Does Functional Electrical Stimulation Improve Power and Reduce Mild Equines in Children with Diplegia?

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Abstract

Background/Objective: For optimal postural stability and balance, the dorsiflexor muscles are crucial. Children with spastic diplegia who appear stiff are more likely to be unsteady and have trouble walking are suffering. This study was to detect the effectiveness of functional electrical stimulation on equines foot and muscle power in children suffering from diplegia.**Methods:** In this study, forty diplegic cerebral palsy (CP) children of both sexes (19 boys and 21 girls) aged from 7 and 12 were recruited. They were randomized into two groups, each consisting of an equal number of participants (A and B). Children in group (A) underwent a specified physical therapy for 90 min, three times per week for 10 weeks, while those in group (B) had the same regimen but also received functional electrical stimulation (FES). The participating children were assessed their four dorsiflexor muscles (Tibialis anterior, Extensor hallucis longus, Extensor digitorum longus, and Peroneus Tertius) in form of assessing dorsiflexion range of motion (ROM) by goniometer, dorsiflexors strength and time to peak force by Lafayette hand-held dynamometer of dorsiflexors before and after the 10-week therapy program, which involved three sessions each week of treatment.**Results:** The obtained results showed clear variances among pre-and post-treatment in the two groups for each of the four dorsiflexor muscles (Tibialis anterior, Extensor hallucis longus, Extensor digitorum longus, as well as Peroneus Tertius) for all measured variables (dorsiflexion (ROM), time to a peak force of dorsiflexion, and dorsiflexion strength). Additionally, post-mean values for all variables that were assessed revealed a statistically significant difference in favor of the group (B).**Conclusion:** To reduce equines foot and improve muscle power in children with diplegic CP, the FES can be added to the physical therapy program.

KeyWords: Ankle dorsiflexion; cerebral palsy; Diplegia; Equines foot; Functional electrical stimulation.

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Introduction

The term “cerebral palsy” (CP) refers to a set of diseases that affect the developing brain without progressing and cause inappropriate central nervous system control of the skeletal musculature, impairing motor function. Spasticity, which frequently results in an equines gait pattern in the lower leg, is one of the symptoms of this issue. The end consequence is frequently reduced active dorsiflexion, ROM, and a lack of heel striking at initial contact [1].

On another level, CP which can refer to a variety of medical complications brought on by damage to the brain before, during, or soon after birth, is not a medical diagnosis [2]. The most typical physical disability in children is CP. The vast majority of CP youngsters have trouble walking. For kids with CP, enhancing walking or other functional abilities is frequently the main therapy objective [3].

Spastic diplegic CP is the most typical type of CP [4]. Spastic CP is marked by uncontrollable muscle contractions in the arms and legs as well as an unnatural “scissor” gait [5]. Hip flexors, hamstrings, psoas, and calf muscles of spastic diplegic children were tight, resulting in a flexed posture [6].

Dropping a foot or true equines can be caused by weak ankle dorsiflexors (such as the anterior tibial muscle), weak ankle plantar flexors, or a combination of these factors [7]. When compared to the knees, children with spastic diplegic CP had more spasticity in the ankles (more distal part). Limited ankle joint movement is associated with ankle spasticity[8]. Although there are different definitions of equines, we can define it as simply having insufficient ankle joint dorsiflexion for proper gait, which leads to disease, compensation in the lower extremities, or a combination of the two[9].

Children with CP may develop equines, deformities. The incapability to dorsiflex the foot over the floor with the hindfoot in neutral with the knee extended is referred to as equine[10]. However, there are numerous definitions of equinus deformity and equinus gait in the literature, which makes it challenging to assess the outcomes of this deformity [11].

For children with CP, limited ankle ROM during gait and balance performance is a known issue [8]. The definition of functional electrical stimulation (FES) is "the electrical stimulation of muscles to create a contraction to produce a functionally beneficial movement in the presence of poor motor control" [7]. Numerous studies have demonstrated that FES is efficient at causing muscle contraction, increasing ROM, and strengthening muscles [12].

The electrical stimulation of muscles with poor motor control to cause a contraction and produce a beneficial movement is known as FES [13]. By activating the ankle dorsiflexor muscles to rise the foot in swing or the quadriceps to extend the knee in stance, for example, FES can be utilized to generate a direct "orthotic" effect during gait. FES may have long-term “therapeutic” benefits, such as a decreased propensity for muscular atrophy and enhanced motor control thanks to more effective neural pathways [14].

