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Original Article

Effect of neurodevelopmental treatment-based physical therapy on the change of muscle strength, spasticity, and gross motor function in children with spastic cerebral palsy

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Abstract. [Purpose] This study aimed to investigate the effectiveness of neurodevelopmental treatment-based physical therapy on muscle tone, strength, and gross motor function in children with spastic cerebral palsy. [Subjects and Methods] One-hundred-seventy-five children with spastic cerebral palsy (88 diplegia; 78 quadriplegia) received neurodevelopmental treatment-based physical therapy for 35 minutes per day, 2–3 times per week for 1 year. Spasticity, muscle strength, and gross motor function were measured before and after treatment with the Modified Ashworth Scale, Manual Muscle Testing, and Gross Motor Function Measure, respectively. [Results] Spasticity was significantly reduced after 1 year of treatment. The Gross Motor Functional Classification System levels I–II group showed a significant increase in muscle strength compared with the Gross Motor Functional Classification System levels III–V, and the latter showed a significant decrease in spasticity compared with the former. [Conclusion] Neurodevelopmental treatment-based physical therapy in children with cerebral palsy seems to be effective in reducing spasticity, but does not improve gross motor function. Therefore, other interventional approaches are needed to improve gross motor function in children with cerebral palsy.
Key words: Cerebral palsy, Spasticity, Neurodevelopmental treatment

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INTRODUCTION

Children with cerebral palsy (CP) show various motor impairments such as muscle weakness, spasticity, limited range of motion, and loss of selective motor function[1)]. These impairments make the development of normal gross motor function difficult[2)]. The focus of therapy in CP is to develop enough gross motor function for performing basic life activities independently. Many researchers have reported methods for improving activity according to the International Classification of Functioning, Disability and Health (ICF) model. Morgan et al. suggested that goals-activity-motor enrichment intervention resulted in advanced motor and cognitive outcomes compared with standard care[3)]. Song found that a task-oriented approach to treatment of the affected arm improves functional activities[4)]. Kim and Park stressed an activity-based intervention for improving functional outcome[5)].

However, in clinical settings, neurodevelopmental treatment (NDT) has been used for treatment of children with CP. NDT is an impairment-focused approach. A key element of this approach is to recover normal movement through inhibition of muscle tone and abnormal reflex and posture[6)]. Gorter et al. found that spasticity was related to gross motor function

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development in infants with CP[7]. However, Ross and Engsberg reported that spasticity did not account for a substantial amount of explained variance in gait and gross motor function in mild to moderate CP[8]. Thus, it is unclear whether spasticity is directly related to gross motor function. It has been reported that muscle strength is positively associated with gross motor function; however, these studies lacked large samples, various severities of CP, and prospective study designs[8–10]. This study aimed to investigate the effect of 1 year of an impairment-based approach on spasticity, strength, and gross motor function in children with CP.

SUBJECTS AND METHODS

The participants were 175 children, aged 3–18 years, with a clinical diagnosis of CP (Table 1). They attended regular physical therapy. Inclusion criteria were spastic quadriplegia or diplegia, at least 1 year post orthopedic surgery, 6 months post botulinum toxin type A injection and no spasticity-altering surgeries prior to the study. All participants were classified according to the Gross Motor Functional Classification System (GMFCS) level; I–II (n=63) or III–V (n=112) for analysis of the effects. Spastic diplegia was present in 49 patients (28.0%) in the GMFCS levels I–II and 38 patients (22.3%) in the GMFCS levels III–V. Informed consent was obtained from the parents of all patients. Ethical approval for this study was granted by the Ethics Committee of Ulsan College.

