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Functional measures in response to electrical stimulation in children with unilateral cerebral palsy

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> Abstract --- Purpose: The purpose of this study was to determine the effect of neuromuscular electrical stimulation of abdominal and back muscles simultaneously on gross motor function measures (GMFM) in children with unilateral cerebral palsy. Materials and Procedures: Thirty children with unilateral spastic cerebral palsy participated in this study. They were classified randomly into two groups of equal numbers, control, and study groups. GMFM was used to evaluate function in the two groups before and after ten successive weeks of application of the treatment programs. The control group (A) received a selected physical therapy program based on the neurodevelopmental approach used for rehabilitation of such patients and the control group received the same selected physical therapy program applied to the study group in addition to 30 minutes of neuromuscular electrical stimulation of abdominal and back muscles simultaneously. Results: Comparing the pre-and post-treatment results for the control and study groups revealed significant improvement in GMFM. Post-treatment significant improvement was recorded in favor of the study group. Conclusion: There was an effect of neuromuscular electrical stimulation of abdominal and back

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muscles simultaneously on function in children with unilateral cerebral palsy.

Keywords---Unilateral cerebral palsy, Neuro-muscular electrical stimulation, Gross Motor Function Measures.

I Introduction

Cerebral Palsy (CP) is the most common cause of physical disability in childhood, with an estimated incidence of 2.11 per 1000 live births (Sadowska et al., 2020 and Stevenson et al., 2003). Cerebral palsy is an umbrella term covering a group of non-progressive, but often changing, motor impairment syndromes secondary to lesions or anomalies of the brain arising in the early stage of its development (Rosenbaum, 2003 and Strauss et al., 2008). Spastic hemiparesis is a unilateral paresis with upper limbs more severely affected than the lower limbs. It is seen in 56% of term infants and 17% of preterm infants (Verheyden et al., 2007 and Einspieler et al., 2019).

Most children with unilateral spastic cerebral palsy have associated sensory deficits. These sensory deficits are reflected as poor muscle. Poor muscles and delayed control of the trunk may affect functional measures as well as balance in those children (Westcott et al., 1997, O'Shea, 2008, and Patel et al., 2020). Neuromuscular Electrical Stimulation (NMES) is a promising therapy for strengthening muscles in patients with CP. It is the application of an electrical current of sufficient intensity to elicit muscle contraction. Two strengthening mechanisms are proposed for the therapeutic effects of NMES: (1) The overload principle, resulting in greater muscle strength by increasing the cross-sectional area of the muscle; and (2) Selective recruitment of type II fibers (fast-twitch, large-diameter fibers), causing improved synaptic efficiency of the muscle (Wright et al., 2012 and Nussbaum et al., 2017).

For individuals with CP, NMES has been recommended for the stimulation of muscles in the limbs and trunk and can lead to significant improvements in muscle strength and range of motion as well as the modulation of excessive muscle tone and enhanced coordination (Bergquist et al., 2011, Giannasiet al., 2015, and Ahmed et al., 2018). NMES has been previously studied in CP children and found to be effective on trunk control. It has also been reported that it is more effective when NMES is combined with other conventional rehabilitation methods (William and Flynn, 2014 and Salazar et al., 2019). We aimed to investigate the effect of applying electrical stimulation over abdominal and back muscles simultaneously on gross motor function measures in children with unilateral cerebral palsy.

II Materials & Methods

For such a randomized controlled trial, thirty children with unilateral spastic cerebral palsy of both sexes were recruited from the outpatient clinic, Faculty of Physiotherapy, the University of Merit in Sohag, and from the Police Hospital in Sohag to investigate the effect of neuromuscular electrical stimulation of abdominal and back muscles simultaneously on the function measures in children with unilateral cerebral palsy.

Their ages ranged from 4 to 8 years. Spasticity ranged from 1 to 2 grades according to the modified Ashworth scale (Harb and Kishner, 2021). They were able to understand and follow simple orders. They had repeated and frequent falling, especially when increasing speed or walking on an uneven surface as a chief complaint of parents.

Any child with one or more of the following was excluded from the study: history of epileptic seizures, receiving anti-spastic drugs, significant visual or auditory defects, fixed deformities in lower limbs, and a history of surgical interference. Children were assigned randomly to two groups of equal numbers, 15 children each. Children in group A received a selected physical therapy program. Children in group B received the same selected physical therapy program as in Group A in addition to 30 minutes in the form of neuromuscular electrical stimulation over abdominal and back muscles simultaneously.

Ethical approval was obtained prior to the study from the local committee of the faculty of physical therapy, Cairo University **(P.T.REC/012/003290).** Ethical consideration: the purpose, nature, and potential risks of the study were explained to all patients. All patients and their families signed a consent form prior to participation in the study.

