

The immediate effect of Kinesio taping and mirror neuron stimulation on gross motor function  
in Thai children with cerebral palsy  
ผลทันทีของการติดเทปไคเนซีโอร่วมกับการกระตุ้นเซลล์กระจกเงาต่อความสามารถด้านการ  
เคลื่อนไหวในเด็กภาวะสมองพิการไทย

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**ABSTRACT**

**Background:** A cerebral palsy is a group of permanent disorders arising from many reasons in the brain during early childhood. It directly affects physical development. The combination of the Kinesio taping and mirror neurons stimulation based VCD program represents a new practical approach to treat cerebral palsy. It is possible to promote motor development in cerebral palsy.

**Objective:** To compare GMFM-66 scores between children who received only Kinesio taping and children who were treated by using Kinesio taping together with mirror neurons stimulation based VCD program.

**Methods:** The 30 participants were 5–12 years old children with spastic diplegia with GMFCS at level 1–3. The children were divided into an experimental group and a control group with 15 children in each group. In the control group, the researcher had applied Kinesio taping on tibialis anterior muscle and rectus femoris by using muscle facilitation technique and functional correction technique at ankle joint for 60 minutes. The participants in the experimental group received Kinesio taping on their lower limb and VCD program for 60 minutes. The GMFM-66 evaluated gross motor function.

**Results:** The GMFM-66 scores of the two groups as calculated by using ANCOVA were not statistically significantly different after the intervention ( $p=0.206$ ). When comparing GMFM-66 scores within each group by applying paired t-tests, then statistically significant differences were observed within both groups ( $p<0.001$ ).

**Conclusion:** Both using only Kinesio taping and using Kinesio tape with mirror neurons stimulation based VCD program had immediately affected on gross motor function in children with spastic diplegia. However, there were no significant differences between groups.

**Keywords:** Cerebral palsy, Kinesio taping, Mirror Neuron, Gross Motor Function

**บทคัดย่อ**

**ที่มาและความสำคัญ:** ภาวะเด็กสมองพิการเป็นกลุ่มอาการของเด็กที่เกิดจากความผิดปกติของสมองอย่างถาวรเนื่องจากสาเหตุหลายประการ ส่งผลให้เกิดพัฒนาการที่ผิดปกติและล่าช้า การรักษาด้วยการติดเทปไคเนซีโอร่วมกับการรักษาด้วยโปรแกรมกายภาพบำบัดสำหรับพัฒนาทักษะการเคลื่อนไหวโดยกระตุ้นการทำงานของเซลล์กระจกเงาในรูปแบบวีดิทัศน์จัดเป็นการรักษาอีกทางเลือกรูปแบบหนึ่งที่สามารถนำมาประยุกต์ใช้ในเด็กภาวะสมองพิการได้จริง และมี

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แนวโน้มที่สามารถส่งเสริมให้เกิดการพัฒนาทางด้านการเคลื่อนไหวในเด็กภาวะสมองพิการได้

**วัตถุประสงค์:** เปรียบเทียบคะแนนความสามารถด้านการเคลื่อนไหวด้วยแบบประเมิน GMFM-66 ระหว่างกลุ่มเด็กที่ได้รับการรักษาด้วยการตีเทปโคเนซีโอเพียงอย่างเดียว กับกลุ่มเด็กที่ได้รับการรักษาด้วยการตีเทปโคเนซีโอร่วมกับการรักษาด้วยโปรแกรมกายภาพบำบัดสำหรับพัฒนาทักษะการเคลื่อนไหวโดยกระตุ้นการทำงานของเซลล์กระจกเงาในรูปแบบวีดิทัศน์