This study used clinical methods for measuring spasticity and strength, bilaterally[5, 8]. A spasticity rating was assigned using the Modified Ashworth Scale (MAS), recorded as 0=no increase in muscle tone, 5=rigid, and strength was measured using the Manual Muscle Test (MMT), recorded as 1=normal, 6=zero. Spasticity in the flexors and extensors of the shoulder, elbow, and wrist was measured in both upper extremities. Spasticity was measured in the hip flexors and extensors, knee extensors and flexors, and ankle plantar flexors and dorsiflexors, in both lower extremities. The reliability of the MAS was high[11]. The strength test was performed in these same muscles. Klingels et al. reported that MMT had a moderately high to very high reliability[12]. The gross motor function measure (GMFM-88) was used to assess gross motor function. The GMFM is a standard criterion-referenced test and consists of five dimensions (lying and rolling; sitting; crawling and kneeling; standing; and walking, running, and jumping). The GMFM is a reliable instrument for assessing motor function and treatment outcome in CP[13].

All participants received NDT-based physical therapy. NDT is a therapeutic exercise that emphasizes restoring normal movement and inhibiting abnormal muscle tone. Physical therapy was provided by therapists, certified in NDT for 35 min per day, 2–3 times per week.

Descriptive statistics were used to investigate the general characteristics of the participants at baseline. A paired t-test was used to examine differences in spasticity, strength, gross motor function between baseline and after intervention. An independent t-test was performed to examine differences in parameters by the GMFCS levels. The level of significance was set at $p<0.05$.

RESULTS

Table 2 shows the differences in the means of spasticity, strength, and GMFM total score between baseline and after 1 year treatment. The only score with a significant difference was spasticity. The mean changes in both spasticity and strength were significantly different between GMFCS levels (Table 3).

Table 1. Baseline characteristics of the subjects

Characteristics		GMFCS levels I–II	GMFCS levels III–V
Age (years)		8.8 ± 4.5	10.8 ± 4.9
Weight (kg)		32.2 ± 19.4	28.9 ± 14.5
Height (cm)		126.7 ± 25.9	119.9 ± 33.7
Gender	Male	34 (19.4%)	65 (37.2%)
	Female	25 (14.3%)	51 (29.0%)
Type	Quadriplegia	14 (8.0%)	73 (41.7%)
	Diplegia	49 (28.0%)	39 (22.3%)
Muscle strength (score)		77.1 ± 29.2	119.2 ± 45.4
Spasticity (score)		30.1 ± 22.3	57.2 ± 34.4
GMFM score (%)		79.1 ± 20.6	26.8 ± 22.0

Table 2. Changes of the muscle strength, spasticity, and GMFM score between baseline and after 1 year treatment

Parameters	Baseline	After1 year treatment
Change of muscle strength (score)	104.7 ± 45.0	105.0 ± 44.2
Change of spasticity (score)	48.2 ± 32.9	44.3 ± 32.1*
Change of GMFM score (%)	42.1 ± 32.6	44.8 ± 32.9

*p<0.05

Table 3. Changes of the muscle strength, spasticity, and GMFM score by groups after 1years treatment

Parameters	GMFCS levels I–II	GMFCS levels III–V
Change of muscle strength (score)	8.3 ± 26.9	−6.4 ± 47.1*
Change of spasticity (score)	−1.1 ± 6. 8	4.9 ± 17.2*
Change of GMFM score (%)	0.5 ± 17.1	1.4 ± 9.4

*p<0.05

DISCUSSION

The aim of this study was to investigate the extent of improvement of motor impairments and gross motor function in children with CP. After 1 year of treatment, only spasticity was decreased; muscle strength and gross motor function were not significantly improved. The mean changes in spasticity, strength, and gross motor function were also analyzed according to GMFCS level. The results showed that spasticity decreased in GMFCS levels III–V more than in levels I–II. Strength was more improved in the GMFCS levels I–II than in levels III–V. There was no significant improvement of gross motor function between levels.

