J. Phys. Ther. Sci. 28: 2843–2848, 2016

The Journal of Physical Therapy Science

Original Article

Effect of task-oriented training and high-variability practice on gross motor performance and activities of daily living in children with spastic diplegia

Hae-Yeon Kwon, MS, PT[1)], So-Yoon Ahn, PhD, PT[2)*]

[1)] *Department of Physical Therapy, College of Nursing and Healthcare Science, Dong-eui University, Republic of Korea*
[2)] *Department of Physical Therapy, College of Health Sciences, Catholic University of Pusan: 57 Oryundae-ro, Geumjeong-gu, Busan 46252, Republic of Korea*

Abstract. [Purpose] This study investigates how a task-oriented training and high-variability practice program can affect the gross motor performance and activities of daily living for children with spastic diplegia and provides an effective and reliable clinical database for future improvement of motor performances skills. [Subjects and Methods] This study randomly assigned seven children with spastic diplegia to each intervention group including that of a control group, task-oriented training group, and a high-variability practice group. The control group only received neurodevelopmental treatment for 40 minutes, while the other two intervention groups additionally implemented a task-oriented training and high-variability practice program for 8 weeks (twice a week, 60 min per session). To compare intra and inter-relationships of the three intervention groups, this study measured gross motor performance measure (GMPM) and functional independence measure for children (WeeFIM) before and after 8 weeks of training. [Results] There were statistically significant differences in the amount of change before and after the training among the three intervention groups for the gross motor performance measure and functional independence measure. [Conclusion] Applying high-variability practice in a task-oriented training course may be considered an efficient intervention method to improve motor performance skills that can tune to movement necessary for daily livelihood through motor experience and learning of new skills as well as change of tasks learned in a complex environment or similar situations to high-variability practice.

Key words: Spastic diplegia, Task-oriented training, High-variability practice

(This article was submitted Apr. 28, 2016, and was accepted Jun. 16, 2016)

INTRODUCTION

Cerebral palsy is a persistent but changeable neurodevelopmental disorder that causes limitations in activity due to a multifocal non-progressive disorder or damage of a developing brain of a fetal or infant[1)]. Children with spastic diplegia constitute the majority of children with cerebral palsy[2)] in which they experience muscle weakness, co-contraction of antagonist muscles as well as muscle coordination damage[3)]. The low tone of the torso also causes postural instability, lack of mobility, and muscle stiffness in the legs[4)]. In other words, due to lack of antigravity movement when performing functional activities, different parts of the body are involved, particularly compensatory movements such as lifting the upper limbs or overly extending the upper trunk[5)].

An effective task-oriented training to improve muscle strength or functioning of patients with neurological disorder[6)] is

*Corresponding author. So-Yoon Ahn (E-mail: syahn@cup.ac.kr)

to provide repetitive practices of well-organized important functional activities or related components by including specific tasks into the training program[7, 8]. Therapeutic intervention for children with cerebral palsy should be composed of goal-directed, functional, and meaningful activities by considering the clinical type, degree of disability, cognitive level and interest of the child. As such, to motivate and more easily induce functional movements from children with cerebral palsy, interesting tasks related to daily livelihood should be repetitively provided through task-oriented training[8]. Also, performing functional skills should also be trained, since children with cerebral palsy show damage not only in the function and an ability to accomplish tasks, but also in the quality of movement[9]. Accordingly, if many changes are applied into the course of repetitively practicing tasks to perform exact motor activity, children with cerebral palsy may learn other performances from the same motor form and contribute to maintaining his/her basic movement pattern while direction, velocity, position, and target is available[10]. In particular, implications for the training and performance of motor skills that have high motor control demands and require precisely coordinated movement[11], it helps to better maintain learning behavior, and allows for improved performance within the boundaries of similar movement form, even if there is a change of task[12].

This study investigates how a task-oriented training and high-variability practice program could affect gross motor performance and activities of daily living for children with spastic diplegia and provides an effective and reliable clinical database for future training protocols to improve motor performance skills.

