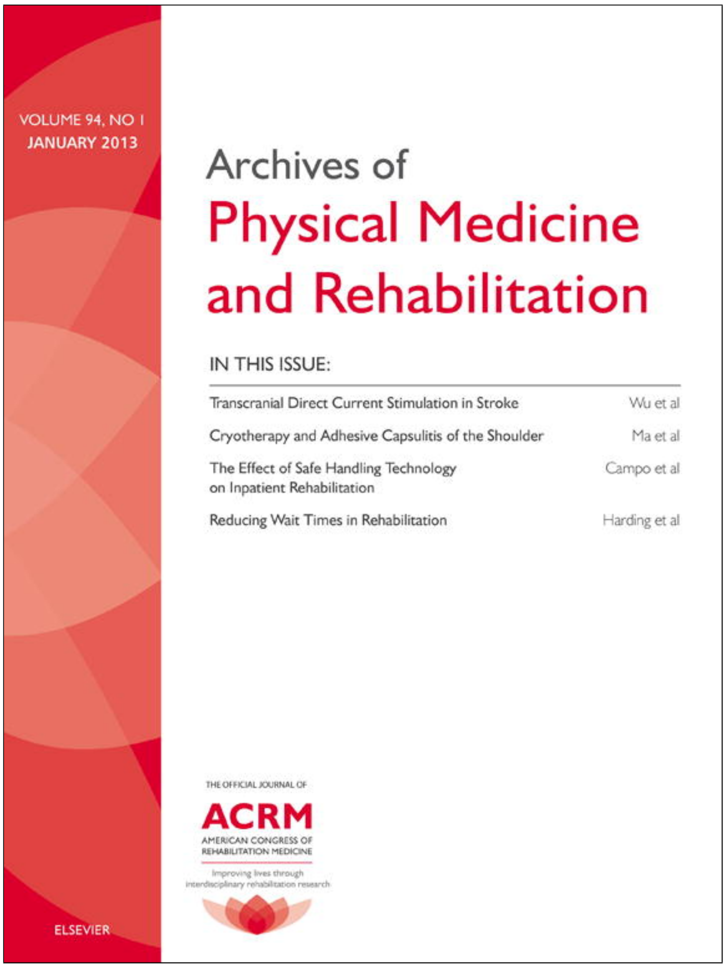
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ORIGINAL ARTICLE

Effects of Carrier Frequency of Interferential Current on Pressure Pain Threshold and Sensory Comfort in Humans

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Abstract

Objective: To assess the effect of carrier frequency of interferential current (IFC) on pressure pain threshold (PPT) and sensory comfort in healthy subjects.

Design: A double-blind randomized trial.

Setting: University research laboratory.

Participants: Healthy subjects (N=150).

Interventions: Application of the IFC for 20 minutes and measures of PPT collected in the regions of the nondominant hand and forearm.

Main Outcomes Measures: We measured PPT and comfort at frequencies of 1kHz, 2kHz, 4kHz, 8kHz, and 10kHz.

Results: There was a significant increase in PPT in the 1-kHz group when compared with the 8-kHz and 10-kHz groups. There was a greater discomfort in the 1-kHz and 2-kHz groups.

Conclusions: IFC with a carrier frequency of 1kHz promotes a higher hypoalgesic response during and after stimulation than IFC with carrier frequencies of 8kHz and 10kHz. Carrier frequencies of 1kHz and 2kHz are perceived as more uncomfortable than carrier frequencies of 4kHz, 8kHz, and 10kHz.

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Interferential current (IFC) is a medium-frequency electrical current amplitude-modulated in low frequency, generated by the superimposition of 2 currents of medium-frequency slightly out of phase.[1,2] It is a type of electrotherapy that theoretically reaches deep tissues by means of the use of a carrier frequency in the kilohertz range with the aim of overcoming the electrical impedance offered by the skin.[1,3-8] Although this claim has been widely reported in the literature, it has been recently questioned because skin impedance to low-frequency pulsed currents depends on the phase duration, not the pulse frequency.[9-11] Moreover, some studies have failed to show differences in hypoalgesic response between IFC and low-frequency pulsed currents delivered by transcutaneous electrical nerve stimulation devices.[5,12,13] Nevertheless, IFC is one of the most common types of electrical current used in Canada[14] and England.[15]