Spasticity was previously suggested to have a significant functional impact on children with cerebral palsy[14]. The treatment strategy of NDT emphasizes reduction in spasticity, with the assumption that it will lead to improvements in motor abilities and function[7]. However, the evidence for this assumption was lacking. Butler and Darrah reported that studies of NDT had small sample sizes, short-term effects, or were otherwise different[6]. Although studies have reported the anti-spasticity effect of intensive NDT, it was applied in combination with medication (e.g. Botulinum toxin)[15, 16]. This study identified the effects of an NDT-based approach without medication on reduction of spasticity, with a relatively large sample size and long-term follow-up. The improvement in spasticity was larger in the GMFCS levels III–V than in the GMFCS levels I–II. However, a previous study suggested that muscle tone as measured with the MAS increases up to 4 years of age and then decreases up to 12 years of age[16]. Hence, interpretation considering the effect of mean age is necessary; in this study, the GMFCS levels III–V=10.8 years; the GMFCS levels I–II=8.7 years. Few studies have focused on improvements in muscle strength as a result of NDT, because this approach does not emphasize muscle strengthening. However, this study showed that muscle strength had improved only in the GMFCS levels I–II. This may be due to other life activities or activity training for normal movement during treatment sessions.

Studies of the effectiveness of NDT have reported inconsistent results[6]. A few studies supported the efficacy of NDT for improving gross motor function; Knox and Evans reported that children with CP showed a significant improvement in gross motor function following Bobath therapy with a preliminary study design[17]. Tsorlakis et al. reported that gross motor function improved significantly after 15 weeks of NDT intervention[18]. However, participants of their study had a variety of motor impairment (i.e. hemiplegia, diplegia, and quadriplegia) and high GMFCS levels. According to previous studies, gross motor function had improved more in patients with spastic CP with high-level GMFCS than at low levels regardless of the treatment option (i.e. NDT, conservative therapy, or medication)[19]. Because patients with spastic hemiplegia have unilateral motor impairments and a higher gross motor function, it may be necessary to analyze patients with spastic hemiplegia separately[20]. Hanna et al. reported that gross motor function progresses rapidly in early years, but declines after the age of approximately 7 years [21]. This trend of deterioration is higher in children with severe CP[22]. Although the average age in this study was over 7 years, there was no deterioration in gross motor function as age increased. This suggests that NDT is useful for maintaining gross motor function. However, an activity-based approach is likely more beneficial than a motor impairment-based approach to enhance gross motor function[23, 24].

This study was limited to children with spastic diplegia and quadriplegia and was conducted without a control group. Thus, it is difficult to extend the results to other types of CP; in the future, prospective longitudinal studies are necessary for broader applicability.

In summary, NDT-based physical therapy in children with CP seems to be effective for reducing spasticity, but not for improving gross motor function. NDT is likely more effective in reducing spasticity in GMFCS levels III–V than in GMFCS levels I–II.

Conflict of interests

The authors declare that they have no conflict of interests.

REFERENCES

1) Gormley ME Jr: Treatment of neuromuscular and musculoskeletal problems in cerebral palsy. Pediatr Rehabil, 2001, 4: 5–16. [Medline] [CrossRef]
2) Yi TI, Jin JR, Kim SH, et al.: Contributing factors analysis for the changes of the gross motor function in children with spastic cerebral palsy after physical therapy. Ann Rehabil Med, 2013, 37: 649–657. [Medline] [CrossRef]
3) Morgan C, Novak I, Dale RC, et al.: Single blind randomised controlled trial of GAME (Goals −Activity −Motor Enrichment) in infants at high risk of cerebral palsy. Res Dev Disabil, 2016, 55: 256–267. [Medline] [CrossRef]
4) Song CS: Effects of task-oriented approach on affected arm function in children with spastic hemiplegia due to cerebral palsy. J Phys Ther Sci, 2014, 26: 797–800. [Medline] [CrossRef]
5) Kim WH, Park EY: Causal relation between spasticity, strength, gross motor function, and functional outcome in children with cerebral palsy: a path analysis. Dev Med Child Neurol, 2011, 53: 68–73. [Medline] [CrossRef]
6) Butler C, Darrah J: Effects of neurodevelopmental treatment (NDT) for cerebral palsy: an AACPDM evidence report. Dev Med Child Neurol, 2001, 43: 778–790. [Medline] [CrossRef]

