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Strengthening of Muscles with 1 KHz Alternating Current

Anjani Agrawal, BPT, MPT, Sports Physiotherapy, Research Fellow*
Kalpana Zutshi, BPT, MPT, Sports Physiotherapy, Lecturer in Physiotherapy*
CS Ram, BPT, MPT, Sports Physiotherapy, Director Physiotherapy**
Dr Rasheeduz Zafar, PhD Pharmacology, Dean*
Col SN Bhaduri, MBBS, PhD, CPM&R, Head, Department of Physical Medicine & Rehabilitation#
Lt Col Rana K Chengappa, MBBS, Dipl Sports Medicine, Sports Medicine Specialist, Department of Sports Medicine#

* Jamia Hamdard University, New Delhi
**Institute of Technology & Science, Murad Nagar, Ghaziabad
#Army Hospital (R&R), New Delhi

Institution where study was done: Army Hospital (Research & Referral), Delhi Cantt, Dhaula Kuan, Delhi

Abstract

Background: Different types of currents with varying stimulus parameters are used in clinical practice to serve different purposes. Out of these different forms of currents, medium frequency alternating currents are preferred due to their advantages over the other currents. For the purpose of strengthening the muscles, the most common frequencies used are 2.5 kHz and 4 kHz, and there is a dearth of literature regarding the use of other frequencies in the range.

Methods: This study was conducted to luate the effect of 4 weeks of neuromuscular electrical stimulation with 1 kHz alternating current on the strength of wrist extensors of 18 healthy subjects.

Results: The 4 week protocol of neuromuscular electrical stimulation with 1 kHz alternating current was found to result in a significant strength gains in the wrist extensor muscles of the included subjects.

Conclusion: From this study it may be concluded that a carrier frequency of 1 kHz is an effective frequency for strengthening of muscles.

Key Words: Neuromuscular Electrical Stimulation; Alternating currents; Strengthening

Introduction

Electrical stimulation is increasingly being used as an adjunct to the physiotherapeutic and rehabilitative treatment procedures for their various clinical benefits such as increasing the rate of healing of fractures, improving circulation and preventing deep venous thrombosis[13], preventing atrophy and most commonly for strengthening of muscles in patients with gross muscular weakness such as after stroke or spinal cord injury[6] or in post surgical rehabilitation such as after total knee arthroplasty[11, 12] and anterior cruciate reconstruction[14]. Also it has been used as an adjunct to strength training of healthy athletes[2, 3, 9].For these different purposes varying stimulus parameters have been used and different physiological effects have been attributed to different parameters. Out of the different types, medium frequency alternating currents i.e. currents in the range of 1 – 10 kHz[5, 8] are the preferred currents for strengthening of muscles as it has been shown that as the frequency of

Address for correspondence: Anjani Agrawal, AC / 142-A, Shalimar Bagh, Delhi 110088. Email: anjaniwithu@yahoo.co.in

applied current increases, the skin offers progressively lower impedance and at 1 kHz frequency the skin impedance is very low; so less electrical energy is dissipated in the superficial epidermis and a higher proportion is available to stimulate the underlying tissues[1]. Within the above mentioned range, the frequencies 2.5 kHz (Russian current) and 4 kHz (Interferential current) have been commonly used. A review of existing literature shows that there is a dearth of studies relating to the use of other frequencies in the range, for strengthening.

Material and Methods

A total of 18 young healthy volunteers (15 females) in the age group of 20-30 years with right hand dominance were included in the study. All individuals were explained about the complete procedure and a written informed consent was obtained. Individuals with any abnormal condition involving the right upper extremity such as musculoskeletal anomaly, neurological problems, any hypersensitivity of skin, history of injury; history of substance abuse; and any previous strength training of the wrist were excluded from the study.

Electrical stimulation was given using: Powerstim muscle stimulator; a purpose built device, to produce constant voltage alternating current.

Measurement of peak isokinetic torque to assess strength of wrist extensors was done using: Biodex Isokinetic Dynamometer system 3 pro. An initial measurement of peak isokinetic torque (pre-test) during wrist extension was obtained at two speeds; 60°/sec and 90°/sec with 1 set of 5 continuous repetitions at each speed and 2 minutes rest between the 2 sets.

Following the torque measurements all subjects received surface electrical stimulation of right side wrist extensors. The stimulation was given using 2 electrodes; the proximal electrode being placed 1 cm distal to the head of radius and the distal electrode placed 5 cm below the proximal electrode on the line joining the head of radius to the distal radioulnar joint[5]. The current parameters were; alternating current at a carrier frequency of 1 kHz burst modulated at 50 Hz with 20% burst duty cycle. The current was applied at the intensity maximum tolerable to the individual using a 10/50/10 regime[1] i.e. current was applied for 10 seconds followed by 50 seconds off time and this cycle was repeated for 10 minutes. Stimulation was given 5 days/week for 4 weeks (i.e. 20 sessions)[10].

