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Acute Effect of Interferential Current on Blood Flow in Spastic Cerebral Palsy Children

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Abstract

Background: Decreased skin temperature observed among children with cerebral palsy is related to increased sympathetic vasomotor tone. The potential of abnormal sympathetic activation in children with cerebral palsy has not received adequate attention. Interferential current electro stimulation changes the velocity of blood flow and the size of blood vessels.

Aim of Study: The aim of the current study was to determine the immediate effect of two different applications of interferential current on improving peripheral blood flow in children with cerebral palsy.

Material and Methods: Thirty children with cerebral palsy enrolled in this study, their age ranged between 8 and 12 years. They were divided randomly into two matched groups; each group consisted of 15 subjects. The study group (A) received direct stimulation of interferential current while the study group (B) received peripheral stimulation of interferential current. All children received the study protocol for intensity: 10-20 m.A, frequency: 100 Hz and time: 20 minutes. Blood volume pulse amplitude was assessed for both groups using plethysmography sensor at big toe pretreatment, immediate post treatment and 15 minutes post treatment.

Results: Data were statistically analyzed and compared. It was revealed a significant difference in blood volume pulse amplitude between the three measurements in group (A) and (B). There was no significant difference in blood volume pulse amplitude between group (A) and (B).

Conclusion: It can be concluded that both interferential current direct sympathetic stimulation and peripheral stimulation had a useful and important therapeutic effect in improving cutaneous blood flow in spastic cerebral palsy children, with no significant difference between the two applications.

Key Words: *Blood supply – Cerebral palsy – Interferential current.*

Introduction

CEREBRAL palsy (CP) is the most prevalent neurodevelopmental motor impairment in children. Patients with this illness require a variety of services throughout their lives, including social, educational, medical and rehabilitative care [1].

The autonomic nervous system (ANS) is made up of three systems: The parasympathetic nervous system, the sympathetic nervous system, and the enteric nervous system. It also known as the vegetative nervous system and it is a branch of the peripheral nervous system that governs glandular and smooth muscle activity, affecting the operation of internal organs. It is a semi-conscious control system that regulates physiological functions like digestion, heart rhythm, respiratory cycle, and pupillary reflex [2].

Individuals with CP exhibited a capillary density that was 38 percent lower than the capillary density of healthy control patients. The low percentage of oxidative fibers, as well as the poor capability for oxidation and limited capillary supply, could explain why muscles with contractures experience higher exhaustion [3].

Svedberg et al., [4] described accompanying symptoms in children with CP. They noted that besides neurological impairments, many children had cold extremities and pain, sleeping disorders, constipation, and impaired well-being. Most children had one or more of these symptoms for over 1 year but the symptoms were largely untreated. Non-walkers generally had more symptoms than walkers.

The autonomic nervous system's blood vessel size control and flow velocity are altered using interferential current (IFC) electrical stimulation [5]. The physiological effects of IFC show an increase in localized blood flow (BF), that reduce swelling so that it can aid in healing process by

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the additional blood flowing locally in that area, removing damaged tissue and helping to bring supportive nutrients necessary for healing to the injury site and an increase in the permeability of the cell membrane, which aids in ion movement in and out of the cell [6].

Therefore, it is really crucial to determine whether children with spastic CP have increased sympathetic vasomotor tone as a result of damage to specific locations of the brain that cause increased vasoconstriction and restricted the cutaneous blood supply. The goal of the current study is to determine the immediate effect of two different applications of interferential current on improving peripheral blood flow in children with spastic cerebral palsy.

Material and Methods

Design of study:

This two group pretest-posttest study design was carried out from September 2019 to March 2020 at the National Institute of Neuromotor system in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki). Ethical committee approvals of the Faculty of Physical Therapy, Cairo University, Egypt obtained before the study beginning. Children's participation was authorized by a signed written consent form with parent's/legal guardian's acceptance for participation before starting the study procedures.

Participants:

Thirty children with spastic cerebral palsy from both sexes were randomly selected from pediatric outpatient clinic of National Institute of Neuromotor system and divided randomly into two equal groups (each group contain 15 children).

