INERVENTIONS

THE INERVENTION´S METHOD

Appendix A: Research Evidences on Electro Therapy in the treatment of spasticity

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Electro-therapy as a feasible method to treat spasticity

Electro-Therapy (ES) is a minimally invasive method with high potential in the treatment of motor impairment pathologies first used as therapeutic treatment in 1997[1, 2] although it use as a therapy strategy began in patients with motor function impairment of the upper extremity in 1979[3]. It is based in the application of electrical currents to the muscles and/or tendons in order to elicit muscle contraction or afferent fibers stimulation reactivating the spinal cord circuits and its neurons. There are several modalities depending on the length and intensity of stimulation. We will focus mainly in two out of the three modalities of Electro-Therapy (TES and NMES also mentioned in some works as TENS). Distinctions between these modalities is worth of mention including protocols of stimulations and studies (either open or Random Control Trials-RCTs-) supporting the efficacy of this methods.

Methods mentioned here are used to modify impairments and activity limitations as a consequence of spasticity in children with CP, adults with some kind of spinal cord injury and stroke. The following table describes the main three different modalities of ES used in many open studies and RCTs.

There are a huge number of reports and research articles in the literature supporting the use of one of these modalities in the treatment of spasticity in different UMN syndromes. We will focus in some of them pointing out the major differences and agreement between reports, as well as how these modalities have been using in different disease, especially in CP, stroke and Spinal Cord Injury (SCI). Last, all the data present in this sections comes from different review and meta-analysis performed among several hundreds of reports on ES as a therapy against spasticity, among the reviews the reader will find meta-analysis in ES in children with CP[4-6], Patients with Spinal Cord Injury (SCI) (http://www.bu.edu/drrk/research-syntheses/spinal-cord-injuries/spasticity)[6] and in stroke patients[6, 7].

Children with CP: Kerr and colleagues (2004)[4] classified the different studies in 5 different levels of empirical research, having the level I or RCT, level II or non-RCT, level III Case-control study (comparison of a study with a historical control group), level IV Before and after the case and a level V or non-empirical research level (Anecdotes and/or experts´ opinions).

Authors	Study Design	Type of CP	Intervention	Control	Outcome measures	Results
[8]	Matched groups RCT	Hemiplegia, diplegia and quadriplegia	NMES (plus physiotherapy)	Usual physiotherapy	Gait analysis, muscle strength, ROM, GMFM, parent questionnaire	ns (all measures)
[9]	RCT	Diplegia	TES (plus physiotherapy)	Usual physiotherapy	GMFM, seat postural control, MMT, muscle tone, ROM, PCI	GMFM ($p=0.001$), other measures ns
[10]	Matched groups RCT	Hemiplegia	NMES (plus physiotherapy)	Usual physiotherapy	ROM, MMT, gait analysis	Active and passive ROM and strength ($p<0.05$)
[11]	RCT	Diplegia	NMES (plus physiotherapy)	Physiotherapy	Radiographic measurement of kyphotic, Cobb´s and lumbrosacral	Kyphonic angle, GMFM sitting score

					angle, GMFM sitting score	(p<0.05) other measures ns
[12]	Crossover RCT	Diplegia	TES (physiotherapy and stretching program)	physiotherapy and stretching program	Gait and LL function, MMt, PDMS	ns (all measures)
[13]	RCT	Hemiplegia, diplegia	TES (plus physiotherapy)	Placebo and usual physiotherapy	Quantitative motor-function test, ROM, Ashworth, muscle bulk	ns (all measures)

Table 8. Summarize of all level I and II empirical research performed using one type of ES in children with CP.

Authors	Type CP	Intervention	Outcome measure	Results
[14]	Hemiplegia	NMES	Hand function, active ROM, wrist movement	Hand function and active ROM (p<0.05)
[15]	Diplegia, hemiplegia	EMG-triggered NMES	Gait, UL videography, goniometry, PDMS	ns (all measures)
[1]	Diplegia, hemiplegia	TES (own controls)	PDMS	All test significant (p<0.01)
[16]	Diplegia, hemiplegia	NMES	Gait	P=0.001

Table 9. Level III and IV of empirical research studies performed on children with CP

Continuing with the review all the level V studies (n=8) reported an improvement in one of the functions and parameters studied[17-22]. We will not mention level VI studies as they are only observations with no quantifications. As we can see the effects of ES in open studies (level III and IV) are greater than those expose in the RCT (level I and II). Summing up, the results from ES as a therapy method in children with CP are very promising, although it is argued the need of increasing the number of RCT and standardized protocols[23, 24].

Note: as we will see in the next chapter inervention´s method is based in level IV studies through the assessment of the mobility and spasticity level in patients before and after using Molli® for a 1 hour's session.

Cauraugh and colleagues (2010)[5] performed a meta-analysis of few selected reports divided in two different groups (n=14 for impairment and n=15 for activity limitations) with a total of 238 patients treated with ES and 224 as control. After performing a heterogeneity test the results showed a positive effect in ES therapy improving the walking impairment and activity limitations of children with cerebral palsy (see Figure 6). Regarding to the studies included in the impairment meta-analysis several of them were performed using NMES[10, 16, 25-28] while others reports differences in the effect size using TES[9, 12, 25]. Regarding to the activity limitation, effectiveness several of the studies addressing walking impairment also are cited in this analysis, and here we can point out that the results were positive using any of the forms of ES available[9, 13, 25, 27, 29, 30].

