Electroacupuncture and Stimulatory Frequencies for Analgesia

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1. Introduction

The electroacupuncture was first used in France in 1970 by Roger de La Fuy with objective analgesics. Long before, however, the use of electric currents for therapeutic purposes, it was getting the usual, especially in the area of physical rehabilitation(Amestoy,1998).The therapeutic effects depend on the type of waveform, intensity, duration and direction of current flow on the type of tissue in which it is applied , involving electrochemical, electrophysical and electrothermal phenomena(Cameron,2003). Electrical stimulation of a tissue triggers an increase in the movement, in special potassium and sodion ions along the axon of the nerve cell.This fact accelerates the familiar process of neuronal depolarization, responsible for nerve conduction (Guyton & Hall, 2002). The fisiological responses by electrophysical stimulation can be perceived by contraction of skeletal or smooth muscle, indirect vascular responses and activation of endogenous mechanisms of analgesia (Alon,2003).This chapter of this book brings a paper with a study of different stimulatory frequencies involved in the analgesia of neck pain, induced by electroacupuncture. The objective of this paper is to evaluate what the best stimulatory frequencies with electroacupuncture,and which promotes better analgesic effects in a population of individuals with cronic neck pain.

1.1 Mechanisms of analgesic action of acupuncture and electroacupuncture

The process of driving and shooting pain to the central nervous system (CNS) is mediated by chemicals or neuromodulators. Likewise, the biochemical process is an analgesic and is modulated by substances called opioids or endogenous opioid neuropeptides, which are divided into three families: dinorphines more related vasomotor changes, hunger, thirst, muscle tone, the encephalins and endorphins, being that the latter two are important in the mechanism of suppression of pain.Analgesia is directly related to the ways that are blocked pain pathways. The transmission of nociceptive information can be changed in different parts of a nervous system**.** Figure 1 is summarized to conduct the painful stimulation, and where the analgesic block souces, such as: analgesic drugs, Transcutaneous Electrical Nerve Stimulation (TENS), acupuncture, and placebo.

The analgesia by acupuncture and electroacupuncture is initiated by placing the needles triggering stimulation of small diameter nerve, A Delta and C fibers, located in the striated muscles that send impulses to the spinal cord. The stimulation of type II fibers that transmit the nociceptive sensitivity in peripheral nerves is defended as necessary for the success rate

of acupuncture (Imamura et al., 2001). Of all the benefits of using electroacupuncture, potentiation of analgesic effects is undoubtedly the most studied and is a superior analgesic important. There is a superior analgesic effect by the electroacupuncture as compared with the traditional systemic acupuncture, especially in musculoskeletal pain (Silverio-Lopes, 2007). The principle of understanding that explains the advantage of joining electrical stimulation to the acupuncture needle is on the premise that electricity to stimulate the electrode triggers a stimulus sufficiently strong. This stimulus, based on the principles of electrotherapy, means that there is a trigger of cell membrane depolarization more agile and therefore more rapid conduction to the CNS.Besides this advantage, there are three neural centers are involved (in the spinal cord, mesencephalon, and pituitary), releasing chemical mediators that block messages from the "pain". The spinal site uses encephalin and dynorphin to block the afferent stimulation and other transmitters such as gamma amino butyric acid (GABA). The mesencephalon uses encephalin to activate the raphe descendant system that inhibits the transmission of pain along the spinal cord through a synergistic effect of the monoamines, serotonin and norepinephrine. In the third center, the hypothalamus-pituitary, initially release of β endorphin in the blood by stimulating the pituitary gland. The hypothalamus in turn sends axons extended to the mesencephalon and activates the descendant pathway of the β endorphin analgesia. The Figure 2 expresses succinctly the process of electroacupuncture analgesia.
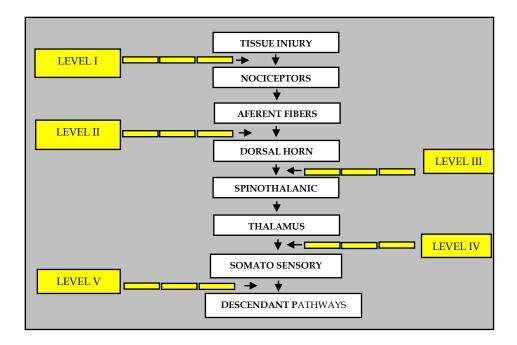

Fig. 1. Conduction pathways of the painful stimulation and block analgesics
LEVEL I-Anagesicas drugs that block prostaglandin; LEVEL II –Acupuncture and TENS; LEVEL III –Acupuncture and TENS; LEVEL IV- Placebo; LEVEL V – Acupuncture.

