EFFECT OF MOTOR IMAGERY TRAINING ON GAIT AND BALANCE IN CHILDREN WITH SPASTIC HEMIPLEGIA

BY

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CHAPTER I
INTRODUCTION

Cerebral palsy (CP) is a group of disorders of movement and posture caused by nonprogressive damage of the developing brain. Progressive musculoskeletal pathology occurs in most affected children. The primary impairments of muscle tone, balance, and strength are directly related to damage in the central nervous system (CNS). Secondary impairments of muscle contractures and deformities develop over time in response to the primary problems and musculoskeletal growth **(Berker and Yalcin, 2010).**

Hemiplegia is a unilateral paresis, with upper limbs more severely affected than the lower limbs. Hemiplegia accounts for 20K to 30K of all cases of CP, and the resulting impairments to extremities affect functional independence and quality of life **(Schitra and Knandani, 2005).**

Children with hemiplegic CP have longer gait, slower speed, and longer support phase compared with healthy children. The stance phase is longer than the swing phase in their affected side. There are significant differences in the angles of the hip, knee, and ankle joint between children with hemiplegic CP and healthy children when touching the ground and during pedal extension **(Park et al., 2006).** They have poor motor coordination and balance during walking, which result in a short stride, increased stride frequency to maintain speed, more swing time, and poor stability **(Wang and Wang, 2012).**

Balance is the ability to maintain the center of body mass over the base of support. CP causes balance impairment which results in decrease in the child's mobility functions and causing activity limitation and participations restrictions **(Laforme Fiss *et al.*, 2019).** Many children with hemiplegic CP have considerable difficulty maintaining the visual, vestibular and somatosensory systems in harmony for adequate postural stability. (**Roberta et al., 2015).**

Muscular endurance is defined as the resistance to fatigue or the ability to withstand fatigue. It represents the capacity of an isolated muscle group to carry out repeated contraction during a specific duration with moderate intensity. It is one of the fundamental components of muscular performance that has strong relation to physical activity. Muscle fatigability is a critical motor disorder that is expected to cause activity limitations in children with CP and has been essentially associated with deterioration of functional capacity, constraints in motor skills, and low life satisfaction **(Doorenbosch et al., 2012).**

Recently, it was proposed that the motor deficits occurring in individuals with CP are related not only to problems with motor execution, but also to impaired motor planning. Recent evidence suggests that motor planning deficits are also a possible underlying cause for compromised performance of activities of daily living **(Steenbergen and Gordon, 2006)**.

Motor planning is the ability to anticipate the end of the upcoming action when preparing a movement towards an object **(Johnson-Frey et al., 2004)**. It is suggested that motor imagery (MI) may play an essential role in action planning **(Deconinck et al., 2009).** As motor imagery is a promising method of training the more 'cognitive' aspects of motor behavior, it may be effective in facilitating motor planning in CP **(Steenbergen and Gordon, 2006)**.

Motor imagery is the mental imagination of movement without any actual body movement. It is a mental activity by which an individual rehearses, or replicates a given action. It is mostly used in sport training as mental practice of action and also in neurological rehabilitation. Motor imagery is likely to develop more 'cognitive' aspects of motor behavior, and may, therefore, be helpful in promoting motor planning in patients with CP **(Coslett et al., 2010).**

Statement of the problem

Does motor imagery training have an effect on balance and kinematic parameters of gait in children with spastic hemiplegia?

Purpose of the study

This study aims to:

- Investigate the effect of motor imagery training on gait kinematics in children with spastic hemiplegia.
- Determine the effect of motor imagery training on balance in children with spastic hemiplegia.
- Assess the effect of motor imagery training on trunk endurance in children with spastic hemiplegia.

Significance of the study

Children with spastic hemiplegia may experience a variety of concomitant health conditions including, movement difficulty, postural and balance instability, muscle spasticity, difficulty with motor planning and control, and cognitive impairments **(Hillary et al., 2016)**.

Postural and balance disturbances occur due to the difficulty in maintaining the body segments aligned on narrow base of support and there is limitation in balance recovery in hemiplegic children contributing to delayed responses of ankle muscles, inappropriate sequencing, and increased coactivation of agonists/ antagonists muscles **(Bigongiari et al., 2007)**.