Medium-frequency alternating currents (MFACs) are defined as currents in the frequency range of 1 to 10kHz and are often used in rehabilitation. IFC is a simple and noninvasive treatment often used to induce analgesia,[16] elicit muscle contractions,[17] and reduce edema.[2,18] Although some mechanisms of pain control with IFC have been proposed in the literature, the exact mechanism of action for this effect is still unknown.[5,19-21] The most popular theory used to explain IFC analgesia is the gate control theory of pain.[19,20]

Modern IFC equipment permits that the carrier frequency of the current can be adjusted in accordance with the therapeutic goal. It is claimed that the frequency of 2kHz is more appropriate to elicit muscle contractions and strengthening, whereas the frequency of 4kHz is ideal to generate hypoalgesia.[18,22] However, this information usually comes from electrotherapy textbooks and equipment manuals and not as results of scientific studies. Moreover, there are conflicts in the literature about the ideal

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parameters for electrical stimulation to be used with a minimum of sensory discomfort.[10,23,24]

When bursts of alternating current (AC) are applied transcutaneously, the threshold voltage for sensory nerve excitation decreases as the burst duration is increased.[1,10] This phenomenon of summation is known as "Gildemeister Effect." Thus, it is possible that a single long-duration burst results in multiple action potentials as a result of summation.[10,25-29] Therefore, the use of MFACs without modulation or with long-duration bursts can decrease the nerve fiber response due to the high number of action potentials and possibly cause synaptic fatigue.[10,22,29] Taking into consideration this neurophysiologic evidence, it is important to administer MFACs with short-duration bursts.

With IFC, burst duration can be defined as the time taken for a cycle of amplitude modulation (period) to occur (fig 1).[10,16,30] In IFC devices the only means of altering burst duration is by altering the amplitude-modulated frequency (AMF). Although experimental studies have failed to show the relevance of setting different AMF values for pain control,[20] it has been claimed that an AMF of 100Hz will produce the greatest analgesia.[18,31,32] Accordingly, an AMF of 100Hz is often used in studies assessing the hypoalgesic effects of IFC.[5,6,8,16,21,30,33]

When the AMF is set at 100Hz, the burst duration is 10 milliseconds, which has been found to be too long when compared with burst durations of 1 to 4 milliseconds, which are reported to be optimal for both sensory and motor stimulation by authors who measured sensory, motor, and pain-tolerance thresholds with MFAC in an experimental model in humans.[34,35] With this concern in mind, when analyzing a way of reducing the depolarization excess of nerve fibers during stimulation with IFC, we considered that carrier current frequency modification would decrease temporal summation and the number of action potentials and promote a higher hypoalgesic response. Therefore, the primary purpose of the present study was to assess the effect of the carrier frequency of IFC on pressure pain threshold (PPT) in healthy humans. A second purpose was to compare the sensory comfort during IFC application with different carrier frequencies.

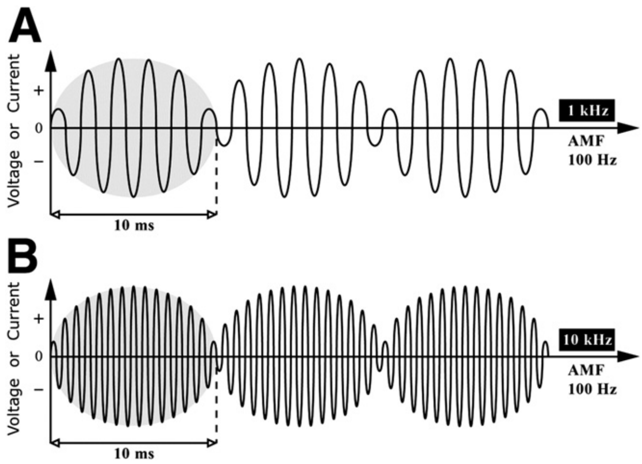

Fig 1 (A) An example of IFC with carrier frequency of 1kHz. This current is produced by the interference of 2 unmodulated MFACs. In this case, 1 current has a frequency of 1000Hz and another 1100Hz. The result is a burst-modulated AC with sinusoidal modulation and frequency of 1050Hz. The burst duration (period) is 10ms, and so the AMF is 100Hz. (B) Similarly, this current with a carrier frequency of 10kHz resulted from the interference of 1 current with 10,000Hz and another with 10,100Hz. The resulting frequency is 10,050Hz. Again, the burst duration is 10ms and the AMF is 100Hz; however, there are now more cycles of AC in each burst than in example A.