For many years, walking has been facilitated by the well-known method known as FES. Dorsiflexor muscle control and preventing the foot from falling during the swing phase have been the key goals of FES. Due to its viability, simplicity, and synchronization with gait, peroneal FES is widely employed [15].

Therefore, the objective of this research was to detect the effectiveness of FES on equines foot and muscle power in children with diplegia.

Materials and Methods

Study design:

This is a randomized controlled trial that was done from January 2022 to May 2022.

Subjects:

The current study was conducted at Wahet El-Hayaa Center for Children’s Rehabilitation and the AbouQeer Hospital in Alexandria, Egypt, where 40 diplegic CP children of both sexes (females and boys) with their age ranged from 7 to 12 years were selected for this study. Children had to meet the following criteria to be included: a) their chronological age ranged from 7 to 10 years, b) their Growth Motor Function Classification System (GMFCS) levels were 1 and 2, c) they had spasticity ranged from grade 1 to grade 1+ according to Modified Ashwarth Scale, d) They are clinically as well as medically stable, and e) they have enough cognition to demonstrate understanding of the study's criteria.

Children with cancerous tumors, children with poorly controlled epilepsy, children with bed sores that limits the using of self-adhesive electrodes, children with a history of significant autonomic dysreflexia, children had any neurological or psychological issues, children had any sensory impairment, children had to be able to understand and follow directions and children with exposed orthopedic metal work in the area of electrical stimulation should be avoided are the exclusion criteria.

Randomization

A computer produced randomized table, generated with the Statistical Package for Social Sciences (SPSS) and prepared ahead of data collection, was used for simple randomization. Each participant was given a unique identifying number that indicated the group that they would be assigned. Individually and consecutively numbered index cards were placed in clear envelopes. Every participant received a hand-picked envelope and also was assigned to a group. The study's purpose and procedures were explained to the children's parents. The youngsters were drawn from the clinic and randomly assigned to one of two groups. For a duration of ten weeks, the group (A) underwent physical therapy, whereas the group (B) obtained FES in conjunction to the identical physiotherapy program.

Procedures

Both reliability as well as validity concern how well a method evaluates something: The consistency of a measurement is referred to as its reliability (whether the findings can be reproduced within the same conditions). The precision of a measure (if the findings truly represent what they are trying to measure) is referred to as its validity). So, all our methods are considered to reliable and valid to be used in this study.

Growth motor function classification system (GMFCS):

Based on the self-initiated movements of children and adolescents with CP, a five-level classification system is used to describe their motor function. The goal of GMFCS is to identify the level that most accurately reflects the kid, existing capabilities, and growth motor function constraints 16.

Modified Ashworth scale:

It is the most widely used clinical test for determining the increase in muscle tone, used to evaluate the resistance encountered during passive range of motion, rapid to complete, and instrument-free. Utilizing this scale, physicians could grade muscle tone and measure the velocity-dependent resistance to passive motion of the involved limb joints, with 0 representing no rise in tone and 4 representing a rigid extremity. They can then track the degree of spasticity on consecutive assessments as treatment is initiated and altered [17].

Measurement of ankle joint ROM:

The assessment procedures were conducted while lying flat or seated. The child was lying supine on a treatment table with their hip and knee extended. He/She was seated on a chair with his hip and knee bent at a 90-degree angle. The moveable arm is parallel to the lateral aspect of the fifth metatarsal bone, the stationary arm is parallel to the lateral aspect of the fibular, and the goniometer axis is positioned on the lateral malleolus of the tested limb. The child's foot was moved into dorsiflexion as the therapist repaired the child's tibial bone. Where the end-feel was felt and no more movement was possible, the dorsiflexion range of motion was assessed. Goniometer measurements of ankle joint range of motion are highly reliable [8].

Measurement of the ankle dorsiflexors strength:

The following components should be standardized as the therapist begins to evaluate the muscle strength of the ankle dorsiflexors (tibialis anterior, extensor hallucis longus, extensor digitorum longus, and peroneus tertius):

1) Before initiating the program, verbal instructions are given to the children.

2) During the test, verbal encouragement is provided.

3) The position of both the therapist and the participant is taken into account.

4) The ideal position of the dynamometer and its accessories is gauged.

5) The right order of the tested muscles.

