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Influence of the stimulating frequency involved in analgesic effects induced by electroacupuncture for neck pain due to muscular tension

Influência da frequência estimulatória envolvida nos efeitos analgésicos induzidos por eletroacupuntura em cervicalgia tensional

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Abstract

Objective: To assess the influence of the stimulating frequency involved in analgesia induced by electroacupuncture for neck pain. **Methods:** The performance of the analgesia produced by 2Hz, 100Hz, 1000Hz and 2500Hz was compared with a group with acupuncture alone (without electrical stimulation), by means of pressure algometry, a visual analog scale (VAS) and heart rate. We used an electrical stimulator with a microprocessor yielding standard, single-phase, rectangular and asymmetrical balanced pulsed waveforms with a secondary phase decreasing exponentially. Stimulation periods were 4s, and resting periods were 3s. The sample included 66 volunteers with neck pain due to muscular tension, mean age 33.67±9.97 years, 89.5% female and 10.5% male. **Results:** There were no differences between the groups regarding the variables of degree of pain (according to the VAS) and heart rate, and all groups presented analgesic improvement. However, when comparing pressure algometry findings for the same individual before and after the treatment, within the same group, we found analgesic advantages in using 2500Hz (p=0.006 for the base of the occipital region, p=0.003 for the right trapezius and p=0.013 for the left trapezius), followed by 100Hz (p=0.035, p=0.016 and p=0.038 for the same regions, respectively). **Conclusion:** We preferentially recommend 2500Hz and 100Hz applications of electroacupuncture for analgesia of neck pain due to muscular tension.
Article registered in the Australian New Zealand Clinical Trials Registry (ANZCTR) under the number 083456.

Key words: electroacupuncture; electrical stimulation; analgesia; neck pain.

Resumo

Objetivo: Avaliar a influência da frequência estimulatória envolvida na analgesia induzida por eletroacupuntura em cervicalgia. **Métodos:** Comparou-se o desempenho da analgesia produzida em 2Hz, 100Hz, 1000Hz, 2500Hz e um grupo só com acupuntura, sem estímulo elétrico, avaliado por meio de algometria de pressão, Escala Visual Analógica (EVA) e frequência cardíaca. Utilizou-se um estimulador elétrico microprocessado, com forma de pulso em padrão pulsado, monofásico, retangular, balanceado assimétrico, com fase secundária em exponencial decrescente, com período de estimulação de 4 segundos e repouso de 3 segundos. A amostra contou com 66 voluntários com cervicalgia tensional, idade média de 33,67±9,97 anos, 89,5% do gênero feminino e 10,5% do masculino. **Resultados:** Não houve diferenças entre os grupos para as variáveis nota atribuída à dor pela EVA e frequência cardíaca, sendo que em todos os grupos houve melhoras analgésicas. No entanto, quando comparado o comportamento antes-depois, por meio da algometria de pressão, para um mesmo indivíduo, dentro de seu próprio grupo, houve vantagens analgésicas para o uso de 2500Hz (p=0,006 para a base da região occiptal; p=0,003 para o trapézio direito; e p=0,013 para o trapézio esquerdo), seguido de 100Hz (p=0,035, p=0,016 e p=0,038, para as mesmas regiões, respectivamente). **Conclusão:** Recomenda-se preferencialmente a aplicação de 2500Hz e 100Hz em eletroacupuntura para analgesia em cervicalgia tensional.
Artigo registrado no Australian New Zealand Clinical Trials Registry (ANZCTR) sob o número 083456.

Palavras-chave: eletroacupuntura; estimulação elétrica; analgesia; cervicalgia.

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Introduction

Acupuncture has incorporated electrical stimulation as an action mechanism to create electroacupuncture, which is considered an indispensable technological resource for the success of this technique[1]. Due to the great interest and to the propagation of electroacupuncture in Brazil, the Ministry of Health has added acupuncture to the Public Health System (SUS)[2]. Eight health-related councils also consider this technique a specialty, including the Federal Council of Physical Therapy and Occupational Therapy[3]. As a physical therapy resource, electrotherapy appears to be more organized with regard to the standardization of procedures and instruments[4]. In contrast, electroacupuncture has yet to establish safe procedures and define effective physical parameters that can be applied during therapeutic practice[5].

The therapeutic principles of electrotherapy are based on physiological interactions at cellular, tissue and systemic level. The electric current flow, through a biological conductive medium, unleashes physiological effects involving electrochemical, electrophysical and electrothermal phenomena[4]. One of the most relevant and studied physical parameters in electroacupuncture is stimulation frequency, especially its relationship with endogenous opioid release in analgesic and anti-inflammatory processes[6].