Methods

Participants

A total of 150 healthy, pain-free participants (75 men, 75 women; age range, 18–35y) were recruited from the staff and students of the University of the City of Sao Paulo (table 1) after approval was obtained from the university's ethical committee. The sample size was calculated considering a difference of 100kPa between groups and an SD of 110kPa obtained from previous data on PPT and electrical stimulation.[11] At a significance level of .05 and power of 80%, it was calculated that 30 participants were required in each group, giving a total number of 150 participants for the study. Participants were screened and excluded if they had injury or nerve damage to the upper limbs, current pain, pregnancy, cancer, chronic illness, cardiac pacemaker, epilepsy, allergies to the electrodes, currently taking pain medication, skin conditions, or deficient skin sensation in the areas of electrode placement.[11,36,37] The participants were informed about the procedures to be used during the data collection and provided written informed consent. They were stratified by sex to ensure equal numbers of men and women in each group[36-39] and randomly allocated to 1 of 5 groups (n=30 per group): 1kHz, 2kHz, 4kHz, 8kHz, and 10kHz. Randomization was performed using the sequentially numbered, opaque sealed envelopes allocation concealment method.[38-41] The envelopes were stored in a secure cabinet that only the allocation investigator had access to and were opened immediately prior to intervention allocation. All participants completed the study.

List of abbreviations:

AC	alternating current
AMF	amplitude-modulated frequency
IFC	interferential current
MFAC	medium-frequency alternating current
PPT	pressure pain threshold

Participants' preparation

Participants' upper limbs were cleaned with soap and water prior to marking electrode placement and PPT recording sites using a marker. The electrode placement sites were marked out as described below. Two PPT recording sites were marked in the nondominant upper limb as follows: (1) 3 centimeter distal to the distal end of the anatomical snuff box in the midline of the belly of the first dorsal interosseous muscle and (2) on the anterior aspect of the forearm, 7.5 centimeter proximal to the distal wrist crease (figs 2A and B).[11,36] These sites of PPT measurements were chosen to examine the effects of IFC within the area of stimulation and in a distal area.[11,36,37] Participants were asked to remain seated in a comfortable upright position with the upper limb leaning on a table during all procedures.

Pressure pain threshold

PPT was recorded by a researcher who was blind to group allocation using a Kratos pressure algometer[a] (DDK 20). The

Table 1 Characteristics of the study participants

Characteristic	1kHz (n=30)	2kHz (n=30)	4kHz (n=30)	8kHz (n=30)	10kHz (n=30)
Sex					
Male	15 (50)	15 (50)	15 (50)	15 (50)	15 (50)
Female	15 (50)	15 (50)	15 (50)	15 (50)	15 (50)
Age (y), mean ± SD	24.53±0.87	25.53±1.04	22.47±0.81	28.57±0.90	29.17±0.91
BMI (kg/m^2), mean ± SD	23.99±0.64	24.62±0.61	23.88±0.83	24.44±0.85	23.86±0.54
Race					
White	19 (63.3)	19 (63.3)	22 (73.3)	20 (66.7)	21 (70)
African	9 (30)	5 (16.7)	5 (16.7)	10 (33.3)	7 (23.4)
Asian	2 (6.7)	3 (10)	1 (3.3)	ND	1 (3.3)
Other	ND	3 (10)	2 (6.7)	ND	1 (3.3)

NOTE. Values are mean ± SEM or n (%).
Abbreviations: BMI, body mass index; ND, no data.

algometer was calibrated prior to the beginning of the study by the manufacturer. The circular probe of the algometer (1cm^2 area) was placed perpendicular to the skin and applied at a constant rate (approximately 5N/s). Participants were asked to say “stop” when the sensation they were feeling changed from pressure to pain. Three measurements (in Newton) were taken from each recording site at each time point and the average used for data analysis. The pressure in kilopascal was calculated using the following formula: P [Pa] = F [N]/A [m^2], where P is the pressure, F is the applied force, and A is the area of the algometer probe.[11] Each participant had 2 practice trials on the dominant upper limb to ensure the participant understood the PPT measurement. At the 2 recording sites, PPT was recorded at 0, 10, 20, and 40 minutes (20min after treatment). During the study, PPT readings from the 2 recording sites were taken in a random order to avoid order bias.[11,36,42]

A preliminary reliability study was conducted by the PPT assessor by recording PPT from the 2 recording points described above from 10 healthy volunteers on 2 occasions, 48 hours apart. This reliability study demonstrated excellent overall between-session intrarater reliability for PPT measurements from the hand (.99) and from the forearm (.99).

