Efficacy of Surface Electrical Stimulation in treatment of cerebral Palsy Children: A Systemic Review

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ABSTRACT

Background and Objectives: *To conduct a systemic review to summarize the effect of surface electrical stimulation (SES) in treatment of problems that affects the motor performance of children with cerebral palsy (CP).* ***Data Sources:*** *50 cerebral palsy and electrical stimulation studies were identified and only 25 studies were accepted.* ***Data extraction:*** *Studies were classified according to the level of intensity of electrical stimulation into motor level including; neuromuscular (NMES) and functional (FES) and sensory level including; therapeutic electrical stimulation (TES), microcurrent and transcutaneous electrical nerve stimulation (TENS). The aim of the studies and the measured variables were extracted and its effects were analyzed.* ***Data Analysis:*** *surface electrical stimulation was highly effective in increasing both active and passive ROM and in improving upper limb function. It was effective in decreasing spasticity, improving gait, strength, gross motor function in lower limb and increasing trunk control and sitting balance.* ***Conclusion:*** *In conclusion, SES is considered a beneficial treatment tool in rehabilitation of subjects with CP. It has a significant result in improve gait, gross motor function in lower limb and upper limb and to improve trunk control and sitting balance. From the literature, there is more evidence to use motor level than sensory level of stimulation and in motor the evidence to use NMES more than FES.*

Key words: *Cerebral Palsy, Surface Electrical Stimulation.*

INTRODUCTION

Cerebral palsy (CP) is the most common pediatric neurological disorder that occurs secondary to one-time lesion lesions of the brain in the early stages of development with a resultant of several motor problems, cognitive dysfunction, communication difficulties, epilepsy, sensory disorders and behavioral problems[50]. The prime focuses of rehabilitation problems on children with cerebral palsy are spasticity, postural problems, muscle weakness and inability to manage everyday activities. These are all factors that can lead to a loss in walking ability, difficulties with transferring oneself and general passivity[4,38].

One of the most common impairments that lead to walking disabilities in CP are muscle weakness and imbalance between agonist and antagonist muscles with a result of muscle contractures and deformities. For example, equines foot affects gait and occurs due to weakness of the tibialis anterior and triceps surae muscles. Weakness of tibialis anterior may decrease foot clearance, which may cause stumbling and falls[39].

Imbalance between agonists and antagonists, spasticity, alignment problems, decreased strength, and impaired motor control are responsible for upper limb impairment which affects the performance of activities of daily living[5]. A common upper limb motor deficit in CP is the stereotypical posture of wrist flexion and ulnar deviation, coupled with finger and thumb flexion into the palm, hinders grasp and release[27].

Children with CP often show the difficulty to achieve well-balanced sitting posture with poor sitting posture such as flexed trunk with kyphotic spine and asymmetry of trunk[44].

In rehabilitation of neurological disorders, electrical stimulation (ES) is considered as a one of the several treatment modalities[29]. In CP, ES can be effective in improving range of movement[21], strengthening muscle[20], and reducing spasticity[10]. ES is considered as a passive, non-invasive, home-based therapy[21,61]. ES is thought to reduce spasticity through stimulation of the antagonist muscle[3], reduce spasticity[10], reduce co-contraction[13], and/or create soft-tissue changes permitting an increased range of motion[62]. It is believed that the effectiveness of strengthening programs may be further enhanced with the addition of ES[41]. So, it might provide an alternative to resistive exercise techniques for children with poor selective muscle control and improve treatment compliance in those children who find exercise programs difficult[30].

The ES shows evidence for improving walking capabilities as it has the potential to offer active muscle assistance that can overcome the locomotor deficiencies experienced by children with CP[47]. Also, several studies have reported improvement in hand function or use following ES treatment. Improvement in active wrist movement and performance of timed object manipulation tasks may be maintained after the stimulation protocol is ended[62]. Although ES has been shown to be useful in the rehabilitation of CP[29], therapists have fears of increasing spasticity through electrical stimulation. For this reason, ES is not a common practice for CP patients[18].

The ES has been applied in different ways, and, therefore, it is important to distinguish between the various types. Stimulation can be applied functionally: stimulation is triggered to assist in a functional activity[62]. ES can be applied therapeutically for shorter durations at the neuromuscular junction and at sufficient intensity to cause muscle contraction[30]. Finally, ES is applied at a low intensity level below contraction level[53].

Need of the study

Surface electrical stimulation (SES) was applied in different types, parameters and levels of intensities to different types of CP for different aims. Early reports on the efficacy of electrical stimulation are undermined by poor methodology. A lack of consensus on optimal treatment parameters and variation in the physical abilities of the participants further confound interpretation of the literature. Using SES alone or with additional modalities like dynamic bracing[40] or with passive stretching[31] may interfere with the obtaining these aims and leads to inconsistency of result.

