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RESEARCH ARTICLE

POSTURAL CONTROL TRAINING VERSUS PROPRIOCEPTIVE EXERCISES PROGRAM ON MOTOR CONTROL OF KNEE JOINT IN SPASTIC DIPLEGIC CEREBRAL PALSIED CHILDREN

Radwa S. Abdul-Rahman[1]., Abd El-Aziz A. Abd El-Aziz[2]., Amr A.Abogazya P.T.D[3] and Anees S.Ghait[4]

[1]Departments of Physiotherapy for Growth & Developmental Disorders in Children and its Surgery, Basic Science, Biomechanics Faculty of Physical Therapy, Cairo University
[2,3,4]Kafrelsheikh University Egypt

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ABSTRACT

Background: children with cerebral palsy are at risk for decreased mobility and health complications, and exercise may combat some of these negative changes.

Objective: To investigate the effect of balance training versus reciprocal electrical stimulation on motor control of knee joint controlling in spastic diplegic cerebral palsied children

Methods: Thirty children were enrolled in this study and randomly assigned into two groups of equal number. Group A include 15 spastic diplegic cerebral palsied children who received a course of balance training program that include static and dynamic postural stability training- for thirty minutes plus traditional physiotherapy program- Group B include 15 spastic diplegic cerebral palsied children who received reciprocal electrical stimulation above knee joint flexors and extensors muscles for thirty minutes in addition to the same traditional physiotherapy program in group (A) three days per week for three moths, Standard plastic goniometr was used to detect and follow knee extension from the point of flexion deformity, flexibility tests was used to detect hamstring, gastrocnemius and gracillis muscles flexibility in addition 10 tape measurement was used alternatively to measure distance between the heel to buttock at the point of extension limitation. These measure means were taken before initial treatment and after 12 weeks of treatment.

Results: Revealed statistically significant improvement in the measuring variables of both groups when comparing their pre and post treatment mean values. Significant differences in the measured variables were also obtained in favor of the group (A) when compared with that of group (B).

Conclusion*:* The use of balance exercise program are superior to reciprocal electrical stimulation for all measurement that include knee mobility and hamstring and gastronomies flexibility.

INTRODUCTION

Spastic dipiegic cerebral palsy (C.P.) caused by brain damage in the outer layer of the brain and the cerebral cortex. Spastic dipiegic cerebral palsy affects nearly 35 percent of C.P. children and is the most common form of cerebral palsy. Spastic dipiegic cerebral palsy symptoms include increased tone or tension in a muscle, tightness of muscles and released pathological reflexes. All four limbs are affected both legs as well as mild affects in the arms are present. Proper treatment can correct toe walking and flexed knees deformity which are common attributes of spastic diplegia [1,2]. The spastic diplegia was known as Little's disease for several years. Gradually, researchers .determined that Little's disease was spaslic diplegia just one of the forms cerebral palsy can take. Diplegia means that both sides of body are affected by a form of paralysis; di is from the Greek for two and plegia is derived from the Greek for some form of paralysis. The term diparesis, which means mild affection in motor disorder [3,4]. The most effective and efficient treatments will focus first on physical problems with the greatest impact on function and address more than one problem at a time. Training balance on an unstable surface contributes not only to use of visual and vestibular inputs but also (to the use of hip strategy, to increase lower extremity strength and to increase motor control on that

Corresponding author:* **Radwa S. Abdul-Rahman
Kafrelsheikh University Egypt

type of surface) [5, 6]. Proprioceptive input to central nervous system is very important for conscious awareness of joint position sense and motion so clinicians need to evaluate kinesthetic deficits and to design exercise programs to improve kinesthetic awareness. [7] A functional movement can be induced by electrical neuromuscular stimulation of the paralyzed muscles with intact excitability of their peripheral innervations. A long-term use of electrical neuromuscular stimulation can strengthen the weak muscles, increases their endurance, improve the range of movement and reduce spasticity. However, the expected and desired beneficial effects of stimulation cannot be clearly predicted in individual patients with spastic hemiplegia.(12)

