Effect of Motor Imagery Training on Shoulder Joint Movement in Children with Hemiplegic Cerebral Palsy

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ABSTRACT

Background: Motor imagery is widely recognized as an effective method to enhance motor performance. **Purpose:** The aim of this study was to investigate the effect of motor imagery training on range of motion of shoulder joint in children with hemiplegic cerebral palsy. **Subjects and Methods:** Thirty children with hemiplegic cerebral palsy, aged from 8 to 12 years of both sexes were participated in this study. They were selected from the Outpatient Clinic of Faculty of Physical Therapy, Cairo University. They were randomly divided into two equal groups, A (study group) and B (control group). Both groups received designed physical therapy program while, group A received motor imagery training program in addition to the designed physical therapy program. The treatment program was conducted for one hour, three times per week for three successive months for each group. Pre- and post-treatment assessments of range of motion of shoulder joint (flexion and abduction) were performed by an electronic goniometer. **Results:** Both groups showed; significant increase in shoulder flexion and abduction ($p<0.001$) after treatment protocols. However, there were no statistically significant differences in the mean values of the measured outcomes between both groups ($p>0.001$). **Conclusions:** Motor imagery training may be used within the rehabilitation program of children with hemiplegic cerebral palsy to improve their range of motion of shoulder joint.

Key Words: Cerebral palsy, Hemiplegia, Motor imagery, Range of motion.

INTRODUCTION

Cerebral palsy (CP) describes a group of permanent disorders of the development of movement and posture, causing activity limitations that are attributed to non-progressive disturbances in the developing fetal or infant brain 1. It is also defined as neuro-developmental condition beginning in early childhood and persisting throughout one's life span. The average incidence is approximately 2-2.5 per 1000 live births 2

Hemiplegic cerebral palsy (HCP) is a unilateral paresis, with upper limbs more severely affected than the lower limbs. Hemiplegia accounts for 20% to 30% of all cases of CP, and is caused predominantly by unilateral damage of the developing brain which leads to unilateral, asymmetric muscle tone abnormalities, and deformities. As a consequence patients with HCP show unilateral, irregular movements and limitations in range of motion 3.

The upper limb deformities of children with CP are shoulder girdle protraction, shoulder flexion, adduction and internal rotation. A few may develop subluxation or dislocation of the gleno-humeral joint. There is tightness of the pectoralis major and subscapularis muscles 4.

Pathological motion of the upper limb has been demonstrated in children with HCP in many studies using three dimensional (3D) upper limb motion analyses. These studies have highlighted differences in shoulder kinematics between HCP and typically developing (TD) children and their role in the orientation of the upper-limb during motion 5. These biomechanical studies reported significant limitations in thoraco-humeral (TH) elevation during shoulder flexion, greater abduction during forward reaching, hand to mouth task and greater internal rotation during forward reaching. The alteration of upper-arm orientation due to shoulder disorders has thus as consequences on the function of the whole upper limb and probably on independence during activities of daily living 6.

Reduced range of motion of the shoulder joint on the frontal plane has been reported in children suffering from CP 7. Similar kinematic characteristics have been found in movements of adults affected by CP 8.

Motor imagery is widely recognized as an effective method to enhance motor performance. Recently, motor imagery training is applied in rehabilitation programs in clinical settings. This training protocol is available to all patients as it does not impose a physical load on patients 9. The advantage of motor imagery training is that, unlike general physical training, there is no limitation on the patient's ability to execute motions as it is a cognitive activity and does not require physical exertion. Because of this advantage, motor imagery training is currently applied for a wide range of body functions 10.

Motor imagery training may be a valid and useful tool to complement upper limb rehabilitation in young children with CP. Although it has been shown to be beneficial in adult post stroke patients, it still rare in young children with CP 11. Therefore, the aim of this study was to investigate the effect of motor imagery training on range of motion of shoulder joint in children with hemiplegic cerebral palsy.