**วิธีการวิจัย:** อาสาสมัครเป็นเด็กภาวะสมองพิการชนิด spastic diplegia อายุ 5-12 ปี มีระดับความสามารถด้านการเคลื่อนไหว (GMFCS) อยู่ในระดับ 1-3 จำนวน 30 คน แบ่งเป็นกลุ่มทดลองและกลุ่มควบคุม กลุ่มละ 15 คน กลุ่มควบคุมจะได้รับการตีเทปโคเนซีโอด้วยเทคนิคกระตุ้นการทำงานของกล้ามเนื้อ tibialis anterior และ rectus femoris ร่วมกับเทคนิคกระตุ้นการทำงานของข้อเท้า เป็นระยะเวลา 60 นาที ส่วนกลุ่มทดลองจะได้รับการรักษาด้วยโปรแกรมกายภาพบำบัดสำหรับพัฒนาทักษะการเคลื่อนไหวโดยกระตุ้นการทำงานของเซลล์กระจกเงาในรูปแบบวีดิทัศน์ เป็นระยะเวลา 60 นาที ร่วมกับการตีเทปโคเนซีโอที่ขา ประเมินผลความสามารถทางด้านการเคลื่อนไหวด้วยแบบประเมิน GMFM-66

**ผลการวิจัย:** เมื่อเปรียบเทียบค่าคะแนน GMFM-66 ระหว่างกลุ่มทดลองและกลุ่มควบคุมภายหลังการได้รับปัจจัยการทดลอง โดยใช้สถิติ ANCOVA พบว่าไม่มีความแตกต่างอย่างมีนัยสำคัญทางสถิติ ( $P=0.206$ ) และเมื่อเปรียบเทียบคะแนน GMFM-66 ภายในกลุ่มโดยใช้สถิติ paired t-test พบว่ามีความแตกต่างอย่างมีนัยสำคัญทางสถิติทั้งสองกลุ่ม ( $p<0.001$ )

**สรุปผล:** การตีเทปโคเนซีโอที่ขาเพียงอย่างเดียว และการตีเทปโคเนซีโอที่ขาพร้อมกับการรักษาด้วยโปรแกรมกายภาพบำบัดสำหรับพัฒนาทักษะการเคลื่อนไหวโดยกระตุ้นการทำงานของเซลล์กระจกเงาในรูปแบบวีดิทัศน์ มีผลทันทีต่อการเพิ่มขึ้นของความสามารถด้านการ

เคลื่อนไหวในเด็กภาวะสมองพิการชนิด Spastic diplegia แต่ทั้ง 2 กลุ่มไม่มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติ

**คำสำคัญ:** สมองพิการ โคเนซีโอเทป เซลล์กระจกเงา ความสามารถด้านการเคลื่อนไหว

## Introduction

Cerebral palsy (CP), the nonprogressive disturbances, is the permanent movement and posture development disorders leading to activity limitation. The impairment of the developing fetal or infant brain is the cause of motor disorders that usually accompanies by disturbances of sensation, perception, cognition, communication, and behaviour, by epilepsy, and by secondary musculoskeletal problems<sup>1</sup>. Neurological lesions have a limitation on the brain and directly affect physical development. Children will have problems doing activities in daily living due to abnormal muscle and joint functionality such as muscle weakness, spasticity, joint contracture and bone deformity<sup>1</sup>. In average, 1.5 to 2.5 out of 1,000 infants are born with cerebral palsy<sup>2</sup>.

Nowadays, physical therapy plays a role in stimulating the musculoskeletal systems in children with cerebral palsy in order to manage their motion to the best abilities. Continuing stimulation of sensory and motor systems are necessary to enhance the stability of motion and to allow the body to memorize the correct motion in children with disability. The movement skills could continuously improve until the patients can manage their motion inappropriate circumstances<sup>3</sup>. Recently, the study found that the mirror neuron system supported the concordant

function of sensory and motor neurons. Buccino et al. in 2004, stated that the mirror neuron system was a perception of action observation. The person could understand the meaning of the others' action, which leads to imitation<sup>4</sup>. The primary method began with picture recognition, and gathering detail of the actions by observation in the visual cortex then links to other motor neuron pathways. Therefore, mirror neurons intertwine to other neurons, and the system then leads to action imitation from action observation. These processes can apply to promote motor skills in children with cerebral palsy by imitative learning from activities that they have seen in mirror neurons stimulation based VCD program. The mirror neurons stimulation based VCD program stimulated the sensory system and linked to the nervous motor system through the parieto-premotor circuit.