SUBJECTS AND METHODS

This study was conducted through a two- group pretest-posttest control design to investigate how task-oriented training and high-variability practices affect the gross motor performance and activities of daily living for children with spastic diplegia. Specific selection criteria for choosing the subject for this study includes children with cerebral palsy of age 4–7 all of whom have been diagnosed with spastic diplegia from a rehabilitation medicine/neurosurgery (or neurology) specialist, children in phase II–III of gross motor function classifications (GMFCs), and children who are able to perform tasks as ordered by the investigator and may engage in proper conversations. Exclusion criteria include children with unstable seizures, children who have recently gone through chemoneurolysis or surgical procedure for muscle stiffness within 6 months, and children with other illness or under anticonvulsive medication. The purpose, method, and procedure of this study, as well as information on direct/indirect discomfort or possible danger was explained to the subjects before implementing this study (incl. legal attorney) and "informed consent" which stated the voluntary participation of the subjects was obtained. Also, this study has been approved by IRB of the Busan Catholic University Hospital and shall bear the responsibility of protecting human rights, dignity, and safety of the subjects (IRB No. CUPIRB-2014-022).

This study randomly assigned seven children with spastic diplegia to each of the intervention groups including the control group, the task-oriented training group, and the high-variability practice group. The control group only received neurodevelopmental treatment for 40 minutes. The task-oriented training group and high-variability practice group implemented a program that comprised of procedures and protocols specified in (Table 1) which was done twice a week, 60 minutes per session for 8 weeks after receiving neurodevelopmental treatment. Task-oriented training was designed to improve body locomotion ability, muscle strength and coordination based on normal motor development, and allowed for interaction of the interest and participation of the children. The high-variability practice group was designed to induce interest and active participation from the children based on knowledge on the results from extrinsic feedback which was given in random order after each task was completed throughout the course of the task-oriented training program. In particular, given orders that were easy for the children to understand were used to improve precision of motor skills and repertoire when combining verbal orders to the complete task. All two training programs are composed of a 5 minute preparatory exercise, a 50 minute main exercise, and a 5 minute of finishing exercise. During the main exercise, each task was given to be performed within 10 minutes, including transfer time. Therapeutic intervention was facilitated by a pediatric physiotherapist having completed neurodevelopmental treatment education with more than 5 years of clinical experience and an adequately trained sub-investigator for task-oriented training and the high-variability practice program whom aided correct posturing and movement of children with cerebral palsy.

GMPM, a measuring tool used in this study, can measure supplementary skills, developmental phases and muscle coordination of children aged 5–12 in less than an hour using minimum capability. This study observed five distinct features of body alignment, stability, muscle coordination, weight shifting and dissociated movement through 20 items deducted from the gross motor function assessment. The assessment score for each item was measured from individualized criterion from 1 (severely abnormal) through to 5 (consistently normal), after which the relative score for each performance items were shown in percentages of maximum performable score (%)[13]. The validity coefficient for applying GMPM on children with cerebral palsy was 0.74–0.84 and the measurement tool was reported to be useful[14]. Functional independence measure for children, a revised version of functional independence measure, was developed to measure the functional level of independence of normal children (6 months–8 yrs), developmental disorder (6 months–12 yrs) or children under 7 years of mental age, and it can be used regardless of one's health condition, development stage, level of education, and environment of the local community[15]. This test is composed of total of 18 items affiliated with six major assessment items of self-care, sphincter control, mobility, transfer, communication, and social cognition. Each item has a 7-score criterion (score 6–7 does not need help, score 3–5 needs help, score 1–2 fully dependent) with a total score ranging from 18 to 126. This measurement tool does