6) The execution of the participant’s tasks; The peak force was measured for each trial, and the mean of the two trials was adopted for the analyzing process[18].

Intervention

- **Physical therapy program:**

Children in group (A) received physiotherapy program for 20 children included the following elements: Exercises for equines correction include passive stretching[19], strengthening exercises for children with cerebral palsy [20], weight-bearing to reduce lower limb contracture through the use of tilting tables and standing frames through a prolonged stretch of the calf muscles[21], and stretching exercises to increase the power of weak dorsiflexors and the corresponding spastic agonists. Ankle joint mobilization, particularly dorsiflexion [22] and e) splinting (high level and custom molded) to restrict ankle plantar flexion and offer passive stretching for the shortened soft tissues, can improve the associated limited ankle ROM characteristic of this condition. These techniques are thought to be an efficient conservative treatment for stopping the progress of equines deformities [23].

Children in group (B) obtained the assigned physical therapy program as the same applied in group (A) altogether with FES for 45 min for 10 weeks.

Chattanooga Primera Portable:

The electrical pulses employed for stimulation are balanced, biphasic, and current-regulated; their amplitudes range from 8 to 50 mA (average values are 15 to 30 mA); their pulse widths are 250 s, and their frequencies are 40 Hz 24.

These variables were shown to elicit a muscular response while causing the patients the least amount of discomfort. A noticeable muscle contraction without any discomfort was anticipated to be brought on by FES. During the sessions, the currently applied intensity was selected based on the patient's sensitivity. The range of greatest intensity during therapy was between 28 and 44 mm. The child was seated in a cozy chair with his/her knees bent 90 degrees and wearing nothing but heels in direct contact with the ground 25.

The electrodes were positioned above the tibialis anterior muscle and close to its motor point on the skin surface of the involved foot. During the stance phase, antagonist stimulation was employed to help the dorsiflexors cause ankle dorsiflexion and prevent plantar flexion spasticity. A pair of electrodes stimulated the proximal part of the tibialis anterior (5 cm below the head of the fibula) to encourage dorsiflexion, whereas a different pair of electrodes stimulated the lateral gastrocnemius valley to encourage plantar flexion 26. The therapist observed the difference in ROM and its impact on muscle power in each group by measuring ROM both before and after therapy.

Statistical analysis:

Unpaired t-tests were done to carry out the comparison of subject characteristics among groups. Chi-squared test was utilized to compare the distribution of spasticity grades and sex between groups. Mann-Whitney U Test the GMFCS of the several groups were compared using a U test. To evaluate if the data seemed to have a normal distribution, the Shapiro-Wilk test was utilized. The homogeneity of variances among groups was investigated utilizing Levene's test. The dorsiflexion ROM, dorsiflexion strength and time to peak force were compared among groups utilizing an unpaired t-test. A paired t-test was used to compare each group's pre- and post-treatment data. The significance level for all statistical tests was p<0.05. For all statistical analyses, SPSS version 25 for Windows was utilized (IBM SPSS, Chicago, IL, USA).

Results

Subject characteristics:

Table (1) highlighted the subject characteristics of groups A and B. There was no clear variance among groups in terms of age, GMFCS, sex, spasticity grades and distribution (p > 0.05).

Table 1. Basic characteristics of participants.

	Group A	Group B	t- value	p-value
Age (years), Mean ± SD	8.35 ± 1.04	8.55 ± 1.39	-0.51	0.61
GMFCS, median	2	2	(U = 112.5)	1
Sex, n (%)				
Girls	11 (55%)	10 (50%)	(χ^2 = 0.1)	0.75
Boys	9 (45%)	10 (50%)		
Spasticity grades, n (%)				
Grade I	16 (80%)	14 (70%)	(χ^2 = 0.53)	0.46
Grade I+	4 (20%)	6 (30%)		

SD, standard deviation; **χ^2,** Chi squared value; **p-value,** level of significance

Effect of treatment on dorsiflexion ROM, dorsiflexion strength, and time to peak force:

Within group comparison:

There was a noticeable rise in dorsiflexion ROM post-treatment compared with that in the pre-treatment stage in both groups A&B (p > 0.001). The percent of change in dorsiflexion ROM in groups A and B was11.21 and 19.92% respectively **(Table 2).**

There was a clear increase in dorsiflexion strength and an apparent decrease in the time to peak force of dorsiflexion post-treatment compared with that pre-treatment in both groups A&B (p > 0.001). **(Table 3-4).**

Between groups comparison:

No substantial variance is noted between groups in the pre-treatment stage ($p > 0.05$). A comparison among groups post-treatments shown a noticeable increase in dorsiflexion ROM ($p > 0.01$) and dorsiflexor strength ($p < 0.05$) of group B compared with that of the group **(Table 2-3).** There was a significant decrease in time to peak force of group B compared with that of group A in the post-treatment stage ($p < 0.01$). **(Table 4).**

Table 2. Mean dorsiflexion ROMpre and post treatment of group A and B.