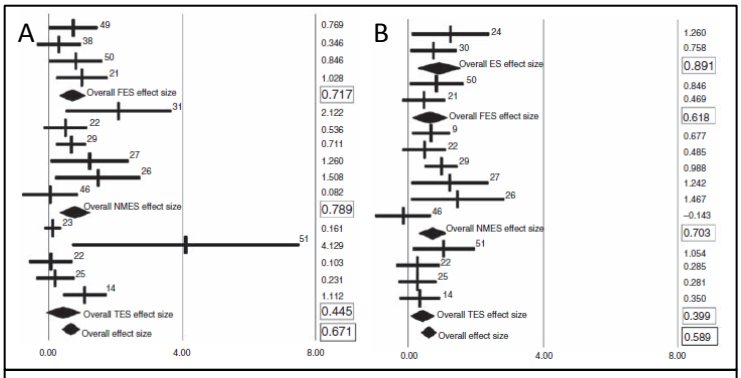

Figure 6. Forest pots showing the individual effect sizes of the 15 (A) and 14 (B) studies based on the impairment and activity limitations respectively. *Modified from Cauraugh et al., 2010*

Summarizing the results presented in ES therapy for the treatment of Cerebral Palsy, we could say that the effects of any type of ES on the spasticity level, as well as in the function improvements are generally positive. Furthermore we have pointed out here that due to these meta-analysis studies, it would be safe to assume the validity of this positive effect, as the heterogeneity or variability of the results among all these kind of studies is low, or said in other words the correlation of the effect of ES is high and reproducible among children suffering of CP.

SCI patients: Spasticity after spinal cord injury (SCI) is a common, complicated, and often frustrating impairment that is generally considered both a "health" problem[31]and a deterrent to function and quality of life[32]. The amount of reports describing effects of ES in the spasticity generated upon SCI are less compare with children with CP. Nevertheless, all the studies here review show positive results of ES treatment in spasticity level and functional recovery. Moreover some of the articles here cited attribute these therapeutically effects to the activation of reciprocal inhibition. Various methods have been employed to treat spasticity of SCI origin among them we can cite: stimulation to the antagonist muscle, application of tetanic contraction to the spastic muscle, functional electrical stimulation (FES), and transcutaneous electrical nerve stimulation (TENS), reporting beneficial effects up to 3 hours after the treatment[33-36]. The mechanism suggested for these positive effects vary among the reports, level of spasticity and muscle groups reported: Stimulation of the antagonist muscle: augmentation of reciprocal inhibition of the spastic muscle[33] Repetitive tetanic stimulation of spastic muscle: fatigue of the muscle due to repetitive tetanic stimulation[33] FES: change the mechanical properties of a spastic joint by strengthening the antagonists of the spastic muscle or might decrease the hyperactivity of spastic muscles through reciprocal inhibition[37] TENS: may involve the stimulation of large diameter afferent fibers that travel from mechanoreceptors to the spinal cord[33]. Other reports have empathized the positive effects only in the spasticity and clonus level[38, 39]. Overall these reports indicated the positive effect of ES in the treatment of spasticity in SCI patients.

Stroke patients: Spasticity upon stroke is been reported to be treated using ES in all its modalities. One of the most notable reviews is done by Quandt and colleagues (2014)[7]. These authors state the obvious benefits of FES in the treatment of spasticity in stroke patient. Although this review is about FES, which is not the electrical therapy modality exerted by Molli®, it does however bring clear and solid evidences of the benefits of the ES treatments from a numerous amount of reports. On the other hand, other reports have been published stating the benefits of other modalities of ES in stroke patients[40]. The overall results from all these studies are that either NMES or FENS are valid and solid therapies to treat spasticity in stroke patients[6, 41-45]. However as we will see in the next chapter, one of the most exciting observations coming out of the application of ES in stroke patients is the possibility that this therapy may affect processes of neuroplasticity, helping the CNS to keep the uninjured cells and support the compensation mechanism exerted by other brain areas upon damage after a ischemic episode in the brain.

Summary

The inervention´s method is based in the application of electrical stimuli onto the muscles in order to facilitate the process of reciprocal inhibition exerted naturally by the central nervous system at the spinal cord level. As we have discussed before ES is a non-invasive, feasible and relatively cheap effective method that helps the body to "train neuronal circuits" in order to reduce spasticity. Most of the reports presented in clinical research are open studies, that is, not so "rigorous" controlled studies. This is true in all cases and therapies proposed to treat spasticity, in many of the reviews and meta-analysis performed in each single of the therapies available two main conclusion can be drawn out of them: **Necessity of more RCT and the combination of therapies in order to achieve the best results.** Summarizing all articles and research reports here presented, there is no an infallible method, but these methods should be considered depending on the type of disease, outcome, type of patient, degree of the symptoms and severity. All other methods here mentioned have also been proven to help in spasticity and most notably as many authors have claimed a therapy approach based in the combination of two or even three of these methods, which could add an additive effect and better and faster positive outcomes in the spasticity´s therapy. Nevertheless ES is the only method available to date that promoters training at different levels (muscle contraction, neuronal synapsis, information transmission…) making possible to train neuronal circuits to achieve an improved outcome in the treatment of spasticity.

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