Original Article

STATIC AND FUNCTIONAL BALANCE IN DIPLEGIC CHILDREN SUBMITTED TO BOTULINUM TOXINS TYPE A AND RECIPROCAL ELECTRICAL STIMULATION

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ABSTRACT

Background and introduction: Balance is fundamental for the efficient accomplishment of all activities of daily living; balance dysfunction is one of the most common problems in diplegic children that could be attributed to unbalanced function of agonist and antagonist, reciprocal electrical stimulation hypothesized to improve the opposed muscle action.
Purpose: The purpose of this study was to evaluate the efficacy of Reciprocal Electrical Stimulation (RES) on dorsi and planter flexors of both ankles in treatment of balance dysfunction after submission to botulinum toxin (BT-A).
Methods: Thirty children with spastic diplegia, aged from 4 to 6 years with mean 4.9±0.779 were assigned randomly into two groups of equal numbers: study group received RES in addition to physical exercise program 3 times weekly for 3 months and control group received the same physical exercise program without RES for the same number of sessions as in study group. Static and the functional balance were assessed pre-treatment and 3 months post-treatment in both groups (using the Biodex Balance system and Berg's balance scale consequently).
Results: Results showed significant improvement in the 2 outcomes when comparing the post treatment mean values of the two groups in favor of the study group ($p<0.05$).
Conclusion: It could be concluded that bilateral RES of dorsi and planter flexors after BT-A submission is effective treatment method of balance dysfunction in children with spastic diplegia.
KEYWORDS: Diplegia; Balance; Functional electrical stimulation.

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BACKGROUND

Spastic diplegia is the most common types of CP, spasticity is predominant in their legs and less severely affecting the arms, they can use their upper limbs functionally [1]. Spasticity and deformities as ankle planter flexion, knee flexion hip adduction and internal rotation are contributing factors of functional limitation and balance problems in cerebral palsied children. [2]
Posture stability is integration of proprioceptive, vestibular and visual sensations required for the effective performance of function [3-5]. The control of an upright posture requires adaptation of motor responses to the demands of the task, to the environment and to the body itself [6]. It the ability to maintain and control the center of gravity of the body within the base of support [7]. Postural disturbances occur due to the difficulty in maintaining the body segments aligned on a narrow base of support [8]. Posture control deficits have been known as the greatest limitation to the sensory and motor development

of children with diplegia. [9,10]

Balance recovery limitation in diplegic children contributing 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. [11]

Currently, there are a number of clinical tests for measuring static and functional balance [3, 7]. Also there are objective laboratory systems provide detailed information about static and dynamic balance [12]. Biodex Balance System is an easy, effective method for quantification of postural stability or static balance [13]. Pediatric balance scale (PBS) is a modified form of the Berg Balance Scale (BBS) was developed as a functional balance measure for children with mild to moderate motor impairments [14]. It is a functional balance measure that indicates balance capabilities needed for gross function.[15]

Botulinum toxin A (BT-A) is used to control of spasticity in ambulant diplegic children to improve motor activities and prevent musculoskeletal deformities [16]. BT-A is widely employed for local reduction of muscle tone [17]. It effectively improve interlimb coordination children with spastic diplegia. [18]

Electrical stimulation is used for the treatment of central nervous system (CNS) lesions to improve motor control, reduce spasticity, prevent deformities and generally used to improve the function of the affected extremity. [19]

Reciprocal electrical stimulation of agonists and antagonists musculature is also a promising form of electrical stimulation in patients with CNS lesions. The rationale for this is to train reciprocal activation. It may be possible to decrease cortical excitability of the spastic antagonist muscle and to improve the strength of the agonist muscle [20, 21]. In the lower extremity a reciprocal functional electrical stimulation of dorsi flexors and plantar flexors can improve the lower limb function. [22]

Based on this reports current study assumed the use of reciprocal electrical stimulation on the anterior tibial group and gastrocnemius muscle after submission of botulinum toxin A for gastrocnemius may results in improvement of muscle sequencing response, decrease ankle muscle co activation then improve balance recovery subsequently.

