Improvement of the Ability of Dynamic Trunk Control in Sitting Position in Children with Cerebral Palsy by Visual and Verbal Cues: A Preliminary Study

การปรับปรุงความสามารถของการควบคุมลำตัวแบบไดนามิกส์ในท่านั่งในเด็กที่มีภาวะสมองพิการ โดยการชี้นำทางการมองเห็นและวาจา: การศึกษานำร่อง

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ABSTRACT

This study aimed to compare the immediate effects of visual, verbal and combined visual and verbal cues on the ability of dynamic trunk control in sitting position in children with cerebral palsy (CP). Ten participants were asked to lean trunk forward, backward, and to the left and the right directions as far as possible in each cue condition during sitting position. The results of this study showed that the limit of stability (LOS) and the center of force (CoF) trajectory in the combined cue conditions was significantly greater than that in no sensory cue and in visual cue conditions (p □ 0.05). Also, the LOS and CoF trajectory in verbal cue condition was significantly greater than that in no sensory cue condition ($p < 0.05$). Additionally, the ability of leaning trunk movement to the left was significantly greater than backward direction ($p < 0.05$). Hence, these results of preliminary study suggested that external sensory cues such as verbal and combined visual and verbal cues may be used to improve ability of dynamic trunk control ($p < 0.05$) in sitting position in children with CP.

บทคัดย่อ

การศึกษานี้มีวัตถุประสงค์เพื่อศึกษาผลเฉียบพลันต่อการให้ตัวชี้นำทางการมองเห็น ทางวาจา และตัวชี้นำรวมการมองเห็นและวาจาต่อความสามารถในการควบคุมลำตัวแบบไดนามิกส์ในท่านั่งในเด็กที่มีภาวะสมองพิการ ผู้เข้าร่วมวิจัยทั้ง 10 คนถูกขอร้องให้โน้มตัวในท่านั่งเท่าที่สามารถทำได้ในทิศทางด้านหน้า, หลัง, ซ้าย และขวาในแต่ละเงื่อนไขของการให้ตัวชี้นำ ผลการศึกษาแสดงให้เห็นว่าขอบเขตความมั่นคงและค่าวิถีของจุดศูนย์กลางแรงในเงื่อนไขการให้ตัวชี้นำรวมการมองเห็นและวาจามีค่าเพิ่มขึ้นอย่างมีนัยสำคัญทางสถิติเมื่อเทียบกับเงื่อนไขที่ไม่มีตัวชี้นำ และมีตัวชี้นำทางการมองเห็น (p □ 0.05) อีกทั้งขอบเขตความมั่นคงและค่าวิถีของจุดศูนย์กลางแรงในเงื่อนไขการให้ตัวชี้นำทางวาจามีค่าเพิ่มขึ้นอย่างมีนัยสำคัญทางสถิติเมื่อเทียบกับเงื่อนไขที่ไม่มีตัวชี้นำ ($p < 0.05$) นอกจากนี้ความสามารถในการโน้มลำตัวในทิศทางซ้ายมีค่ามากกว่าทิศทางหลังอย่างมีนัยสำคัญทางสถิติ ($p < 0.05$) ดังนั้นผลของการศึกษานำร่องนี้ชี้ให้เห็นว่าตัวชี้นำทางระบบประสาทสัมผัสภายนอกอาทิเช่น ตัวชี้นำทางวาจา และตัวชี้นำรวมการมองเห็นและวาจาอาจจะช่วยเพิ่มความสามารถในการควบคุมลำตัวแบบไดนามิกส์ ($p < 0.05$) ในท่านั่งในเด็กที่มีภาวะสมองพิการ

Keywords: Visual and Verbal cues, Dynamic trunk control, Children with cerebral palsy

คำสำคัญ: ตัวชี้นำทางการมองเห็นและทางวาจา การควบคุมลำตัวแบบไดนามิกส์ เด็กที่มีภาวะสมองพิการ

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Introduction

Cerebral palsy (CP) is a group of movement and postural disorders that appeared during infancy or early childhood. CP is caused by non-progressive damage to the brain before, during, or shortly after birth (Berker, Yalcin, 2005; Rosenbaum et al., 2007). The incident of cerebral palsy has been reported at 2-2.5 per 1000 live births (Cans et al., 2000; Paneth et al., 2006). Children with CP shows a complexity of motor and sensory disorders such as muscle tone abnormalities, muscle weakness, and perception impairments leading to the limitations of mobility and self-care activities. Furthermore, there has been reported that children with CP have difficulty in controlling movements since their trunk control is poor (Berker, Yalcin, 2005; Heyrman et al., 2013).