Treatment will vary depending on the severity of impairments, level of activity, participation, and on the priorities highlighted by the patient. Walking is often identified as a main goal, and there is evidence that children with hemiplegia can take steps before regaining standing balance, which would support early walking. Many advanced treatment approaches are used to help improve motor function and gait in patients with hemiplegic CP **(Dobkin, 2005).**

Current rehabilitation techniques are predominantly focused on alleviating the compromised motor execution facet of action performance, and have not specifically targeted the motor preparation or planning processes. Motor imagery is proposed to be a backdoor mechanism to access the motor system. It being a theoretically feasible method to activate the immature networks involved in motor control. Therefore, for individuals with motor planning problems this cognitive MI training may be useful to improve motor skills **(Sharma et al., 2006).**

Although it has been shown to be beneficial in adult patients with stroke, and it still awaits empirical testing in young children with CP **(Steenbergen et al., 2013).**

Despite the potential benefits of motor imagery training, clinical use of motor imagery training for improving walking and balance abilities is not yet common compared with other conventional modalities in rehabilitation of children with hemiplegic CP. Consequently, more research and further confirmation are needed regarding the impact of motor imagery training on the gait performance, balance and trunk endurance in children with hemiplegic CP. Therefore, the purpose of this study to investigate the effect of motor imagery training on balance and kinematic parameters of gait in children with hemiplegic cerebral palsy.

Delimitations:

Children with spastic hemiplegia from both genders will be selected from Mansoura Specialized Hospital and New Mansoura General Hospital according to the following criteria:

- Their age ranging from 7 to 10 years.
- All children will have degree of spasticity ranged from 1 to 1+ according to the Modified Ashworth Scale **(Bohanon and Smith, 1987).**
- Their motor function will be at level I according to Gross Motor Function Classification System **(Palisano et al., 2008).**
- Assessment will be conducted using two-dimension analysis in order to measure kinematic parameters of gait, HUMAC balance system will be used to measure balance and trunk endurance tests in order to measure trunk muscles endurance.
- Treatment will be applied using motor imagery training program for the study group.

Null Hypothesis:

Motor imagery training will not affect functional balance and kinematic parameters of gait in children in children with spastic hemiplegia.

Basic assumptions:

It will be assumed that:

- All children will attend the treatment program regularly.
- The results of the study will be helpful for physical therapists dealing with similar cases in pediatrics.
- All children will be cooperative and following the instructions given to them.

CHAPTER II

LITERATURE REVIEW

1) Hemiplegic cerebral palsy

2) Gait

3) Balance

4) Motor Imagery

1- Hemiplegic Cerebral Palsy

Hemiplegic cerebral palsied children characterized by unilateral paresis with upper limb more severely affected than the lower limb due to larger cortical representation of the hand and the arm **(Aicardi, 2009).**

The Prevalence of spastic hemiplegia accounted for about 0.6 per 1000 live births. Hemiplegic children account more than 38 % of CP children **(Krägeloh-Mann and Cans, 2009).**

- **Types of hemiplegic CP**

Hemiplegia may happen before, during or soon after birth (up to two years of age approximately), when it is known as congenital hemiplegia (or unilateral cerebral palsy), or later in life as a result of injury or illness, in which case it is called acquired hemiplegia. Injury to the left side of the brain will cause a right hemiplegia and injury to the right side will cause a left hemiplegia.it is a relatively common condition, affecting up to one child in 1,000. About 80% of cases are congenital, and 20% acquired **(Ki et al .,2015).**

The presentation of congenital spastic hemiplegia is variable. It is usually caused by a cortical lesion. Thus, the arm typically is more affected than the leg. The condition may be missed during the newborn period and become evident during a later examination. It may be detected when an infant's caregiver notices hand dominance, reduced movement, or abnormal posturing on one side. The disorder sometimes is detected after a seizure occurs **(Pryse, 2009)**.

- **Motor problems of hemiplegic CP**

Hemiplegic children suffered from loss of dissociation between lower limb movement and less weight bearing on the affected side, affecting the ability to maintain an upright standing and gait **(Bax et al., 2005).** A symmetrical weight-bearing distribution between legs result in spinal deformity in hemiplegic children. Hemiplegic children depend on unaffected side for weight support **(Anker et al., 2008).**

Children with spastic hemiplegia experience decreased balance ability and abnormal gait because of decreased weight-bearing in the paretic leg. Diminished motor ability in the paretic leg causes weakening of the quadriceps, ankle plantar flexors, and ankle dorsiflexors. **(Ki et al ., 2015).**

Spastic hemiplegic children show decrease in force during push-off the affected limb, while the non-affected limb shows greater force during push-off, they have a shorter step length on the affected side mainly due to decrease in force production and increase in step frequency due to increased stiffness **(Kuo and Donelan, 2010).**