The inclusion criteria for both groups stipulated that: (1) All children aged 8-12 years; (2) Their lower limbs' spasticity graded 1 to 2 according to Modified Ashworth Scale [7]; (3) They had levels I and II at the Gross Motor Function Classification System (GMFCS) [8]; (4) Children in both groups abled to follow instructions and understand commands given during test procedures. Children who met the following criteria excluded from this study; epileptic fits, dermatological problems, fever, tumors were excluded from current study.

Sample size and randomization:

Fifty spastic cerebral palsy children were assessed for eligibility. Twelve children did not meet the inclusion criteria. Thirty of the remaining 38 recruited into the study while eight children refused to engage in this study. The recruited children were allocated randomly on a computerized base using SPSS (version 18) into two equal groups of 15 children each. Randomization performed simply by adding a specific identification number for each child. These two groups named as study group A, who received direct stimulation of IFC and study group B, who received peripheral stimulation of IFC.

Instrumentations:

Instrument used for assessment is Photoplethysmography blood volume pulse (PPG) biofeedback system (Model: NEXUS 10, Netherland) which considered a reliable research tool for assessment and modification of peripheral blood volume by biofeedback applications, Medical Comunidad Europe certified, U.S. Food and Drug Administration registered [9].

Instrumentation used for treatment is Etuis electrotherapy apparatus (ASTAR, Poland), it is a modern and ergonomic unit intended to use in electrotherapy and electro diagnostics of nervous-muscle system [10].

Procedure:

For all participated children measurements were made in a temperature-controlled room at a physiotherapy clinic. The participants were asked to lie on the bed for 10min in order to stabilize circulation and match their skin temperature with room temperature, and then skin was prepared by using isopropyl alcohol to clean it, remove dead skin cells and minimize skin impedance [11].

For both groups blood flow was assessed by blood volume pulse (BVP) sensor at big toe pre-treatment, immediate post treatment (post I) and 15 minutes post treatment (post II) for 3 minutes [12].

Training procedure:

For study group (A), four paded electrodes were placed on level of T1 and L2 paravertebral 2cm to the spinous processes [5], for study group (B), two channel were used, in the first channel: one paded electrode was placed below medial malleolus while the other was placed on lateral malleolus and the second channel: Both paded electrodes were placed on medial aspect of the leg at the lower half of tibial shaft [11].

Specification [13]

- Intensity: 10-20 m.A.
- Frequency: 80-100 HZ.
- Time: 20 minutes.

Data analysis:

Descriptive statistics and unpaired *t*-test were conducted for comparison of the mean age, weight and height between groups. Mann-Whitney U test was conducted for comparison of median values of GMFCS between groups. Chi squared test was conducted for comparison of sex and spasticity grades distribution between both groups. Mixed MANOVA was conducted for comparison of blood volume pulse amplitude between pre-treatment, post I and post II in each group and between groups. The level of significance for all statistical tests was set at ($p<0.05$). All statistical measures were performed through the statistical package for social studies (SPSS) version 25 for windows.

Results

Table (1) lists the general physical characteristics of the 30 participants in our study. There were no statistically significant differences in the mean values of age, weight, and height among both groups with $p>0.05$. Also, there were no significant differences in the Chi squared test of gender, and spasticity grade distribution and median values of GMFCS between groups with $p>0.05$.

Table (1): Demographic characteristics of participants in both groups.

	Group A n=15 X ± SD	Group B n=15 X ± SD	MD	*t*-value	*p*-value
Age, (years)	9.33±1.29	9.46±1.24	–0.13	–0.28	0.77
Weight, (kg)	30.2±7.15	29.93±7.51	0.27	0.1	0.92
Height, (cm)	130.73±10.98	130.93±11.29	–0.2	–0.04	0.96
Gender, n (%)	7(47%)/	7 (47%)/		χ^2=0	1
Boy/Girl	8 (53%)	8(53%)			
Spasticity grade, n (%)	9 (60%)/	9 (60%)/		χ^2=0.34	0.84
1/1+/2	4 (27%)/	3 (20%)/			
	2 (13%)	3 (20%)			
GMFCS level, (median) I/II	1	1		U-value= 105	0.71

Note: Data are expressed as mean ± standard deviation or number.
χ^2 =Chi-square test.
U: Mann-Whitney U test value.
Level of significance at $p<0.05$.