MATERIALS AND METHODS

Subjects

A sample of thirty children with hemiplegic CP of both sex agreed to participate in the present study with their ages ranged from eight to twelve years. They were selected from the Outpatient Clinic of Faculty of

Physical Therapy, Cairo University. They had a diagnosis of hemiplegia that was obtained from their medical records and confirmed by radiological examination and neurologist. They had spasticity up to grade 2 according to Modified Ashwarth Scale [12]. The children were at level I and II on Gross Motor Function Classification System (GMFCS) [13] and able to follow instructions of evaluation and treatment procedures. Participants were excluded if they had any of the following; Fractures of upper limb, visual, auditory, or perceptual deficits, surgical interference for the upper limb, seizures or epilepsy, received botulinum toxin in the upper extremity musculature during the past 6 months.

Approval by the Ethical Committee of the Faculty of Physical Therapy, Cairo University (P.T.REC/012/002425), band written consent forms from parents of children, were obtained at the beginning of the study.

Design and Randomization

This study was a randomized controlled trail that was conducted from September 2019 up to February 2020. Thirty-four hemiplegic children were screened for participation in the current study. Two children were excluded because they failed to fulfill the inclusion criteria, and two children’s parents refused to participate in the study. The remaining thirty children were randomly allocated into two groups; the control group who received a designed physical therapy program and the study group who received the same program combined with motor imagery training program The way of randomization was sealed envelopes, each envelop contained a sheet of paper that showed the child was either in the study or control groups. The process of randomization was performed by an independent person who was blinded to the purpose or protocol of the study. Flow of participants was demonstrated through a flow chart which based on Consolidated Standards of Reporting Trials (CONSORT) (Figure 1).

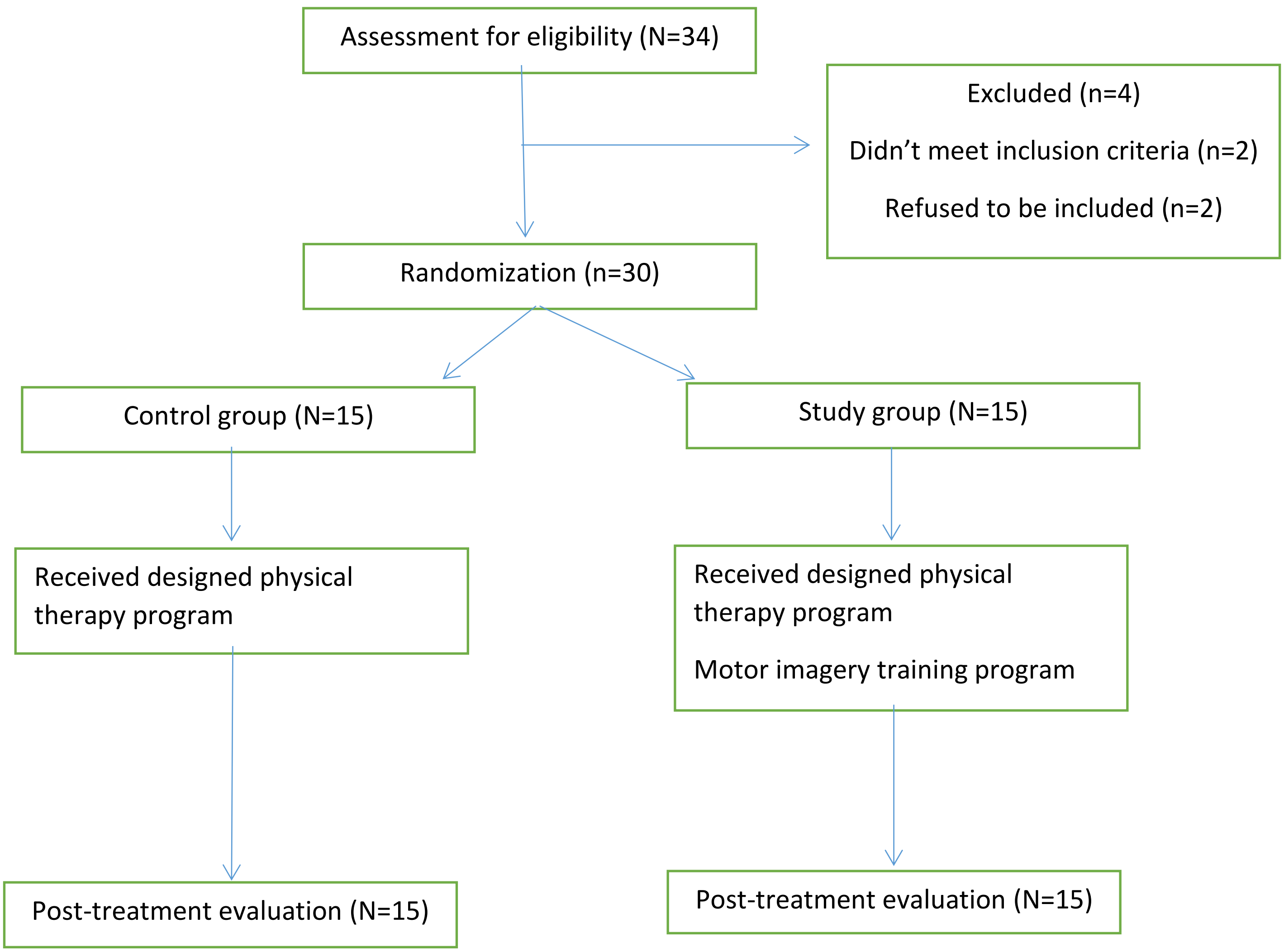
During the study, the children did not receive any treatment to improve involved upper extremity functions other than the study interventions. They did not participate in any previous trials with orthotic undergarment, adhesive tape, or spiral strapping to the upper limbs.