In the first generation of electroacupuncture research, studies were conducted on rats with induced pain in rats to relate stimulation frequencies to biochemically released substances such as: cholecystokinin 8 (CCK 8) at 100Hz[7]; endorphin at 2Hz[8]; encephalin and dynorphin at 2 and 100Hz[6]; endomorphin at 2Hz[9], and substance P at 10Hz[10]. The studies on humans, as well as those involving higher frequencies, are scarce and use different methodologies, such as analgesia in back pain with the application of 50Hz[1] and 80Hz[11], postoperative analgesia at 100Hz[12-14], neck pain at 120Hz and 250Hz[15] and indications for acute pain at frequencies of 800 to 1000Hz[12]. The scarcity of scientific studies on humans in this area can be explained by the difficulties which surround the assessment of human pain, as well as methodological errors, which have already been criticized by other authors[16,17]. Therefore, it is important to evaluate the analgesic effects of therapeutic procedures to determine whether they should continue to be used.

The symptom of neck pain due to muscular tension was chosen because it is part of the population profile since it affects a great number of individuals. According to Côté[18], neck pain affects 30% of men and 43% of women at some point in their lives, and it is a complaint that keeps a large number of workers away from their professional activities. Neck pain can have several sources, such as postural changes, mechanical traumas, spine rectifications, joint compressions and others[19]. It is known that neck pain due to muscular tension is not a pathology in itself, but a symptom or a manifestation of muscle pain syndromes. Another relevant aspect in choosing this symptomatology was the fact that acupuncture has already shown good therapeutic results in neck pain[15,20] and, as consequence, there is extensive literature on this symptom and the acupuncture application points[20-25].

The present article describes a clinical-experimental study on humans. Its aim was to compare the performance of analgesia induced by acupuncture alone (without electrical stimulation) with the performance induced by electroacupuncture. The employed stimulation frequencies were 2Hz, 100Hz, 1000Hz, and 2500Hz.

Methods

For the experimental protocol, we used stainless steel disposable acupuncture needles (0.25 diameter x 40mm length); 70% alcohol solution; absorbent cotton; a chronometer; a Wagner digital algometer; and a sharps disposal box. We also used a class I, BF type electrostimulator (NKL, model EL608, ANVISA 80191680002) with microprocessed stimulus generation and control and 8 isolated outputs through pulse transformers. The output current can reach a maximum value of 10mA per pulse or mean intensity of 6mA.

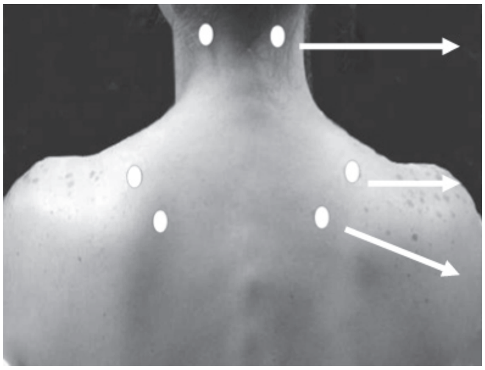
The pulsed shape generated by the stimulator was configured as monophasic, rectangular, asymmetrical, with secondary phase in decreasing exponential obeying, a pulsed pattern with 4-second stimulation periods and 3-second resting periods, according to Knihs[5]. The equipment was calibrated at the Rehabilitation Engineering Laboratory of PUC/PR, following the technical norms NBR IEC 60601-1 and NBR IEC 60601-2[26,27].

The subjects were recruited at the outpatient clinics of Instituto Brasileiro de Therapias e Ensino of Curitiba. Initially, following the inclusion criteria, a population sample of 88 subjects was selected. However, at the time of intervention, a few subjects showed inadequacies such as drop in blood pressure, fear, intolerance to the electrical stimulation, use of analgesic drugs, among others. These subjects received treatment but were not considered as part of the sample. The sample consisted of 66 individuals, aged 18 to 53 years with a mean age of 33.67±9.97 years, 89.5% female and 10.5% male. A subject screening instrument was prepared and validated using the technical reports of 10 orthopedics specialists. The objective of this instrument was to characterize the volunteers as neck pain sufferers due to muscular tension to outline the sample profile to guarantee group homogeneity. Based on the defined inclusion criteria, we selected: normotensive individuals, with neck pain due to muscular tension in the trapezius and neck muscle region, at least in the last 4 weeks before the selection. The exclusion criteria were: smokers, because tobacco was pointed out by Piovesan et al.[28] as a factor in the decrease in nociceptive sensibility in algometry evaluation; pacemaker carriers and pregnant women, because the use of electroacupuncture is contraindicated for those individuals[29]; individuals who had received physical therapy treatment, massage or acupuncture in the last two weeks before the intervention, or who had taken anesthetic drugs, painkillers, muscle relaxants, psychotropic drugs or anti-inflammatories in the last two days before the intervention. This project was approved by the Research Ethics Committee of PUC-PR, protocol CEP 1035/2006. All the volunteers signed a consent form. With the intention of partially blinding the study, a physical therapist was invited to evaluate the subjects, who were systematically distributed between the groups. The measurement instruments were also evaluated before and after the therapeutic intervention.