In mildly affected HCP child, the postural abnormalities are more apparent during walking or running. However, unless severe intellectual disability is present, independent walking usually occurs at the appropriate age or is only slightly delayed **(Pirilä, 2006).**

Most children with spastic hemiplegia also have sensory deficits. These are correlated with poor growth of the affected side, although not with the severity of the motor deficit **(Sindhurakar and Carmel, 2017).**

2- Gait

It is one of the more difficult movement tasks. This complex neuromuscular system is distributed by neurological damage, gradual degenerations, injury or fatigue **(Van Zwieten., 2011).**

Gait analysis is the systematic study of animal locomotion, more specifically the study of human motion, using the eye and the brain of observers, augmented by instrumentation for measuring body movements, body mechanics, and the activity of the muscles. Gait analysis is used to assess and treat individuals with conditions affecting their ability to walk **(Levine et al., 2012).**

- **Spatiotemporal parameter of Gait:**

Gait analysis is used for clinical identification of deviations from normal gait. Kinematic gait analysis is concerned with the description of gait components. It deals with movement as opposed to kinetic which deals with the forces acting on or exerted by the body. For this we can use distance (spatial) and time (temporal) parameters **(Haim et al., 2011)**

Spatial Parameters (Distance parameters) include:

- **Step Length** –This is the distance between corresponding successive points of heel contact of the opposite feet. If the gait is normal the right step length is equal to left step length. This parameter can give a great insight into a patient's problem.
- **Stride Length** – This is the distance between successive points of heel contact of the same foot. In normal gait this is equal to double the step length. **(Bar-Ziv et al., 2013)**.

Temporal Parameters (Time parameters) include:

- **Cadence** – This is the number of steps per unit time.
- **Speed** (Velocity) – This is the distance covered by the body per unit time, usually measured in m/s. Patients with problems tend to walk at a slower

velocity in order to decrease the forces and moments they have to cope with in gait. If the patient's condition is improved the velocity should go up.

- **Single limb support-** This is the amount of time spent on a limb expressed as a percentage of the gait cycle. This parameter is of great importance as it has been shown that it decreases when there is a problem with the knee joint. This gives us an easy to use, functional, quantifiable, objective measure of the patient's problem. **(Bar-Ziv et al., 2013).**

3-Balance

Postural control refers to the child's ability to support and stabilize the body in the standing position and maintain balance and in order to achieve balance in quiet standing, the imaginary vertical line passing through the body's center of mass (COM) should lie within the support base **(Cássia et al., 2018).** Controlling body balance (or postural sway) is considered an important indicator of the proper functioning of the sensorimotor system and therefore must be evaluated not only in patients but in healthy individuals **(Horak, 1987).** The control of posture (body orientation and alignment) and balance depends primarily on the ability of the visual, somatosensory, and vestibular systems to indicate the spatial position of each body segment correctly **(Assaiante et al., 2005)**.

- **Balance problems in hemiplegic cerebral palsy**

Balance recovery limitation in hemiplegic CP children contributes to delayed responses of ankle muscles, inappropriate sequencing; and increased co activation of agonists/antagonists. Proper muscle response organization and reduced co-contraction of after training help to improve balance recovery **(Woollcott, 2005).**

Impaired postural control in children with hemiplegic CP may result from multiple factors such as musculoskeletal problems, including contractures, reduced range of motion, and shifts in initial alignment, all affect reactive balance control in children with hemiplegic CP. Other motor components include the disruption of the spatial and temporal aspects of postural muscle responses during the recovery of stability following an unexpected external perturbation and the onset of postural muscle activity in children with hemiplegic CP is delayed compared with typically developing children. In addition, the sequencing of multiple muscle action is impaired and there is a high level of co activation of agonist and antagonist muscles at a joint **(Dewar et al.,2015)**, while difficulty in organizing redundant sensory cues for posture control is another source of instability in children with hemiplegic CP **(Santamaria, 2015).**

4- Motor imagery training

Motor imagery is the mental representation of movements that involve motor planning and an internal simulation of motor activity. It is a complex cognitive operation that is self-generated using sensory and perceptual processes, enabling the reactivation of specific motor actions within working memory **(Sabaté et al., 2004)**.