	Group A	Group B	MD	t- value	p-value
	Mean ± SD	Mean ± SD			
Dorsiflexion ROM (degrees)					
Pre treatment	11.6 ± 1.67	11.8 ± 1.47	-0.2	-0.4	0.69
Post treatment	12.9 ± 1.74	14.15 ± 1.46	-1.25	-2.45	0.01
MD	-1.3	-2.35			
% of change	11.21	19.92			
t- value	-7.25	-12.93			
p-value	*p = 0.001*	*p = 0.001*			

SD, standard deviation; **χ²,** Chi squared value; **p-value,** level of significance

Table 3. Mean dorsiflexors strength pre and post treatment of group A and B.

Strength (kg)	Group A	Group B	MD	t- value	p value
	Mean ± SD	Mean ± SD			
Tibialis anterior					
Pre treatment	0.73 ± 0.11	0.74 ± 0.1	-0.1	-1.02	0.31
Post treatment	0.76 ± 0.09	0.83 ± 0.11	0.24	2.57	0.01
MD	-0.03	-0.09			
% of change	4.11	12.16			
t- value	-5.64	-18.98			
p value	*p = 0.001*	*p = 0.001*			
Extensor hallucis longus					
Pre treatment	0.71 ± 0.09	0.73 ± 0.08	-0.15	-1.63	0.11
Post treatment	0.74 ± 0.09	0.84 ± 0.08	0.24	2.49	0.01
MD	-0.03	-0.11			
% of change	4.23	15.07			
t- value	-8.32	-21.55			
p value	*p = 0.001*	*p = 0.001*			
Extensor digitorum longus					
Pre treatment	0.72 ± 0.07	0.73 ± 0.08	-0.14	-1.58	0.12
Post treatment	0.74 ± 0.08	0.81 ± 0.08	0.2	2.26	0.02
MD	-0.02	-0.08			
% of change	2.78	10.96			
t- value	-8.82	-22.99			
p value	*p = 0.001*	*p = 0.001*			
Peroneus tertius					
Pre treatment	0.72 ± 0.06	0.74 ± 0.07	-0.1	-1.45	0.15
Post treatment	0.74 ± 0.07	0.82 ± 0.08	0.24	2.78	0.008
MD	-0.02	-0.08			
% of change	2.78	10.81			
t- value	-9.82	-40.89			
p value	*p = 0.001*	*p = 0.001*			

SD, standard deviation; **MD,** mean difference; **p-value,** level of significance

Table 4. Mean time to peak force of dorsiflexors pre and post treatment of group A and B.

Time to peak force (sec)	Group A	Group B	MD	t- value	p value
	Mean ± SD	Mean ± SD			
Tibialis anterior					
Pre treatment	4.31 ± 0.24	4.41 ± 0.37	-0.01	-0.29	0.77
Post treatment	4.13 ± 0.26	3.89 ± 0.31	-0.07	-2.51	0.01
MD	0.18	0.52			
% of change	4.18	11.79			
t- value	12.91	7.16			
p value	*p = 0.001*	*p = 0.001*			
Extensor hallucis longus					
Pre treatment	4.34 ± 0.24	4.49 ± 0.31	-0.02	-0.7	0.48
Post treatment	4.19 ± 0.27	3.95 ± 0.34	-0.1	-3.59	0.001
MD	0.15	0.54			
% of change	3.46	12.03			
t- value	12.18	11.38			
p value	*p = 0.001*	*p = 0.001*			
Extensor digitorum longus					
Pre treatment	4.34 ± 0.25	4.48 ± 0.31	-0.01	-0.43	0.66
Post treatment	4.07 ± 0.28	3.87 ± 0.26	-0.07	-2.51	0.01
MD	0.27	0.61			
% of change	6.22	13.62			
t- value	10.4	17.23			
p value	*p = 0.001*	*p = 0.001*			
Peroneus tertius					
Pre treatment	4.45 ± 0.22	4.55 ± 0.2	-0.02	-0.97	0.33
Post treatment	4.15 ± 0.22	3.91 ± 0.29	-0.08	-2.96	0.005
MD	0.3	0.64			
% of change	6.74	14.07			
t- value	13.99	13.92			
p value	*p = 0.001*	*p = 0.001*			