Procedures

A) Evaluative procedure

In this study, an electronic goniometer was used for the measurements of range of motion of shoulder joint in order to track progress in a rehabilitation program.

The electronic goniometer has proved to be a highly reliable tool for measuring joints range of motion in children with CP [14]. It has adequate concurrent criterion-related validity as a tool for assessment of joint range of motion and equivalent inter- and intra-rater reliability as the universal goniometer [15].



(Figure 1) Flow chart for the selection of participants

Evaluation of shoulder flexion

Each child was asked to maintain the arm and hand beside the body in a relaxed, neutral position. The children were asked to keep the palm of the hand aligned with the sagittal plane during the movement, the elbow as extended as possible, the wrist as close to neutral as possible and to reach their maximum range of shoulder flexion. The goniometric measurement was taken with the fulcrum placed inferior and lateral to the acromion process, the stable arm parallel to the trunk and the moving arm parallel to the longitudinal axis of the humerus.

Evaluation of shoulder Abduction

Each child was asked to maintain the arm and hand beside the body with the palm of the hand in the frontal plane during the movement, the elbow as extended as possible, the wrist as close to neutral as possible and to reach their maximum range of shoulder abduction. The goniometric measurement was taken with the fulcrum placed at the midpoint of the posterior aspect of shoulder joint, the stable arm parallel to the trunk and the moving arm parallel to the longitudinal axis of the humerus.

B) Treatment procedures

Treatment procedures of both groups were carried out at Outpatient Clinic of Faculty of Physical Therapy, Cairo University.

- For control group

The children in control group received a designed physical therapy program. It was individualized, according to the child's abilities and conducted for one hour, three times per week over twelve consecutive weeks. The treatment program involved the following exercise; graduated active exercises for shoulder flexion and abduction [16]. Scapular mobilization in all directions, shoulder mobilization exercise [17].

