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Effects of trancutaneous electrical nerve stimulation and interferential current on pain threshold in cold induced pain among apparently healthy subjects

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Research Report

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Purpose: Studies on the relative efficacy of Interferential Current (IFC) and Transcutaneous Electrical Nerve Stimulation (TENS) is still inconclusive. This study compared the pain threshold of IFC and TENS on experimental cold induced pain among apparently healthy volunteers. **Materials and methods:** The subjects were 60 consented apparently healthy individuals (30 males, 30 females). Their age ranged between 20 and 25 years with mean age of 23.1±1.49. Subjects were randomly assigned into any of the 3 groups (IFC, TENS or Placebo). An Enraf-Nonius Endomed 582 ID electrical stimulator was used to generate TENS or IFC. The placebo group did not receive stimulation via a connected dummy stimulator. Stimulation was done on the forearm of the subjects while the hand was deep into cold water maintained at 0ºC. The duration of time that the subjects could tolerate the pain and self reported pain intensity were outcome measures. **Results:** The results revealed no statistical significance in pain intensity among the three groups ($F=1.18$; $p>0.05$). Similarly, the pain threshold among the three groups showed no significant difference ($F=1.36$; $p>0.05$). **Conclusion**: No significant difference was found in the pain threshold and pain intensity using either TENS or IFC or placebo on cold induced pain among apparently normal volunteers.

Key words: Transcutaneous electric nerve stimulation, Interferential current, Pain threshold, Pain intensity.

Sağlıklı bireylerde transkutenöz elektriksel sinir stimulasyonu ve enterferansiyel akımın soğukla oluşturulan ağrı eşiğine etkileri

Amaç: Enterferansiyel akım (EFA) ve transkutenöz elektriksel sinir stimulasyonunun (TENS) etkislerine yönelik çalışmalar hala yetersizdir. Bu çalışmada, deneysel buz uygulaması ile ağrı oluşturulan sağlıklı gönüllülerde, EFA ve TENS'in ağrı eşiği üzerine etkisi karşılaştırıldı. **Gereç ve yöntem:** Gönüllülük esasına göre 60 birey çalışmaya alındı (30 kadın, 30 erkek). Yaşları 20-25 arasında değişmekteydi ve ortalama 23.1±1.49 yıl idi. Bireyler rastgele yöntemle 3 gruba (EFA, TENS, Plasebo) ayrıldı. EFA ve TENS için Enraf Nonius Endomed 582 ID elektrik stimulatoru kullanıldı. Plasebo grubuna kablo bağlandı; ancak akım verilmedi. Bireylerin elleri 0ºC soğuk suya daldırıldıktan sonra önkollarına stimulasyon uygulandı. Bireyler ağrıyı tolere edebildikleri kadar soğuk suda kaldılar ve ağrı şiddetleri kaydedildi. **Sonuçlar:** Ağrı şiddeti yönünden üç grup arasında fark yoktu ($F=1.18$; $p>0.05$). Benzer şekilde, üç grup arasından ağrı eşiği yönünden de fark yoktu ($F=1.36$; $p>0.05$). **Tartışma:** Gönüllü sağlıklı bireylerde, soğuk uygulaması ile elde edilen ağrı üzerinde, TENS, EFA ve plasebonun ağrı şiddeti ve ağrı eşiği üzerine etkileri arasında herhangi bir fark bulunmadı.

Anahtar kelimeler: Transkutenöz elektriksel sinir stimulasyonu, Enterferansiyel akım, Ağrı eşiği, Ağrı şiddeti.

Pain management has been a major challenge to the health care providers over the years. Because pain is a major reason why the patients come to the hospital, various modalities have been introduced in pain management. Physical therapy as an integral part of the health team deals with non-pharmacological approach to meet the growing demands of the patients.