Reciprocal electrical stimulation, has been more widely used in clinical practice and has received more attention in the clinical research. Researchers focused on correcting abnormal gait patterns in children with spastic CP by using electrical stimulation to flexors and extensors muscle of knee joint aiming to increase the muscles power lead to gait improvement. [8] The spastic diplegic children when they want to walk they need some flexion of hips and knees. Therefore they start walking with both hips and knees in some degree of flexion, adduction and internal rotation. The weight is then taken on the media! border of the feet which results in a valgus deformity of their feet. He moves further forward by bending his trunk over his hips, his legs then follow, toes down first to prevent him falling forwards [9]. Spastic diplegic patients start walking with both hips and knees in some degree of flexion, adduction, internal rotation, the weight is then taken on the medial border of the feet which results in valgus deformity of the feet [10]. Hamstring muscle is functionally important hip extensors. Tightness of hamstring cause inability to perform hip extension lead to tightness of hip flexors lead to anterior pelvic tilting lead to hyper lordosis and forward trunk walking. Tightness of gastrocnemius and gracillis with hamstring lead to knee flexion deformity.

Subjects, Instrumentations and Methods

Subjects: Thirty children from both sexes with spastic diplegic were enrolled for this study.

Inclusion criteria

(1) age range of seven to eleven years, (2) The degree of spasticity was determined according to the modified Ashworth's scale to be within the range of 1 and 1+ grades, (3) They had tightness in both hamstring and limitation in knee extension(4) They were able to understand any command given to them, with an IQ level within (4) They have to have the ability to stand with support, walk with assistance in flexion hip and knee and valgus of the foot.

Exclusion criteria (1) shorting or contracture (2) cardiovascular diseases, (3) surgery within the previous 24 months, (4) sensory defensiveness, and (5) Post operative released of hamstring were excluded. The study sample was divided randomly into two groups of equal number (A and B). Group A includes 15 spastic diplegic C.P. children who received a course of balance training program that include static and dynamic postural stability training plus traditional physiotherapy program. Group B; Includes 15 spastic diplegic C.P. children who received reciprocal electrical stimulation plus the same traditional physiotherapy program in group (A).

Instrumentations

I-For evaluation

1-Guymon goniometr (LAFAYETTE type), (model 01129), USA. It is a digital bi-dimensional goniometer that can measure any joint angle or range of motion quickly and accurately.

II -For treatment

1- Biodex stability system which produce perturbation in all directions, medical ball, balance board, wedges and rolls

Procedure

For Evaluation

All spastic diplegic children From supine lying position the untested limb put in flexion position, tested limb put in flexion hip 90, flexion knee 90, then perform gradual knee extension to detect flexibility of hamstring. The tightness detected from (limitation in knee extension, resistance in knee extension and facial expression). Then perform to the other limb.

- From supine lying position, untested limb is extended and supported to physiotherapist chest, other limb is flexed in hip 90, knee 90, sole of the foot support on the chest and by gradual dragging of the heel of the tested limb on therapist chest performing gradual stretch on hamstring to show the limitation, resistance, facial expression. To increase stretch gradually therapist lean the trunk forward till tightness appears.
- From supine lying position the tested limb taken passively from extended knee to abduction hip (to test gracillis muscle), pillow under knee and from extended knee perform dorsiflexion (to test gastrocnemius muscle).
- By using standard plastic goniometer used to detect and follow passive range of knee extension from the point of flexion deformity. The child was placed in supine with thorax firmly strapped to the table to prevent body shift. Normally the knee extension is the starting position (zero de gree) by using goniometer therapist measure improvement in knee flexion deformity pre and post treatment.
- Another method to detect limitation in extension, alternatively measure the heel to buttock distance in the point of extension limitation pre and post treatment. This can be a very accurate way of detecting small alterations in range and is useful for follow-up of knee flexion deformity and checking progress in treatment.