Mahasup et al. in 2012, designed and developed mirror neurons stimulation based VCD program<sup>5</sup>. The contents consisted of stretching exercises and activities to promote body balance in sitting and standing positions and during walking. Physiotherapy specialists who had various experiences in cerebral palsy treatment approved content validity. Results showed that the mirror neurons stimulation based VCD program was able to improve gross motor function (the GMFM-66 scores) in thirty children with cerebral palsy (2–10 years old) as much as a standard physical therapy<sup>5</sup>. Furthermore, the various study found that mirror neuron therapy could increase gross motor function in disability patients. Buccino et al. in 2006, found that the primary stroke

patients who watched the daily activity film and imitated limbs movement had better functional scores<sup>6</sup>. Chaipayat et al. in 2009, created a home rehabilitation program by applying mirror neuron theory for Thai ischemic stroke patients. The results showed that the program could increase the ability of movement<sup>7</sup>. As for the stimulating mirror neuron treatment had been reporting the increase children with cerebral palsy movement ability in 1 month<sup>5</sup>. Therefore, there was a possibility that the movement ability might improve within one month after initiate treatment. The researcher was interested in studying the immediate effects of the treatment of the mirror neuron stimulation program.

The Kinesio taping method (KT) had developed and increasingly popular. This method designed for promoting the natural healing system of the body via activates neurological and circulatory processes. Moreover, KT also had influenced the muscles through skin input. There were five major physiological systems affected by KT, including stimulating mechanoreceptors, increasing interstitial fluid flow, lifting skin, improving muscle contraction and improving joint biomechanics<sup>8,9</sup>. The previous study found that the Kinesio tape, using muscle facilitation and functional correction technique, is effective in improving muscle contraction and joint biomechanics. Kase et al. in 2003 had hypothesis muscles stimulation mechanisms by using KT. The stretching effect of KT on the skin had stimulated muscle spindle, which stimulated muscle contraction and muscle activity<sup>10</sup>. Hsu et al. in 2009, compared EMG of lower trapezius muscle

between KT and sham tape in shoulder impingement and found the increase of lower trapezius muscle activity in 60-30° arm lowering phase in KT conditions<sup>11</sup>. Huang et al. in 2011 studied the effect of the KT on muscle activity and vertical jump performance in healthy inactive people. They found the muscle activity of medial gastrocnemius trend to increase in the KT group when compared with elastic tape<sup>12</sup>. Costa et al. in 2013, discovered that KT could improve efficiency in moving and changing position from sitting to standing in children with cerebral palsy<sup>13</sup>. Kinesio tape with muscle facilitation and functional correction techniques was found to be effective in children with cerebral palsy. Also, Simsek et al. in 2011, showed that KT helped to improve balance in sitting position of children with cerebral palsy<sup>14</sup>. The study also revealed that KT was more supportive of muscle facilitation and functional movement. As a result of this, KT might improve gross motor function in children with cerebral palsy.

In addition, Dos Santos et al. in 2019, studied the immediate effect of the Kinesio tape on rectus femoris muscle in children with unilateral cerebral palsy. They found that KT could increase rectus femoris muscle function and stimulated trunk extension movement during sit to stand<sup>15</sup>. Also, Dos Santos et al. in 2018, studied the immediate effect of the Kinesio tape on knee extensor torque in children with unilateral cerebral palsy (GMFCS level 1-3). They found the Kinesio tape could increase the knee extensor peak torque<sup>16</sup>. The researcher interested in the immediate treatment of the Kinesio tape because

the prolong applying KT on children with cerebral palsy might cause tape allergies. Moreover, children might feel uncomfortable, including maybe lead to the accumulation of pathogens on the skin. In consideration of the mentioned findings, applying KT and combined with mirror neurons stimulation based VCD program might promote motor development to achieve maximum success.

The authors decided to study the immediate effects of the Kinesio taping and mirror neurons stimulation based VCD program for children with cerebral palsy on GMFM-66 scores<sup>5</sup>. The hypothesis of the research was the gross motor function measure score in the experimental group that receives the Kinesio tape and combined with mirror neurons stimulation based VCD program was different from the control group that receives only the Kinesio tape.

## Methods

### Study design

This study was a randomized control trial which had been approved by the Ethical Review Sub-Committee Board for Human Research Involving Sciences, Thammasat University, No. 3 (ECScTU). The registration took place at Thai Clinical Trials Registry with permit number TCTR20180713003.