Table 1. Task-oriented training and high-variability practice program

Task-oriented training	High-variability practice
Preparatory exercise (5 min)	
Create emotional stability and establish close rapport Range of motion and stretching exercise	
Main exercise (50 min)	
First, play the boccia game in a ring sitting posture or play around by throwing and rolling a gymball. Second, wear and take off one's top and pants while. Third, pick up an object from the floor in a standing position, then in a kneel standing position, raise right/left foot the front, and then stand(assistive if necessary). Fourth, kick the ball rolled by the pediatric therapist while standing by alternating between the right/left foot. Firth, walk while crossing various obstacles(assist if necessary).	First, learn body awareness Body scheme: perception the relation between body posture and body parts. Magnitude of force: strong, moderate, weak Second, learn concept of time Speed: fast, moderate, slow Control relative motor timing Third, learn spatial relations Distance: close, moderate, far Direction: front, diagonal, side Height: high, moderate, low
Finishing exercise (5 min)	
Deep respiratory movement Body massage	

Table 2. Characteristics of the subjects (*N*=21)

Variables	Control	Task-oriented training	High-variability practice
Gender (boys/girls)	3/4	3/4	4/3[a]
Age (years)	6.14 (1.34)	5.14 (1.57)	5.71 (1.80)[b]
Gestational age (weeks)	33.57 (2.15)	33.57 (5.29)	37.43 (2.76)
Birth weight (g)	2,235.71 (407.96)	2,604.29 (758.72)	2,845.71 (584.46)
Height (cm)	112.60 (14.22)	104.70 (10.79)	101.27 (14.34)
Weight (kg)	20.59 (6.47)	16.73 (3.92)	15.76 (5.04)

[a] Number (%).[b] Mean (SD)

not assess damage, but how the subject being assessed is capable of independent daily living[16]. The test-retest reliability for the daily living activity assessment conducted on school age children was 0.83–0.99, and reliability among those measured was 0.74–0.96[15].

This study used SPSS 22.0 (IBM Corp., USA) for windows to analyze collected materials and significance level (α) used for statistical verification was set as 0.05. General features of the subjects were calculated through descriptive statistics, and normality for measuring variable was verified through a Shapiro-Wilk test. In order to analyze the difference of gross motor performance and activities of daily living for the three intervention groups before and after 8 weeks of training, a paired t-test was conducted. Moreover, a one-way ANOVA was implemented to compare the difference in the amount of change before and after the training among the three intervention groups. A post-hoc results were completed using the Bonferroni analysis.

RESULTS

General characteristics of the subjects are listed in Table 2. Table 3 shows the results of analyzing the difference in the amount of change among the three intervention groups before and after the training as well as the difference in GMPM before and after 8 weeks of training. All three intervention groups showed significant statistical results in the total GMPM including dissociated movement, coordination, body alignment, weight shifting, and stability before and after 8 weeks of training ($p<0.05$). Also, a difference in the amount of change before and after the training among the three intervention groups showed significant statistical results for the total GMPM including dissociated movement, muscle coordination, body alignment, weight shifting, and stability ($p<0.05$). A post-hoc results, the control group and the task-oriented training group, and the control group and high-variability practice group showed significant difference in the total GMPM including dissociated movement, body alignment, and weight shifting, while the control group and high-variability practice group, and the task-oriented training group and high-variability practice group each showed statistically significant differences in

Table 3. Comparison within and between groups (*N*=21)