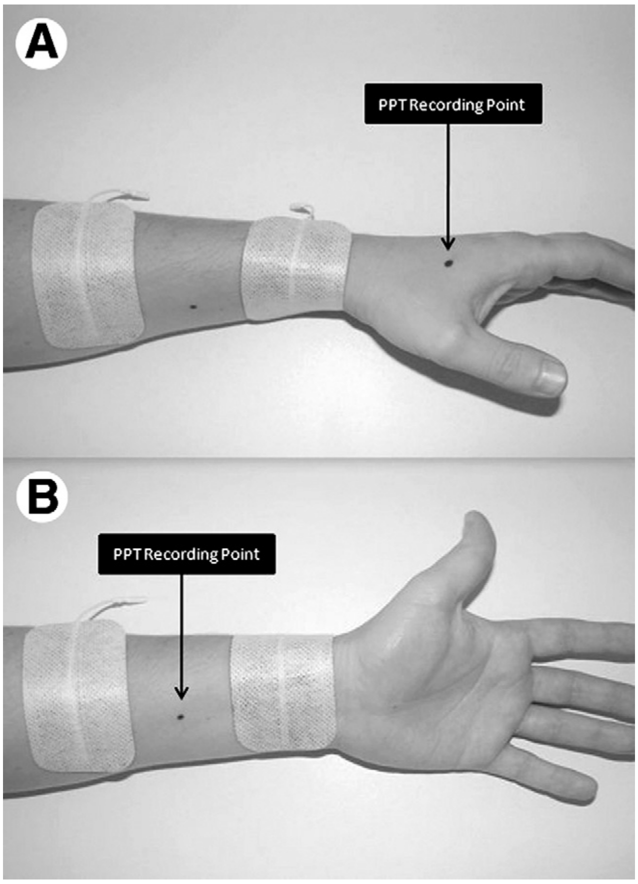

Fig 2 (A) Positioning of electrodes for IFC application and location of PPT recording point on the hand. (B) Positioning of electrodes for IFC application and PPT measurement site on the forearm.

IFC procedure

Two self-adhesive electrodes (50×90mm) (ValuTrode)[b] were placed on the lateral aspect of the forearm at the level of the distal wrist crease and the lateral aspect of the forearm, 10 centimeters proximal to the distal wrist crease (figs 2A and B).[11,36]

An electrical stimulator was provided by IBRAMED[c] and delivered premodulated IFC. This IFC device was modified exclusively for this study and is not commercially available. The unit was calibrated using a digital oscilloscope and 1-kΩ resistor before starting the study.

After the electrodes were positioned, the IFC parameters were adjusted by an investigator not involved in outcome assessments. The equipment was adjusted with the following parameters: carrier frequency according to group allocation and AMF=100Hz. After the parameters had been adjusted, the device display was covered to keep the outcome assessor blind to the participant’s group allocation. The outcome assessor then recorded the PPTs (0min). After the measurement of the PPTs, the outcome assessor left the room and the current amplitude was increased until the participant reported a strong, but comfortable paresthesia. At 5-minute intervals, the participants were asked if the sensation had faded and the current amplitude was increased again until the participant reached the prior sensation.[11] In all groups, IFC was administered for 20 minutes.

Ten minutes from the beginning of IFC application PPT was recorded again followed by a discomfort measurement. Discomfort was assessed with a 10-centimeter visual analog scale where the far left end indicated “very comfortable” and the far right end indicated “very uncomfortable.”[43] Both PPTs and discomfort measurements were repeated at the 20th minute. At the 40th minute (20min after treatment), only PPT was measured.

Current amplitude

The current amplitude required to reach sensory threshold and to promote a strong but comfortable paresthesia was recorded for all study groups throughout the treatment session.

Data analysis

Data were analyzed by a researcher who did not know the group allocation. The average of the 3 PPT scores recorded at each time point was used for analysis.