For treatment

The children were treated 3 times per week, each treatment session lasted 1 hour. The treatment program includes:

A- ***Traditional physiotherapy program which includes the following***

- Faradic stimulation for anterior tibial group to triggering the mass flexion of lower limb so inhibit the extensor spasticity with support ankle in dorsi-flexion to prevent cross electricity to reach calf muscles because these spastic muscles are more sensitive to electric stimulation than ankle dorsiflexors.
- Prolonged stretch to spastic muscles to gain relaxation via; at first quick stretch occur lead to stimulate gamma fibers lead to stimulate contractile part of intrafusal muscle fiber lead to stimulate non contractile part which include stretch receptors sending afferent signals to PHC. Then to AHC then to alpha motor neuron causing con traction of extra-fusal muscle fibers. At second step just one contraction or repeated contraction occurred stimulate GTO sending lb afferent to PHC then to lb inter neuron which reverse the stimulated signals into inhibitory signals inhibiting AHC (alpha motor neuron) then relax the extrafusal muscle fibers. Techniques used as prolonged stretch (positioning, night splint, reflex inhibiting pattern, Bobath technique) [10].
- Facilitation of anti-spastic muscles (lapping followed by movement, quick stretch, triggering mass flexion, biofeedback, weight bearing, clenching to toes, compression on bony prominence, rapping the muscle, approximation, TVR, irradiation to weak muscles by strong muscles, ice application for brief time) [11,12].
- Passive stretching to tight muscles (most common tight muscles are; tendo-acchihis muscles, ham string, hip flexor and hip adductor). Concentration focused on hamstring, gastrocnemius and gracillis muscles because their tightness responsible on knee flexion deformity. It must be decent gentle gradual stretch not over stretch at all [10].
- Graduated active exercise for trunk muscles (abdominal, para-spinal, lateral flexors).
- Gait training using aids in closed environment using obstacles, side walking then by pass walking)
- Hot packs to improve circulation and relax muscle tension. Quadribed disturbance forward, backward, side- way then by raising one limb then disturbance as above then others, then both one upper limb and opposite lower limb with disturbance.
- Kneeling and half kneeling in addition to disturbance in all directions sudden raising of one upper limb then release and other limb then both upper limbs. Standing against wall, ball, stand bar, corner, manual support standing with disturbance in all direction then by narrowing BOS then disturbance then by shifting of one lower limb then disturbance then decrease the support by remove one hand from support then disturbance then by taking forward step then disturbance, then ask the child to push me and sudden release in all direction.
- Changing positions, stooping and recovery exercises to facilitate balance training. The child backed to me in standing then by lowering foot of one limb below plinth ask the child to raise, ask him to do stoop and recovery, using of abdominal belt to perform change of position training [9].

Group A- ***Balance training program***

This program was introduced to group A only which includes

Static balance training

- o Ability to maintain posture in different position about 20 second.
- o Maintain quadriped position, kneeling, half kneeling, standing; standing with step forward, with large BOS then narrow BOS, shifting to one limb.

Dynamic balance training

Ability to control the body when the support surface is moving or when the body is moving on a stable surface. Medical ball to train automatic postural reactions (righting reaction training via sitting on ball and make tilting to body then the child right his head and thorax- Equilibrium reaction training via different positioning as prone on ball, supine on all, quadruped on balance board, sitting on ball, kneeling with disturbance, half kneeling with disturbance, standing with disturbance, standing with step forward with disturbance, narrow BOS with disturbance, shifting with disturbance) all these produced motor response as raised side of body have equilibrium reaction and lowering side on the other side have protective reaction, axial parts have righting reactions,

***Group B**:* engaged to reciprocal electrical stimulation on knee joint muscles flexors and extensors for thirty minutes ”. reciprocal electrical stimulation program was conducted three times / weak over a period of three months.

RESULTS

Data analysis was available on 30 spastic diplegic C.P. children. were randomized to Group A include 15 spastic diplegic cerebral palsied children who received a course of balance training program that include static and dynamic postural stability training-plus traditional physiotherapy program- Group B include 15 spastic diplegic recieved reciprocal electrical stimulation in addition to the same traditional physiotherapy program in group (A) Demographic data in (Table 4) revealed that *p-value* <0.05 for some variables, this means that has affected on the study at 5% level of significant. But, *p*-value >0.05 for age, group and sex, this means that all of them have not affected on the study at *5%* level of significant.