ES may or may not produce a muscle contraction depending on the intensity of the current. There are primary types of electrical stimulation used to modify impairments and activity limitations in children with CP.

Neuromuscular electrical stimulation (NMES) is the application of an electrical current of sufficient intensity and short in duration to elicit muscle contraction. When applied in a task specific manner, in which a muscle is stimulated when it should be contracting during a functional activity, the stimulation is referred to as functional electrical stimulation (FES)[58]. (TES) has been described as a low-level, sub-contraction electrical stimulus applied continuously for a long duration at home during sleep[17]. Microcurrent or low-intensity direct current stimulation works at the microampere level and thus mimics the electrical intensity found in the living tissues[34]. Transcutaneous Electrical Nerve Stimulation (TENS) is the use of electric current produced by a device to stimulate the nerves for therapeutic purposes. TENS is applied at high frequency (>50 Hz) with an intensity below motor contraction (sensory intensity)[1].

These inconsistent findings clearly indicate a need for a systematic review. Indeed, investigating ES studies will increase our understanding about effective treatments. There are many problems affecting motor performance of CP subjects and different types of ES applied to stimulate different muscle and/or muscle groups in upper, lower limb or even trunk. So, there is need to conduct this type of research to summarize effect of SES used in different previous studies and the amount of SES, as non invasive technique, recommended to achieve that effect on problems which affect the motor performance like increased spasticity, decreased range of motion, impaired trunk control, gross motor function in upper, lower limb or grip and pinch strength in upper limb in children with CP.

METHODS

Search strategy:

A search was conducted for articles, written in English, on the use of electrical stimulation for treatment of children with CP. Computerized databases were searched for cerebral palsy and electrical stimulation articles focused on the following computerized databases: 1) Pubmed. 2) EBSCO Hot Data Base. 3) Medline. 4) Sage Journal online. 5) CINAHL. 6) Embase. Key search words included cerebral palsy, surface electrical stimulation, electrotherapy and electrostimulation.