Evaluation procedures

After completing the procedures with consent and collecting data using the evaluation sheet and determining the degree of spasticity, we started Before data collection, each child's parent completed informed consent and a health history form, which were used to identify children who were not eligible to participate in the study due to medical or developmental conditions.

The 66 items of the GMFM were measured by observation of the child and scored on a 4-point ordinal scale (0: does not initiate, 1: initiates 10% of activity, 2: partially completes 10% to 100% of activity, 3: completes activity). The items were weighted equally and grouped into 5 dimensions: (1) lying and rolling (17 items), (2) sitting (20 items), (3) crawling and kneeling (14 items), (4) standing (13 items), and (5) walking, running, jumping (24 items). By the age of 5 years, children without motor delays can generally accomplish all the items of the GMFM. Scores for each dimension were expressed as a percentage of the maximum score for that dimension. The total score was obtained by averaging the percentage scores across the 5 dimensions. The original intent of the GMFM developers was to have one measure that could be used for children across a spectrum of ability levels to make it possible for children with different gross motor abilities to enter clinical trials and be assessed with the same measurement tool. In addition, the measure needed to be useful for tracking individual children over time **(Taub et al., 2004)**.

Treatment procedures

1- Selected physical therapy program:

The two groups received the physical therapy treatment program three times per week, every other day for ten successive weeks. Neurodevelopmental approach directed towards inhibiting abnormal muscle tone and abnormal postural reflexes and facilitation of normal movement patterns of postural control through reflex inhibiting positions using proximal and distal key points of control. Proprioceptive training, as well as balance training, were applied in addition to training for active trunk extension to improve postural control. Gait training activities also were applied. Stretching exercises to maintain the length and the elastic properties of the muscles which are liable for shortening were applied (Nelson et al., 2004 and Wright et al., 2012).

2- Neuromuscular electrical stimulation:

The area of skin to be treated was cleaned with alcohol to reduce linear electrical resistance (reactance arising from capacitance is unchanged) and the electrodes were adhesive. This was useful when treating regions such as the trunk where it is difficult to strap an electrode. Faradic stimulation was delivered over the abdominal and back muscles at the following parameters: pulse width 250usec, frequency 35HZ with 10 sec on and 12 sec off interval for 30 minutes per session for 3 days per week for 10 successive weeks. The intensity was adjusted to the tolerance of the child, which was kept at the intensity of muscle contraction felt and seen. Neuromuscular electrical stimulation was delivered over the abdominal and back muscles simultaneously via four surface electrodes, two applied on rectus abdominus and two applied on erector spinae muscles.

Statistical analysis:

Statistical analysis was carried out using SPSS for Windows, version 22 (SPSS Inc., Chicago, Illinois, USA). The mean value and standard deviation were calculated for each variable measured during this study. The P-value is the degree of significance(<0.05) that was considered to be significant. Non-parametric statistical tests were used to compare within a group and between groups.

III Results

Data obtained from both groups before and after following the treatment program regarding GMFM were statistically analyzed and compared.

Baseline characteristics

Group (A): The mean \pm SD of age, weight, height, and BMI were 6.066 \pm 1.624 years, 20.933 \pm 3.881 kg, 116.4 \pm 9.3411cm, and 15.317 \pm 1.0977 kg/m² respectively as shown in table (1)

Group (B): The mean \pm SD of age, weight, height, and BMI were 6 \pm 1.463 years, 21.866 \pm 3.4819 kg,115.33 \pm 8.7885 cm, and 16.295 \pm 1.3468 kg/m² respectively as shown in table (1)

Comparing the general characteristics of the subjects of both groups revealed that there was no significant difference between the two groups in the mean age, weight, height, or BMI (p > 0.05).

Item		Group (A)	Group (B)	p-value
Age (year)		6.066±1.624	6 ± 1.463	0.896
Weight (Kg.)	Mean	20.933±3.881	21.866± 3.4819	0.398
Height (cm)	± SD	116.4±9.3411	115.33±8.7885	0.735
BMI (kg/m ²)		12.317±1.0577	12.295± 1.0468	0.039

Table 1.	Baseline	characteristics
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Kg.: Kilogram, cm: centimeter, BMI: Body Mass Index, and p-value>0.05: No significant difference.

Sex distribution:

The distribution of males and females in group A was 47% and 53% respectively and regarding group B, it was 60% and 40% respectively.

Table 2. The frequency distribution of sex in groups A and B.

Item		Group A	Group B
Malaa	No.	7	9
males	%	47%	60%
Females	No.	8	6
	%	53%	40%
Total	No.	15	15
	%	100%	100%

Degree of spasticity

The degrees of spasticity in group A were 33%, 47% and 20% respectively and for group B were 20%, 40% and 34% respectively.

Table 3. The frequency distribution of the degrees of spasticity in groups A and B.