7) Gorter JW, Verschuren O, van Riel L, et al.: The relationship between spasticity in young children (18 months of age) with cerebral palsy and their gross motor function development. BMC Musculoskelet Disord, 2009, 10: 108. [Medline] [CrossRef]
8) Ross SA, Engsberg JR: Relationships between spasticity, strength, gait, and the GMFM-66 in persons with spastic diplegia cerebral palsy. Arch Phys Med Rehabil, 2007, 88: 1114–1120. [Medline] [CrossRef]
9) Eek MN, Tranberg R, Zügner R, et al.: Muscle strength training to improve gait function in children with cerebral palsy. Dev Med Child Neurol, 2008, 50: 759–764. [Medline] [CrossRef]
10) Andersson C, Grooten W, Hellsten M, et al.: Adults with cerebral palsy: walking ability after progressive strength training. Dev Med Child Neurol, 2003, 45: 220–228. [Medline] [CrossRef]
11) Mutlu A, Livanelioglu A, Gunel MK: Reliability of Ashworth and Modified Ashworth scales in children with spastic cerebral palsy. BMC Musculoskelet Disord, 2008, 9: 44. [Medline] [CrossRef]
12) Klingels K, De Cock P, Molenaers G, et al.: Upper limb motor and sensory impairments in children with hemiplegic cerebral palsy. Can they be measured reliably? Disabil Rehabil, 2010, 32: 409–416. [Medline] [CrossRef]
13) Nordmark E, Hägglund G, Jarnlo GB: Reliability of the gross motor function measure in cerebral palsy. Scand J Rehabil Med, 1997, 29: 25–28. [Medline]
14) Tilton AH: Management of spasticity in children with cerebral palsy. Semin Pediatr Neurol, 2004, 11: 58–65. [Medline] [CrossRef]
15) Thomas RE, Johnston LM, Sakzewski L, et al.: Evaluation of group versus individual physiotherapy following lower limb intra-muscular Botulinum Toxin-Type A injections for ambulant children with cerebral palsy: a single-blind randomized comparison trial. Res Dev Disabil, 2016, 53–54: 267–278. [Medline] [CrossRef]
16) Desloovere K, De Cat J, Molenaers G, et al.: The effect of different physiotherapy interventions in post-BTX-A treatment of children with cerebral palsy. Eur J Paediatr Neurol, 2012, 16: 20–28. [Medline] [CrossRef]
17) Knox V, Evans AL: Evaluation of the functional effects of a course of Bobath therapy in children with cerebral palsy: a preliminary study. Dev Med Child Neurol, 2002, 44: 447–460. [Medline] [CrossRef]
18) Tsorlakis N, Evaggelinou C, Grouios G, et al.: Effect of intensive neurodevelopmental treatment in gross motor function of children with cerebral palsy. Dev Med Child Neurol, 2004, 46: 740–745. [Medline] [CrossRef]
19) İçağasıoğlu A, Mesci E, Yumusakhuylu Y, et al.: Rehabilitation outcomes in children with cerebral palsy during a 2 year period. J Phys Ther Sci, 2015, 27: 3211–3214. [Medline] [CrossRef]
20) Pfeifer LI, Silva DB, Funayama CA, et al.: Classification of cerebral palsy: association between gender, age, motor type, topography and Gross Motor Function. Arq Neuropsiquiatr, 2009, 67: 1057–1061. [Medline] [CrossRef]
21) Hanna SE, Rosenbaum PL, Bartlett DJ, et al.: Stability and decline in gross motor function among children and youth with cerebral palsy aged 2 to 21 years. Dev Med Child Neurol, 2009, 51: 295–302. [Medline] [CrossRef]
22) Voorman JM, Dallmeijer AJ, Knol DL, et al.: Prospective longitudinal study of gross motor function in children with cerebral palsy. Arch Phys Med Rehabil, 2007, 88: 871–876. [Medline] [CrossRef]
23) Zoccolillo L, Morelli D, Cincotti F, et al.: Video-game based therapy performed by children with cerebral palsy: a cross-over randomized controlled trial and a cross-sectional quantitative measure of physical activity. Eur J Phys Rehabil Med, 2015, 51: 669–676. [Medline]
24) Löwing K, Bexelius A, Brogren Carlberg E: Activity focused and goal directed therapy for children with cerebral palsy—do goals make a difference? Disabil Rehabil, 2009, 31: 1808–1816. [Medline] [CrossRef]