- For study group

Children in this group received the same program as control group in addition to motor imagery training program and conducted for one hour, three times per week over twelve consecutive weeks. The time of the session was divided into half an hour for the designed physical therapy program and half an hour for the motor imagery program. The motor imagery program was through a computer device that displays movies provided visual cues, the movie was presented to children then a blank screen appeared, during this time, children was instructed to explicitly imagine their arm completing the movement just by observing. After the movement was imagined, children depressed the space bar on the computer to advance to the next movie. The program was in the following sequence:10 minutes of listening to a tape-recording of relaxation techniques and 20 minutes of exercises related to motor imagery. In the first to second week, the motor imagery training involved the usage of computer images and movies to analysis steps and sequences required to successfully complete a task. In the third to fourth week, children trained to identify problems they had with the tasks and to correct them using motor imagery. In the fifth to sixth week, they practiced the corrected tasks mentally as well as perform the actual tasks. From seventh to twelve week, repetitive practice to correct the tasks was performed mentally as well as perform the actual tasks [18].

Data Analysis

Data were statistically described in terms of mean ± standard deviation (± SD), median and range, or frequencies (number of cases) and percentages when appropriate. Numerical data were tested for the normal assumption using Shapiro Wilk test. Comparison of numerical variables between the both groups was done using Student *t* test for independent samples in comparing normally distributed data and Mann Whitney *U* test for independent samples for comparing not-normal data. Within group comparison of numerical variables was done using paired *t* test in comparing normally distributed data and Wilcoxon signed rank test for paired (matched) samples when data was not normally distributed. For comparing categorical data, Chi-square (χ^2) test was performed. Exact test was used instead when the expected frequency is less than 5. Two sided *p* values less than 0.05 was considered statistically significant. All statistical calculations were done using computer program IBM SPSS (Statistical Package for the Social Science; IBM Corp, Armonk, NY, USA) release 22 for Microsoft Windows.

RESULTS

Subject characteristics

Table 1 shows the subject characteristics of both groups. There were no significant differences between both groups in the mean age and grade of spasticity (p<0.05). Also, there were no significant differences in sex distribution and affected side between groups.

Within group comparison

Both groups showed significant improvement in the range of motion of shoulder flexion and abduction after treatment (P< 0.05) (Table 2, 3).

Between group comparison

There was no significant difference between study and control groups in the mean values of shoulder flexion and abduction range of motion pre-treatment between both groups ($P > 0.05$), as presented in (Table 2, 3).Also, there were no statistically significant differences between the mean values of shoulder flexion and abduction range of motion post treatment of both groups ($P > 0.05$).

DISCUSSION

The current study was conducted to evaluate the effect of motor imagery training on range of motion of shoulder joint in children with hemiplegic CP. The treatment protocols led to significant improvement of all measuring variables in both groups after three months of treatment. However, there were no statistically significant differences in the mean values of shoulder flexion and abduction post treatment between the study and control groups.

The present study supports the work of **Steenbergen et al.** [19] who reported that motor imagery training may be a valuable additional tool for rehabilitation in children with hemiplegic CP, it is a theoretically feasible method to activate motor networks involved in motor planning.

The result of the present study regarding the control group revealed the benefit of traditional physical therapy protocols to achieve higher range of motion of the affected limbs. Additionally, repetition of our physical therapy program over three successive months helped the children in this study to improve their selective motor control and shoulder range of motion. This explanation agrees with **McLaughlin et al.** [20] who stated that repetitive activities guided by a therapist improve activities of daily living. This improvement may be due to the lying down of new engrams through repetitive activities.

Findings of **Wilson et al.** [21] who examined motor imagery training in children with developmental coordination disorder (DCD) on motor skill development, and showed reasonable development of movement skill in children with DCD. These results may support the significant differences in post-treatment compared with pre-treatment of the study group.

The significant increase in shoulder joint range of motion within the study group may due to motor imagery training program combined with physical practice. This opinion is supported by **Domellöf et al.** [22] who illustrated that motor imagery training led to faster aiming movements particularly to higher angular velocity at the shoulder. Increased adaptability has been shown at this joint in children with CP to deal with task demands in reaching.