MATERIALS AND METHODS

Study Design: This study was a randomized controlled trial, performed over the period from June to September 2013 at the outpatient clinic faculty of physical therapy, Cairo University, Egypt.

Subjects: Thirty children aged 4-6 years (16 girls and 14 boys) referred to the physical therapy department from neuropediatrician with clinical diagnosis of spastic diplegia were participated in this study. Children were selected for the study randomly assigned to two groups of equal number, study and control groups. They met the following inclusive criteria, their age ranged from 4 to 6 years, their motor function were classified as level III by the Gross Motor Function Classification System (GMFCS), their equinus deformities were dynamic and were indicated for neuromuscular block by BT-A in the gastrocnemius muscle, they were able to walk independently with or without assistive aids, all participants received BT-A injection for their calf muscles bilaterally and they were free of perceptual or cognitive disorder so that they can follow orders during both evaluation and treatment. Exclusion criteria consisted.

Procedures:

Outcome Measures: Two Outcomes measures were assessed for both groups 1 week after BT-A submission before receiving the treatment intervention and after 3 months of treatment intervention. First; Overall Stability Index (OS1) as an indicator of static balance using the Biodex Balance System (BBS). It allow 8 stability levels with level 8 is the most stable and level 1 the least stable one to quantify postural stability on unstable surface. All participants were given an explanatory session before the evaluative procedure to be aware of the different test steps. The test input parameters (child chronological age, weight and height) were introduced before they were tested for 8th level (the most stable) and 4th level (the least stable) for 3 repetitions for each trial, the mean OSI of the three trials was calculated and recorded. Second; The functional balance evaluated by Pediatric Balance Scale; it is 14-item scale designed to measure functional balance in pediatrics. Each item scored utilizing item from 0-4 based on the lowest criteria the indicate the best performance after three trials then the total test score of the 14 items was calculated from the maximum score of 56.

Treatment Intervention

In Control Group (Group 1): Fifteen diplegic children received only the physical exercise program that consisted 1- stretching exercises for tight calf bilaterally 2-facilitation of contraction of the anterior tibial group (tapping, quick stretch, tonic vibration reflex, wrapping of the muscles, biofeedback, approximation, compression on bony prominence or triggering of the mass flexion pattern of the lower limb 2- facilitation of righting, equilibrium and protective reactions 3- gait training and facilitation of normal movement patterns. The procedure consisted of 36 sessions, 3 times weekly, 1 hour for each session for duration of 3 months.

In Study Group (Group 2): Fifteen diplegic children received the same physical exercise program as control group in addition to the RES of the dorsi and planter flexors of the ankle bilaterally with surface electrodes (3 cm X 3cm) positioned on the dorsi flexors (one electrode on the fibular head and the other on the lower 1/3 of the dorsal aspect of legs) and planter flexors (one electrode just below the popliteal fossa and the other on the lower 1/3 of the posterior aspect of the legs). The parameters were: frequency of 30 Hz, pulse from 300 ìs [23], 10 second ramp up and 10 second ramp down alternatively for both groups for a total duration of 20 minutes. The intensity was set as high as the participant can tolerate and the intensity were increased during the intervention for the dorsi flexors to maintain sufficient dorsi flexion [24]. A visible contraction were produced in the stimulated muscles, with the child seated in long sitting with both knees slightly flexed on a small cushions.

Data Analysis: All statistics were calculated by using the statistical package of social sciences (SPSS) version 20. Descriptive statistics (mean and standard deviation) were computed for all data. P

aired t- test was applied within the group for OSI and functional balance. Unpaired t- test was applied for the two outcomes between both groups.