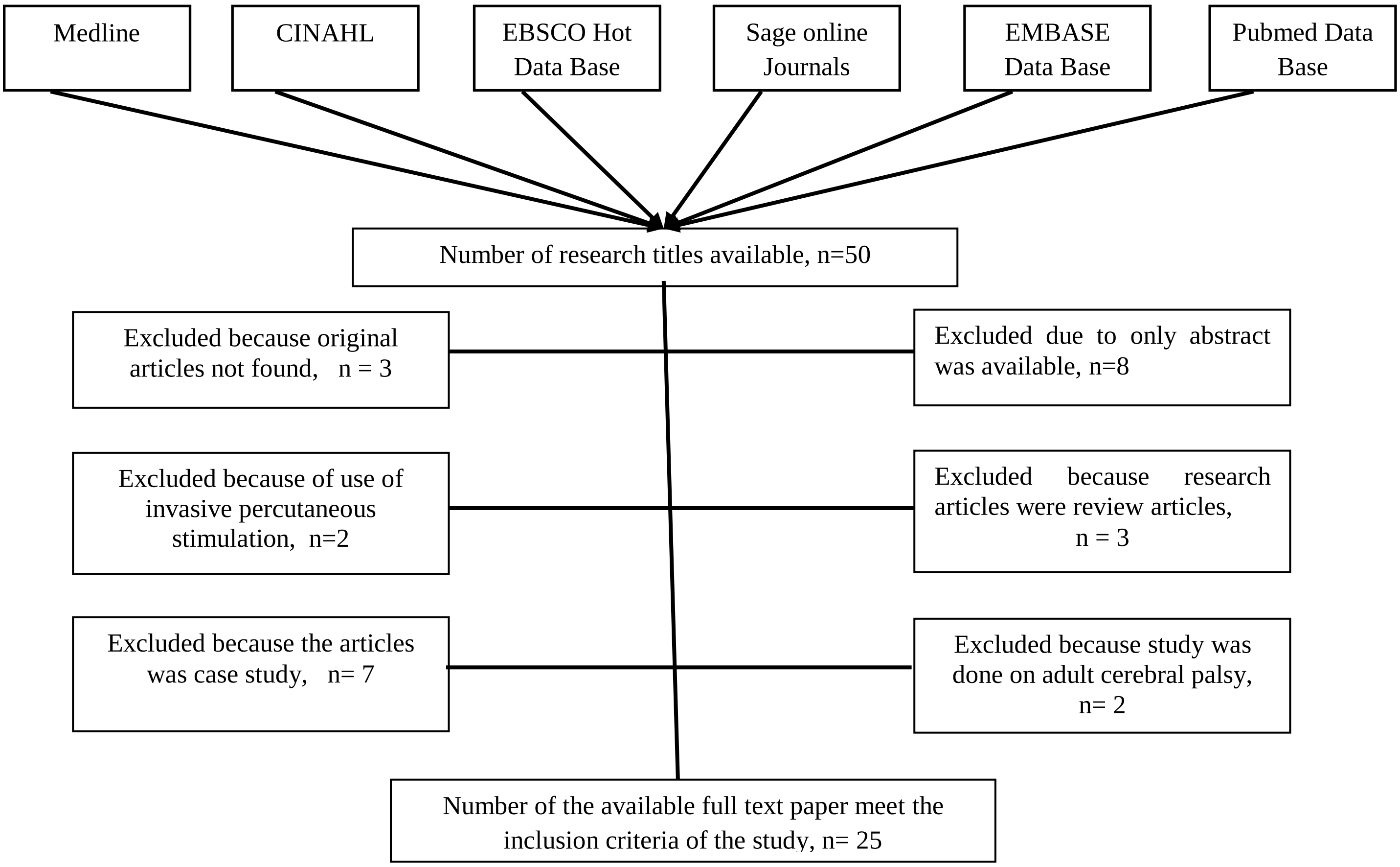
Inclusion and exclusion criteria

All trials investigating surface electrical stimulation for the treatment of CP subjects were included. The initial literature search identified 50 articles include all search words. All search result was collected and reviewed to follow certain criteria and to exclude the unrelated articles according to inclusion and exclusion criteria. The excluded articles based on the following criteria as shown in flow chart in figure 1.

Articles were excluded if electrical stimulation was not the primary intervention, if the participants were not diagnosed with CP, if they were review articles[12,23,29,44], full article was not available[6,9,42] or abstracts[10,26,43,45,46,52,55,59]. According to the nature of the study with an electrical stimulation treatment for children with cerebral palsy, Literature reviews and case studies were excluded[7,11,16,46,56,61].

Another exclusion criterion involved the studies used invasive intramuscular percutaneous stimulation which is not applied in physical therapy clinical practice[39,54]. The last exclusion criterion involved the studies were applied on Adult cerebral palsy patients[25,56,61].

The remaining 25 studies were included for data extraction. Each study used specific surface electrical stimulation protocol as an intervention in treatment of CP subjects. Table (1-3) provide specific details about each study include CP type present in the study, number of patient participated with their mean ages, the aim of the study, the variables measured and the results. The authors were arranged in alphabetical order. The next tables (4-6) provide the specific characteristics in each study of the electrical stimulation in either motor level; NMES (Table 4) and FES (Table 5) or sub-threshold sensory level as in (table 6) including TES, microcurrent and TENS.



Flow chart 1: summary of the available articles for data extraction.

Table (1): Review of studies used electrical stimulation in CP subjects for gait improvemment.

Author name	Design of the study	N. of Patients	Mean age	C.P Type	Aim of study	Variables measured	Results
Al-Abdulwahab and Al-Khatrawib[2]	Quasi-experiment (non-randomized)	31	7.4	31 diplegia	improve gait	Muscle tone Gait recording and analysis	Significant declined in muscle tone and improvement in the temporal-spatial parameters.
AlAbdulwahab and Al-Gabbani[1]	randomized, controlled clinical trial	35	10.22	27 diplegia	improve standing and, gait,	Spasticity Gait performance Knee position	Significant improvement was recorded in spasticity of hip adductors and gait parameters.
Comeaux et al.,[15]	Randomized cross-over design	14	9.14	10 Diplegia 4 Hemiplegia	Improve gait	Ankle range of motion Dorsiflexion at heel strike	Significant Improvement in variables measured
Durham et al.,[19]	Quasi-experiment (non-randomized)	10	9.5	10 Hemiplegia	Improve asymmetrical walking /gait	Foot contact symmetry	Significant Improvement in Heel–toe contact pattern and symmetry
Hazlewood et al.,[21]	Non-blind randomized trial	20	8.67	20 hemiplegia	Improve gait by stretching	Active ankle dorsi-flexion with knee flexed; Passive range of motion Gait patterns	Significant Improvement in passive range of movement and little change to Gait analysis
Ho et al.,[22]	Randomized cross-over design	13	7.57	5 Diplegia 4 Hemiplegia	Improve gait	Kinematic data (impulse and stiffness) stride length and Frequency	Significant increasing impulse during walking but not in decreasing stiffness, stride length and Frequency
Jeronimo et al.,[24]	Quasi-experiment (non-randomized)	10	4.6	5 Hemiplegia	Improve gait	Step symmetry	Significant improvement in gait symmetry in the step lengths.
Liron-Keshet et al.,[32]	Quasi-experiment (non-randomized)	60	7.7	60 diplegia	improve the quality of gait	Range of knee and ankle motion Gait recording and analysis	Non significant improvement in gait quality occurred
Postans et al.,[47]	Quasi-experiment (non-randomized)	8	13.2	6 diplegia 2 hemiplegic	Improve ambulation	motion analysis kinematic data, temporal–spatial variables mode of initial contact	Significant Improvement in variables measured in 5 of 8 patients.
Sommerfelt et al.,[53]	Randomized cross-over design	16	8.69	12 Diplegia	Improve ambulation and muscle strength	Ankle dorsi-flexion: sitting; Video evaluation by 3 physical therapists	No significant effect of TES on motor or ambulatory function
van der Linden et al.,[58]	Single-blind randomized trial	18	8	6 Diplegia 6 Hemiplegia 2 Monoplegia	improve gait kinematics	Peak dorsi-flexion in swing. Gillette gait index	Significant effect on gait kinematics