Knee flexion

A comparison of the pre and post treatment for the right lower limbs in both groups as shown in (Table 1) revealed that there is highly statistical significant difference ($p<0.01$) for the (Rt) knee flexion pre and post treatment of the study .group (A) also statistically significant difference ($p<0.05$) to the right lower limb in group (B) (Table 1) and Fig. (1). On the other hand there is a highly statistical significant difference of the (Lt) knee flexion pre and post treatment in, the study group ($p<0.01$) but non significant difference to the (Lt) knee flexion in the control group *($p>0.05$)*. The percentage of decreasing in. knee flexion in the group A was -7.5% on. Rt and -7% on the Lt in study group and -1.43% on Rt and -2.1% on Lt in group B as shown in (Table 3).

Table 1 the mean values of Knee flexion in degree

Data	Group A				Group B			
	Pre-rt	**Post-rt**	**Pre-lt**	**Post-lt**	**Pre-rt**	**Post-rt**	**Pre-lt**	**Post-lt**
Mean	45.07	41.67	44.27	41.13	45.4	44.73	44.46	43.46
Standard deviation	3.24	3.13	3.08	2.8	4.3	4.1	3.9	3.6
Difference mean	3.45		3.13		0.66		1	
p-value	<0.01		<0.01		<0.05		>0.05	

Table 2 The mean values of distance between buttock and heel in cm

Data	Group A		Group B		Group A		Group B	
	Pre-rt	**Post-rt**	**Pre-lt**	**Post-lt**	**Pre-rt**	**Post-rt**	**Pre-lt**	**Post-lt**
Mean	27.86	32.5	28.26	32	27.33	27.8	29.06	29.73
Standard deviation	1.68	1.72	1.67	2.9	1.79	2.27	2.05	2.01
Difference mean	4.67		3.86		0.46		0.67	
p-value	<0.01	<0.01	<0.05	<0.05	<0.01		>0.05	

Table 3 Percentage of improvement of variables

Side	Knee flexion		Distance between buttok and heel	
	A	**B**	**A**	**B**
Rt	-7.5 %	-1.43%	16.95%	1.62%
Li	- 7 %	- 2.1%	13.72%	2.36%

Table 4 Demographic data (ANOVA)

Source	Df	Ss	Adj ss	Adj ms	F	p-vaue	Test
Variables	1	12499.3	12499.3	12499.3	1076.8	0.0	Sig.
Age	1	2.8	5.2	5.2	0.49	0.484	No. sig.
Sex	3	42.9	43.8	14.46	1.37	0.252	No. sig.
Group	1	1.5	1.5	1.5	0.14	0.707	No. sig.
Error	233	2474.8	2474.8	10.6			
Total	239	15021.2					

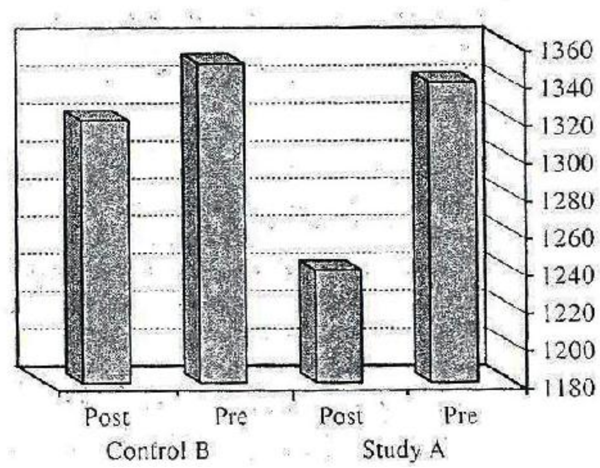

Fig.1 Values of knee flexion pre and post treatment for group A and B in degree.

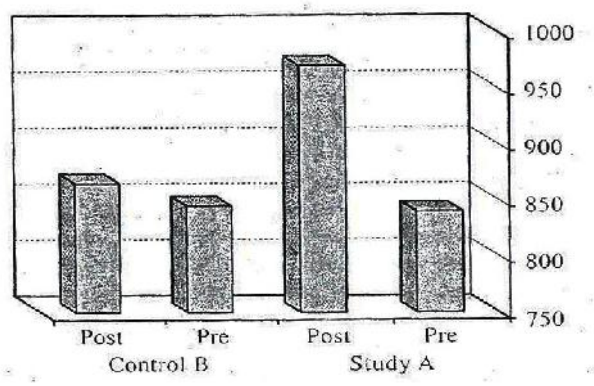

Fig. 2 Values of distance between buttock and heel pre and post treatment for group A and B in cm.

