

Efficacy of High versus Low Frequency Microcurrent Electrical Stimulation on Resistivity Index and Blood Flow Volume in Normal Subjects

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Abstract

Background: Blood flow is a vital and an essential factor in human life that can affect the whole body organs and systems. Many electrical currents have been shown to produce long term effects on vascularization at the capillary level. Microcurrent is one of these currents. Therefore, this study was conducted to investigate the effects of different frequencies of microcurrent electrical stimulation (MES) on resistivity index (RI) and blood flow in normal subjects.

Methods: Thirty normal subjects, with the mean age of 28.77 (SD= ± 3.501) years and the mean body mass index of 23.20 (SD= ± 1.332) kg/m² were assigned randomly to two equal groups: group (A) to receive high frequency MES (125 Hz, 30 min) or group (B) to receive low MES (40 Hz, 30 min). All subjects were assessed for RI, total blood flow volume, mean blood flow velocity and peak systolic velocity using Ultrasonic Doppler before and immediately after microcurrent application.

Results: Intragroup comparison showed significant differences in both groups before and immediacy after microcurrent application regarding RI, total blood flow volume, mean blood flow velocity and peak systolic velocity in posterior tibial artery (P<0.05). In comparison to group (B), group (A) showed significant reduction in RI while total blood flow volume, mean blood flow velocity and peak systolic velocity showed no significant difference as the mean difference for all variables were (0.075, 0.088, 0.904, 8.011), respectively.

Conclusion: In normal subjects, both high frequency and low frequency MES are beneficial in improving blood flow. In addition, high frequency MES decreases RI more than low frequency MES.

Keywords: Microcurrent electrical stimulation; Resistivity index; Total blood flow volume; Mean blood flow velocity; Peak systolic velocity

increase oxygen and food supply and facilitate removal of debris and waste materials, so it could promote healing. There is some evidence that many physiotherapeutic modalities increase blood flow locally [1].

Most of physiotherapeutic modalities that improve the blood flow are dependent on heat application such as infrared, short wave, microwave, ultrasound and hot pack as they cause vasodilatation and hyperemia. But there are several conditions which need vasodilatation without heat application such as atherosclerosis, diabetic angiopathy and ischemia [2]. So, we still need for an athermic and a subsensory method for improving blood flow like microcurrent electrical stimulation (MES).

MES involves the application of a very small electric current, less than 1 mA, to the body for therapeutic effect. Unlike other forms of electrotherapy such as transcutaneous electric nerve stimulation and interferential currents, MES is normally subsensory. When microcurrent is applied to a patient via small electrodes the treatments generally produce no noticeable sensory or neuromuscular effect. Based on that, the patient cannot feel the current because the intensity is not enough (low) to stimulate the sensory nerve fibers [3].

Over recent decades, MES has demonstrated a considerable potential for the treatment of several forms of tissue damage because the evidence suggests that it may be capable of alleviating symptoms of tissue damage and promoting tissue repair [4,5]. The application of microcurrent can influence the behavior of cells involved in healing processes, such as migration, proliferation and production of proteins and cytokines. At the tissue level, microcurrent can promote angiogenesis and neural sprouting and increase rates of tissue synthesis [6].

Microcurrent is clearly effective in pain alleviation, tissue regeneration, facilitating wound and fracture healing. It is repressing bacterial growth and improving the blood flow rate by relieving tension in the sympathetic nervous system [7].

It presumes the principle that injured tissue produces abnormal electrical potentials, termed injury potentials which are associated with a disturbance in homeostasis. In accordance with this theory, microcurrent therapy re-establishes normal electrical balance in the tissue and minimizes this disruption,

Introduction

Blood flow is an important factor which can affect the repair and healing of injured tissues. Any increase in blood flow would

resulting in a more rapid regeneration and return of normal function [3].

Recently, many studies investigated the effect of MES on circulation and they reported that extremity blood flow rate increased with applied microcurrent stimulation [8]. It was used also as a cosmetic treatment for the skin as it increases production of natural collagen and elastin, and increases blood circulation within twenty days [9].

Most studies explained the significant effects of microcurrent either in pain relief, wound healing or treating the edema were due to the increased blood circulation without available literature about the effect of microcurrent on blood circulation. There is a lack in the quantitative knowledge and information in the available published studies about the effect of different frequencies of microcurrent on the blood flow in normal subjects. Moreover, there is still a need for athermic and subsensory modality that could improve blood flow and help patients with blood flow abnormalities. Therefore, the purpose of this study was to investigate the effect of different frequencies of MES (high, 125 Hz and low, 40 Hz) on resistivity index (RI) and blood flow in normal subjects.