- **Types of motor imagery training**

According to **Bowering et al. (2013),** motor imagery is broken down into three treatment techniques, each exercising your brain in different ways:

1. Left/right discrimination

The ability to identify left or right images of their body part(s), this ability appears to be important for normal recovery from pain. The brain is plastic and changeable, if given the right training for long enough.

2. Explicit motor imagery

Explicit motor imagery means essentially thinking about moving without actually moving. These imagined movements have been demonstrated to activate motor cortical areas similar to those activated in the actual execution of that movement. This is most likely because 25 percent of the neurons in your brain are 'mirror neurons' and start firing when you think of moving or even watch someone else move. By imagining movements, you use similar brain areas as you would when you actually move. This is why sports people imagine an activity before they do it.

3. Mirror therapy

If you put your left hand behind a mirror and right hand in front, you can trick your brain into believing that the reflection of your right hand in the mirror is your left. You are now exercising your left hand in the brain, particularly if you start to move your right hand.

- **Mechanism of action**

Motor imagery training can provoke an activation of brain areas related to planning, adjustment, automation and execution of voluntary movements in a similar fashion to when the action actually occurs **(Gatti et al., 2013).** Although the neurophysiological activity is qualitatively the same, this neurophysiological activity is quantitatively lower during the movement representation techniques than during the actual execution of the action **(Buccino, 2014; Di Rienzo et al., 2019).**

Motor imagery therefore present a common neurophysiological basis based on the mirror neuron system. It activates the premotor and parietal areas, primary sensory-motor cortex and subcortical regions such as basal ganglia and the cerebellum, as well as corticospinal pathways**.** In addition, MI could promote neuroplasticity similar to active interventions **(Borges et al., 2018; Di Rienzo et al., 2014).**

- **Uses of motor imagery training**

A growing body of evidence suggests that internal movement simulation of part(s) of the body, or motor imagery, involves the same neural mechanisms as those activated when planning and executing overt movements **(Johnson et al., 2001).** So that motor imagery training may be an effective adjunct to physical practice for lower limb rehabilitation **(Sharma et al., 2006).**

There is abundant evidence of the positive effects of motor imagery practice on motor performance and learning in athletes, people who are healthy, and people with neurological conditions (e.g., stroke, spinal cord injury, Parkinson disease) **(Dickstein and Deutsch, 2007).**

Motor imagery is widely recognized as an effective method to enhance motor performance. Currently, motor imagery training is applied in rehabilitation programs in clinical settings. This training, which can be made available to all patients because it does not impose a physical load on patients, was confirmed through clinical evidence from meta - analysis **(Langhorne et al., 2009).**

The biggest advantage of motor imagery training is that, unlike general physical training, there is no limitation on the patient's ability to execute motions because motor imagery 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 **(Hamel and Lajoie, 2005).**

Motor imagery training also facilitates muscle strength, but without muscle hypertrophy **(Lebon et al., 2010).** Combining motor imagery training with physical practice has generally proved to be more effective than physical practice alone **(Weinberg, 2008).**

Positive effects of motor imagery training are examined in children with developmental coordination disorder (DCD; age range 7–12y) on motor skill development, and showed reasonable development of movement skill in children with DCD **(Wilson et al., 2016).**

Motor imagery training may be a valuable additional tool for rehabilitation in children with hemiplegic CP. The use of this rehabilitation tool has not been explored in hemiplegic CP, but it is a theoretically feasible method to activate motor networks involved in motor planning. Results of clinical studies in patients with acquired brain damage (stroke) and DCD are promising in this respect **(Steenbergen et al., 2009).**

CHAPTER III

SUBJECTS, MATERIALS AND PROCEDURES

Study Design

Randomized Controlled trail

A. Subjects:

Children with spastic hemiplegia, from both genders, will be recruited from Mansoura Specialized Hospital and New Mansoura General Hospital. Each participant's caregiver will sign a consent form authorizing the participation of their children in this study.

Sample size estimation will be conducted to determine the number of recruited children.

Randomization:

The selected children will be allocated by simple randomization via sealed envelopes into two matched groups (Control group and Study group) by an independent person opaque envelope from a box following a numerical sequence; the envelope will be contained a letter indicating whether the child will be allocated to the study or to the control group.

Inclusive criteria:

- Their chronological age will be ranged from 7-10 years.
- Their motor function will be at level I according to according to Gross Motor Function Classification System GMFCS **(Palisano *et al.*, 2008).**
- The degree of spasticity for these children will ranged from grade 1 to 1+ according to Modified Ashworth Scale **(Bohannon and Smith, 1987).**
- They will be able to follow instructions during evaluation and treatment.