Variables	Group	Pre-training	Post-training	Change values
Dissociated movement	Control	54.03 ± 5.52	55.70 ± 5.97*	1.67 ± 0.90[a]
	Task-oriented training	58.35 ± 7.85	61.86 ± 7.72*	3.50 ± 0.64[b]
	High- variability practice	55.61 ± 13.60	59.17 ± 13.54*	3.56 ± 1.94[b]
Coordination	Control	51.40 ± 7.51	53.08 ± 6.68*	1.67 ± 1.00[a]
	Task-oriented training	55.81 ± 11.44	59.35 ± 11.19*	3.54 ± 1.15[a]
	High- variability practice	48.94 ± 7.87	53.32 ± 6.84*	4.38 ± 2.24[b]
Alignment	Control	64.62 ± 9.24	65.69 ± 8.65*	1.01 ± 1.00[a]
	Task-oriented training	57.20 ± 11.51	60.63 ± 11.69*	3.43 ± 1.58[b]
	High- variability practice	63.14 ± 12.32	66.71 ± 11.97*	3.57 ± 2.06[b]
Weight shift	Control	50.71 ± 10.96	52.11 ± 10.57*	1.40 ± 1.07[a]
	Task-oriented training	52.49 ± 17.63	56.39 ± 16.86*	3.90 ± 1.48[b]
	High- variability practice	49.70 ± 10.31	53.27 ± 10.14*	3.56 ± 1.44[b]
Stability	Control	60.25 ± 12.79	61.81 ± 12.46*	1.56 ± 0.94[a]
	Task-oriented training	69.08 ± 12.41	72.43 ± 12.43*	3.35 ± 0.82[a]
	High- variability practice	62.19 ± 15.53	66.61 ± 13.96*	4.41 ± 2.29[b]
Total GMPM	Control	56.20 ± 5.43	57.67 ± 5.14*	1.46 ± 0.54[a]
	Task-oriented training	58.59 ± 6.35	62.13 ± 6.34*	3.54 ± 0.43[b]
	High- variability practice	55.92 ± 7.12	59.81 ± 6.54*	3.90 ± 0.86[b]

Values are means (%) ± SD. *p<0.05

Table 4. Comparison within and between groups (*N*=21)

Variables	Group	Pre-training	Post-training	Change values
Motor	Control	62.29 ± 17.48	63.86 ± 17.67*	1.57 ± 0.79[a]
	Task-oriented training	61.57 ± 8.52	63.86 ± 8.41*	2.29 ± 0.49[a]
	High- variability practice	60.14 ± 6.91	62.86 ± 6.89*	2.71 (0.49)[b]
Cognition	Control	24.43 ± 8.02	24.86 ± 8.21	0.43 (0.53)
	Task-oriented training	23.57 ± 4.96	24.29 ± 4.72	0.71 (0.95)
	High- variability practice	25.29 ± 6.99	26.14 ± 6.84*	0.86 (0.69)
WeeFIM	Control	86.71 ± 24.18	88.71 ± 24.32*	2.00 (0.82)[a]
	Task-oriented training	85.14 ± 11.26	88.14 ± 11.58*	3.00 (1.00)[a]
	High- variability practice	85.43 ± 7.99	89.00 ± 8.14*	3.57 (0.98)[b]

Values are means (score) ± SD. *p<0.05

coordination and stability.

Table 4 shows the results for analyzing the difference in WeeFIM before and after 8 weeks of training among the three intervention groups as well as the difference in the amount of change before and after the training among the three intervention groups. For motor domain and WeeFIM, all three intervention groups showed statistically significant differences before and after 8 weeks of training, but the cognitive domain showed no significant results between the control group and task-oriented training group, except for the high-variability practice group (p<0.05). The cognitive domain did not show any significant difference in the amount of change before and after training among the three intervention groups, except for motor domain and WeeFIM, which showed statistically significant difference (p<0.05). A post-hoc results showed a statistically significant difference in the control group and task-oriented training group, and the control group and high-variability practice group for motor domain and WeeFIM.

DISCUSSION

Traditional intervention method for children with cerebral palsy is composed of simple movements which do not induce any interest and lacks any feedback for each movement, leading to improper movements and thereby undermining training effects[17]. Children with cerebral palsy lack dissociated movement due to spasticity, muscle weakness and decreased selective motor control[18]. Moreover, poor body alignment and abnormal weight shifting may occur due to contracture development from pelvic asymmetry and spaticity[5]. As such, in order to minimize the effect of the musculoskeletal system and neuromuscular system damage, it should be recommended to learn motor control strategies that allows for maximum energy efficiency and functional adjustment. Since children with cerebral palsy can receive more information that is usable in an environment aside from direct tasks, they can more easily perform precise perception activities than those that are more abstract, even if they involve the same movement[19].

