
   Functional electrical stimulation to the dorsiflexors and quadriceps in children with cerebral palsy.

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   **PURPOSE:** To assess the effects of functional electrical stimulation (FES) of the ankle dorsiflexors and quadriceps in children with cerebral palsy.

   **METHODS:** Fourteen children (mean age 8 years) were randomly allocated to a treatment or control group. The treatment group received 2 weeks of neuromuscular electrical stimulation followed by 8 weeks of FES used at home and school. The control group continued with its usual physiotherapy program. Assessment took place at baseline and before and after the treatment period. Both control and treatment groups were fitted with FES for gait analysis at the second and final assessments.

   **RESULTS:** In both groups, FES of the ankle dorsiflexors resulted in a significant (p < 0.01) effect on gait kinematics. However, no long-term treatment effect of using FES for 8 weeks was found.

   **CONCLUSIONS:** FES for selected children with cerebral palsy, receiving adequate support, can be a practical treatment option to improve gait kinematics.

   **PMID:** 18300930 [PubMed - indexed for MEDLINE]

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Effects of strength training aided by electrical stimulation on wrist muscle characteristics and hand function of children with hemiplegic cerebral palsy.

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Nine children with spastic hemiplegic cerebral palsy underwent 24 sessions of wrist muscles strengthening in the extended wrist range aided by electrostimulation. Isometric strength of flexors and extensors was registered in three wrist positions (30 degrees of flexion, neutral, and 30 degrees of extension) to infer on angle-torque curves. Passive stiffness of wrist flexors and wrist flexion angle during manual tasks and hand function were also documented. Significant strength gains were observed at 30 degrees of wrist extension for flexors (p= 0.029) and extensors (p= 0.024). No gains were observed at 30 degrees of flexion. The difference in extensor strength between the three test positions changed after intervention (p< 0.034), suggesting a shift in the angle-torque curve. No changes were observed in passive stiffness (p= 0.506), wrist angle (p< 0.586), or hand function (p= 0.525). Strength training in specific joint ranges may alter angle-torque relationships. For functional gains to be observed, however, a more aggressive intervention and contextualized task training would probably be needed.
2. **CLIN REHABIL. 2010 NOV;24(11):963-78. EPUB 2010 AUG 4**

Children with cerebral palsy: a systematic review and meta-analysis on gait and electrical stimulation.

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**OBJECTIVE**: To conduct a systematic review and meta-analysis using the International Classification of Functioning to determine the summary effect of electrical stimulation on impairment and activity limitations relevant to gait problems of children with cerebral palsy.

**METHODS**: We identified 40 cerebral palsy and electrical stimulation studies, and 17 gait studies qualified for inclusion. Applying enablement classification methods to walking abnormalities created two subgroups: impairment (N = 14) and activity limitations (N = 15). Overall, 238 participants experienced electrical stimulation treatments and 224 served as a no stimulation control group. Calculations followed conventional data extraction and meta-analysis techniques:

(a) individual standardized mean differences,
(b) summary effect size,
(c) I² heterogeneity test,
(d) fail-safe N analysis and
(e) moderator variable analyses.

**RESULTS**: Common outcome measures associated with impairment (n = 3) and activity limitations (n = 6) were submitted to separate random effects models meta-analyses, and revealed significant cumulative effect sizes: (a) impairment = 0.616 (SE = 0.10) and (b) activity limitations = 0.635 (SE = 0.14). I² indicated low and medium amounts of dispersion, whereas fail-safe analyses revealed high N-values for both disablement categories. Moderator variable analyses further confirmed the positive treatment effects from both functional and neuromuscular stimulation.

**CONCLUSIONS**: The present systematic review and meta-analyses determined medium effect sizes for electrical stimulation on walking impairment and activity limitations of children with cerebral palsy.

**PMID**: 20685722 [PubMed - in process]

3. **PEDIATR PHYS THER. 2010 SUMMER;22(2):199-206**

Functional electrical stimulation to lower limb muscles after botox in children with cerebral palsy.

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PURPOSE: This study examined the effect of lower limb functional electrical stimulation (FES) after botulinum toxin injection in children with cerebral palsy on self-selected walking speed, plantar flexor and dorsiflexor muscle strength, and an optimal time frame for initiating FES after the injection.

METHODS: Five subjects participated in a single-subject design. All subjects received a single botulinum toxin injection into the calf muscle, followed by a 4-week FES home program. Three subjects followed the protocol as prescribed; 2 subjects received no FES.

RESULTS: FES after botulinum toxin increased isometric plantar flexor muscle strength, but did not produce changes in self-selected walking speeds or isometric dorsiflexor strength. A 32-day interval between botulinum toxin and the start of FES was most effective.

CONCLUSIONS AND RECOMMENDATIONS FOR CLINICAL PRACTICE: FES after botulinum toxin seems to be effective in improving some gait variables, although further research is needed for substantiation.

PMID: 20473105 [PubMed - in process]

4. ARTIF ORGANS. 2010 MAR;34(3):230-4

Botulinum toxin, physical and occupational therapy, and neuromuscular electrical stimulation to treat spastic upper limb of children with cerebral palsy: a pilot study.