Methods

Design of the study

Pre- and post-control test design was used in the study. A single trained investigator evaluated all subjects and collected all data to eliminate inter-investigator error.

Participants

Thirty healthy normal subjects from both genders (16 females and 14 males) were participated in the study. They were recruited randomly from the Faculty of Physical Therapy employers, Cairo University. Their ages ranged between 25 and 35 years, with BMI was (18.5-24.9) kg/m². They were assigned randomly to two equal groups by simple method and each group contained 15 subjects. Each subject was permitted to fill a consent form which included subject's approval and all study procedures and instructions before the beginning of the study. The study was approved by the Institutional Ethics Committee of the Faculty of Physical Therapy, Cairo University, Egypt (No: P.T. REC/102/00735). The anonymity and confidentiality were assured and all the procedures were performed in compliance with relevant laws and institutional guidelines.

Inclusion criteria of participants

All participants were normal healthy subjects from both genders and their age ranged from 20-35 years while their BMI was normal (18-25).

Exclusion criteria of participants

Subjects were excluded if they had any peripheral vascular diseases, neurological conditions, cardiac abnormalities, diabetes and blood pressure abnormalities. The dominant leg was determined by asking the subject to kick a ball and was

stimulated and the non-dominant leg was served in placebo microcurrent. The subject was assigned to one of the following groups: Group A (high frequency MES group): (125 Hz frequency, 100 μ A intensity and biphasic polarity for 30 min). Group B (Low frequency MES group): (40 Hz frequency, 100 μ A intensity and biphasic polarity for 30 min). In both groups, the active microcurrent was applied on the dominant leg while Placebo microcurrent was applied on the non-dominant leg. RI, peak systolic velocity, mean blood flow velocity and total blood flow volume of posterior tibial artery were measured in both groups by Duplex Doppler ultrasound pre and immediately after microcurrent application.

Procedures

Each subject was allowed to have 15 min rest period before the evaluation; the room temperature was constant at 27°C during the study. The subjects were fully acquainted with details of procedures which were undertaken through a demonstration session. Each subject was assessed by Duplex Doppler ultrasound for RI, peak systolic velocity, mean blood flow velocity and total blood flow volume through posterior tibial artery. The assessment performed before and immediately after microcurrent electrical stimulation [10].

Microcurrent was applied immediately after completing the measurement of all variables. Subject was in a comfortable long sitting position with fully extended and relaxed knees. The skin at the site of electrode application was cleaned; any metals at the site of application were removed. The positions of the subject and equipment were standardized throughout the study. Two microcurrent devices were used simultaneously on both legs, one of them was operating and the other one was not operating but lightening [11]. Each device has 2 channels with 4 adhesive electrodes. In the first channel: one electrode was placed just below the medial malleolus, while the other electrode was placed just below lateral malleolus. In the second channel: the both electrodes were placed on the medial aspect of the leg at the lower half of tibial shaft and above each other.

Statistical analysis

Data raised from this study were analyzed for comparisons by descriptive analysis in form of means, standard deviation, and percentage of variations for all groups. Dependent paired t-test was used to measure the changes in all variables within the groups, while unpaired t-test was used to measure the difference in the changes in all variables between the groups. Level of significance was set at 0.05. All statistical calculations were done using computer program IBM SPSS (Statistical Package for the Social Science; IBM Corp, USA) release 22 for Microsoft Windows [12].

Results

None of the patients in either treatment groups dropped out throughout the study period. There was no significant difference ($P>0.05$) between both groups regarding demographic data (Table 1).

Table 1 Descriptive analysis of the demographic data for both groups; S: Significance; NS: Non-Significant.

	Group A	Group B	P-value	S
Age (years)	28.47 ± 3.796	29.07 ± 3.283	0.7756	NS
Height (cm)	174.1 ± 5.994	174.7 ± 5.982	0.6013	NS
Weight (kg)	71.10 ± 7.647	70.43 ± 7.312	0.7610	NS
BMI (kg/cm ²)	23.40 ± 1.619	23.01 ± 0.986	0.1873	NS

There was a non-significant difference ($p > 0.05$) between pre and post treatment variables in control limb for all participants in both groups. There was a significant difference ($P < 0.05$) between pre-treatment and post-treatment mean values of RI, total blood flow volume, mean blood velocity and peak systolic velocity in groups A and B (**Table 2**).

Table 2 Pre and post treatment mean values for all variables within groups (A&B); SD: Standard Deviation; S: Significance.