RESULTS

The mean age was 4.87±0.83 years of the control group and was 4.93±0.78 years of the study group. There were no significant differences in age between the study and control group as P-value was 0.82 (P> 0.05). The mean height was 122.13 ±10.08 for the control and 124.40±4.66 cm for the study groups. It also showed no significant difference as P-value was 0.436 (P> 0.05). The mean difference in weight was 23.87 ±2.67 for the control and 24±3.92 kg for the study group and p-value was 0.706(P> 0.05) that indicated non-significant difference between both groups (table 1).

Table 1: Baseline characteristics of the participants of both groups

Groups	Age	Sex (M/F)	Weight (kg)	Height (cm)
A	4.87±0.83	6/9	23.87 ±2.67	122.13 ±10.08
B	4.93±0.78	8/7	24±3.92	124.40±4.66

Measurement data were expressed as mean ± SD. Age (years); M: Male; F: female; Weight (kg) and Height (cm).

Table 2: Mean values of Overall Stability Index and Functional Balance for both groups A and B.

Variables	Time	Control group (A) Mean±SD	Study group (B) Mean±SD	P-value
Overall Stability Index	Pre	2.953±0.421	2.726±0.460	0.17
	Post	2.640±0.584	2.227±0.423	0.035
	p-value	0.002	0.004	
Functional	Pre	40.667±2.024	40.267±1.831	0.575
Balance	Post	43.333±2.319	45.733±1.534	0.002
	p-value	0.003	0.001	

The mean changes in the Overall Stability index and Functional Balance for the control and study groups pre and post treatment in both groups is summarized in Table 2. Comparison revealed that there were no significant differences in mean changes for all measurements between the two groups pre-treatment (P> 0.05). Results of Overall Stability index and Functional Balance showed that there was a significant difference pre and post-treatment in control group (P<0.05) and significant difference in study group (P> 0.05). Comparison between groups showed a significant difference in the two outcomes in favor of the study group (P-value < 0.05).

Fig. 1 demonstrates the mean values difference of Overall Stability index pre and post-treatment in both groups and Fig. 2 demonstrates the mean values difference of Functional Balance pre and post treatment in both groups. Fig. 3 demonstrates the post treatment mean values of Overall Stability index for both groups and Fig. 4 demonstrates the post treatment mean values of Functional Balance for both groups.

Figure 1: pre and post treatment mean values of the overall stability index for both groups A and B.

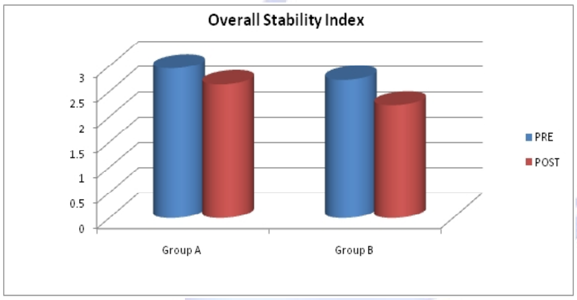


Figure 2: pre and post treatment mean values of the functional balance for both groups A and B.

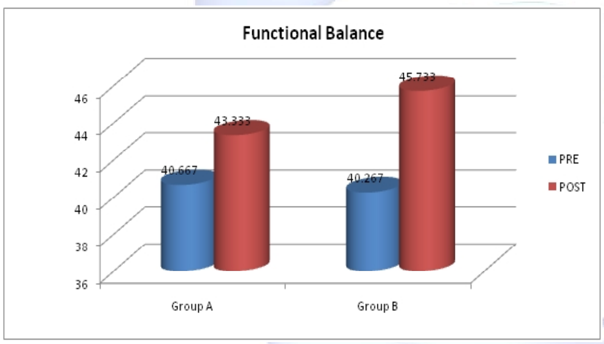


Figure 3: post treatment mean values of Overall Stability Index for both groups A and B.