Table (2): Review of studies used electrical stimulation in CP subjects for gross motor function improvement.

Author name	Design of the study	N. of Patients	Mean age	C.P Type	Aim of study	Variables measured	Results
Dali et al.,[17]	Double-blind randomized trial	82	10.92	32 Diplegia 25 Hemiplegia	Improve motor function	ROM Degree of Spasticity Muscle growth Leg ability index	No significant differences in variables measured
Katz et al.,[28]	Case–control study	7	3.3	4 Diplegia 1 Hemiplegia	Improve motor function	Active knee moment for extension	Significant increase in the average motion velocity. Decrease in motion jerk and quadriceps-hamstrings co-contraction.
Kerr et al.,[30]	Non-blind randomized trial	63	11	55 Diplegia 1 Quadriplegia 1 Dystonia 1 Ataxia 2 Non-Classifiable	Improve strength	Peak torque, most affected leg: post NMES & post TES Gross motor function post NMES & post TES	No significant differences in strength or function. Significant differences in impact of disability
Khalili et al.,[31]	Non-blind randomized trial	11	13	11 Diplegia	Improve motor function	Spasticity Passive knee extension	Significant decrease in the spasticity score and increase in passive knee extension.
Maenpaa et al.,[34]	Quasi-experiment (non-randomized)	12	10.0	12 hemiplegia	Increases (ROM) of the ankle joint	Active and passive ankle dorsiflexion	Significant increase in the passive ROM of ankle dorsiflexion.
Nunes et al.,[36]	Single-blind randomized trial	10	11.34	10 Hemiplegia	Improve range of motion Muscle strength Gross motor function	Active ankle range of motion. Muscle strength Gross motor function	Significant increases in muscle strength, gross motor function and passive ROM of ankle dorsiflexion and in active dorsiflexion in the first group
Steinbok et al.,[55]	Single-blind randomized trial	44	7.21	44 Diplegia	Improve motor function	Hip abductors strength Maximum passive hip extension Gross motor function	Significant Improvement in variables measured
van der Linden et al.,[57]	Single-blind randomized trial	22	8.5	14 Diplegia 7 Hemiplegia 1 Quadriplegia	Improve motor function, strength and gait	Maximum passive hip extension Gross motor function	No statistically or clinically significant improvement in variables measured

Table (3): Review of studies used electrical stimulation in CP subjects for upper limb function and trunk control improvement.

Author name	Design of the study	N. of Patients	Mean age	C.P Type	Aim of study	Variables measured	Results
Cila et al.,[14]	Quasi-experiment (non-randomized)	13	5.92	13 hemiparesis	Improve upper limb function	Wrist extension range of motion Quality of Upper Extremity Skills	significant improvement in wrist extension range of motion
Kamper et al.,[27]	Quasi-experiment (non-randomized)	8	10	8 hemiparesis	Decrease the upper limb impairment	Wrist extension ROM Spasticity, Passive Resistance, Maximum voluntary Strength	Significant improvement in wrist extension range of motion and extensor strength across wrist postures against gravity. No significant change in spasticity
Maenpaa et al.,[35]	Quasi-experiment (non-randomized)	12	3.9	12 Hemiplegia	Improve motor function : range of motion and strength	Hand function ROM Forearm muscles strength	Significant Improvement in Active elbow extension, wrist dorsiflexion, and forearm supination
Ozer et al.,[40]	Single-blind randomized trial	24	8.7	24 hemiplegia	Improve upper limb function	Dexterity of the upper extremity. Grip and pinch strength.	Significant effect of combined NMES with bracing lasted for only 2 months after discontinuation of the treatment.
Park et al.,[44]	Single-blind randomized trial	26	13.6	14 diplegia	improving sitting balance	Cobb's angle Kyphotic angle lumbo-sacral angle Sitting Gross Motor Function	Significant improvement in kyphotic angle, sitting Gross Motor Function. No significant effect to Cobb's angle
Wright and Granat,[62]	Quasi-experiment (non-randomized)	8	10	8 hemiplegia	Improvements in hand function	Active wrist extension Wrist extension moment	Significant improved Hand function and active wrist extension

Table (4): Neuromuscular electrical stimulation treatment characteristics.