Transcutaneous Electrical Nerve Stimulator (TENS) and Interferential Current (IFC) are non-invasive analgesic techniques that are very popular in modulating musculoskeletal pain. Various experts have reported analgesic effects of the two modalities.[1,2] Transcutaneous Electrical Nerve Stimulation is a low frequency current of about 100Hz while IFC is medium frequency (3000-5100Hz) alternating current with a beat frequency ranging from between 0 and 250Hz.[3] It is not yet clear whether these modalities produce similar analgesic effects. Recent findings have shown that TENS and IFC including placebo stimulation produced analgesic effects.[4,5] Johnson and Tabasam concluded that TENS, IFC and placebo have no significant difference in pain intensity or unpleasantness ratings during cold-induced pain among normal subjects.[6] In their later study, they reported no differences in the magnitude of analgesia between IFC and TENS. While IFC reduced pain intensity to a greater extent than sham, the apparent reduction in pain intensity during TENS did not reach statistical significance when compared with sham treatment.[7]

Cold induced pain is reported to be a reliable and safe method of recording pain outcomes which has been widely used to establish the analgesic effects of TENS and IFC Jonnson. Although there is no actual damage to tissue during cold induced pain insult, which make the pain perception to be different from the sensory characteristics of clinical pain (hyperalgesia and allodynia); the deep aching pain is reported to be representative of subjective sensation of pathological pains that arise from direct nociceptor activation.

The aim of this study was to determine which one of TENS and IFC would produce better pain threshold during cold induced pain.

MATERIALS AND METHODS

Subjects

Sixty apparently healthy university students (30 males, 30 females) volunteered were recruited for the study. Their ages ranged between 20 and 25 years. Sample of convenience was used in choosing the participants into the study. Potential participants who expressed an interest were briefed verbally that the experiment is designed to determine whether there are differences in the degree of pain threshold produced by IFC device and TENS. The volunteers were also told what they would experience during the cold-induced pain test by immersing their non-dominant hand into cold water. Participants were briefed verbally that the experiment is designed to determine whether there are differences in the degree of pain relief produced by IFC device and TENS. They were informed that they will immerse their non-dominant hand in warm water maintained at 37ºC for 5 minutes then remove it and immerse in cold water maintained at 0 ºC for as long as they can tolerate while a form of electrical stimulation will be applied to their forearm.

Exclusion criteria included peripheral vascular disease, tumor, skin infection, and abnormal skin sensation. All subjects who met the criteria signed consent form. They were randomly assigned to one of the three experimental groups (IFC, TENS or placebo groups).

Before the start of the study, the Ethics and Research Committee of the Obafemi Awolowo University Teaching Hospital Complex, Ile-Ife, approved the experimental protocol for the study.

Procedure

An Enraf-Nonius Endomed 582 ID machine which can produce both interferential frequency current (IFC) and transcutaneous electrical nerve stimulations (TENS) currents was used for the study. Semantic differential scale was used to rate pain perception of the subjects. Tape measure was also used to measure the distance between the wrist crease and the distal electrodes, and the distance between the distal and proximal electrodes.

Each subject weight was measured in light dressing without shoes on a bathroom scale (Hanson) with the feet placed together and arms relaxed at the side. To measure their height, subjects removed their shoes, looking straight ahead with heels together and knees extended. Measurements were taken by using a ruler to touch the subjects' vertex without undue pressure and the equivalent point on the stadiometer.

Participants were stratified by gender and later randomly assigned to a group. Four rubber electrodes (6 cm x 8 cm) were applied to the medial and lateral anterior surface of the forearm to deliver quadripolar currents. Stimulator setting was adjusted to appropriate treatment groups although and was on for 20 minutes before immersing the hand into cold water. Subjects immersed their non-dominant hand into warm water bath maintained at 37°C for 5 minutes. The hand was then plunged up into a cold water bath maintained at 0°C.

Subjects experienced the sensations in the immersed hand until it became definitely painful and unbearable. Participants were asked to indicate when the pain becomes unbearable. The hand was then removed once the participants indicate unbearable pain. Pain threshold was recorded as the time from the hands immersion into cold water until unbearable pain is felt. Semantic differential scale was used to measure the pain level of the subjects.[8] The subjects then completed verbal rating pain scale for pain threshold by reflecting on their experience of pain just before removing the hand from the water.