Findings of **Spruijt et al.** [23] who mentioned that adolescents with left, right, or bilateral paresis due to CP had their imagery capacity evaluated by means of chronometry of imagined and physically executed walking across paths combining different lengths and widths. Results showed that individuals with right or left hemiparesis could improve manual movements from motor imagery training. This may support our results within the study group who had significant differences in post-treatment compared with pre-treatment after motor imagery training protocol.

The improvement of range of motion of shoulder joint flexion in study group is supported by the finding of **Sharma et al.** [24] who mentioned that, internal movement simulation of part(s) of the body, or motor imagery (MI), involves the same neural mechanisms as those activated when planning and executing overt movements. So, that motor imagery training may be an effective adjunct to physical practice for upper limb rehabilitation.

The current results are supported by the finding of **Liu et al.** [25]**, Page et al.** [26]**, Hwang et al.** [27] **and Cho et al.** [28]**.** In those studies, rehabilitation protocols combining motor imagery training (MIT) and physical practice have been compared against exclusive physical practice of functional tasks. Consistent with experimental results showing advantage of combination of imagery and physical practice. Those clinical studies have reported the benefit of associating MIT with physical practice protocols to achieve improved movement control of the affected limbs.

The current study has some limitations such as the small sample that it may not be possible to generalize these results to the whole population of children with hemiplegic CP. Further studies on a larger population of children with hemiplegic CP have to be carried out. Additionally, the children who participated in this study were restricted to one type of CP with the age group from eight to twelve years. So, similar studies are needed on other types of CP.

CONCLUSION

Based on the results of this study, motor imagery training may be a useful tool in the rehabilitation of children with hemiplegic CP.

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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 (suppl 109): 8-14.
2. Odding E, Roebroeck ME, Stam HJ. The epidemiology of cerebral palsy: incidence, impairments and risk factors. *Disabil Rehabil*. 2006; 28(4):183-191.
3. Feltham MG, Ledebt A, Deconinck FJA, Savelsbergh GJP. Assessment of neuromuscular activation of the upper limbs in children with spastic hemiparetic cerebral palsy during a dynamical task. *J Electromyogr Kinesiol*. 2010; 20 (3): 448-456.
4. Jaspers E, Desloovere K, Bruyninckx H, Molenaers G, Klingels K, Feys H. Review of quantitative measurements of upper limb movements in hemiplegic cerebral palsy. *Gait Posture*. 2009; 30 (4): 395-404.
5. Butler EE, Ladd AL, Louie SA, LaMont LE, Wong W, Rose J. Three-dimensional kinematics of the upper limb during a Reach and Grasp Cycle for children. *Gait Posture*. 2010; 32(1): 72-77.
6. Reid S, Elliott C, Alderson J, Lloyd D, Elliott B. Repeatability of upper limb kinematics for children with and without cerebral palsy. *Gait Posture*. 2010; 32(1): 10-17.
7. Coluccini M, Maini ES, Martelloni C, Sgandurra G, Cioni G. Kinematic characterization of functional reach to grasp in normal and in motor disabled children. *Gait Posture*. 2007; 25(4): 493-501.
8. Ricken AXC, Bennett SJ, Savelsbergh GJP. Coordination of reaching in children with spastic hemiparetic cerebral palsy under different task demands. *Motor Control*. 2005; 9(4): 357-371.
9. Langhorne P, Coupar F, Pollock A. Motor recovery after stroke: a systematic review. *Lancet Neurol*. 2009; 8(8): 741-754.
10. Hamel MF, Lajoie Y. Mental imagery. Effects on static balance and attentional demands of the elderly. *Aging Clin Exp Res*. 2005; 17(3): 223-228.
11. Steenbergen B, Jongbloed-Pereboom M, Spruijt S, Gordon AM. Impaired motor planning and motor imagery in children with unilateral spastic cerebral palsy: challenges for the future of pediatric rehabilitation. *Dev Med Child Neurol*. 2013; 55:43-46.
12. Charalambous CP. Interrater reliability of a modified Ashworth scale of muscle spasticity. In: *Classic Papers in Orthopaedics*. Springer; 2014: 415-417.
13. Alshryda S, Wright J. Development and reliability of a system to classify gross motor function in children with cerebral palsy. In: *Classic Papers in Orthopaedics*. Springer; 2014: 575-

577.