Task-oriented training provides interesting tasks to children with cerebral palsy in objective functional aspects[8], and repetitive training in an environment that can stimulate activity and participation which may ultimately enhance motor performance. In addition, by applying high-variability practice into the course of the task-oriented training course, this may induce the trainee to better adjust to his/her ability to cope with errors involving distance, speed, direction or relative timing of motor movement within activity phases through different practices in which action variables or part of a task change when each practice is similar in general.

Since high-variability practice allows for the pediatric physiotherapist to induce rapid change in motor procedure, it can stimulate interest in movement forms suitable to the task and adapt to selective diversity, thereby coordinating motor activities in a harmonious manner. A study conducted by Latas et al.[20], showed that diverse tasks were practiced to improve finger muscle coordination of adolescents suffering from down syndrome. As such, high-variability practice can improve stability and muscle coordination which allows for the trainee to intentionally perform precise, smooth, and efficient movements that are appropriate in each situation by exercising mutual supplement and revision of movements based on speed, direction, magnitude of force production, and biomechanical efficiency during the course of acquiring motor skills.

Recent literature on motor control disability focuses on tasks that are important in daily functioning and for all kinds of environments, and accepts the importance of frequent and diverse tasks in motor tasks[21]. Children with cerebral palsy receive inherent information from perception receptors, and other information through various forms of extrinsic feedback receiving information from external causes, and through this knowledge, children with cerebral palsy can understand the principles and features of movement processes[22]. In other words, the ability to conduct a safe and independent daily life can be improved as the subjects independently find solutions for new tasks after observing movements through internal/external physical stimulations and compiling them to cope with the changing environment.

Limitations in the play of children with physical disabilities may affect the experiential learning derived from play and may result in decreased independence, motivation, imagination, creativity, assertiveness, social skills, and self-esteem[23]. Like in the case of children with cerebral palsy with difficulty in their learning movement, they should be trained to remember solutions and use them even when their ability to cope with new environments may be limited. As such, pediatric physiotherapists should conduct challenging and meaningful treatment that can help such children not only in their functioning but also their cognition so that they can connect directly to their daily lives. High-variability practice can improve cognitive ability by observing functional tasks and different environments through a feed-forward mechanism, finding solutions for new tasks on his/her own, and making attempts to change according to various situations. In other words, trainees can learn concepts, perceptions, and language and improve his/her cognition and social skills by understanding the influence of men and objects surrounding him/her through repetitive sessions on changes in attention grabbing and functional tasks.

Pediatric physiotherapists should provide therapeutic intervention upon considering that children with cerebral palsy suffer from not only difficulty in accomplishing tasks, but also from limitations in the quality of movement with which they can perform a specific activity in a precise manner. Applying high-variability practice into the course of the task-oriented training course allows repetitive and diverse motor on objectives connected with a functional task. Therefore, it may be considered as an efficient intervention method to improve motor performance that can tune in with movements necessary in daily lives based on experience and learning new skills and changes in a task learned in complex environment or similar situations.

