels, postural control skills, balance and functional independence in daily living activities of these cases.

Conflict of interest

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