14. Herrero P, Carrera P, García E, Gámez-Trullén EM, Oliván-Blázquez B. Reliability of goniometric measurements in children with cerebral palsy: A comparative analysis of universal goniometer and electronic inclinometer. A pilot study. *BMC Musculoskelet Disord*. 2011; 12(Figure 1): 1-8.
15. Carey MA, Laird DE, Murray KA, Stevenson JR. Reliability, validity, and clinical usability of a digital goniometer. *Work*. 2010; 36(1): 55-66.
16. Adler SS, Beckers D, Buck M. *PNF in Practice: An Illustrated Guide*. Springer; 2007.
17. Kisner C, Colby LA. Therapeutic exercise. foundations and techniques. *FA Davis Co*. 2002.
18. Rajesh T. Effects of Motor Imagery on Upper Extremity Functional Task Performance and Quality of Life among Stroke Survivors. *Disabil CBR Incl Dev*. 2015; 26(1): 109.
19. Steenbergen B, Crajé C, Nilsen DM, Gordon AM. Motor imagery training in hemiplegic cerebral palsy: A potentially useful therapeutic tool for rehabilitation. *Dev Med Child Neurol*. 2009; 51(9): 690-696.
20. McLaughlin JF, Bjornson KF, Astley S. Efficacy of selective dorsal rhizotomy in cerebral palsy: changes in mobility after 12 months. *Dev Med Child Neurol*. 1996; 38(Suppl 74): 4.
21. Wilson PH, Adams ILJ, Caeyenberghs K, Thomas P, Smits-Engelsman B, Steenbergen B. Motor imagery training enhances motor skill in children with DCD: A replication study. *Res Dev Disabil*. 2016; 57:54-62.
22. Domellöf E, Rösblad B, Rönnqvist L. Impairment severity selectively affects the control of proximal and distal components of reaching movements in children with hemiplegic cerebral palsy. *Dev Med Child Neurol*. 2009; 51(10): 807-816.
23. Spruijt S, Jouen F, Molina M, Kudlinski C, Guilbert J, Steenbergen B. Assessment of motor imagery in cerebral palsy via mental chronometry: the case of walking. *Res Dev Disabil*. 2013; 34(11): 4154-4160.
24. Sharma N, Pomeroy VM, Baron JC. Motor imagery: A backdoor to the motor system after stroke? *Stroke*. 2006; 37(7): 1941-1952.
25. Liu KP, Chan CC, Lee TM, Hui-Chan CW. Mental imagery for promoting relearning for people after stroke: a randomized controlled trial. *Arch Phys Med Rehabil*. 2004; 85(9): 1403-1408.
26. Page SJ, Szaflarski JP, Eliassen JC, Pan H, Cramer SC. Cortical plasticity following motor skill learning during mental practice in stroke. *Neurorehabil Neural Repair*. 2009; 23(4): 382-388.
27. Hwang S, Jeon H-S, Yi C, Kwon O, Cho S, You S. Locomotor imagery training improves gait performance in people with chronic hemiparetic stroke: a controlled clinical trial. *Clin Rehabil*. 2010; 24(6): 514-522.
28. Cho H, Kim J, Lee G-C. Effects of motor imagery training on balance and gait abilities in post-stroke patients: a randomized controlled trial. *Clin Rehabil*. 2013; 27(8): 675-680.