Author name	Parameters	Frequency of treatment	Site of Stimulation
Al-Abdulwahab et al.,[2]	Biphasic asymmetrical waveforms with frequency of 20 Hz and pulse width of 50 μs.	15min./3 Session for 7days	gluteus medius muscles
Comeaux et al.,[15]	32 Hz stimulation; 0.5 s onset; amplitude turned slowly until visible contraction observed; in comfort range.	15m / 7D / 4 weeks	Gastrocnemius
Kamper et al.,[27]	Symmetric biphasic pulses pulse duration was fixed at 280 μs, stimulation frequency was set to 35 Hz, and a pattern of five seconds extensors on/five seconds extensors off/five seconds flexors on/and five seconds flexors off was employed. Ramp up time was set to 0.5 seconds and ramp down time to zero.	15 minutes / 6 weeks/ 12 weeks.	wrist flexor and extensor muscles
Kerr et al.,[31]	35 Hz stimulation; pulse duration 300 ms; on:off time 7 : 12 s; ramp up 2 s; ramp down 1 s; NMES: 60 min at highest intensity tolerated;	5 days/week for 16 weeks	quadriceps muscles
Khalili et al.,[31]	30 Hz stimulation; pulse-width 0.4 ms; on : off time 4 : 4 s; ramp up 0.5s	3times/week for 4 weeks	quadriceps muscles
Nunes et al.,[36]	50 Hz; pulse-width 250ms stimulation; current intensity 28–44 mA; on:off time 5 : 10 s	Group 1: 14 sessions Group 2:7 sessions	anterior tibial muscle
Ozer et al.,[40]	Biphasic symmetric rectangular pulses with a 200 ms duration. The pulse rate ranged between 40 and 60 pulses/second	30-minute /two sessions/ 6 months	Wrist extensors
Park et al.,[44]	Intensity 25-30 mA intensity, 250 /jsec pulse width, 35 Hz frequency, 10 sec on /12 sec off interval.	30 / 6 for 6 weeks	abdomen and posterior back muscles
van der Linden et al.,[57]	Asymmetrical rectangular biphasic pulse; 5–15 s on:off cycle; rest period 5–15 s; duration 60 min. Varying frequency: 10 Hz–1st week; 30 Hz–1st session, 2nd week; 10 Hz–2nd session, 2nd week. Time between pulses: 75 ms–1st week, 100 ms–1st session and 75 ms–2nd session, 2nd week	6 days/week for 8 weeks	gluteus maximus

Table (5): Functional electrical stimulation treatment characteristics.

Author name	Parameters	Frequency of treatment	Site of Stimulation
Cila et al.,[14]	The Intensity of stimulation ranged from 10mA to 40mA, frequency 50Hz, pulse width T 300us.	15-30 min. / 5 days / 3 weeks.	wrist extensor muscles
Durham et al.,[19]	40 Hz stimulation; pulse width 3 to 350ms and ramp of 0–4 s; intensity 15–100mA	12 weeks	Ankle dorsiflexors
Ho et al., 2006[22]	32 Hz stimulation; ramp time of 0.2 s and pulse duration of 300ms; amplitude 10–40 mA; 15 trials/session	2 sessions	gastrocnemius-soleus muscle
Jeronimo et al.,[24]	biphasic, symmetric current, at a pulse frequency of 40 Hz, and pulse width of 250 ms. The ON – OFF relation of the stimulation cycles was of 1/2 (TON < 6 seconds and TOFF < 12 seconds).	25min. / 3 times / for 12 sessions.	anterior tibial muscle
Postans et al.,[47]	pulse frequency was set to either 33Hz or 50Hz, depending on the child's preference. The pulse width was 300μs. The rise time for stimulation intensity was between 0.1s and 0.2s following onset.	2 sessions in two days for 10 consecutive walks of 6 metres	Ankle dorsiflexion Knee extension
Van der Linden et al.,[58]	Amplitude range 20–70 mA; pulse duration 3–350 ms; frequency: 40 Hz (FS); duration whole day, except sports activity time	6 days/week for 8 weeks	ankle dorsiflexors and quadriceps
Wright and Granat[62]	frequency of 30 Hz, and a pulse width of 300 ms. on-time of 10 s (includes a ramp up of 1 s, and a ramp down of 1 s), an off-time of 10 s	30-minute daily sessions for 6 weeks	wrist extensor muscles

Table (6): Sensory-level electrical stimulation treatment characteristics.