Statistical analysis using mixed design MANOVA indicated that there was no significant interaction effect of treatment and time ($p=0.63$). There was a significant main effect of time ($p=0.0001$ *). There was no significant main effect of treatment ($p=0.44$) as shown in Table (2).

Table (2): Mixed MANOVA for the effect of treatment on blood volume pulse amplitude.

Mixed M ANOVA		
Interaction effect (treatment*time)		
F=0.45	*p*=0.63	NS
Effect of time		
F=13.88	*p*=0.0001	S
Effect of treatment		
F=061	*p*=0.44	NS

F value : Mixed MANOVA F value.
p-value : Probability value.
S : Significant.
NS : Non-significant.

The results of this study showed no significant differences ($p>0.05$) in the pre-treatment mean values of BVP amplitude in both groups. No statistically significant difference observed in BVP amplitude between group A and B at post I ($p=0.5$) and post II ($p=0.31$) (Table 3).

Table (3): Comparison of mean values of blood volume pulse amplitude at pretreatment, post I and post II between group A and B.

	Blood volume pulse amplitude (mV) X ± SD Group A n=15	Group B n=15	MD	F-value	*p*-value	Sig.
Pretreatment	14.18±4.41	14.94±3.16	–0.76	0.29	0.59	NS
Post I	16.95±7.05	18.42±4.43	–1.47	0.46	0.5	NS
Post II	14.44±3.89	15.96±4.29	–1.52	1.03	0.31	NS

X : Mean.
SD : Standard deviation.
MD: Mean difference.
t-value: Unpaired *t*-value.
p-value: Probability value.
NS : Non significant.

Considering the results of the study group (A), there was a significant difference in BVP amplitude between the three-time intervals ($p=0.01$). The significant increase in BVP amplitude was shown when comparing post I with pretreatment ($p=0.007$) and with post II ($p=0.02$). There was no significant difference in BVP amplitude between pretreatment and post II ($p=1$) as shown in Table (4).

Table (4): Comparison of mean values of blood volume pulse amplitude between pretreatment, post I and post II of group A.

Blood volume pulse amplitude (mV)			F-value	*p*-value	Sig.
X ± SD					
Pretreatment	Post I	Post II			
14.18±4.41	16.95±7.05	14.44±3.89	5.61	0.009	S

	Multiple comparison (Bonferroni test)			
	MD	% of change	*p*-value	Sig.
Pretreatment vs post I	–2.77	19.53	0.007	S
Pretreatment vs post II	-0.26	1.83	1.00	NS
Post I vs post II	2.51	14.81	0.02	S

X : Mean.
SD : Standard deviation.
MD: Mean difference.
t-value: Unpaired *t*-value.
p-value: Probability value.
S : Significant.
NS : Non significant.

The results of the study group (B) also showed a significant difference in BVP amplitude between the three-time intervals (p=0.01). The significant increase in BVP amplitude was shown when comparing post I with pretreatment (p=0.001) and with post II (p=0.02). There was no significant difference in BVP amplitude between pretreatment and post II (p=0.29) as shown in Table (5).

Table (5): Comparison of mean values of blood volume pulse amplitude between pretreatment, post I and post II of group B.

Blood volume pulse amplitude (mV)			F-value	*p*-value	Sig.
X ± SD					
Pretreatment	Post I	Post II			
14.94±3.16	18.42±4.43	15.96±4.29	8.73	0.001	S

	Multiple comparison (Bonferroni test)			
	MD	% of change	*p*-value	Sig.
Pretreatment vs post I	–3.48	23.29	0.001	S
Pretreatment vs post II	–1.02	6.83	0.29	NS
Post I vs post II	2.46	13.36	0.02	S

X : Mean.
SD : Standard deviation.
MD: Mean difference.
t-value: Unpaired *t*-value.
p-value: Probability value.
S : Significant.
NS : Non significant.