Subjects were not aware of the treatment they were been given. Four rubber plates electrodes (6 cm x 8 cm) padded with wet lint to improve conductivity were applied to the anterior and posterior surfaces of the forearm of the subjects.

IFC: Electrodes sites were chosen based on the recommendation of Johnson and Tabasam to target deep afferents emerging from the painful (immersed) hand.[7] Electrodes were placed in a quadripolar manner to the anterior surface. The distal electrodes for channel A and B were attached to the medial and lateral aspects the subjects forearm 5cm proximal to the wrist crease. The Proximal electrodes were applied 3cm above the distal electrodes. The subjects were informed that the intensity must be maintained at a strong but comfortable level. A physiotherapist was in charge to adjust the current amplitude to maintain the sensation. The IFC used for this study was an amplitude modulated frequency of 100Hz, continuous mode generated by mixing 4000 and 4100Hz sinusoidal waves.

TENS: TENS was delivered via a 4 electrodes to standardize the amount of current administered by the two modalities. Electrodes were placed in an identical manner to that of IFC. The electrical characteristics of TENS were set to deliver 200-microsecond biphasic pulsed currents at a pulse frequency of 100pps and a continuous pulse pattern. Study has shown that these settings are similar to the parameters selected for IFC.[9]

Placebo Group: Similar procedure was followed for the placebo group. All the parameters used were the same except that the intensity was not increased at all. The time was monitored for pain threshold and the verbal rating scale was completed.

Statistical analysis:

One Way Analysis of variance (ANOVA) was used to compare the physical characteristics of the subjects in the three groups. Furthermore, ANOVA was used to compare the pain rating and the duration of onset of pain perception among the three groups. The level of significance was accepted as $p<0.05$.

RESULTS

The results of the mean age and physical characteristics of the subjects are presented in Table 1. There was no significance differences in the ages ($F=0.46$; $p>0.05$); height ($F=2.84$; $p>0.05$) and; weight ($F=2.49$; $p>0.05$) of the three groups.

The result ANOVA on pain intensity in this study indicated no statistically significance among the three groups ($F=1.18$; $p>0.05$) (Figure 1). Similarly, the pain threshold among the three groups showed no significant difference ($F=1.36$; $p>0.05$) (Figure 2).

Table 1. Physical characteristics, pain intensity and pain threshold results of the three groups.

	IFC	TENS	Placebo		
	Mean±SD	**Mean±SD**	**Mean±SD**	**F**	**p**
Age (yrs)	23.30±1.53	22.85±1.60	23.10±1.33	0.46	>0.05
Height (m)	1.64±6.85	1.65±7.27	1.59±0.11	2.84	>0.05
Body weight (kg)	57.75±7.42	59.55±5.18	62.35±6.91	2.49	>0.05
Pain intensity (VRS)	6.8±1.44	6.7±1.42	7.3±1.08	1.18	>0.05
Pain threshold (sec)	42.35±11.4	44.55±9.35	35.05±16.04	1.36	>0.05

VRS: Verbal rating scale.

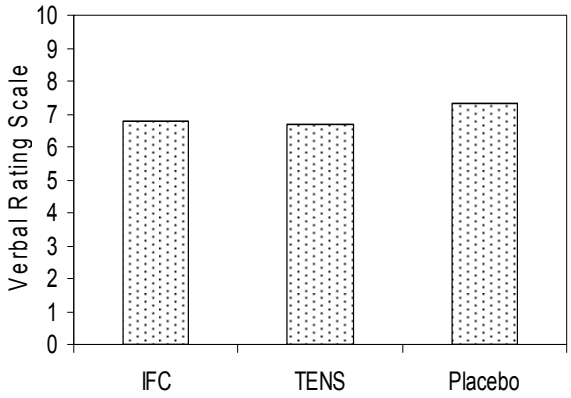

Figure 1. Pain intensity assessment.