DISCUSSION

A course of traditional physiotherapy program plus balance training were significantly more effective than reciprocal electrical stimulation plus traditional physiotherapy alone. Knee flexion was decreased by -7.5%, -7% in study group in comparison with control group which decreased by -1.43%, -2.1% and increase of the distances between buttock and heel by 16.95%-13.72% in group A while group B increased by 1.62-2.36%.

Underlying mechanism of balance training: Balance control requires the interaction of the nervous and musculoskeletal systems and contextual effects.

The *nervous system provide the following*

1. Sensory processing for perception of body orientation in space provided by visual, vestibular, and somato-sensory systems.
2. Sensori-motor integration essential for linking sensation to motor responses (centrally pro grammed postural adjustments that precede voluntary movement).

Motor strategies for planning, programming and executing balance response. Information from peripheral receptors including visual, vestibular, and somato-sensory. (proprioceptive including conscial which are joint receptors, unconscial proprioceptors which are muscle spindle and GTO in addition to cutaneus receptors) to the cord and brain stem then be sensitized by the thalamus then localized by post central gyrus (sensory areas) to make three functions (percep-tion of sensation, cognition, formation of sensory strategies) then reach to cerebellum and basal ganglion to prevent excessive activity, smoothening of information then to the precentral gyrus which perform permanent changes lead to motor strategies and long term memory of this skill this means increase of anatomical (numbers) and physiological (efficiency) of synapses this means formation new neurological circuit which means learning of balance skill then formation of motor command via tracts to final common pathway (alpha and gamma MN) which provides two motor response [13].

Internal responses

- Reflexly response via stretch reflex comprises the first response to external perturbation producing contraction of antigravity muscles to regain balance.
- Voluntary response produces highly variable motor output by reaching to nearby stable surface.
- Automatic postural reactions produce prevention from fallen down.

External responses

- Ankie strategies produced by small disturbance (forward movement produce forward body sway shifting line of gravity backward produces contraction of paraspinal muscles, hamstring, calf muscles, backward movement produces backward body sway shifting line of gravity anterior produce contraction of abdominal, quadriceps, ant-tibial group.
- ***Weight shift strategies:*** This moves COG in a lateral plane primarily through activation of hip abductor and adductor muscles,
- ***Hip strategy:*** Produced by large and fast disturbance. Large rapid forward movement of board lead to backward sway shifting of line of gravity anterior leads to contraction of abdominal, quadriceps and ant-tibial muscles. Large backward movement leads to forward body sway shifting of COG backward produces contraction paraspinal, hamstring and calf muscles.
- ***Step strategy:*** Produced by large force perturbation feads to forward or backward step to increase BOS to regain balance control. In addition to ihe effect of balance training on motor control and strengthen of weak muscles, vestibular stimulation will trigger vestibule-spina! tract which affects on alpha motor neuron producing modulation of muscle tone, stimulates also the co-ordination of different parts of the body parts to learn the difficult and new situation to overcome it after that [14].

Heitkamp *et al*., [15] studied the gain in strength and muscular balance after balance training which was performed on instability training devices as rolling board and large rubber ball. Strength gain was similar for the flexors and extensors. Affected limbs improve after balance training greater than increase over the strength training group. The results indicate that balance training be effective for gain in muscle strength, equalization of muscular imbalances which may be achieved after balance training.

Goddard *et al*., [16] studied the effect of force platform feedback for standing balance training after stroke. There are no significant effects on laboratory postural sway indicators and clinical measure of functions at follow-up assessment. Force platform feedback improves stance symmetry but not sway in standing, clinical balance outcomes.

CONCLUSION

Balance training with traditional physiotherapy program should be considered in tightness of muscles and limitation of ROM. The use of balance training program plus traditional physiotherapy program are superior to reciprocal electrical stimulation plus traditional physiotherapy alone for ail measurements that include knee mobility and muscles flexibility after 12 weeks follow-up.

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