Initially, the subjects were asked to score the pain on the visual analog scale (VAS) where zero was defined as "no pain", and ten as "the worst pain". The subject's heart rate was then measured. The evaluation through pressure algometry began with an explanation about the test and how the subject should verbalize the tolerance to the pressure. An example was given before the real test for clarity. The example consisted of a mechanical stimulus applied to the right elbow crease until the subject expressed discomfort to the pressure by immediately saying "stop". At that moment, the compression was instantly blocked, and the reading was checked on the algometer. For the pressure measurement, the algometer (with calibration certificate) was set at the C function (self-calibration in kgf/cm^2). The tolerance was standardized as the expression of the onset of discomfort caused by the pressure of the algometer's rubber tip on the skin. The VAS, heart rate and pressure algometry procedures were performed at least 10 minutes before the intervention, taking advantage of the interview time when the subject remained seated and at rest. The procedures were repeated 10 minutes after the acupuncture needles were removed.

For the pressure readings, we selected three bilateral and symmetrical combinations of points on the neck and trapezius muscle with a total of six reading areas: 1 and 2 (occipital insertion of the right and left trapezius, respectively); 3 and 4 (midpoint of the upper border of the right and left trapezius, respectively); 5 and 6 (supraspinatus muscle above the medial border of the right and left spine of the scapula, respectively), as demonstrated in Figure 1. These points were chosen based on the literature because they are painful points in myofascial pain syndromes[30].

The subject remained seated during all of the procedures. A sequence of algometry readings was standardized in such a way that, when the first reading of the six points was completed, a new "round" of readings in the same sequence began. Overall, three readings were performed on each point, before and after the intervention. The values were grouped for mean calculation, considering measure 1 with measure 2, 3 with 5, and 4 with 6. After the pre-intervention evaluations were completed, the acupuncture needles were applied bilaterally. The acupuncture points were selected based on bibliographical indications for neck pain as follows: B10 (*tianzhu*), VB21 (*jianjing*), TA15 (*tianliao*), IG4 (*hegu*) and ID3 (*houxi*)[23-25]. The needles used on points TA15 and VB21 (trapezius muscle, bilaterally) were selected to receive electrical stimulus, acting as needle-electrodes. These points were chosen due to the anatomical proximity to the painful region, to the muscle relaxation function attributed to these points, and the fact that the needles can be easily and more comfortably applied to them. The needle's depth of insertion was approximately 1.27cm (0.8 in), except in ID3 (on the hand), where the depth was about



Reading 1. Insertion of the right occipital muscle
Reading 2. Insertion of left occipital muscle

Reading 3. Midpoint of the top border of the right trapezius
Reading 4. Midpoint of the top border of the left trapezius

Reading 5. Supraspinatus muscle above the medial border of the right spine of the scapula
Reading 6. Supraspinatus muscle above the medial border of the left spine of the scapula

Adapted from Melzack[30].

Figure 1. Algometry points and anatomical/topographical references.

0.4cm (0.3 in). The needles were inserted and removed in the same sequence for all the subjects.

The groups were coded by draw with letters A (2500Hz), B (2Hz), C (1000Hz), D (100Hz) and E (without electrical stimulation). The subject and the researcher had no knowledge of the frequencies that corresponded to each letter. The stimulation frequency was the variable modified during the experiments because it was the physical parameter under evaluation. The adjustment of the current intensity respected the stimulus tolerance of each subject, therefore individualized, based on the electroacupuncture technique[5,29].

The subjects were divided into groups A, B, C, D and E by systematic distribution conducted by the invited examiner. The amount of time the needles were left in place, including the time of electrostimulation, was 20 minutes. At the end of this interval, the electrostimulator cables and the needles were removed. Care was taken to avoid pressure close to the reading locations. A rest period of 10 minutes was standardized until the VAS, heart rate and algometry evaluations were repeated, which constituted the post-intervention data collection. The present study included 66 volunteers divided into five groups: A (2500Hz, n=13), B (2Hz, n=13), C (1000Hz, n=13), D (100Hz, n=13), E (without electrical stimulation, n=14).