Exclusive criteria:

Children will be excluded from the study if they have:

- Cardiovascular or respiratory disorders.
- Botulinium muscular injection in the last 6 months
- Surgical interference in lower limbs.
- Musculoskeletal problems or fixed deformities in the spine and/or lower extremities.
- Seizures.
- Visual or hearing impairment.
- Mentally retarded children

B. Materials

I. For selection

1. Modified Ashworth Scale

Modified Ashworth Scale will be used to measure the degree of spasticity in pediatrics and adults who have upper motor neuron lesions **(Bohannon and Smith, 1987). Appendix (A)**

2. Gross Motor Function Classification System:

The gross motor function of children and young people with cerebral palsy can be categorized into 5 different levels using a tool called the Gross Motor Function Classification System (GMFCS). It is a practical system that can be used in the clinics and rehabilitation team. The GMFCS is a reliable, valid and standard method for classifying gross motor function into five levels with emphasis on transfer, sitting and mobility **(Palisano *et al.*, 2007) (Appendix B).**

II. For evaluation:

1. Kinematic gait parameters:

- Markers: Round markers 1.5cm in diameter will be attached to bony land marks (greater trochanter, lateral femoral epicondyle, lateral malleolus and 5th metatarsal head) using double face plaster.

- **Digital camera:** Nikon camera, Model: 3200D, Lens: 18-55mm, Quality: 1080×1920-50fps.
- **Tripod stand:** The digital camera was placed on adjustable tripod stand at 3 meters from the 4-meter walkway and placed at a height 1 meter from the ground at 90^0 for standardization **(Puig-Diví et al., 2019).**
- **Computer system:**

Laptop DELL was used for the Kinovea measurement analysis. The following parameters will be measured including step length, stride length, cadence, walking speed and angular displacement for hip, knee and ankle joints during midstance and terminal stance.

- **Kinovea software:**

It is a software that uses the angle and track path tools to analyze position, velocity and acceleration data. It was successful in measuring both these parameters and poly articular angular movements **(Guzman-Valdivia et al., 2013).** It is a valid, precise and reliable (both inter- and intra-rater) program with which we can obtain angles and distance data from coordinates **(Puig-Diví et al., 2019).**

2.HUMAC balance system:

It is a reliable and valid way of balance assessment that proved its efficacy when it was compared to the results of the conventional force platform **(Koltermann et al., 2017; Clark et al., 2010).**

The system consists of the following:

1- A force platform with dimensions 50 centimeter (CM) in length and about 5 cm in height, its surface divided into vertical and horizontal lines to determine the position of the foot on the platform, also there were oblique lines in protractor like shaped to determine the foot angle position. The (USB) cable was connected to the operator device which will run the different tests on its screen as shown in figure (1).
2- HUMAC Software on DVD which would be installed on the operating device.
3- Foam surface It was another unstable surface could be put on the surface of the platform and has the same lines and angles found on the original platform to determine the position and angle of the foot on the foam surface.

Figure (1): The HUMAC balance system

3. Trunk endurance tests:

Endurance of the trunk muscles will be evaluated using three endurance tests designed to establish the isometric trunk muscles endurance including; trunk flexor endurance test, trunk extensor endurance test, and side bridge test **(McGill et al., 1990 and Dejanovic et al., 2012).**

Trunk endurance tests have high reliability with a reliability coefficient of more than 0.97. A stop watch was used to record the time a child can maintain the test position (**Evans et al., 2007 and McGill et al., 1990)**

III. For Treatment:

The following tools will be used for application of physical therapy program including; gymnastic mat, medical ball, different sizes of pediatric therapeutic wedges, different sizes of bolsters (rolls), stairs and balance board and beam.

A Dell Laptop device with 14.5-inch screen size will be used for showing computer-facilitated imagery program to children in the study group. Computer generated movies provided visual cues to the children.

C. Procedures:

I. For Evaluation:

1. **Two-dimension (2D) gait analysis**

Temporo-spatial gait variables will be measured using a 2D motion analysis system which has been shown to be valid and reliable.