Ability to control trunk in either static or dynamic movement has been reported as a crucial role in postural control (Van Der Heide et al., 2003). Impairments of trunk control has been found as a primary impairment in children and adolescents with CP and may affect their functional activities in daily life such as sitting, reaching and walking (Prosser et al., 2010; Ju et al., 2012; Heyrman et al., 2013; Saether et al., 2015). Many techniques for improving the trunk control ability have been reported such as traditional exercise, trunk targeted training, electrical stimulation, hippotherapy, and functional training with virtual reality game (Konrad et al., 2001; Park et al., 2001; Kang et al., 2012; Barton et al., 2013; Unger et al., 2013; ElBasatiny, Abdelaziem, 2015). In addition, the external sensory cues such as visual and verbal cues have been applied with functional training. These cues enhanced performance and improved motor learning (Hartveld, Hegarty, 1996; Baram, Lenger, 2012) by provided an essential information through the feedback mechanisms to improved results of movement (Shumway-Cook, Woollacott, 2012).

Nowadays, the majority of the studies of effects of external sensory cues on motor performance and functional activities were conducted in adult population. However, there has been a few studies of the effects of external sensory cues on motor performance and functional activities in children with cerebral palsy. In 2012, a study of the effects of gait training with visual and auditory feedback cues on walking abilities in children with CP showed that visual and auditory feedback cues could improve gait parameters such as walking speed and stride length in children with CP (Baram, Lenger, 2012). Moreover, studies have rarely used visual and verbal cues to focus ability of dynamic trunk control during leaning movement in sitting position. Therefore, this pilot study was conducted to investigate the immediate effects of visual and verbal cues on the ability of dynamic trunk control during leaning movement in sitting position in children with cerebral palsy.

Objectives of the study

To compare of the immediate effects of visual, verbal and combined visual and verbal cues during leaning forward, backward, to the left, and to the right directions in sitting position in children with CP.

Methodology

This study was cross-sectional study design. All study protocols were approved by the Ethics Review Committee for Research Involving Human Research Subjects, Health Science Group, Chulalongkorn University. The

informed consent was obtained from all participants and their parents or guardians once the study procedure was fully explained.

Participants

Ten children with cerebral palsy (5 males, 5 females) aged 11.60 ± 0.50 years old were recruited from Srisangwan school, Nonthaburi province, Thailand. All participants had been diagnosed as spastic diplegia subtype within GMFCS level II-III. Additionally, they were meet the following criteria: able to sit in high bench without trunk, hand and feet supports; able to upright and keep knee at 90 degrees in sit position; had good visual acuity (participants could be used glasses or lens for correction); did not receive tendon transfer in the last 6 months or hip surgery performed in the last 12 months; did not receive botulinum toxin injections at trunk and lower limb area performed in the last 6 months; did not receive a drug that induces drowsiness within 24 hours such as conventional antihistamines; had no history of epilepsy in the last a years; and able to understand in Thai language and understand test instructions. They would be excluded from this study if they were unable to follow the command or instructions and unable to participate until the end of the process.

Outcome Measures

The outcomes of this study consisted of limit of stability (LOS) (Preuss, Popovic, 2010) and center of force (CoF) trajectory (Kim, Yoo, 2014) were measured by seat pressure mat device (Tekscan CONFORMat, Boston, USA). The LOS is the total area during maximum trunk leaning movement in four directions including forward, backward, left, and right. LOS is represented in square centimeters (cm^2). Before collecting data, the investigator performed LOS measurement with excellence in both of intra-rater and inter-rater reliability ($ICC_{(3, 1)}$ = 1.00, 0.99, respectively)

The CoF trajectory is the maximum anterior/ posterior and left/ right leaning movement away from the subject's center of sitting balance in centimeters (cm). Test-retest reliability of CoF trajectory was evaluated with intraclass correlation coefficient (ICC) prior data collection. The values of intra-rater and inter-rater reliability were excellence ($ICC_{(3, 1)}$ = 0.99, 0.99, respectively).