Author name	Type of Current	Parameters	Frequency of treatment	Site of Stimulation
AlAbdulwahab et al.,[1]	Transcutaneous electrical nerve stimulation	Pulse duration of 0.25 ms, a frequency of 100Hz and intensity to cause just a tingling sensation.	15/ 3 times /one week.	Bilateral hip adductor muscles (adductor longus)
Dali et al.,[17]	Therapeutic stimulation	35 Hz stimulation; pulse amplitude 1 5mA; 360 min	6 nights/ week for 12 months	quadriceps femoris and tibialis anterior muscles
Hazlewood et al.,[21]	Therapeutic stimulation	30 Hz stimulation; pulse width 100ms; 2 s rise time and 15 s off; 60 min duration	35 days	anterior tibial muscle
Katz et al.,[28]	Therapeutic Electrical stimulation	20 Hz stimulation, pulse-width 0.25ms constant current; intensity 1–5mA	Daily for 3 months	anterior tibial muscle
Kerr et al.,[30]	therapeutic electrical stimulation	TES: 480 min at sensory threshold level < 10mA	5 days/week for 16 weeks	quadriceps muscles
Liron-Keshet et al.,[32]	therapeutic electrical stimulation	Frequency 20Hz, pulse-width 0.25 msec, and intensity was individually adjusted for each subject. The minimal intensity was 8 mA and was carefully increased up to the subject's tolerance of stimulus.	20 /, 4 times / six to ten weeks	quadriceps and dorsiflexors
Maenpaa et al.,[34]	Therapeutic Electrical stimulation	10–20 Hz stimulation; pulse duration 300 ms; intensity ranged from 4 to 20 mA; on : off time 1 : 1 s for 20- 40 minutes	12 sessions/ 4-5 weeks	Infraspinatus wrist dorsiflexors muscles
Maenpaa et al.,[35]	microcurrent stimulation	The treatment parameters were a 300 mA constant slopewave current with 30 Hz.	1 hour five times a week for 4 weeks.	gastrocnemius muscle
Sommerfelt et al.,[53]	Therapeutic stimulation	40 Hz stimulation; intensity510 mA; pulsewidth 300 ms; duration 300 min	6 days/week for 12 months	quadriceps and on the tibialis anterior muscle groups
Steinbok et al.,[55]	Therapeutic stimulation	35 Hz stimulation; pulse duration 300 ms; < 10mA intensity; on: off time 8 : 8 s with 2 s rise; 480–720 min	6 nights/week for 12 months	Hip abductors

Data Analysis

Characteristics of Cerebral palsy subjects

A number of 577 C.P. subjects in 25 articles were participated in the present review and only 508 patients were identified with mean age of 8.8 years with 69 withdrawals, dropped in the studies or considered as control children. All patients were categorized as 171 hemiparetic CP, 331 diaplegic CP, two quandiplegic CP, one with monoplegia, one with dystonia and two were none classified.

Review of measured variable in the studies

The main aim of 11 studies primary were improving gait by direct measure foot contact symmetry[19], Step symmetry[24], dorsiflexion at heel strike[15], mode of initial contact[47], gait pattern[21], gait Parameters (stride length, frequency)[22], gait performance[34], kinematic data[22], spatio-temporal parameters[47], gait analysis recorded by videotape[53].

Some authors (nine articles) aimed to improve gait or improving motor function in lower limbs[30,36,55,57]. They measured the improved in motor function in nine articles by change in active and passive ROM[23,50,51,21,24], level of spasticity spasticity[17,31], lower limb muscle strength[28,30,36,55], or measure gross motor function[30,36,55,57].

Five articles discuss the effect of surface electrical stimulation on CP subjects in change in motor function in upper limb function. They measured hand function[35], degree of spasticity[27], upper limb muscle strength[27,35], grip and pinch strength[40], active wrist ROM17,27,35,62, or the quality of Upper limb skills[17].

Only one article measured the changes after stimulation of trunk muscles by measuring cobb's, kyphotic, lumbosacral angels or measure sitting gross motor function[44].

Effectiveness of surface electrical stimulation

Muscle contraction depending on the intensity of the SES current. ES that elicits a muscle contraction can be applied to single or multiple muscle groups, during functional activities and in combination with voluntary effort. ES which does not elicit a muscle contraction uses low-intensity sensory stimulation[42]. Although, some researchers believe that this latter form of electrical stimulation increases voluntary strength, most do not.

NMES with motor level of stimulation was applied on trunk muscles as abdominal and back muscles for improving trunk control, and applied over gluteus medius, quadriceps femoris, gastrocnemius, tibialis anterior muscles for improving gait and lower limb gross motor functions or applied over the wrist flexor and extensor muscles to improve upper limb motor function. The time of application and the protocol of stimulation varied according to aim of the study for at least one week stimulation for improving gait and control spasticity until 6 months for improving upper limb function with significant effect in seven of nine studies. NMES had significant effects on improving gait parameters, reduction of spasticity, increasing active and passive ROM, improving upper limb function and trunk control.