Skin markers will be placed at (greater trochanter, lateral femoral epicondyle, lateral malleolus and 5^{th} metatarsal head). Tripod fixed with a video camera will be placed 3 meters away from the walkway and focused on the middle part to record around 3 gait cycles of sagittal plane motion. The video will be analyzed in slow motion so the video will be monitored frame by frame, Proper frames will be selected. Lines and arrows will be added to measure angles of hip, knee and ankle joints. Selected Frames will be: Initial swing (ISw), Mid stance (MSt), Initial contact (IC) **(Guzman-Valdivia et al., 2013).**

The kinovea video motion analysis software was used to measure th e three angles as following:

a. **Hip joint angle:** The angle between the thigh segment and the vertical line passed through the greater trochanter represents the hip joint angle.

b. **Knee joint angle:** The line between greater trochanter and lateral femoral epicondyle represents the thigh segment, while the line between lateral femoral epicondyle and the lateral malleolus represents the leg segment. 180 minus the angle between these two lines represents the knee joint angle.

c. **Ankle joint angle:** The angle between the leg segment and the line passed through the lateral malleolus and 5th metatarsal head minus 90 represents the ankle joint angle.

The Kinovea software version 8.15.0 will be used to measure step length, stride length, cadence and walking speed. The measurement involved one trial of walking at the preferred gait speed along the 4 meters walkway **(Puig-Diví et al., 2019).**

The initial contacts of each limb will be marked on the video using the Kinovea software, and step length and stride length will be measured. The distance from the point of initial contact of one limb to the contralateral limb will be measured for step length. Stride length will be calculated from the sum of left and right step lengths. Gait speed was calculated from stride length divided by stride time. Cadence will be calculated by determining number of steps per minute **(Bovonsunthonchai et al., 2020).**

4- HUMAC Balance System:

The device provides assessment of balance through variable tests which are:

- The mCTSIB test
- The stability test
- The mobility test
- The stability envelope test

- The weight bearing test
- The weight bearing XY test
- The weight shift test
- The center of pressure test
- The limit of stability test

The assessment procedure will be utilized the following tests **(Koltermann et al., 2017; Clark et al., 2010):**

- **Clinical Test of Sensory Organization and Balance (CTSIB):**

It will be used to test how a patient's vision, vestibular, and somatosensory systems interact and if an deficit exists compared to a normal population. The CTSIB is sometimes referred to as the Romberg or Foam and Dome test.

- **Stability:**

It measures a patient's ability to stabilize their balance at locations around their neutral position. Results are reported as the percent of time a patient holds their COP in each of the eight targets.

- **Mobility:**

It will be used to test a patient's ability to hold their Center of Pressure on moving target that circles around a patient's neutral balance point. Results are reported as the percent of time a patient holds their COP inside the moving target.

- **Stability Envelope:**

It will be used to measure a patients maximum Angle of Lean in 8 directions around their neutral balance point starting with the 12:00 position. The Patient is instructed to lean as far in the direction of the arrow as they feel comfortable. When the clinician feels the patient has stabilized their balance, the clinician clicks the location on the screen to record the patient position (indicated by the magenta target). Results document a patient’s maximum stability envelope.

- **Weight Bearing:**

Display the Patient's Right/Left or Anterior/Posterior weight distribution.

- **Weight Shift:**

It will be used to measures a patient's ability to shift their COP from right to left, anterior to posterior, or in between without going outside the target zone. Results measure good hit to bad hit ratio and time needed to complete the exercise.

- **Center of Pressure (COP):**

It will be used to measure the variation in a patient's center of pressure during exercise. Display the Patient's Right/Left and Anterior/Posterior weight distribution.

- **Limits of Stability (LOS):**

The goal is for the patient to move the round cursor (their COP) to the highlighted target. After the patient remains in the target for the Hold Time, the system turns the target to gray and moves to the next target. The patient moves between the center target and each surrounding target in a random order.

3- Assessment of trunk muscular endurance

In trunk endurance measurement, the examiner instructed the child to hold the test position as long as possible prior to all testing. Each position will be tested three times and the average time will be recorded. Endurance of the trunk muscles will be evaluated using three endurance tests designed to establish the isometric trunk muscles endurance including:

A. Trunk flexor endurance test:

It will be started with the child in the sit-up position with trunk supported at 60◦ of trunk flexion by an inclined wedge, knees and hips flexed 90◦, arms crossed over chest, and feet secured by strap. The support of the trunk "wedge" will be pulled back 10 cm, and the child maintained the position as long as possible. The test will be ended when the child's back returned to the wedge or when a maximum time of 300 seconds will be reached **(Willson et al., 2005).**