### Participants

The participants were 5–12 years old children with spastic diplegia classified by the gross motor function classification system (GMFCS) at level 1–3. The inclusion criteria were 1) able to communicate with others, 2) absence of

joint contracture, 3) never received Kinesio taping on lower extremity before. The exclusion criteria were 1) botulinum toxin injection or limb surgery within the last six months before the study was conducted, 2) severe visual and hearing deficits, 3) allergic to Kinesio tape, and 4) no muscle contracture which limits limb movement. Thirty children with cerebral palsy were recruited in this study to comply with the results of sample size calculation (effect size = 1.0, confidence level = 95%, power = 80%). These 30 children were divided into two groups with 15 children each<sup>5</sup>.

### Procedures

At the begin of the research process children and parents or guardians signed informed consent. Then the participants received a skin test to confirm that they did not have Kinesio tape allergy. To this effect, a 2×2 cm patch of Kinesio tape had adhered to the medial side of the upper arm, and the skin observed for allergic reactions for 24 hours. After that, the baseline gross motor function was evaluated by GMFM-66. Then randomization was performed in order to classify the children into either control or experimental group (Figure1).

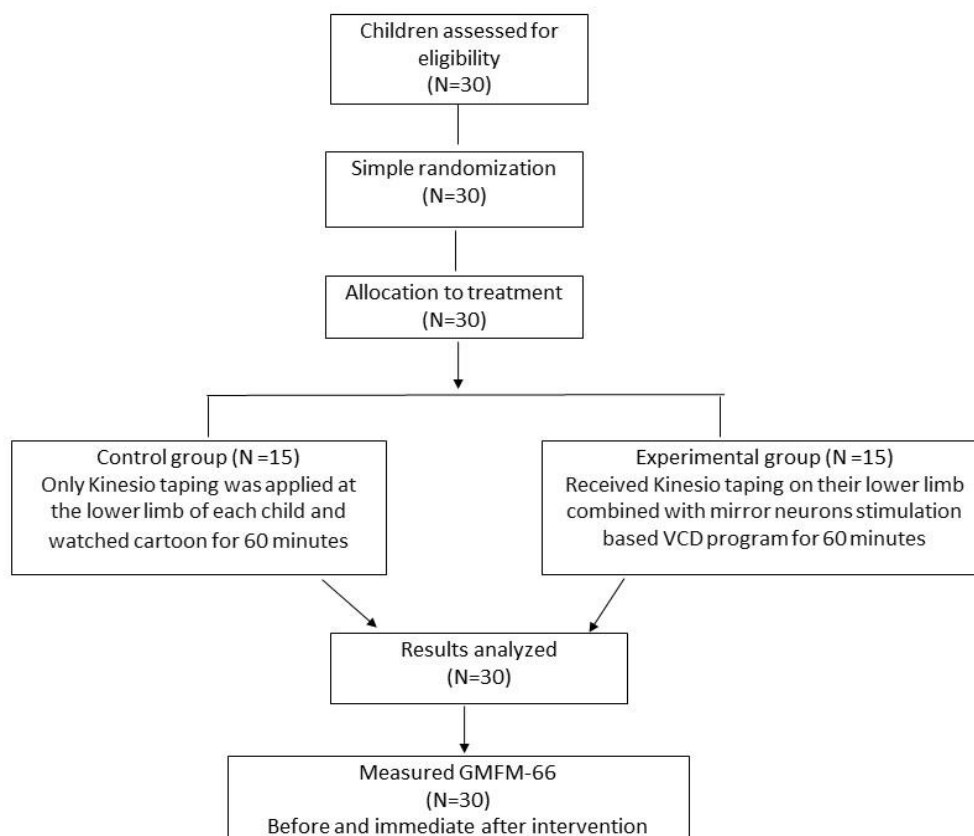


Figure 1 Flow chart of the children through the study

### Interventions

In the control group, only Kinesio taping was applied at the lower limb of each child and watched cartoon for 60 minutes. The experimental group received Kinesio taping on their lower limb combined with mirror neurons stimulation based VCD program developed for 60 minutes<sup>5</sup>. The video contents consisted of lower limb stretching, activities which stimulate movement from sitting to standing and walking.