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Spasticity has been successfully managed with different treatment modalities or combinations. No information is available on the effectiveness or individual contribution of botulinum toxin type A (BTA) combined with physical and occupational therapy and neuromuscular electrical stimulation to treat spastic upper limb. The purpose of this study was to assess the effects of such treatment and to inform sample-size calculations for a randomized controlled trial. BTA was injected into spastic upper limb muscles of 10 children. They received 10 sessions of physical and occupational therapy followed by 10 sessions of neuromuscular electrical stimulation on the wrist extensors (antagonist muscles). Degree of spasticity using the Modified Ashworth scale, active range of motion, and manual function with the Jebsen hand test, were assessed. Meaningful improvement was observed in hand function post treatment (P = 0.03). Median spasticity showed a reduction trend and median amplitude of wrist range of motion registered an increase; however, neither of these were significant (P > 0.05). There is evidence of a beneficial effect of the combined treatment. Adequate information has been obtained on main outcome-measurement variability for calculating sample size for a subsequent study to quantify the treatment effect precisely.

PMID: 20447049 [PubMed - indexed for MEDLINE]
5. **DEV MED CHILD NEUROL. 2009 OCT;51 SUPPL 4:154-65**

Review of electrical stimulation in cerebral palsy and recommendations for future directions.

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Electrical stimulation (ES) for treatment of neuromuscular disorders is introduced. Various forms of ES are defined. Characteristics of cerebral palsy (CP) and treatment options are given. The clinical objectives of ES for CP treatment are stated. A review of the literature for treatment in CP is given.

Several common themes within the literature and limitations in prior studies are explored. The majority of studies have used surface stimulation, which has several inherent limitations. To address these limitations, implanted devices may be used. Implanted device systems include percutaneous stimulation systems, and fully implantable leded systems. While both of these technologies have advantages over surface stimulation, they also have their own limitations. To further address the limitations of percutaneous and fully implantable leded systems, the Alfred Mann Foundation has developed a completely implantable, telemetered device known as the Radio Frequency Microstimulator (RFM). Results from a study using the RFM for arm rehabilitation in poststroke patients are given. A list of desirable design features for an ES system for CP is given. The next generation microstimulator device under development at the Alfred Mann Foundation is presented. This device may well serve the needs for ES in CP.

PMID: 19740224 [PubMed - indexed for MEDLINE]

6. **NEUROREHABILITATION. 2009;24(3):209-17**

Neuromuscular electrical stimulation of the gluteus medius improves the gait of children with cerebral palsy.

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Neuromuscular electrical stimulation (NMES) of the gluteus medius muscles using a surface electrode during functional walking training has never been reported as a management option to improve gait in spastic diplegic children.PURPOSE: This study was investigates the short and longer term effects of simultaneous continuous NMES of both hip abductors during walking on the temporal-spatial gait characteristics and hip adductor muscle tone in children with spastic diplegia caused by cerebral palsy (CP).

**SUBJECTS:** Three groups of subjects participated: an experimental group of twenty-one ambulant spastic diplegic children; a CP control group containing ten ambulant spastic diplegic children; and a healthy control group with twenty normal children.

**METHOD:** The experimental group received three different NMES management programs. The first NMES program was designed to evaluate the immediate short-term effects of simultaneous continuous NMES of both gluteus medius muscles during walking.
The second NMES program aimed to evaluate the effect of 15 minutes of simultaneous and continuous NMES of both gluteus medius muscles during walking, three sessions a day for a week. The third program was similar to the first and was designed to detect any additional changes in gait after full adaptation to NMES and completion of the second program. A dual channel stimulator with self-adhesive electrodes at the tolerable motor threshold level was used with a frequency of 20 Hz and pulse width of 50 micros. The effect of NMES programs was assessed using a three-dimensional gait analysis system and the Modified Ashworth Scale.

RESULTS: Significant improvement in the temporal-spatial parameters and hip adductor muscle tone of the experimental group (p < 0.001-0.05) was observed.

CONCLUSION: The NMES management programs used in this study improved the gait of spastic diplegic CP children.

PMID: 19458427 [PubMed - indexed for MEDLINE]


[Rehabilitation treatment of patients with children cerebral palsy using functional muscle electrostimulation during gait].

[Article in Russian]

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A technique for investigation of biomechanical and electromyographic parameters of gait in patients with diplegic form of children cerebral palsy (CCP) was described. Peculiarities of biomechanical and innervation structure of locomotor act in such patients were found. Recommendations for muscle electrostimulation during gait were specified. The best therapeutical effect was achieved in the combined four-channel electrostimulation of gluteus maximus muscles in the first half of support phase and of anterior tibial muscles in the end of the support phase and during the transfer phase. The muscle electrostimulation during gait demonstrated a positive effect of the treatment on the process of movement rehabilitation of CCP patients with diplegic form.

PMID: 19156083 [PubMed - indexed for MEDLINE]