B. Trunk extensor endurance test

In this test, the child will lay prone with the hips in line with the edge of a treatment table. Pelvis, hips, and knees will be secured to the table by straps, while a chair supported the trunk and upper extremities. The child will be held a horizontal body position for as long as possible with arms crossed over chest. The test will be ended when the child unable to maintain a horizontal position or when he/she reached 300 seconds **(Moreau et al., 2001).**

Lateral trunk endurance test (for the affected side):

The side bridge tests will begin from side-lying position with the child's knees extended and the top foot will be in front of the lower foot. The top arm is will be held across the chest with the hand placed on the opposite shoulder. The child supported his/her weight only on his/her lower elbow and feet while lifting the hips off the treatment table to make a straight line over the entire body length. The test stopped when the child lost the side-lying position, or when the hips returned to the supporting surface, or a maximum time of 300 seconds will be achieved **(McGil et al., 1999).**

II. Procedures for Intervention:

The Control group will receive a selected physical therapy program for 60 minutes, 3 times/week for 3 successive months including the following exercises

-Facilitation of balance reactions from standing position including:

Standing on one leg, weight shifting from standing position, stoop and recover from standing, squat from standing, standing on balance board and pushing the child in different directions.

-Facilitation of counterpoising mechanism through instructing the child to kick ball from standing position as well as catching and throwing ball with his hands.

- Strengthening exercises for weakened muscles in upper and lower limbs muscle.

-Strengthening exercises for back and abdominal muscles.

- Stretching exercises for tight muscles in upper and lower limbs.
- Gait training activities for correction of gait pattern including: walking on balance beam, walking on balance board, walking on uneven surface, walking using different obstacles (rolls, wedges, stepper) and walking up and down stairs.
- Jumping in place and jumping a board.

Motor Imagery training program:

Children allocated to the study group will receive the same selected physical therapy program given to the control group for 30 min in addition to 30 minutes motor imagery training program according to **Shah, et al. (2016) and Gupta, (2017)** which state the following treatment protocol. The frequency of the whole program will be three times per week, for three successive months.

- As a preparation each child in the study group will be shown a video of 5 minutes of normal movements in a quiet room.
- They will be positioned in a comfortable position (semi-reclined sitting or high sitting with feet supported).
- the screen is in the child's visual field. Adequate rest periods will be given between and after the video sessions as required.
- Children will be asked to close their eyes and imagine they will perform the physically practiced task for 10 minutes, similar to one shown in the video; subjects will be urged to imagine themselves from a first-person perspective, to feel their trunk, legs, hands and feet to concentrate on their movements. Sequence of the task will be verbally explained to the child for better recalling of sensations in muscles during the movements. During the entire exercise schedule child's attention will be focused on the position, and movement of their body, on proprioceptive inputs coming from the leg muscles (quadriceps and adductors) and on the tactile sensations of foot floor contact.

- Thereafter, the child will be asked to perform the sequence of tasks, rehearsed mentally for 20 minutes.
- Repetition of the exercises will be based on their ability which could be a minimum of five repetitions per session to a maximum of ten repetitions per exercise session.
- At the end children will be asked to relax.

Tasks for first Month include:

- Sitting at the table and forward reach outs, lateral trunk flexion, and pelvic lifts, which were progressed to forward reach outs in multiple directions, increasing the lateral flexion arc of movement and pelvic shuffling, respectively.
- Chair rises: repeated rising from a seated position, progressing from using arms to not using arms and from high to lower surface.
- Toe rises: repeated rising up on toes, progressing from upper extremity support to no support and from bilateral rises to unilateral rises on affected lower extremity only.
- Heel rises in standing to strengthen the affected plantar flexor muscles.
- Standing up from chair walking a short distance and returning to the chair to promote a smooth transition between the two tasks.
- Bridging in supine progressing to unilateral bridging with single arm or leg raises and upper and lower trunk flexion with rotation, respectively.

Tasks for second month:

- Standing with base of support constrained, with feet in parallel and tandem conditions reaching for objects, including down to the floor, to improving standing balance.
- Partial squats: progressed by increasing movement magnitude.
- Wall exercises: repetitions of standing from a wall and falling backwards with the trunk straight to contact the wall with the upper back and bouncing upright again, progressing to greater distances from wall.

- Standing on balance disk.
- Sudden stops and turns during walking.

Tasks for third month:

- Step ups: repeated stepping anteriorly and laterally onto a step: up with affected leg and down with unaffected leg, progressing to higher step and decreasing upper extremity support.
- Kicking a ball with either foot.
- Marching: Repeated marching in place, progressing from upper extremity support to no support.
- Unilateral standing with 90-degree knee extension with both lower extremities one after the other.
- Walking over stairs will provide the opportunity for practice of walking under variant conditions.