Discussion

This research concerned with evaluating the effect of two application of interferential current stimulation on peripheral blood supply in children with spastic cerebral palsy.

Trophic disorders like reduced skin blood circulation are well-known epiphenomenon of CP. They can influence quality of life and can lead to skin damages and, as a consequence, to decubitus. Therefore, it is important to analyze temperature regulation in patients with CP. Thermal imaging camera was used to study the dependency of skin blood circulation in upper extremities of patients with CP on hand dominance, hand force and hand volume. A slight correlation was established between the hand grip force of the working hands and their warm up time. The results confirm that there is a connection of peripheral blood circulation to upper limb motor functions **[14]**.

This study protocol used interferential current stimulation as an intervention tool to improve blood supply in CP children, as confirmed by Santos et al., who stated that, the employment of an IFC to stimulate ganglion mid-frequency neuromuscular electrical stimulation attenuates the peripheral reactions induced by muscle metaboreflex activity, allowing peripheral BF and peripheral vascular resistance to remain within normal ranges. The blockage of sympathetic arteriolar fibers, which results in an increase in peripheral circulation at the site of application due to a reduction in sympathetic tonus in the muscle layer of these vessels, is the primary mechanism by which cutaneous BF is improved in healthy individuals **[15]**.

Interferential current stimulation was applied for 20 minutes to both study groups. The selection of this average time comes in agreement with Youn et al., **[16]** who concluded that, the effective treatment duration used for IFC therapy have been shown to range between 10 and 30 minutes.

Descriptive statistical analysis for comparison of the mean age, weight and height between the two groups revealed no statistical difference which revealed homogeneity between the groups.

Statistical analysis of the median values of Growth Motor Function Classification System (GMFCS) of the two groups revealed no significant difference which revealed no gross motor and functional difference can affect the results between the two groups tested, also there was no significant difference between the two tested groups in spasticity grade distribution on Modified Ashworth Scale as spasticity grade can affect the vasomotor mechanism. Dhindsa et al., **[17]** discovered that, greater degrees of muscle spasticity are substantially related with decreased peripheral BF.

Regarding the study group (A) who received direct stimulation of IFC by two channels on dorsolumbar sympathetic chain, the results revealed significant improvement of peripheral BF on post I compared with pretreatment as a result of the effect of IFC sympathetic stimulation on increasing

BVP amplitude and enhancement of peripheral circulation, while there was no significant difference in BVP amplitude between pretreatment and post II (*p*=1), and the mean difference between post I and post II revealed a significant increase in BVP amplitude at post I compared with post II (*p*=0.02) which support the temporal effect of IFC sympathetic stimulation on peripheral circulation and the return of the BVP amplitude to near pretreatment values after 15 minutes of ending the interferential stimulation, this results come in agreement with Kim et al., [18] described that, painful muscle tension can be relieved by increasing the levels of local blood and lymphatic circulation, which is achieved with IFC. Previously, it was assumed that an increase in skin temperature of this magnitude (50-150 Hz for 15 minutes) was suggestive of vasodilation caused by a decrease in sympathetic nerve activity.

The findings of study group (B) revealed a significant increase in BVP amplitude at post I compared with pretreatment (*p*=0.001) while, there was no significant difference in BVP amplitude between pretreatment and post II (*p*=0.29), and a significant increase in BVP amplitude at post I compared with that at post II (*p*=0.02), which support the temporal effect of IFC peripheral stimulation on peripheral circulation.

Schnizer et al., [19] & Sherry et al., [20] confirmed that, BF increased only if the frequency and intensity of current were sufficient to induce muscle contraction. They concluded that the effects of current were dose-dependent.

These results were also supported by Al Abdulwahab & Beatti [21] who reported that, because of the vasodilatation action of IFC, it is possible that IFC increased the concentration of chemical substances in the area around the nerve root.