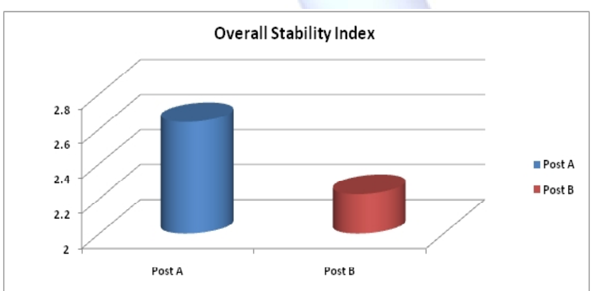
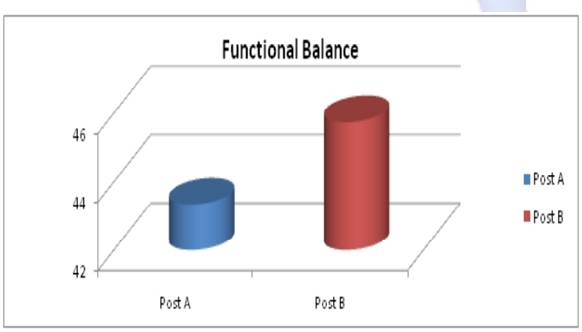


Figure 4: post treatment mean values of functional balance for both groups A and B.



DISCUSSION

Static and functional balances are important for standing and walking and every day activities. It is automatically controlled in normal children but often considered as a challenging goal for diplegic children. So, further studies of static and functional balance control may help us to enrich our therapeutic approaches for children spastic diplegia.

Ferdjallah, et al. reported the alteration of postural control mechanism in children with spastic diplegia and suggested that poor control at the ankle joint is likely to cause the compensatory postural control strategy [25]. Also Winter et al. ankle (dorsi and planter flexion) strategy is very important for balance control as it totally dominates in antro-posterior balance [26]. Crouched posture of diplegic children may be contributed to decreased ability to recover balance and inappropriate and delayed ankle muscles responses. [11]

However, there are very limited or no reports showing the effects of RES on static and functional balance, as far as we know. Therefore, we think that this is the first study investigating the effect of RES on static and functional balance for children with spastic diplegic cerebral palsied children.

This study was conducted to evaluate the efficacy of Reciprocal Electrical Stimulation (RES) on dorsi and planter flexors of both ankles in treatment of balance dysfunction after submission to botulinum toxin (BT-A) in spastic diplegic cerebral palsied children.

Results of this study demonstrated significant improvements in the two outcomes measures [there was improvement of the overall stability index as an indicator of static balance and increased score of Berg's balance scale as an indicator of functional balance in both groups when comparing pre and post treatment mean values within each group. Also results demonstrated a significant improvement in the 2 outcomes in favor of the study group that received the RES in addition to the exercise program when comparing the post treatment mean values of the two outcomes of both groups.

The findings of our study may be contributed to the effect of RES that may improve ankle muscle control. This is evidenced by Taylor et al. [27] who reported that when a muscle contracts in response to electrical stimulation antagonist muscle activity reduced. This is known as reciprocal inhibition and its effect can be exploited by stimulating the antagonist muscle to the spastic muscle. On the other hand stimulation of the spastic muscles has also been shown to have a relaxing effect. Therefore reciprocal stimulation of ankle dorsi and planter flexor pairs can be an effective way to control its function. And these changes in co activation could be a learned adaptation manifested as an improvement in coordination and balance skill by repetition of stimulation of ankle dorsi and planter flexor muscles. [28]

CONCLUSION

The finding of this study suggest that using reciprocal electrical stimulation as an adjunct to the physical exercise program is effective to improve static and functional balance in spastic diplegic cerebral palsied children.

List of abbreviations

BBS	Berg's Balance scale
BT-A	Botulinum Toxin type A
CNS	Central Nervous System
CP	cerebral palsy
OSI	Overall stability index
PBS	Pediatric Balance Scale
RES	Reciprocal Electrical Stimulation
SPSS	Statistical Package of Social Sciences

Conflicts of interest: None

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