After completion of the protocol, peak isokinetic torque measurements (post-test) were obtained according the same procedure as for pre-test.

Results

The mean age of the patients was 22.2 ± 1.1 years with an average height of 159.8 ± 6.4 cms and the mean weight was 56.6 ± 10.2 kgs.

A comparison of mean pre test and post test values of average isokinetic torque at the speed of 60°/second (Fig 1) as well as 90°/second (Fig 2) demonstrates that the torque values during post test are higher than those during pre test for all subjects (Table 1).

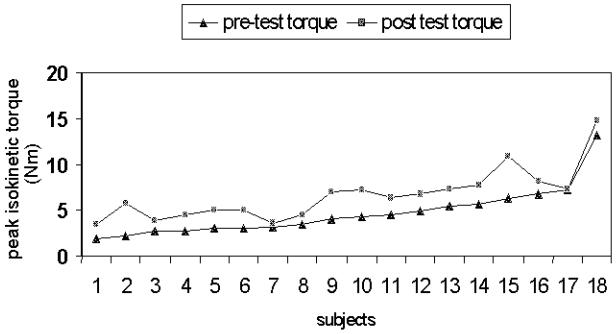

Figure 1: Comparison of pre test and post test isokinetic torque measured at 60°/second for all subjects

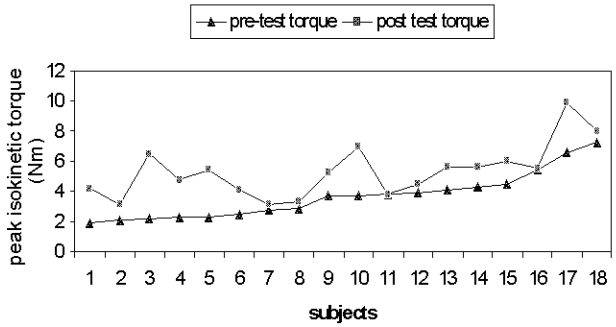

Figure 2: Comparison of pre test and post test isokinetic torque measured at 90°/second for all subjects

Speed	*Pre-Test Mean±SD*	*Post-Test Mean±SD*	*Related 't' test*	
			t	*p*
60°/sec	4.69 + 2.64	6.63 + 0.66	7.734	0.000
90°/sec	3.67 + 1.53	5.31 + 1.76	5.534	0.000

Table 1: Comparison of pre test and post test mean isokinetic torque measured at the speeds of 60°/sec and 90°/sec

A statistical analysis of the data using related 't' test also shows that there is a statistically significant difference (p = 0.000) between the pre-test and post-test torque values (Table 1).

Thus the results show a significant improvement in the torque production after 4 weeks of electrical stimulation.

Discussion

It is generally well accepted in the literature on electrical stimulation that electrical stimulation training effectively retards muscle wasting and prevents atrophy during forced immobilization or in case of neurogenic lesions. But great variability exists about electrical stimulation being applied to healthy individuals. Cummings et al 1980 reported strength gains of 30 - 40% following 20 sessions of electrical stimulation[2]. On the other hand a study by Diane et al[4] has shown that there is no significant improvement in strength after electrical stimulation using alternating current at 2.5 kHz frequency. These conflicting results could be because of disparity in training protocols, electrical stimulation parameters and testing procedures.

In our study we tried to standardize all the parameters[1, 15, 16] such as burst frequency, duty cycle, and stimulation protocol on the basis of existing literature to study the effect of alternating current with a frequency of 1 kHz on strength of wrist extensors.

The principle behind strengthening with electrical stimulation has been shown to be overload principle as for voluntary contraction strengthening. Keeping this in mind the intensity of stimulation in our study was kept at a level maximal tolerable to the individual and was progressed during each session according to the individual's perception.

In the present study the torque responses that is the gain in peak isokinetic torque from pre-test to post-test was found to be 54.3% $\pm$ 39.9% at 60°/sec and 80.5% $\pm$ 36.1% at 90°/sec. Individual variability in strength gains can be attributed to differences in the existing strength capacity for further strengthening within each individual. These gains were in accordance with the strength gains claimed in previous studies.[1, 2, 3, 7, 10]

Conclusion

It can be concluded from the present study that the frequency of 1 kHz is effective in improving the strength of wrist extensors of the healthy individuals. Electrical stimulation is commonly recommended to athletes as a way to generate high muscular strength, obtained by high intensity of stimulation, aimed at improving the performance. The observation from the present study, suggests that electrical stimulation using alternating current at a frequency of 1 kHz can be used to improve strength in sedentary and poorly performing people.

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