	Group A				Group B			
	Pre	Post			Pre	Post		
	Mean ± sd	Mean ± sd	P value	S	Mean ± sd	Mean ± sd	P value	S
Resistivity Index	1.008 ± 0.1064	0.829 ± 0.095	0.0001	S	1.018 ± 0.1080	0.904 ± 0.099	0.002	S
Total blood flow volume	0.978 ± 0.564	2.028 ± 1.101	0.0001	S	1.133 ± 0.902	2.116 ± 1.582	0.004	S
Mean blood flow velocity	3.82 ± 2.612	8.24 ± 5.567	0.0005	S	3.606 ± 3.612	7.336 ± 6.083	0.014	S
Peak systolic velocity	43.01 ± 8.175	61.07 ± 15.92	0.0003	S	47.65 ± 11.472	69.18 ± 23.016	0.0001	S

As shown in **Table 3**, there was a significant difference ($P < 0.05$) in post-treatment values of RI, as was observed in favor of group A, while there was non-significant difference in post treatment values of other variables between group A and B.

Table 3 Post treatment mean values of all variables between group A and B.

Post values/A vs. group B	Resistivity Index	Total blood flow volume	Mean blood flow velocity	Peak systolic velocity
Mean Difference	0.075	0.088	0.904	8.11
P value	0.04	0.08	0.67	0.27
Sig.	S	NS	NS	NS

Power analysis

The effect size was calculated for each variable. As compared to the placebo treatment for both high and low frequency, the effect size of the mean blood flow for High frequency was (Cohen's $d=0.82$, $r=0.38$) and for low frequency (Cohen's $d=0.83$, $r=0.38$). The effect size of the Resistivity Index for High frequency Cohen's was ($d=-1.90$, $r=-0.69$) and for low frequency was (Cohen's $d=-1.33$, $r=-0.55$). Total Blood flow effect size was (Cohen's $d=1.32$, $r=0.55$) for high frequency and (Cohen's $d=0.76$, $r=0.36$) for low frequency. Peak systolic Velocity effect size was (Cohen's $d=1.32$, $r=0.55$) for high frequency and (Cohen's $d=1.28$, $r=0.54$) for Low frequency. Based on the average effect size, power analysis was calculated. It revealed power ($1-\beta$ err prob)=0.69 with 55 Effect size d . 28 degree of freedom and 15 subjects for each group.

Discussion

This study demonstrated statistical significant difference in RI, TBFV, MBFV and PSV (V_{max}) for both groups as P-values were < 0.05 . While the inactive current on non-dominant leg demonstrated no statistical difference either in all variables as p values were > 0.05 .

By comparing the results between both groups it was found that there was a statistical significant difference between Group A and group B in RI but there was no statistical significant difference between groups for other variables.

Depending on these previous results it was revealed that the microcurrent electrical stimulation increases the blood flow in lower limb by affecting the values of resistivity index (RI), total blood flow volume (TBFV), mean blood flow velocity (MBFV) and peak systolic velocity (V_{max}).

Microcurrent has an effect on pain control and healing through the modification and recruitment of cell membrane ATP by increasing intracellular ATP concentration, improving protein synthesis, and increasing the cell's ability to absorb nutrients. It increases the blood flow rate by improving peripheral blood circulation. This is agreed with [7,9,13].

Microcurrent also reserves circulation and replies ATP, so nutrients can again flow into injured cells and waste products can flow out which is necessary for the development of healthy tissues. It releases plasma vascular endothelial growth factor (VEGF) and nitric oxide (NO) which may lead to improved blood flow and tissue temperature and, consequently, wound healing [14,15].

Microcurrent has a physiological effect on the body as spasmolysis of blood, lymph vessels and hollow organs, and this in turn improve the circulation of blood and lymph. The total number of cells will increase as well as the number of newly formed blood vessels, epithelial thickness, and compaction of mature collagen fibers in the stimulated area [16,17].

Substance P (SP) produces vasodilation through smooth muscle relaxation by endothelium-dependent and independent manners and it is revealed that microcurrent has a positive effect on SP so augmentation of blood flow increase by MES that is due to the release of SP or other vasodilator agents released from nerve endings [18].

But the result of this study was contradicted with [19,20] who reported that the logic effective way of increasing blood flow to a limb by using electrical stimulation is to elicit large muscle contractions and this means that the level of stimulation must be above the motor threshold and the frequencies must result in tetanic contractions to increase the blood flow in the stimulated limb.

Limitations

The number of subjects in the current study was based on reviewing of some literatures concerning the effect of electrical stimulation on blood flow and we did not formerly use the statistical power of analysis. Based on this limitation, the current study could be considered a preliminary helpful study for future research

Conclusion

It was revealed that both high frequency and low frequency microcurrent improve the blood flow in normal subjects.

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