Descriptive statistics were calculated for all variables in the study. Shapiro-Wilk tests showed that the data were normally distributed. Therefore, we compared PPT between groups using a 3-way mixed analysis of covariance with group as between-subject factor, time and site as within-subject factors, and baseline PPT as covariate. The post hoc tests were based on estimates of multiple confidence intervals adjusted by Bonferroni correction. The variation of initial values (0min) of current amplitude at the end of treatment (20min) was calculated using the following equation: Current Amplitude Difference = Amplitude 20 minutes − Amplitude 0 minute. A 1-way analysis of variance and post hoc Tukey tests were used to compare discomfort and current amplitude between groups.

All analyses were performed using SPSS[d] (version 15.0). All tests were performed assuming a significance level of $P \leq .05$. Data are presented as mean ± SEM.

Results

PPT data

Data for the raw mean ± SEM PPT scores for all experimental groups at each time point are summarized in table 2.

Figure 3 summarizes the baseline-adjusted mean PPT ± SEM in the hand measurement site for all experimental groups. There was a significant hypoalgesic effect in the 1-kHz group when compared with 8-kHz and 10-kHz groups at 20 and 40 minutes ($P<.05$). There was no significant difference between any other groups ($P>.05$).

The baseline-adjusted mean ± SEM of PPT in the forearm over the 40 minutes are summarized in figure 4. Similar to the hand data, statistical analysis showed differences between the 1-kHz group when compared with the 8-kHz and 10-kHz groups at 20 and 40 minutes ($P<.05$). No significant differences were found between any other groups ($P>.05$).

Discomfort data

The discomfort scores measured with the visual analog scale at 10 and 20 minutes are presented in figure 5. One-way analysis of variance showed significant differences in both time points ($P<.0001$). Post hoc Tukey tests indicated a higher discomfort in the 1-kHz and 2-kHz groups than in the 4-kHz, 8-kHz, and 10-kHz groups.

Current amplitude

With regard to the amplitude of the current necessary to reach the sensory threshold, the groups presented significant differences ($P<.0001$). The 1-kHz and 2-kHz groups showed significant differences from the 4-kHz ($P<.0001$), 8-kHz ($P<.0001$), and 10-kHz ($P<.0001$) groups. The 4-kHz group showed significant differences from the 8-kHz ($P=.008$) and 10-kHz ($P=.001$) groups (fig 6). Table 3 summarizes the current amplitude applied in all experimental groups over time.

Figure 7 shows the current amplitude differences (Amplitude 20min − Amplitude 0min). Four-kilohertz, 8-kHz, and 10-kHz groups required a higher current amplitude increase over the treatment time than did the 1-kHz group ($P<.05$). Eight-kilohertz and 10-kHz groups also required a higher current amplitude increase than did the 2-kHz and 4-kHz groups ($P<.05$).

Discussion

To our knowledge, this is the first study conducted to investigate the effect of different carrier frequencies of IFC on PPTs and discomfort. In the present study, we showed that although low carrier frequencies were more uncomfortable they promoted a higher hypoalgesic response. Hans Nemec developed the IFC in the early 1950s with a carrier frequency of 4kHz, claiming that this particular frequency would be more comfortable for patients.[10,44] However, we have not found studies in the literature showing whether the frequency of 4kHz is really the most

Table 2 Mean ± SEM raw PPT scores for all time points, for each group for hand and forearm PPT measurements

			IFC Application		Post-IFC
	Group*	Baseline	10min	20min	40min
Hand	1kHz	328.55±38.24	391.43±47.26	431.34±51.98	377.07±48.65
	2kHz	319.85±38.28	372.56±47.97	395.31±51.45	348.80±38.29
	4kHz	274.70±35.00	314.96±36.18	336.77±36.00	315.11±40.58
	8kHz	227.55±17.21	244.89±16.64	263.44±18.61	240.43±18.95
	10kHz	210.86±11.52	226.88±12.11	237.15±8.47	213.12±11.94
Forearm	1kHz	402.91±36.92	454.75±45.46	490.20±47.92	457.19±48.10
	2kHz	415.22±45.68	457.99±50.55	472.53±49.56	444.52±46.09
	4kHz	391.67±38.66	417.30±37.36	426.90±35.53	424.27±42.35
	8kHz	298.47±15.94	318.55±15.76	334.46±18.07	309.44±17.13
	10kHz	288.52±13.38	303.62±11.60	311.76±10.92	283.67±10.80

NOTE. All values are expressed in kilopascal.
* n=30 per group.