Kinesio taping was performed on the children's lower limb by a certified Kinesio Taping Association Practitioner (CKTP) physiotherapist (Kinesio Taping Association International). The applied Kinesio taping techniques followed Kase, 2003 and Costa, 2013<sup>10,13</sup>. Muscle facilitation technique applied 15–35% tension the Kinesio tape at the origin to the insertion of the anterior tibialis muscle as "I" shape and "Y" shape on the rectus femoris muscle. In addition, functional correction techniques was applied 50–75% tension at the proximal 1/3 of the tibia to the head of the metatarsal bones (Figure 2).

### Outcome measures

All participants in both groups received the gross motor function measure (GMFM-66) test before and after the experiment. The evaluation was assessed by an independent pediatric physical therapist who was blinded for treatment allocation at entry. The GMFM-66 is a standardized instrument designed to measure the change in gross motor function in children with cerebral palsy. The GMFM-66 has suitable psychometric property and high inter-rater and intra-rater reliability. The GMFM-66 would be used

to evaluate five dimensions of gross motor function including lying/rolling (4 items), sitting (15 items), crawling/kneeling (10 items), standing (13 items) and walking/running/jumping (24 items). Scores range from 0-3, higher scores denote better performance. The Gross Motor Ability Estimator (GMAE) was used to convert the ordinal scale to interval scale. The maximum score was 100<sup>17</sup>.



**Figure 2** Kinesio taping on tibialis anterior and rectus femoris muscles by using muscle facilitation technique and functional correction technique at ankle joint

### Data analysis

Statistical analysis was conducted using STATA. Qualitative variables described by frequency and percentage. Quantitative variables described by mean and the standard deviation. The chi-square test was used to compare the characteristics between both groups. The Independent t-test was used to compare the mean baseline score between groups. Analysis of Covariance (ANCOVA) was used to compare mean scores of GMFM between two groups after adjusting for the baseline scores at entry.

## Results

The mean age in the two groups was statistically significantly different ( $p=0.020$ , Table 1). The mean age of children with cerebral palsy who received only Kinesio taping for treatment (control group) was  $8.3\pm 1.9$  years (range: 5.0–12.0 years). The mean age of children who were treated by using Kinesio taping together with mirror neurons stimulation based VCD program (experimental group) was  $10.1\pm 2.1$  years (range: 6.0–12.0 years). Sex distribution was not statistically significantly different between the two groups. The level distribution of the Gross Motor Function Classification System (GMFCS) between the two groups was statistically significantly different ( $p = 0.043$ ) with the number of children who had GMFCS at level 3 higher in the control group.

Analysis of covariance (ANCOVA) of the GMFM-66 scores after intervention showed that they were not statistically significantly different between the two groups ( $p=0.206$ , Table 2). Nevertheless, within each group, the GMFM-66 scores before and after intervention were statistically significantly different in a paired-test ( $p<0.001$ , Table 2). The GMFM score after the intervention was increased by 1.83 in the control group and by 1.18 in the experimental group.

GMFM-66 scores of children with cerebral palsy in both groups were classified by level, according to GMFCS (Table 3). Statistical analysis of GMFM-66 scores at each GMFCS level between experimental and control group was not performed because there were too few children in each GMFCS level.

**Table 1** Characteristics of children with cerebral palsy in both groups

Characteristics	Control Group (n=15)	Experimental group (n=15)	p-value
Mean age (SD) in years (Range)	8.3 (1.9) (5.0–12.0)	10.1 (2.1) (6.0–12.0)	0.020*
Sex, n (%)			
Male	8 (53.0%)	11 (73.0%)	0.256
Female	7 (47.0%)	4 (27.0%)	
GMFCS (Gross Motor Function Classification System), n (%)			
I	0 (0.0%)	1 (7.0%)	0.043**
II	2 (13.0%)	6 (40.0%)	
III	13 (87.0%)	8 (53.0%)	
On anti-spasticity medications, n (%)			
Yes	6 (40.0%)	6 (40.0%)	1.000
No	9 (60.0%)	9 (60.0%)	
Baseline GMFM-66, mean (SD)	52.59 (3.45)	56.19 (8.76)	0.150