Procedure testing

All participants were asked to sit in the most upright position on COMFORMat sensors with their arms cross over chest and look straight forward. Participant's legs, back and feet were not supported. Then, they were asked to perform a block of dynamic trunk control with random directions and cue conditions. Four conditions included no sensory cue, visual cue, verbal cue and combined visual and verbal cue conditions. In each condition, participants were randomly measured their ability to control trunk in four directions including forward (F), backward (B), left (L) and right (R) directions by using research randomizer to generate random number (Urbaniak, Plous, 2013). Safety guard to prevent participants from falling did by a research assistant who was a physical therapist. The four conditions of this study was described as follow:

Condition 1: The participant did not received any augment sensory cue, “no sensory cue”. The instruction was to “lean as far as possible without falling and no use lower limbs to help with the movements”. During leaning, participants were asked to look straight forward in all test directions.

Condition 2: The participant received one augment sensory cue, “visual cue”, during leaning movement in all directions. In each direction, all participants were asked to look at the target during leaning. The target was an adjustable PVC pipe. The height of PVC pipe was set at the shoulder level of each participant. The distance between adjustable PVC pipe and participant in each direction was equal to a participant’s arm range**.** The instruction, “look at the target and try to approach the target by leaning the trunk as far as possible without falling and no use lower limbs”, was given to the participants

Condition 3: The participant was received another augment sensory cue, “verbal cue”, which was verbal commands during leaning in all directions. Participants were asked to look straight forward while leaning toward desired direction. The verbal commanded, “further, further, further”, was given to the participants at the end range of the leaning movement. The instructions were delivered in the same tone of voice by the same person.

Condition 4: In this condition, the participant was received combined sensory cues which were visual and verbal cues. During movement, the participants were asked to look at the target which was described in condition 2 and tried to approach the target as much as possible. They were also received the verbal command, “further, further, further”, at the end range of the leaning movement.

Before testing, all participants were received the information of the testing procedure. An investigator firstly demonstrated all of the processes in each condition. Then, the participants were asked to practice leaning movement in sitting position for two times per condition to make sure that participants understand the test protocol. Participants had to perform the task until three complete trials were achieved. A completed trial was defined as moving trunk toward a desired direction and back to the starting position. The mean of the three complete trials was calculated and used for further analysis. In each condition, one-minute break was allowed between directions. In addition, each subject was asked to take a rest for 20 minutes between conditions. During the rest period, participants were have a snack and drink, and enjoy themselves with playing games and drawing a pictures.

Statistical analysis

The statistical analysis was performed with SPSS version 17.0 for window. The descriptive statistic was used to describe the demographic data. The Shapiro-Wilk test was used to test normality of data for all variables. All data will be presented as mean ± SD.

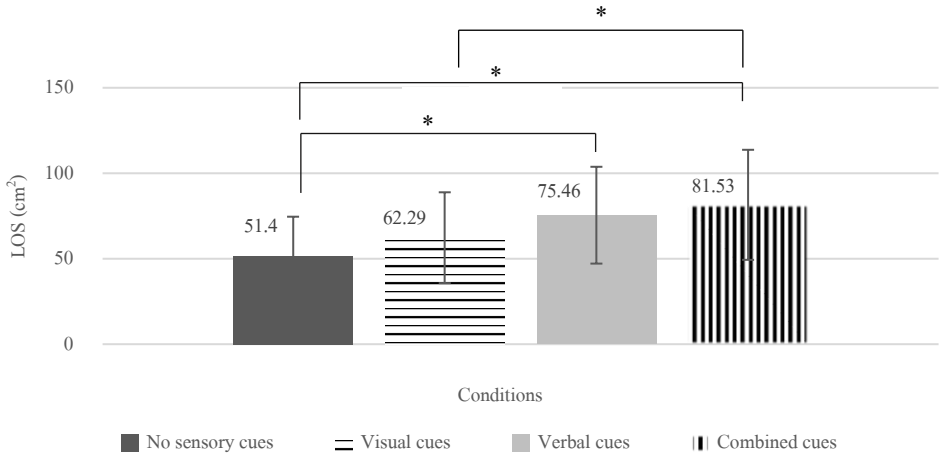
For the LOS, the one-way repeated measurement analysis of variance (ANOVA) was used to analyze within group effect. A Bonferroni post-hoc test for differences between each condition. For the CoF trajectory of four directions in four conditions (4 conditions × 4 directions) were analyzed by two-way repeated measurement ANOVA. A LSD post-hoc test for differences between each condition and direction. The level of statistically significant difference was set at p-value = 0.05.