Item		Group A	Group B
One de 1	No.	5	4
Glade I	%	33%	20%
One de 1	No.	7	6
Grade 1+	%	47%	40%
Grade 2	No.	3	5
	%	20%	34%
Tata1	No.	15	15
Total	%	100%	100%

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Distribution of the more affected side

The distribution of the more affected side in right and left side in group A was 47% and 45% respectively and for group B was 60% and 34% respectively.

Side		Group A	Group B
Dight	No.	7	9
Right	%	47%	60%
Loft	No.	8	6
Leit	%	53%	40%
Toto1	No.	15	15
TUTAL	%	100%	100%

Table 4. The frequency distribution of the more affected side in groups A and B.

Gross motor function measurement (GMFM): Table (5)

The mean values \pm SD regarding group A before treatment was 23.07 \pm 4.64 while after treatment was 35.2 \pm 1.93. The mean difference was 12.13. There was a significant difference between pre-and post-treatment in GMFM (p = 0.00064). The mean values \pm SD regarding group B before treatment was 26.07 \pm 6.28 while after treatment was 46.13 \pm 9.26. The mean difference was 20.06. There was a significant difference between pre-and post-treatment in GMFM (p = 0.00758). Also, when comparing mean values between groups concerning post-treatment results, there were significant statistical differences (p = 0.04).

Table	5.	Within	and	between	groups	comparisons	for	GMFM	variable
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Variable	group (A)		group (B)	p-		
variable	Pre-	Post-	Pre-	Post-	value **	
GMFM	23.07±4.64	35.2±1.93	26.07±6.28	36.13±9.26	0.04	
p-value *	0.00064		0.00758		0.04	

GMFM: Gross Motor Function Measure, *: within-group comparison (Wilcoxon signed-rank test), **: between groups comparison (Mann-Whitney U test), and p-value<0.05: Significant difference.

IV Discussion

This study was conducted to investigate the effects of neuromuscular electrical stimulation on the abdomen and back muscles simultaneously on gross motor function measures in children with unilateral spastic cerebral palsy, in addition to regular physiotherapy programs in such cases. For this purpose, thirty children with unilateral spastic cerebral palsy were selected. They were divided into two groups of the same size. Each group consists of 15 children. All patients were evaluated before and after the treatment program using total motor function measurements using the standing domain (GMFM) as a mirror of trunk control.

Observation of the pretreatment mean in this study confirms the results of children with unilateral spastic cerebral palsy reported problems in function due

to poor arm, leg, and trunk muscle control. Maintaining and recovering the center of gravity (COG) within the base of support (BOS) in response to disturbances or voluntary movements is compromised **(Panibatla et al., 2017).** The results of this study show that physiotherapy intervention with neuromuscular electrical stimulation of the abdomen and back muscles simultaneously improves function significantly in children with unilateral spastic cerebral palsy. Post-treatment study group mean values may be due to the application of neuromuscular electrical stimulation of the abdominal and back muscles, showing a very significant improvement and significant differences in all variables that provided a better trunk. Balance and control and stability are essential for functional

NMES has been studied in children with CP and has been shown to be effective in controlling the trunk. It has also been reported to be more effective when NMES is combined with other traditional rehabilitation methods (Salazar et al., 2019). This was reported by **Bergquist et al.**, (2011) as they discovered that low-frequency electrical stimulation significantly increased the isokinetic strength and endurance of core muscles.

This significant improvement observed in the research group is consistent with **Baldwin et al., (2006)** and **Karabay et al., (2012)** who reported that neuromuscular electrical stimulation, used in combination with conventional treatments, is more effective than conventional treatments alone in maintaining core control. They used (GMFM) to assess seat balance and radiographic measurements of Cobb's angle to assess trunk symmetry. The statistically significant reduction in bump angle may be due to improved trunk control by electrical stimulation, which helps correct body asymmetry.

This also applies to **Smith et al., (2003)** and **Qi et al., (2018).** Neuromuscular electrical stimulation via core muscles is a useful therapeutic tool for achieving better core control in children with spastic hemiplegia when combined with conventional physiotherapy indicated. **Rose et al., (2002)** and **Bosques et al., (2016)** also stated that electrical stimulation has been shown to be a useful tool in treating a variety of disabilities in children with dysfunction. It is often used as a therapeutic aid to maximize strength (including core strength). These results are from **Stevenson et al., (2003)** and **Jones et al., (2016)** concluded that NMES could allow children with poor motor control to participate in gradual strength training programs. NMES can also lead to motor learning.

V Conclusion

From the results obtained in this study, it can be concluded that neuromuscular electrical stimulation of the abdominal and back muscles simultaneously could be used to improve the function measures of children with unilateral spastic cerebral palsy. Therefore, it can be added as an additional treatment to such children's rehabilitation programs.

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activity.

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