SD, standard deviation; **MD,** mean difference; **p-value,** level of significance

Discussion

The objective of current study was to detect the effectiveness of FES on equines foot and muscle power in children with diplegia. The obtained results showed clear variances among pre-and post-treatment in the two groups for each of the four dorsiflexor muscles (Tibialis anterior, Extensor hallucis longus, Extensor digitorum longus, and Peroneus Tertius) for all measured variables (dorsiflexion (ROM), time to a peak force of dorsiflexion, and dorsiflexion strength). Additionally, post-mean values for all variables that were assessed revealed a statistically significant difference in favor of the group (B).

Mobility is frequently hindered by spasticity, particularly when walking. Dropping a foot or true equines can be caused by ankle plantar-flexor spasticity, ankle dorsiflexor weakness, and inadequate selective control. Children with CP consequently frequently travel shorter distances and trip and fall more frequently [27].

Significant improvement of both groups was reinforced by **Dietz et al.**[28] who noted that the treatment of ankle equines by lengthening exercises of the Achilles tendon contributes to the development of crouch gait in an unacceptable number of spastic diplegic and quadriplegic children, comparing the pre-and post-treatment of the group (A) revealed significant differences in all measured variables. They found that many mobile patients with spastic diplegia saw a steady decrease in gait over time.

The previously obtained findings could be confirmed by **Ozen et al.**[29] who reported that physiotherapy after application on the equines foot of diplegic CP children. It maintains the biomechanics as well as ROM of the musculoskeletal system, improves muscular strength and endurance, provides a balance among agonist and antagonist muscles, and provides proprioceptive training.

However, for many years, the main treatment strategy for hypertonia in children with CP has been exercise intervention. To achieve this, physical therapy stretching programs for CP patients frequently involve passive, active stretching, as well as prolonged posture [19]. In this regard, stretching one to 3 sessions per week has been demonstrated to reduce spasticity in children suffering from CP, and a 30-minute exercise routine is a typical use [30].

Also, the results of current research were supported by previous research that has revealed that children with spastic CP had lower medial gastrocnemius muscle volume and ankle dorsiflexion angle; nevertheless, plantar flexor strength training would lead to increases in medial gastrocnemius muscle volume and ankle dorsiflexion angle [31]. Therefore, in these participants or other people in a similar situation, the extra advantages of physical therapy such as re-establishing the balance between muscle volume and strength as well as spasticity control should not be disregarded as useful [32].

Significant variations in all assessed variables between the pre-and post-treatment of the group (B) were found, supporting the claim made by **Moll et al.**[7] that FES lowers ankle joint muscle contraction by addressing defective reciprocal inhibition. FES causes the tibialis anterior muscle to contract, which inhibits the gastrocnemius muscle, allowing the foot to be properly prepositioned for the stance phase of gait. The observed improvements in the ankle joint's selective motor control may be attributed to this reciprocal inhibition in combination with the heightened awareness brought on by the stimulation.

Through its impact on higher centers, FES can lessen spasticity by desensitizing the spinal pathway generally in addition to its localized effects. This is consistent with **Kralj and Bajd's**[33]findings that electrical stimulation can potentially stimulate the remodeling of neuromuscular activity by impacting higher brain areas in addition to the nerve fibers that supply the muscles.

The stimulation of the peroneal nerve, which actively dorsiflexes the ankle and fortifies the muscles, has a positive impact on these children's ability to regain their walking gait. In addition to producing hip and knee flexion at high levels, common peroneal nerve stimulation has also been suggested to lessen or treat spasticity [34, 35]. This could result in a general improvement in walking ability and, possibly, a reduction in the price of oxygen use. Children may walk further and more efficiently throughout therapy, taking more steps while using less energy [26].

According to **Damiano**[36], performing progressive strength training activities daily is necessary to maintain the advantages of increased muscle strength and to enhance walking without causing increasing stiffness. Our research on the impact of stopping physical therapy treatments for spasticity may help in the creation of effective rehabilitation plans for kids with cerebral palsy.