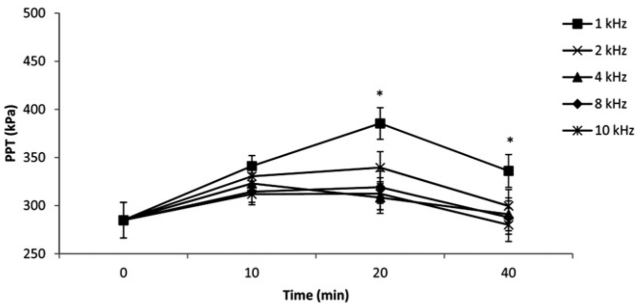

Fig 3 PPT data for hand measurements, for each experimental group (baseline-adjusted mean ± SEM). *Indicates significant difference ($P<.05$) from 8-kHz and 10-kHz groups.

comfortable and whether it produces a better hypoalgesic response than do other kilohertz-range frequencies. Manufacturers of electrotherapy devices produce commercial equipment of IFC with frequencies ranging from 1kHz to 10kHz.[30] The most often used frequencies are 2kHz for muscle contractions and 4kHz for pain control[20,22] despite the lack of evidence to support these claims.

In the current study, PPTs recorded from both hand and forearm showed a significantly higher hypoalgesic response in the 1-kHz group than in the 8-kHz and 10-kHz groups in the 20th and 40th minutes. A more pronounced hypoalgesic effect was observed when using lower carrier frequencies (1kHz), which may be explained on the basis of the decrease in summation and reduction in multiple firing. Long burst durations can lead to more summation and multiple nerve fires in each burst, causing fiber dropout due to neurotransmitter depletion (synapse fatigue), propagation failure, and/or nerve block, resulting in a lesser hypoalgesic effect.[24,29,45,46] In our study, the burst duration was always the same (10ms); however, we conclude that using lower carrier frequencies the number of cycles per burst decreases and summation consequently decreases, leading to a lesser nerve firing frequency.

High frequencies of AC can reduce the nerve response because successive stimuli fall within the relative or eventually absolute refractory period of the action potential, impairing nerve fiber repolarization.[18,22] The sensitivity of nerve fibers decreases, and a higher current intensity is needed to depolarize the nerve membrane. Prolonged stimulation with high frequencies causes the axon to cease conducting, and this phenomenon is known as Wedensky inhibition.[18] Bowman and McNeal[47] assessed the response of single alpha motoneurons for neural block, using

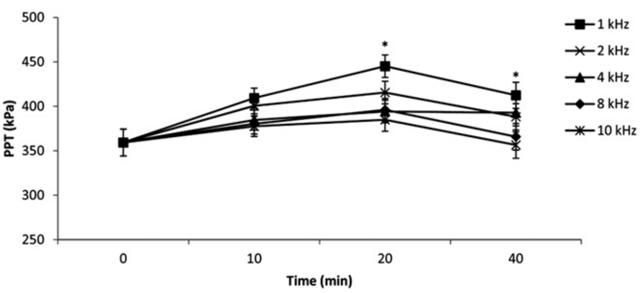

Fig 4 PPT data for forearm measurements, for each experimental group (baseline-adjusted mean ± SEM). *Indicates significant difference ($P<.05$) from 8-kHz and 10-kHz groups.

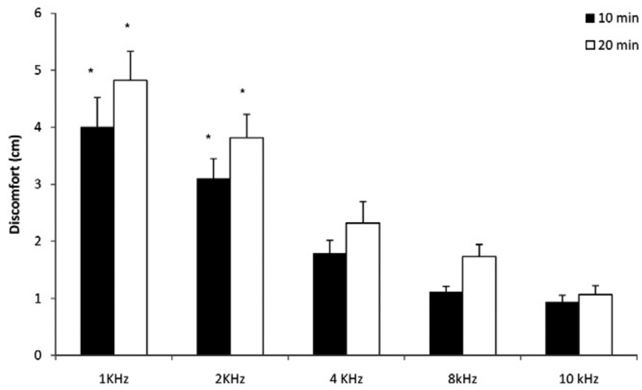

Fig 5 Mean ± SEM values of sensory discomfort measured by visual analog scale at the 10th and 20th minutes during IFC for each group (n=30 per group). *Represents a statistically significant difference when compared with the 4-kHz, 8-kHz, and 10-kHz groups ($P<.05$).