Results

The demographic data of participants were showed in table 1. The results showed that there were significant difference in the LOS performance among the four cue conditions ($F_{(3, 27)}$ = 10.89, p □ 0.05). The LOS in combined cue conditions was greater than in no sensory cue and visual cue conditions (p □ 0.05). In addition, the area of LOS in verbal cue condition was greater than in no sensory cue condition (p < 0.05) (Figure 1).

Table 1 The demographic data (N=10)

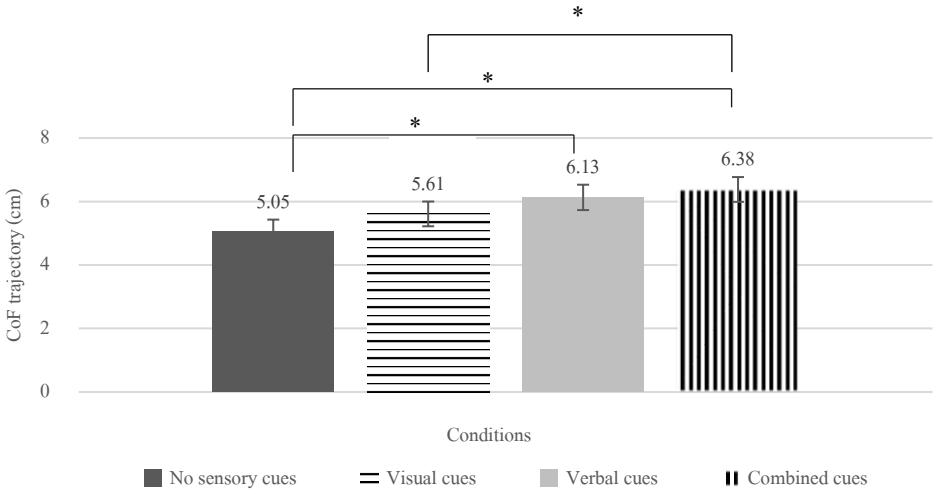
Variables	Mean ± SD
Age (Years : Mean ± SD)	11.60 ± 0.50
Gender (Male : Female)	5 : 5
Weight (kilograms: Mean ± SD)	33.55 ± 2.77
Height (centimeter: Mean ± SD)	138.60 ± 3.17



* Significant difference; p-value □ 0.05

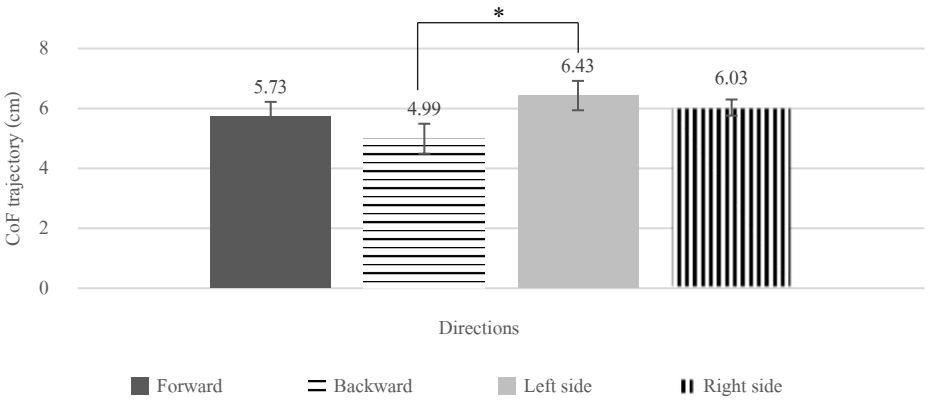
Figure 1 Mean ± SD of the limit of stability (LOS) in each cue condition (cm^2)