Our findings also supported by the findings of Minassian et al., [22] who suggested that, high frequency-low intensity sensory stimulation promoted vasoconstriction and enhanced BF velocity, and it is hypothesized that, this type of stimulation could also boost normal venous return through the same electrophysiological mechanisms that caused these effects. Furthermore, following compression of the veins in the leg using an obstructive BF monitoring technique, electrical stimulation increased BF towards the heart, indicating that it is appropriate to utilize electrical stimulation to lower the risk of embolism.

The study results concerned with the comparison of the mean values of BVP amplitude pretreatment, post I and post II between both study groups showed no statistical significant difference which support that, both peripheral and sympathetic IFC stimulation increased BVP amplitude and improve the peripheral circulation within group, with no significant advantage to any application over the other whether peripheral or sympathetic IFC stimulation was used.

This was confirmed by the results of Park & Hwang [23] who confirmed that, BF velocity and vessel size have an impact on circulatory function through both sympathetic and peripheral processes, and that electrical stimulation can produce physiologic changes by activating sympathetic tone through muscle contraction.

According to the results of this research, it was be concluded that, electrical current stimulation has highly important effect in the field of physical rehabilitation, the present study is important, because it clarified that, IFC electrical stimulation has a great effect on improving the ANS and lead to better treatment outcomes.

Conclusion:

From the previous results of our study, it was concluded that IFC stimulation had a significant therapeutic effect in enhancing peripheral BF in spastic cerebral palsy children.

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التأثير الفورى للتيار المتداخل بطريقتين مختلفتين على الدورة الدموية الطرفية عند الأطفال المصابين بالشلل الدماغى

الخلفية : الأطراف الباردة وضعف تدفق الدم المحيطى بخلل وظيفى فى الجهاز العصبى اللاإرادى عند الأطفال المصابين بالشلل الدماغى. التحفيز الكهربائى التداخلى، والذى قد يكون مرتبطاً بتغلغل أكبر للأنسجة العميقة، قد يعيد تدفق الدم عن طريق التعديل العصبى السمبثاوى.

الهدف من الدراسة : الحالية تحديد التأثير الفورى لتطبيقين مختلفين للتيار المتداخل على تحسين تدفق الدم الطرفى لدى الأطفال المصابين بالشلل الدماغى.

المشاركين والأساليب : ثلاثون طفلاً مصابين بالشلل الدماغى قد شاركوا فى هذه الدراسة وتراوحت أعمارهم بين (٨–١٢) سنة وقد تم تقسيمهم بشكل عشوائى إلى مجموعتين متطابقتين، كل مجموعة تتكون من ١٥ طفل. تلقت المجموعة الأولى (أ) التحفيز السمبثاوى للتيار المتداخل على الفقرات الصدرية والقطنية، بينما تلقت المجموعة الثانية (ب) التحفيز الطرفى للتيار المتداخل على الساق والقدم. أستقبل كل الأطفال بروتوكول الدراسة لمدة ٢٠ دقيقة وقد تم تقييم نبض حجم الدم باستخدام مستشعر تخطيط الحجم الليزرى والقياس من إصبع القدم الكبير قبل التطبيق وبعد التطبيق وبعد ١٥ دقيقة من التطبيق مباشرة.

النتائج : تم تحليل البيانات ومقارنتها إحصائياً. كان هناك تحسن مؤثر فى حجم الدم وسعة النبض بين الفترات الثلاث فى المجموعة (أ) و(ب). بينما لم يكن هناك فرق مؤثر فى حجم الدم وسعة النبض بين المجموعة (أ) و (ب).

الخلاصة : نستطيع أن نستخلص أن كلا التطبيقين المباشر للتحفيز السمبثاوى والتحفيز الطرفى للتيار المتداخل أدى إلى زيادة فى تدفق الدم الطرفى مع عدم وجود ميزة كبيرة لأى تطبيق على الأخر. يمكن أن يؤدى التحفيز الكهربائى لتيار المتداخل إلى نتائج علاجية جيدة فى الاضطرابات الحركية الوعائية فى الشلل الدماغى عندما يكون هناك خلل فى الجهاز العصبى اللاإرادى.