Results

In order to accomplish the statistical treatment, the analysis of covariance (ANCOVA) was applied to the algometry data. The non-parametric Kruskal-Wallis test was used for the VAS, and the Wilcoxon and *t* tests were used for within-group evaluations.

Pain score (VAS)

There was statistical significance to the reduction in the percentage variation of the mean pain scores, which shows improvements in the analgesic effect noticed by the subjects in all groups. The values were: A (2500Hz) reduction of 52.12% and p=0.003; B (2Hz) reduction of 32.93% and p=0.028; C (1000Hz) reduction of 52.41% and p=0.002; D (100Hz) reduction of 41.92% with p=0.013; and E (without electrical stimulation) reduction of 65.95% and p=0.002.

Tolerance to pressure

An evaluation per anatomical region (Figure 1) found statistical significance between pre- and post-intervention pressure tolerance. This form of evaluation, from a statistical point of view, reduces individual variability among subjects because it compares each individual to himself (paired sample). Table 1 shows that there was statistical significance for groups A (2500Hz) and D (100Hz) in all evaluated anatomical regions, which demonstrates the effectiveness of the therapeutic intervention. The other groups did not show statistical relevance.

Heart rate

The percentage variation between pre- and post-intervention heart rate had no significant difference between groups (p=0.716). In all groups, there were subjects with no change in heart rate; however, some had an increase and others had a reduction, as demonstrated in Figure 2. Group E (without electrical stimulation) had the highest number of cases of increased heart rate (43%).

Discussion

The results and statistical analyses show that there was statistical significance in all groups between the pre- and post-intervention pain score (VAS) and heart rate, which indicates therapeutic improvement, but without prominence of a specific group. However, the evaluation of within-group therapeutic performance for pressure tolerance showed better results for 2500Hz, followed by the 100Hz frequency. This result was confirmed in all the regions evaluated by pressure algometry.

These results disagree with some authors such as Han[6] and Filshe and White[29], who point out the advantages of using low-stimulation frequencies (2Hz) for analgesic effects based on biochemical and immunohistological studies on rats and mice. Research in animals are important because it is based on the analgesic effects of neurotransmitter release. In contrast, it does

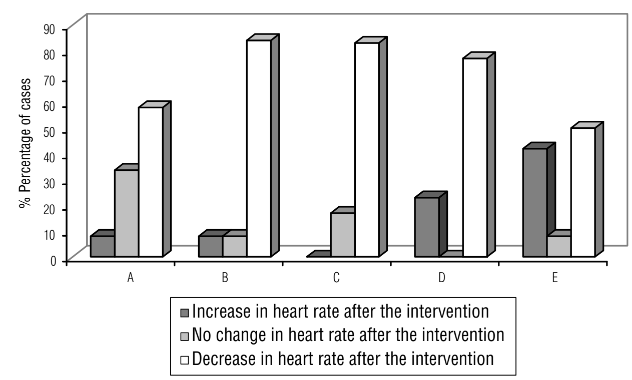


Figure 2. Comparison between the evaluated groups with regard to the incidence of cases increased, changed or decreased heart rate after the intervention. Groups: A (2500Hz), B (2Hz), C (1000Hz), D (100Hz) and E (without electrical stimulation).

not take into account emotional, cultural and biomechanical variables experienced in human pain.

Filshe and White[29] conducted a survey of controlled experiments on humans which had very few findings, but verified that lower electroacupuncture frequencies had better analgesic results than the higher frequencies. The authors also reported that the therapeutic effects last longer in chronic painful conditions. Unfortunately, electroacupuncture studies in humans are still scarce, particularly the ones which intend to compare parameters.

Tienyou[31], Yin[22] and Cui[32] defend that electroacupuncture has analgesic advantages over acupuncture. The results of the present study partially confirm this statement by showing that there was statistical significance for pressure algometry in all evaluated regions in two out of four groups treated with electroacupuncture (2500Hz and 100Hz), and that there was no difference in the group treated only with acupuncture. However, the results of the VAS evaluation show that group E, which received only acupuncture, demonstrated the highest mean reduction in the pain score (65.95%), although there was no statistical difference in comparison to the other groups. A possible explanation for this result is based on the fact that the mere possibility of an electrical current passing through the body causes anxiety in the subject and consequent negative psychological effect. It is worth noting that the VAS score has a subjective and emotional component, according to Ferreira[19].