For the immediate effects of different cues on the CoF trajectory in four directions showed significant main effect of conditions ($F_{(3, 27)} = 9.61$, $p < 0.05$) and directions ($F_{(3, 27)} = 3.16$, $p < 0.05$). However, the interaction effect between conditions and directions was not found ($F_{(9, 81)} = 0.36$, $p > 0.05$). Post-hoc analysis showed that the CoF trajectory was greater in combined cue conditions than in no sensory cue and visual cue conditions ($p < 0.05$). In addition, the CoF trajectory in verbal cue condition was greater than it was in no sensory cue condition ($p < 0.05$) (Figure 2). For direction main effect, the CoF trajectory in the left direction was greater than in backward direction ($p < 0.05$) (Figure 3).



* Significant difference; p-value < 0.05

Figure 2 Mean ± SD of the center of force (CoF) trajectory (cm) in each condition



* Significant difference; p-value < 0.05

Figure 3 Mean ± SD of the center of force (CoF) trajectory (cm) in each direction

Discussion and Conclusions

This study investigated the immediate effects of different sensory cues on the ability of dynamic trunk control in sitting position in children with CP. Ability of dynamic trunk control was measured by the LOS and the CoF trajectory. The results suggested that verbal cue and combined visual and verbal cues were effectively improved ability of dynamic trunk control in the children with CP.

This finding was consistency with the previous clinical studies (Suteerawattananon et al., 2004; Baram, Lenger, 2012). They reported that the cueing can improve motor functional such as walking in patients with neurological disorders. Recently, Baram, Lenger (2012) founded that either visual cue or auditory feedback cue training could improve walking speed and stride length from baseline data in patient with CP. In addition, Suteerawattananon et al. (2004) showed significantly improve gait speed, cadence and stride length when cues were used in patients with Parkinson's disease. The different sensory cues demonstrated the different effects on the functional performance. The auditory cue significantly improved gait speed and gait cadence. However, visual cue significantly improved only stride length (Suteerawattananon et al., 2004).

In the results of this study, the visual cue could not effectively stimulate awareness of the body to improve dynamic sitting performance in children with CP when compared with the verbal cue and the combined visual and visual cues. It may be due to the visual cue alone may not sufficiently drew attentional focus on task in children with CP. Whereas, verbal cue which a key word of instructions can help to directly drew a attentional focus and directly attempted to perform the task in children with CP. In addition, a younger children or lower skill person was a greater benefit from verbal cue than older children or higher skill person (Landin, 1994). Furthermore, the verbal cue in this preliminary study, "further, further, further", was the positive reinforcement that could made an extrinsic motivation inducing the improvement of the motor skills (Skinner, 1969). Therefore, the verbal cue and the combined visual and visual cues would be helpful in training program to improve dynamic trunk control in children with CP.

Moreover, when considering of the CoF trajectory, the longest distance was found in leaning to the left side and the shortest distance was found in backward direction. In addition, the results showed that the CoF trajectory was significant different between leaning to the left and backward direction. The assumption would be that most of participants may have the severity of spasticity on the right side more than on the left side of the body. This led to the interference of the ability of leaning trunk movement on the right side and showing a better performance on the left side. However, this assumption was lack of the information of the severity of spasticity on each side of the body in children with CP.

This study demonstrated that the using of cues could improve ability of dynamic trunk control in term of LOS and CoF trajectory during sitting position in children with CP, especially verbal cue and combined visual and verbal cues. However, the interpreting of the results would be with care because this study conducted with a small sample size. In order to generalize these results, a further study would be needed to investigate a large number of subjects with aged-matched control. Additionally, the severity of spasticity should be recorded to clarify whether more severity affect more on the distance of CoF trajectory.

In conclusion, this preliminary study suggested that either verbal or combined visual and verbal cues may be used as external sensory to improve the ability of dynamic trunk control in sitting position in children with CP.

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