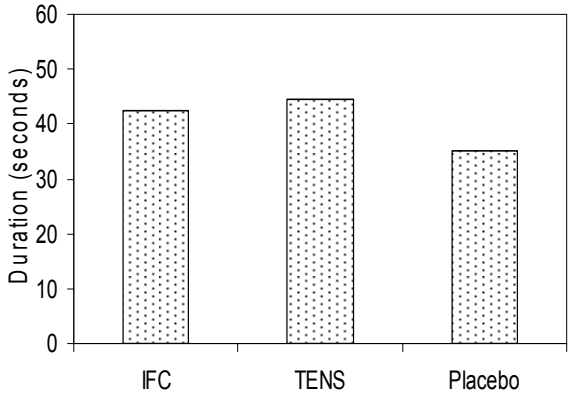

Figure 2. Pain threshold across the three groups.

DISCUSSION

The present study demonstrated no significant difference in the pain threshold among the TENS, IFC, placebo groups. Our findings reflect those of Cheing and Hui-Chan,[10] who found no significance difference in the heat pain threshold between TENS and IFC groups while researching on the analgesic effect of IFC and TENS on heat pain in healthy subjects.

Roche et al also reported that TENS produced a better response to ischemic pain when compared with no stimulation and that the effect was dependent on the time course of the pain and the intensity and time duration of TENS.[11]

Several experimental works have been conducted on the analgesic effects of IFC. It has been demonstrated that IFC elevates pain threshold using cold induced pain in healthy volunteers.[7] The analgesic effect of IFC on clinical pain was reported to be better than placebo among patient with knee osteoarthritis.[12]

Several authors in the field of electroanalgesia have highlighted a key issue of whether IFC is superior to TENS or even different to TENS.[6,10] These authors found no significant difference in pain threshold between the two modalities. The finding from our present study showed no statistically significant difference between the two groups.

It has been observed that IFC and TENS had different effects on cold-induced pain, with TENS

increasing threshold but not altering pain intensity ratings whereas IFC decreased intensity ratings but had no effects on threshold.[13]

Our study revealed that participants in the TENS group has longer pain threshold than IFC although not statistically significant. Both TENS and IFC have longer duration that placebo group. Cheing and Hui-Chan found that both IFC and TENS increased heat pain threshold to a similar extent during stimulation,[10] but that effects of IFC was more prolonged than that of TENS. It is plausible that TENS produces its antinociceptive effects faster that that of IFC but quickly wane down.

The average length of periods the subjects could sustain the cold induced pain were 42.35, 44.55, and 38.05 seconds for IFC, TENS and Placebo respectively. While reporting on the optimal stimulation of TENS in the management of Osteoathritic knee pain, Cheing et al[1] concluded that 40 minutes was the optimal treatment duration of TENS, in terms of pain reduction and the duration of post stimulation analgesia for knee osteoarthritis. It is possible that longer threshold duration would have been recorded if at least 30 minutes stimulation was done to allow the stimulation of endogenous pain inhibitory system before the hand is plunged into the cold water. The mechanisms of pain relief of TENS and IFC are well documented by Cheing et al.[1] The mechanisms centre on pain gate theory, the physiologic block and the endogenous pain inhibitory system. Further study is necessary to know the actual period that antinociceptic agents are produced and the period they decay during and after stimulation.

The results of this study should be interpreted with caution because of its obvious limitation. Experimental pain is usually acute and localized unlike clinical pain which may involve chronic pain with characteristics of diffuse and dull sensation.[14] Patients suffering from clinical pain are said to be different in affective aspect. While people with experimental pain are anxious, patients with clinical pain tend to be depressed.[10] Nonetheless, this study has corroborated previous studies on the need for prolong TENS and IFC treatment in order to achieve maximum analgesic effects. Being relatively homogenous subjects the different responses felt could be attributed treatment effects. Patients with clinical pain may be difficult to form homogenous group as they usually have variations in terms of the history, severity and causes and duration of pain.

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