Data analysis

The data obtained will be statistically analyzed using statistical package of social sciences (SPSS) version 26 including:

1-Descriptive statistics:

- The mean and SD will be calculated for demographic characteristics including age, weight and height and also for all measured variables.

2-Inferential statistics:

- Paired t-test will be used for within group comparison before and after the intervention.
- Independent t-test was used to compare the demographic data and the baseline characteristics of both groups as well as the pre- and post-treatment mean differences in all measured variables.
- The statistical significance level was set at 0.05.

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APPENDIX (A)

The Modified Ashworth Scale

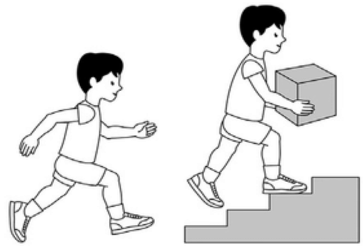
Grade	Description
0	No increase in muscle tone
1	Slight increase in muscle tone, manifested by a catch and release or by minimal resistance at the end of the ROM when the affected part(s) is moved in flexion or in extension
1+	Slight increase in muscle tone, manifested by a catch, followed by minimal resistance throughout the reminder (less than half) of the ROM
2	More marked increase in muscle tone throughout most of the ROM, but affected part(s) easily moved
3	Considerable increase in muscle tone, passive movement is difficult
4	Affected part(s) rigid in flexion or extension

(Bohanon and Smith, 1987)

APPENDIX (B)

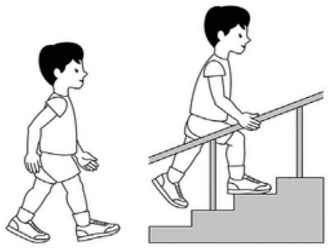
Gross Motor Function Classification System

GMFCS E & R between 6th and 12th birthday: Descriptors and illustrations



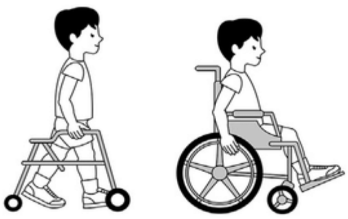
GMFCS Level I

Children walk at home, school, outdoors and in the community. They can climb stairs without the use of a railing. Children perform gross motor skills such as running and jumping, but speed, balance and coordination are limited.



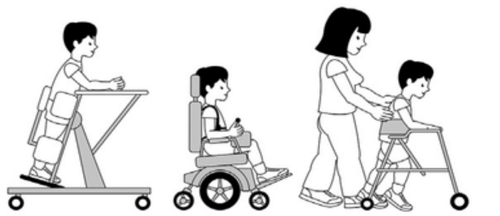
GMFCS Level II

Children walk in most settings and climb stairs holding onto a railing. They may experience difficulty walking long distances and balancing on uneven terrain, inclines, in crowded areas or confined spaces. Children may walk with physical assistance, a hand-held mobility device or used wheeled mobility over long distances. Children have only minimal ability to perform gross motor skills such as running and jumping.



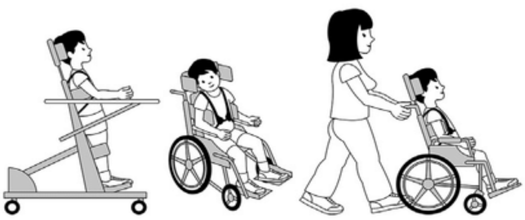
GMFCS Level III

Children walk using a hand-held mobility device in most indoor settings. They may climb stairs holding onto a railing with supervision or assistance. Children use wheeled mobility when traveling long distances and may self-propel for shorter distances.



GMFCS Level IV

Children use methods of mobility that require physical assistance or powered mobility in most settings. They may walk for short distances at home with physical assistance or use powered mobility or a body support walker when positioned. At school, outdoors and in the community children are transported in a manual wheelchair or use powered mobility.



GMFCS Level V

Children are transported in a manual wheelchair in all settings. Children are limited in their ability to maintain antigravity head and trunk postures and control leg and arm movements.

GMFCS descriptors: Palisano et al. (1997) Dev Med Child Neurol 39:214-23
CanChild: www.canchild.ca

(Palisano et al., 2008)

تأثير برنامج التدريب الحركي التخيلي علي المشي والاتزان
عند الأطفال المصابين بالفالج الشقي