**Note:** \*significant difference ( $p < 0.05$ ) between groups using independent t-test, \*\*significant difference ( $p < 0.05$ ) between groups using chi-Square

Table 2 Analysis of GMFM-66 scores at entry and after intervention

GMFM-66	Control Group (n=15) Mean (SD)		Experimental group (n=15) Mean (SD)		Adjusted mean changes between experimental and control groups	
	Baseline	After intervention	Baseline	After intervention	Mean difference <sup>#</sup> (95% CI)	p-value <sup>##</sup>
Total score	52.59 (3.45)	54.42 (3.63)	56.19 (8.76)	57.37 (8.45)	- 0.52 (-1.34, 0.30)	0.206
Mean difference between baseline and after intervention (95% CI)	1.83 (1.14, 2.52)		1.18 (0.72, 1.65)			
p-value	p<0.001*		p<0.001*			

**Note:** <sup>#</sup> mean scores difference of the after intervention between experimental and control groups after adjusted for the baseline level, <sup>##</sup> p-value was based on the analysis of covariance between experimental and control groups at the end of treatment after adjusted for the baseline level, \* significant difference ( $p<0.05$ ) within each group between baseline and after intervention using paired t-test

Table 3 Mean GMFM-66 scores classified by level according to GMFCS

GMFM-66 scores (Mean $\pm$ SD)	Control Group (n=15) Mean (SD)			Experimental group (n=15) Mean (SD)		
	GMFCS	GMFCS	GMFCS	GMFCS	GMFCS	GMFCS
	level 1 (n=0)	Level 2 (n=2)	level 3 (n=13)	level 1 (n=1)	Level 2 (n=6)	level 3 (n=8)
Baseline	-	56.39	52.00	76.75	59.87	50.85
GMFM-66 total scores	-	(0.66)	(3.33)	(0.00)	(7.33)	(3.22)
After intervention	-	58.95	53.73	76.75	61.14	52.13
GMFM-66 total scores	-	(0.54)	(3.38)	(0.00)	(7.25)	(2.82)

## Discussion

Both Kinesio taping (control group) and Kinesio tape with mirror neurons stimulation based VCD program (experimental group) had immediately affected to gross motor function in children with spastic diplegia. However, there were no significant differences between groups.

Mean age and GMFCS level distribution of the control and experimental groups were statistically significantly different at  $p = 0.020$  and  $p = 0.043$ , respectively. The mean age in the experimental group was higher, and significantly more children in the control group were classified at GMFCS



level 3. Age and GMFCS levels might have affected the GMFM-66 scores<sup>18</sup>. Therefore, it was cautiously considered whether the children in the experimental group were capable of performing gross motor function better than the children in the control group. However, the GMFM-66 scores before intervention were not statistically significantly different between the two groups ( $p=0.150$ ). Therefore, the children in both groups had a similar gross motor function at the start of the intervention. Thus, age and GMFCS level were not confounding factors that affected the GMFM-66 scores recorded after the intervention.

Following the intervention, it was comparing GMFM-66 scores by analysis of covariance (ANCOVA) between the experimental and the control group after adjusting for the baseline scores. There was a significant increase after intervention in each group. Nevertheless, There were not significantly different between groups. It can conclude that Kinesio taping had an immediate effect to facilitates gross motor function as efficiently as Kinesio taping combined with the mirror neurons stimulation based VCD program. Same as Costa et al. in 2013, discovered that KT could improve efficiency in moving and changing position from sitting to standing in children with cerebral palsy<sup>13</sup>. Simsek et al. in 2011, showed that Kinesio taping helped to improve balance in sitting position of children with cerebral palsy<sup>14</sup>. The study also revealed that the Kinesio tape was more supportive of muscle facilitation and functional movement. Simon et al. in 2014, stated that Kinesio taping might improve functional movement via stimulating cutaneous

mechanoreceptors. Sensory feedback from KT send the information to the somatosensory cortex. This feedback helped to adjust the proprioceptive information and caused feedback for a better joint position sense which then promotes a better motion. It could conclude that Kinesio taping tended to enhance movement<sup>19</sup>.