frequencies between 100Hz and 10kHz, and they concluded that at higher AC frequencies (4kHz or more), the rate of decrease in activity was higher, with the firing frequency dropping to 0 in less than a second using stimulus intensities of 5 times the threshold.[10] Other studies have also demonstrated a neural conduction block using high-frequency ACs.[46,48] Accordingly, the use of frequencies of 8kHz and 10kHz could have impaired the neurophysiologic response of large-diameter (Aβ) afferent fibers, preventing them from activating the neural inhibitory circuits located in the posterior horn of the spinal cord (gate control theory of pain), decreasing the hypoalgesic response of IFC. Only 1 study compared 2 carrier frequencies of IFC (2kHz and 4kHz) and concluded that there was no difference in the hypoalgesic response in individuals with low back chronic pain.[49] Nevertheless, this is an unpowered study because only 7 patients were included in each group, which makes the identification of significant differences between groups difficult.

In the present study, we increased the current amplitude at 5-minute intervals over the treatment time in order to avoid

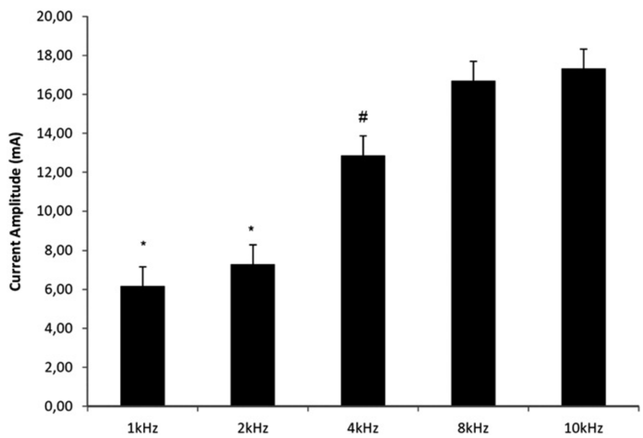

Fig 6 Mean ± SEM values of the amplitude of current required to achieve the sensory threshold for each group (n=30 per group). *Represents a statistically significant difference when compared with the 4-kHz, 8-kHz, and 10-kHz groups. #Represents a statistically significant difference when compared with the 8-kHz and 10-kHz groups.

Table 3 Mean ± SEM current amplitude applied in all experimental groups over time

Group	Sensory Threshold	0min	5min	10min	15min	20min
1kHz	6.17±0.34	13.07±0.90	16.07±1.03	18.43±1.14	20.43±1.25	22.40±1.41
2kHz	7.30±0.42	15.33±1.10	18.97±1.27	21.87±1.42	24.77±1.61	27.10±1.78
4kHz	12.87±0.64	22.73±1.32	27.70±1.59	31.43±1.78	34.90±1.84	37.73±1.97
8kHz	16.70±1.06	29.53±2.99	36.30±3.14	42.90±3.54	48.00±3.74	51.97±3.85
10kHz	17.33±1.14	30.62±2.33	38.07±2.38	44.21±2.54	49.24±2.58	53.62±2.85

NOTE. All values are expressed in milliampere.

habituation, based on a previous study that showed the importance of this practice to obtain maximal hypoalgesia.[11] It is important to note that the increase necessary to maintain a strong but comfortable parasthesia over the 20 minutes of IFC application was greater at higher than lower frequencies as shown in figure 7. This finding reinforces the hypothesis of synapse fatigue, propagation failure, and/or nerve block with the use of IFC with higher frequencies.

Some previous studies designed to assess the effects of IFC with a carrier frequency of 4kHz have failed to show an increase on PPTs[13,50,51] in contrast with studies using low-frequency pulsed currents.[11,36,37,52-56] Nevertheless, Ward and Oliver[29] showed that an MFAC with a carrier frequency of 1kHz and a 4-millisecond burst duration was equally effective as a low-frequency pulsed current to increase cold pain threshold in healthy humans. Therefore, it is possible that IFC parameters commonly used in scientific studies and/or in physical therapy practice currently are suboptimal.

During the present study, each individual used a visual analog scale for the assessment of sensory discomfort related to the current. The carrier frequencies of 4kHz, 8kHz, and 10kHz presented a higher sensory comfort when compared with 1kHz and 2kHz. This result can be related to strength-duration curves.[57,58] A carrier frequency of 1kHz presents a phase duration of 500 microseconds, whereas a carrier frequency of 10kHz presents a phase duration of 50 microseconds. Thus, according to the strength-duration curves, longer phase durations would be more uncomfortable because there is less separation between sensory, motor, and pain responses; thus, they can reach the pain threshold with smaller current amplitudes.