FES was applied both to lower limb (quadriceps femoris, gastronomies- soleus, tibialis anterior muscles) and upper limb (wrist extensor) muscles for improving gait and upper limb function. FES was applied in trial as in gait training with at least 2 sessions with 30 trials up to 8 weeks gait training. FES had a significant effect in all studies (seven) in this literature as FES was effective in increase gait parameters in both kinematic data of gait and gait analysis. Also FES was effective in improving ROM, moment and quality of upper extremity skills.

Sensory level of stimulation includes all kind of stimulation used like TES (eight studies) TENS (one study) and microcurrent stimulation (one study). All these ES were applied to improve gait, increasing lower limb motor function and to increase upper limb function. Although the protocol of treatment was extended up to 12 months of treatment during the whole six nights per week applied to quadriceps and anterior tibial muscles during sleeping, TES was effective in only four studies of eight. TES was effective in reducing spasticity and improve gait and microcurrent was effective in increasing ROM in elbow extension and wrist extension.

DISCUSSION

This systemic review represents the effects of SES in treatment of CP subjects. SES was used to improve gait, gross motor function in lower limb and upper limb and to improve trunk control and sitting balance.

According to review, SES was highly effective in increasing both active and passive ROM in majority of the studies with different ES currents and different protocols. Also it has significant effects in improving upper limb function.

SES was effective in decreasing spasticity, improving gait parameters, strength and gross motor function in lower limb. And finally it has quiet effect in increasing trunk control and sitting balance. In this review, FES was effective in improving gait and gait parameters more than NMES while the result of NMES was more effective in improving gross motor function in both upper and lower limbs. With sensory level of stimulation, TES has low treatment effect as compared with microcurrent and TENS currents.

Initially, there was a considerable amount of variance in the studies. Even in a particular type of electrical stimulation. To achieve the same treatment goals, methodologies differ by location, intensity and length of treatment times. Furthermore, patients with cerebral palsy show a great deal of heterogeneity (e.g. diplegia, hemiplegia, athetoid gait, and spastic gait, all with more or less severe symptoms).

The research is dominated by uncontrolled studies with small numbers of participants, which are thought to provide less powerful evidence than the criterion standard randomized controlled trial[8]. Only Steinbok et al.,[55] and Van der Linden et al.[57] reported pre-study estimation of sample size and power analysis. Most studies recruited either children with hemiplegia or diplegia, effectively reducing their available participant numbers and the potential for generalization of results.

Also, reasons for such variability may be in differences in the basic techniques involved in FES and NMES. Specifically, FES is applied to the muscle or nerve during the time the muscle would normally be active. Neuromuscular stimulation has no such restriction and this stimulation is provided to produce a muscular contraction and strengthening. In addition, the goals of these two stimulation protocols are different.

NMES elicit muscle contraction by two different mechanisms. first, the overload principle, resulting in greater muscle strength by increasing the cross-sectional area of the muscle, and second, selective recruitment of type II fibres (fast twitch, large diameter fibres), causing improved synaptic efficiency of the muscle. Stimulation can be provided regardless of the nature of the activity that the patient is participating in[48].

NMES reduce spasticity on alleviating the associated disability (ie, difficulty walking, difficulty eating) exist in refereed literature[49]. Essentially, three ways of applying NMES to reduce spasticity can be identified based on the neurophysiology of motor units and spinal networks: (1) Stimulate the antagonist of the spastic muscle[5], (2) stimulate the spastic muscle (agonist)[49], and (3) alternately stimulate the spastic agonist and antagonist muscles[60]. Each of the methods relies in part on activating segmental neuromuscular reflexes to reduce the overactivity of the spastic muscle. Stimulating the antagonist to the spastic muscle activates the la afferent of the antagonist, which activates the la interneuron and reciprocally inhibits the spastic (agonist) alpha motoneuron of the muscle, reducing the activity of the spastic muscle. ES of the antagonistic muscles may improve the efficacy of stretching by providing an additional stretch to the agonistic muscles. It may also reciprocally inhibit the stretched muscle[31].

TES proposed that increased blood flow during a time of heightened trophic hormone secretion could result in increased muscle bulk[43]. Although, there are several conflicting reports on its efficacy have been published.

Microcurrent or low-intensity direct current stimulation (MENS) can interact with the tissue cells (e.g. keratinocytes, macrophages and fibroblasts) which can also exhibit polarity as seen in the cell membranes. The membranes are also sensitive to mechanical forces such as pressure and stretching. It has been shown in vitro that mild mechanical stimuli affect the mechanosensitive cell membrane receptors more effectively than strong forces[13].