The mirror neurons stimulation based VCD program used in this study was developed by Mahasup et al.<sup>5</sup> and contained physical therapy content that complied to the standards of imitation learning. The result revealed that the VCD program was able to improve gross motor function similar to conventional physical therapy. Thus, the program was tested for treating the children in the experimental group combined with Kinesio taping. After the intervention, the GMFM-66 score was increased but no statistically significantly different from the control group who received only Kinesio taping. Various factors might have affected the result. For example, GMFM-66 was undoubtedly able to assess gross motor function quantitatively but was insufficient to judge qualitative aspects of the children's movement abilities. Therefore, differences in quality of movement between the two groups were not measured in the research. While a psychological assessment of being treated with Kinesio taping was not taken, it could be that the taping positively affected the children's sensibility of gross motor function. Thus they were motivated to follow GMFM after the intervention, and this could have been a factor that enhanced the scores<sup>20</sup>.

When analyzing the increasing GMFM-66 scores through each item of the activities, it was revealed that the activities in standing posture (dimension: standing) caused similar increasing GMFM scores in both groups. The items in standing posture (dimension: standing) were item number 53 (standing: maintains, arms free, 3 seconds), item number 54 (standing: holding on to the large bench with one hand, lifts a right foot, 3 seconds), item number 55 (standing: holding on to the large bench with one hand, lifts left foot, 3 seconds), item number 56 (standing: maintains, arms free, 20 seconds), item number 65 (standing, two large hands-on benches: cruises five steps to the right), item number 66 (standing, two large hands-on benches: cruises five steps to the left), item number 67 (standing, two hands held: walks forward ten steps), item number 68 (standing, one handheld: walks forward ten steps). The other activity items required higher motor skill function and exceeded the ability of the children at that time.

It was not possible to statistically evaluate GMFM-66 scores for each GMFCS level between experimental and control group because there were only a few children clustered in each GMFCS level. In the control group, there was not a single child classified in GMFCS level 1 and only one child in the experimental group with unchanged GMFM score. The children had worked extremely hard to get the best baseline scores prior to the intervention, which may have resulted in an unchanged score after the intervention. As a

result, it was possible that it was also the cause of the experimental group's lower mean score.

The research was conducted as a randomized control trial due to reduce selection bias in the research, and all children were randomly selected into either the control group or experimental group. Also, a single-blind experiment was also imposed on the result analyzer. The assessor was blinded about group allocation to reduce measurement bias.

The mirror neurons stimulation to imitate movement as a natural mechanism of humans because mirror neurons are related to the motor learning process. Previously studied show that the mirror neurons stimulation in children with cerebral palsy could improve motor function at 1-3 months, depending on the participant's nature and treatment program<sup>5-7</sup>. The mirror neurons stimulation based VCD program may not be able to improve functional movement immediately because the learning effect can improve by time. The application of the Kinesio tape should be a starting point for encouraging children to learn movement. In future research, the time of treatment should be extended to see whether the mirror neurons stimulation based VCD program has long term benefits. After treatment, the GMFM-66 scores of both groups were found to be statistically significantly higher but not different from each other. The results showed what the children were able to achieve in only 60 minutes of treatment. Definite differences between the two groups were not detected in this research.

## Conclusion

This research explored whether mirror neurons stimulation based VCD program was a useful tool in the treatment of children with cerebral palsy. The VCD program was also considered based on a literature review. Furthermore, all advisors were experts with experience in rehabilitation for children with cerebral palsy such as medical practitioners and physiotherapists from various institutes, including skilled paramedics. We had also received feedback from parents or guardians of participating children from a pilot study<sup>5</sup>. The VCD program could be a new solution for all children with cerebral palsy who are unable to receive constant treatment at a clinic. The results show that this combined methodology, VCD program with Kinesio taping, requires further investigation.

Either giving treatment to children with diplegia by only Kinesio taping on their lower limb or by Kinesio taping together with VCD program, it potentially empowers gross motor function. Under both conditions, GMFM-66 scores were statistically significantly raised from the baseline at  $p < 0.001$ . In terms of generalization, the study could be applied to children with cerebral palsy who fulfil the criteria of inclusion and exclusion as used in this research. A further study should use a more prolonged treatment in order to conclude any benefits of the additional VCD program. The number of participants should be increased. Moreover, children with other kinds of cerebral palsy should be investigated in further study as well.

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