In pressure algometry, however, the reference is more quantitative and it is associated with nociceptive sensibility based on a concrete mechanical stimulus, which is the rubber tip of the algometer. In addition, the algometry reading points

Table 1. Variations in the pressure tolerance measurements and statistical significance (kgf/cm^2) before and after the intervention within groups A (2500Hz), B (2Hz), C (1000Hz), D (100Hz) and E (without electrical stimulation).

Group A	Time	n	Mean	Median	Low	High	Standard deviation	p value
Region 1-2	Before	13	3.03	2.51	1.54	5.45	1.27	0.006
	After	13	3.62	3.53	1.51	5.68	1.33	
Region 3-5	Before	13	3.24	2.62	1.02	7.35	1.99	0.003
	After	13	4.11	3.88	1.14	7.04	1.83	
Region 4-6	Before	13	3.09	2.39	0.91	8.17	2.14	0.013
	After	13	3.93	4.04	1.05	6.63	1.71	
Group B								
Region 1-2	Before	13	2.53	2.24	1.07	4.68	1.09	0.254
	After	13	2.76	2.58	1.41	5.77	1.21	
Region 3-5	Before	13	2.53	2.63	0.58	4.84	1.24	0.100
	After	13	2.93	2.55	0.91	6.45	1.56	
Region 4-6	Before	13	2.77	2.39	0.68	5.46	1.58	0.821
	After	13	2.81	2.45	0.95	6.34	1.42	
Group C								
Region 1-2	Before	13	2.53	2.31	1.07	4.62	0.89	0.906
	After	13	2.51	2.44	1.20	3.91	0.77	
Region 3-5	Before	13	2.28	2.13	0.78	4.14	0.87	0.257
	After	13	2.52	2.44	1.19	3.65	0.80	
Region 4-6	Before	13	2.45	2.32	0.80	4.16	0.92	0.249
	After	13	2.71	2.61	0.99	3.91	0.90	
Group D								
Region 1-2	Before	13	2.36	2.43	1.10	4.66	1.19	0.035
	After	13	2.85	2.66	1.33	5.52	1.19	
Region 3-5	Before	13	2.53	2.39	0.90	4.92	1.39	0.016
	After	13	3.12	2.74	1.29	6.64	1.65	
Region 4-6	Before	13	2.58	2.48	1.03	5.31	1.45	0.038
	After	13	3.09	2.45	1.34	7.06	1.79	
Group E								
Region 1-2	Before	14	2.70	2.72	0.81	6.02	1.16	0.634
	After	14	2.81	2.45	1.30	5.78	1.30	
Region 3-5	Before	14	2.73	2.29	0.49	9.14	2.06	0.457
	After	14	2.92	2.46	1.25	9.10	1.92	
Region 4-6	Before	14	2.78	2.30	0.44	7.28	1.62	0.614

chosen for the present study were close to the insertion location, and the stimulus caused by the electrical current in the groups with electroacupuncture also had an enhanced local effect, unlike the stimulus of acupuncture needles alone. With regard to heart rate variations, before and after the therapeutic intervention, there were no differences between the researched groups.

There are no studies in the literature that associate heart rate with analgesic effects of acupuncture or electroacupuncture. Although there was no statistical difference between the evaluated groups, one result is worth noting: most of the subjects in the groups submitted to electroacupuncture demonstrated a reduction in heart rate after the intervention (Figure 2). The same fact did not occur in the group which received only acupuncture (without electrical stimulation), in which 43% of the subjects had an increase in heart rate after the intervention, 50% had reduction and 7% showed no change.

Melzack[33] and Guyton[34] discussed the influence of stress and external stimuli on heart rate modulation, as well as the anatomical and physiological pathways of that influence. Pomeranz[17] found a relationship between low-frequency electroacupuncture and analgesic and sedative effects, which suggests possible indirect effects on heart rate. The studies by Yang et al.[35] confirm that electroacupuncture reduces heart rate, blood pressure and catecholamine release, reducing stress. Based on these references, the results of the present study indicate that electroacupuncture has a greater effect on the autonomous and hypothalamic tonic regulation than acupuncture, which explains the higher proportion of subjects with heart rate reduction in the groups with electrostimulation.

Although no significant statistical differences were found between groups with regard to pain score and heart rate, the present study recommends electroacupuncture application at a frequency of 2500Hz and 100Hz for analgesia of neck pain due to muscular tension because these frequencies demonstrated the highest individual efficiency in the algometry evaluation.

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