Another possible mechanism by which microcurrent therapy can affect the state of tissues and whole organisms is by very sensitive C-axons in the skin. They do not react to thermal or nociceptive stimuli but to gentle touch or pressure. The information from these kinds of axons goes through the spinal cord and the thalamus to the insula. Feelings of pleasure and relaxation are the results of the stimulation of C-axon stimulation[37].

TENS can affect regional blood flow in cortical areas to where very sensitive C-axons send signals[30]. Because low-intensity alternating current TENS can produce these effects, MENS stimulation can also be anticipated to activate these axons as well, although it is not capable of depolarizing thicker sensory or motor axons[37].

Functional immediate or longitudinal effects beyond the testing situations were reported with a additional complications in determining electrical stimulation effects on the gait of children with cerebral palsy include: (a) age, (b) location of stimulated electrodes (e.g. dorsi-flexors vs. plantarflexors of the ankle), (c) stimulus parameters (i.e. intensity, duration, frequency and number of sessions), and physiological responses.

Difficulties arose when trying to compare studies owing to variations in stimulation parameters. Clarity in the reporting of stimulation parameters is essential because of their potential influence on study results and in facilitating replication and thus validation of study findings. Authors did not mention specific guidelines with regard to their choice of parameters. Existing guidelines differ on optimal settings, Low and Reed[63] suggesting 50 to 100 Hz for strengthening and Carmick[11] advocating 30 to 35Hz to ensure that sustained contraction is achieved.

Many studies would have benefited from the use of valid and reliable outcome measures but the measurement tools and procedures used were not. It is necessary for therapists to use validated functional outcome measures when measuring functional change. However, accurate measurement of the components of functional tasks (e.g. range of motion and strength) is also invaluable because it can provide information on the causes of the problems experienced, and the mechanisms by which treatments might affect them.

The issue of accurate measurement affects a key question when evaluating any treatment: how much change has to occur before it is considered clinically significant. Atwater et al., 1991[6] and Steinbok et al., 1997[55] defined clinical significance for their outcome measures. Several authors reported parent/career perceptions of treatment effects that were not always supported by the study results[6,57,58,62].

Conclusion

In conclusion, SES is considered a beneficial treatment tool in rehabilitation of subjects with CP. It has a significant result in improve gait, gross motor function in lower limb and upper limb and to improve trunk control and sitting balance. From the literature, there is more evidence to use motor level than sensory level of stimulation and in motor the evidence to use NMES more than FES. The findings of the studies must be interpreted with caution because they generally had insufficient statistical power to provide conclusive evidence for or against these modalities. Further studies employing more rigorous study designs and follow-up, larger sample sizes, and homogeneous patient groups are required for the unequivocal support of the use of SES.

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الملخص العربي

فعالية التنبية الكهربي السطحي في علاج الشلل الدماغي عند الأطفال. استعراض الأدبيات السابقة

الهدف : استعراض أدبيات الأبحاث السابقة لإظهار تأثير التنبية الكهربي السطح ي في علاج الأطفال الذين يعانون من الشلل الدماغ ي . **مصادر المعلومات :** بعد البحث في مصادر المعلومات المختلفة ، تم استعراض 50 بحثاً واختيار 25 بحثاً فقط الذين وافقوا شروط البحث عن استخدام التيارات الكهربية السطحية في علاج الأطفال الذين يعانون من الشلل الدماغ ي . **استخلاص المعلومات :** تم تقسيم الدراسات السابقة حسب نوع التيار المستخدم من التنبية الكهربي العصبي العضلي والتيار الكهربي الوظيفي والتيار الكهربي العلاجي والتنبيه الكهربي عبر الجلد والتيار الكهربي متناهي الشدة. كما تم استعراض نوع الدراسة ونوع حالات الشلل الدماغ ي . **تحليل المعلومات :** تبين من خلال الدراسات السابقة أن التنبية الكهربي السطحي له فعالية في زيادة المدى الحركي الايجابي والسلبي كما يعمل على تحسن القدرة على المش ي والوظائف الحركية في الأطراف العلوية والسفلية وذلك من خلال تقليل التشنج وزيادة قوة العضلات وتحسين التحكم في الجزع والاتزان في الجلوس . **الاستنتاج :** يعتبر التنبية الكهربي السطحي من الوسائل المفيدة في تأهيل الأطفال الذين يعانون من الشلل الدماغ ي والذي أثبت فعاليته في زيادة المدى الحركي وقوة العضلات وتحسين القدرة على المشي والوظائف الحركية للأطراف العلوية والسفلية كما يعمل على زيادة التحكم في الجزع وتحسن الاتزان في الجلوس .

الكلمات الدالة : الشلل الدماغي – التنبية الكهربي السطحي .