It is in agreement with **Chiu and Ada's**[37] findings that FES is effective, that is, it is better than no FES intervention, but that it is no more effective than activity training, that is, practicing the activity without FES will be just as effective, when post-treatment mean values are compared between two groups (A and B). FES may be more efficient; it may be helpful for kids who have cognitive disabilities and find exercise programs challenging since the stimulation may call attention to the muscle that needs to be addressed.

Similarly, **Comeaux et al.**[38] showed that applying neuromuscular electrical stimulation (NMES) to the gastrocnemius or the gastrocnemius/tibialis anterior improved both range of motion and gait patterns. The reciprocal inhibition was credited with positive outcomes. The co-activation of the two muscles is reduced because activating the tibialis anterior inhibits the gastrocnemius and stimulating the gastrocnemius inhibits the tibialis anterior. NMES also offers proprioceptive input and functions as a form of biofeedback.

The restoration of normal muscle contraction sequences, which were compromised in children with CP and involved the activation of the anterior tibial group first, followed by the proximal lower limb muscles, and then the trunk muscles, maybe the cause of the improvement in postural stability in the group (B). Additionally, the FES increased synaptic transmission of intact neural fibers, the development of new synaptic pathways, and the support of linking alignments in the nervous system. This was accomplished by repeatedly and continuously stimulating the muscles and nerves [39].

The research of **Van der Linden et al.**[14] employed two groups in their study and found that FES of the ankle dorsiflexors had a substantial impact on gait kinematics after 2 weeks of neuromuscular electrical stimulation followed by 8 weeks of FES performed at home and school. FES was used for 8 weeks, but no long-term therapy effects were discovered. **Postans and Granat**[40], on the other hand, discovered that six of the 21 children who were initially recruited did not tolerate the stimulation. In this study, the patient's comprehension and acceptance of the electrical stimulation may have been aided by the two weeks of cyclic stimulation.

Maenpaa et al.[41] disagreed with the considerable improvement in favor of group (B), stating that numerous writers have noted that inconsistent terminology used in the field of NMES has made it difficult to evaluate and compare the findings of various investigations. **Prenton et al.**[42] also disputed the study's conclusions, arguing that, contrary to popular opinion, ankle foot orthoses exhibit the same favorable combined-orthotic benefits as FES on crucial walking metrics for stroke-related foot drop.

Physical therapy has not been shown to have a favorable impact on the treatment of hypertonia in several earlier trials. **Pin et al.**[43] found out that passive stretching alone was insufficient to maintain muscle length and recommendation that the addition of orthoses or casts to stretching programs would boost their efficacy. However, several research works have supported the clinical hypothesis that children with CP can benefit from physical therapy to reduce spasticity and avoid contracture [44].

It was determined in the current study that FES and designed physical therapy had a greater impact on reducing equines foot than designed physical therapy alone group in diplegic CP, rejecting the null hypothesis that there would be no effect of FES and designed physical therapy program on dorsiflexion ROM in cases of equines foot in diplegic CP.

Limitations of the study:

1. There was no analysis done of the psychological consequences of the treatment programs.
2. Sample size estimation was not conducted, so it is difficult to generalize the results.

Conclusion:

It was found that group (B) (designed physical therapy program and FES had greater effectiveness than group (A) (planned physical therapy program only) in reducing equines foot and improve muscle power in diplegic CP children. The designed physical therapy program and FES can be introduced to the physical therapy program.

Recommendations:

The following suggestions should be taken into consideration in light of the study's findings: Additional research is required to determine the impact of functional electrical stimulation on dorsiflexion range of motion in children with diplegic CP who have equines feet across a range of age groups. Additional research is required to determine the impact of FES and physical therapy programs on diplegic CP kids with flat feet. Additional research is required to determine how FES and specially developed physical therapy programs affect the muscle weakness and gait patterns of diplegic CP cases.

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Ethical approval:

The Ethical Committee of the Faculty of Physical Therapy at Cairo University approved this study (No: P.T.REC/012/003404)

Authors contributions:

HMH conceived and designed the study, conducted research, provided research materials, and collected and organized the data. **MSM and EHE** analyzed and interpreted data, wrote the initial and final drafts of the article, and provided logistic support. **All authors** have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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