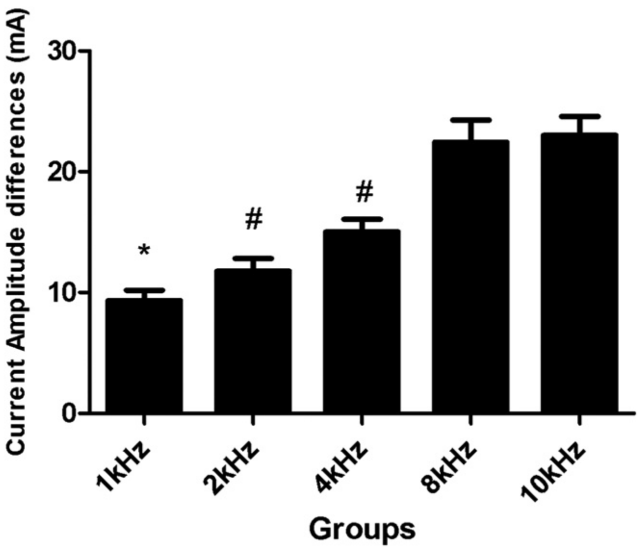

Fig 7 Mean ± SEM values of the differences of the amplitude of current (amplitude applied at 20min − amplitude necessary to promote a strong but comfortable paresthesia, applied at the beginning of treatment) for each group (n=30 per group). *Represents a statistically significant difference when compared with the 4-kHz, 8-kHz, and 10-kHz groups. #Represents a statistically significant difference when compared with the 8-kHz and 10-kHz groups.

Previous studies of electrical stimulation for pain control have shown that a strong intensity is required to promote higher hypoalgesia.[11,37,59-61] Olsen et al[61] compared the effects of low- and high-intensity transcutaneous electrical nerve stimulation for painful postpartum uterine contractions and verified that even though women receiving high-intensity transcutaneous electrical nerve stimulation experienced a greater discomfort during stimulation, they presented less pain than women in the low-intensity group. Thus, the greater discomfort observed when using lower frequencies (1 and 2kHz) in the present study may be related to a higher hypoalgesia.

With regard to the current amplitude we observed that to reach the sensory threshold in the groups using higher frequencies (8 and 10kHz) it was necessary to use higher amplitudes. This result can be explained by the fact that there is a decrease in phase duration as the frequency of the electrical current is increased. Again, as observed in strength-duration curves, a smaller phase duration needs a higher current amplitude to reach the excitatory response.[23,57,58] On the other hand, as the current frequency is increased, the electrical impedance of the skin decreases and facilitates the electrical stimulus reaching the nerve fiber. Thus, the threshold of activation of nerve fibers depends on the balance of the impedance of the skin and the sensitivity of nerve fibers.[23,62]

An interesting finding observed in the present study is that the hypoalgesic effects of IFC appear to be maximized after 20 minutes of treatment and are still significant 20 minutes post-treatment. This suggests that applying IFC for 10 minutes is less than optimal for pain control.

Study limitations

The present study has certain limitations that need to be taken into account. Some of the limitations include the generalizability of the results. Participants were pain-free; thus, future clinical studies should be performed to confirm these results in patients experiencing pain. In addition, we did not perform electrophysiologic tests to observe how nerve fibers would respond to each carrier frequency.

Conclusions

In summary, it can be concluded that IFC with a carrier frequency of 1kHz promotes a higher hypoalgesic response in an experimental pain model during and after stimulation than IFC with a carrier frequency of 8kHz and 10kHz. Carrier frequencies of 1kHz and 2kHz are more uncomfortable than carrier frequencies of 4kHz, 8kHz, and 10kHz.

Suppliers

a. Neurovector; Industria Brasileira de Equipamentos Médicos Ltda., Av. Dr Carlos Burgos, 2800, Jd. Itália, Amparo, São Paulo, Brazil.
b. ValuTrode Electrodes; Axelgaard Manufacturing Co, Ltd, 520 Industrial Way, Fallbrook, CA 92028.
c. Algometer; Kratos Equipamentos, Rua Etiópia, 294, Bairro Rio Cotia, Cotia, São Paulo, Brazil.
d. SPSS, Inc, 233 S Wacker Dr, 11th Fl, Chicago, IL 60606.

Keywords

Electric stimulation therapy; Pain threshold; Physical therapy modalities; Rehabilitation

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