REFERENCES

1) Rosenbaum P, Paneth N, Leviton A, et al.: A report: the definition and classification of cerebral palsy April 2006. Dev Med Child Neurol Suppl, 2007, 109: 8–14. [Medline]
2) Sankar C, Mundkur N: Cerebral palsy-definition, classification, etiology and early diagnosis. Indian J Pediatr, 2005, 72: 865–868. [Medline] [CrossRef]
3) Maruishi M, Mano Y, Sasaki T, et al.: Cerebral palsy in adults: independent effects of muscle strength and muscle tone. Arch Phys Med Rehabil, 2001, 82: 637–641. [Medline] [CrossRef]
4) Yokochi K: Gait patterns in children with spastic diplegia and periventricular leukomalacia. Brain Dev, 2001, 23: 34–37. [Medline] [CrossRef]
5) Kim Y, Lee BH: Clinical usefulness of child-centered task-oriented training on balance ability in cerebral palsy. J Phys Ther Sci, 2013, 25: 947–951. [Medline] [CrossRef]
6) Leroux A, Pinet H, Nadeau S: Task-oriented intervention in chronic stroke: changes in clinical and laboratory measures of balance and mobility. Am J Phys Med Rehabil, 2006, 85: 820–830. [Medline] [CrossRef]
7) Bayona NA, Bitensky J, Salter K, et al.: The role of task-specific training in rehabilitation therapies. Top Stroke Rehabil, 2005, 12: 58–65. [Medline] [CrossRef]
8) Blundell SW, Shepherd RB, Dean CM, et al.: Functional strength training in cerebral palsy: a pilot study of a group circuit training class for children aged 4–8 years. Clin Rehabil, 2003, 17: 48–57. [Medline] [CrossRef]
9) Franjoine MR, Gunther JS, Taylor MJ: Pediatric balance scale: a modified version of the berg balance scale for the school-age child with mild to moderate motor impairment. Pediatr Phys Ther, 2003, 15: 114–128. [Medline] [CrossRef]

10) Maxwell JP, Masters RS, Eves FF: The role of working memory in motor learning and performance. Conscious Cogn, 2003, 12: 376–402. [Medline] [CrossRef]
11) Wulf G, Shea C, Lewthwaite R: Motor skill learning and performance: a review of influential factors. Med Educ, 2010, 44: 75–84. [Medline] [CrossRef]
12) Shea CH, Lai Q, Wright DL, et al.: Consistent and variable practice conditions: effects on relative and absolute timing. J Mot Behav, 2001, 33: 139–152. [Medline] [CrossRef]
13) Boyce WF, Gowland C, Russell D, et al.: Consensus methodologies in the development and content validation of a gross motor performance measure. Phys Ther Can, 1993, 45: 94–100.
14) Ko J, Kim M: Inter-rater reliability of the K-GMFM-88 and the GMPM for children with cerebral palsy. Ann Rehabil Med, 2012, 36: 233–239. [Medline] [CrossRef]
15) Wong V, Wong S, Chan K, et al.: Functional Independence Measure (WeeFIM) for Chinese children: Hong Kong Cohort. Pediatrics, 2002, 109: E36. [Medline] [CrossRef]
16) Aybay C, Erkin G, Elhan AH, et al.: ADL assessment of nondisabled Turkish children with the WeeFIM instrument. Am J Phys Med Rehabil, 2007, 86: 176–182. [Medline] [CrossRef]
17) Flynn S, Palma P, Bender A: Feasibility of using the Sony PlayStation 2 gaming platform for an individual poststroke: a case report. J Neurol Phys Ther, 2007, 31: 180–189. [Medline] [CrossRef]
18) Siri M, Ann-Krstin G, Beatrix V, et al.: Relationship between body functions and upper extremity activity in children with cerebral palsy. J Dev Med Child Neurol, 2010, 52: 29–34. [CrossRef]
19) van der Dussen L, Nieuwstraten W, Roebroeck M, et al.: Functional level of young adults with cerebral palsy. Clin Rehabil, 2001, 15: 84–91. [Medline] [CrossRef]
20) Latash ML, Kang N, Patterson D: Finger coordination in persons with Down syndrome: atypical patterns of coordination and the effects of practice. Exp Brain Res, 2002, 146: 345–355. [Medline] [CrossRef]
21) French B, Leathley M, Sutton C, et al.: A systematic review of repetitive functional task practice with modelling of resource use, costs and effectiveness. Health Technol Assess, 2008, 12: iii, ix–x, 1–117. [Medline] [CrossRef]
22) Kilduski NC, Rice MS: Qualitative and quantitative knowledge of results: effects on motor learning. Am J Occup Ther, 2003, 57: 329–336. [Medline] [CrossRef]
23) Suzann KC, Robert JP, Margo NO: Physical therapy for children, 4th ed. Elsevier, 2012, p 601.