When approaching the analgesic effect of acupuncture, is necessary to remember that other effects such as: muscle relaxation, hypnotic, sedative, antidepressant and anti-inflammatory that can also be simultaneously involved (PAI et al., 2007). In the process of musculoskeletal analgesia, these factors may then add to the biochemical response itself. The pituitary, for example, when stimulated, releases, beyond endorphins, the adrenocorticotropic hormone (ACTH-1).
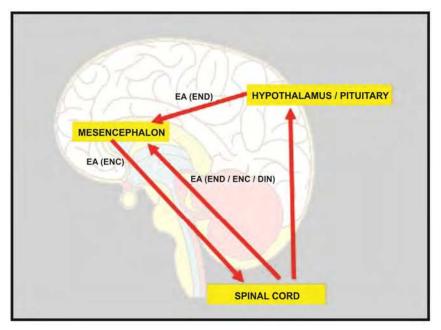

Fig. 2. Schematic representation of routes of analgesia by electroacupuncture at the level of the central nervous system (CNS) and the main endogenous opioids released.
EA = electroacupuncture END = Endorphin ENC = Encephaline DIN = Dynorphin

1.2 Stimulatory frequencies and analgesia

Frequency, from the perspective of physics, represents the number of cycles per second an electromagnetic wave and its unit is in hertz (Hz). There is also specificity in the release of neurotransmitters, depending on the frequencies used in the electrical stimulaton system (Silverio-Lopes, 2008). AMESTOY (1998) recommends the pulsed currents for electroacupuncture and refers to the shape, pulse duration and frequency, among other parameters that must be strictly controlled by the acupuncturist. Han(1999), Han(2003, 2004), and Lin (2002), sustains the importance of the frequency range in the anti-inflammatory and analgesic effects of electroacupuncture. 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: dinorphin at 100Hz (Han, 2003); endorphin at 2Hz (Han, 2004); encephalin and dynorphin at 2 and 100Hz (Zhang et al., 2005a); endomorphin at 2Hz (Han, 2004), and substance P at 10Hz (Zhang et al., 2005b).

Briefly, it was organized in Table 1 from data collected, showing endogenous opioid and each frequency band in which electroacupuncture was released, according to the reports of the studies evaluated. The data confirm that most are the release of endorphins in the β frequency of 2 Hz and dynorphins in the frequency of 100 Hz. It is found that the frequency bands chosen in this research fluctuate between 2 and 100 Hz. In our research we found a shortage of equipment for electrical stimulation to acupuncture resources with higher frequency (Silverio-Lopes et al., 2006). The lack of clinical research with high frequencies stimulatory and few options for equipment with high frequencies was one of the motivations of our researches in electroacupuncture.Remember that in clinical electroacupuncture at the use of high frequencies are more comfortable than low. Authors such as Han (2004) and Zhang (2005b) suggest alternately involve the use of low frequencies (2 Hz) and high frequency (100 Hz) in the same session.

Pomeranz (2005) supports the the use of electrical stimulation of low frequencies for electroacupuncture, arguing that at high frequencies (above 100Hz), the mesencephalon has a circuit that prevents links endorphinergic. 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 2500 Hz (Mehret,2010) postoperative analgesia at 100Hz (Amestoy,1998;Lin,2002) neck pain at 120Hz and 250Hz (Qing et al.,2000) or with 1000Hz and 2500Hz (Silvério-Lopes &Nohama,2009). 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 methodologic inaccuracies, which have already been criticized by other authors (Ezzo et al., 2000; Pomeranz (2005). Therefore, it is important to evaluate the analgesic effects of therapeutic procedures to determine whether they should continue to be used.

Frequencies (Hz)	Releases opioides						
	P substance	Encephaline	B Endorfine	Dinorfine	Endomorfine	CCK8	Orphaniine
100				x	x	x	x
15		x	x	x			
10	x						
4				x	x		
2		x	x		x		

Table 1. Release of opioid stimulatory function of frequency used.

1.3 Electrical stimulation equipments and diagnosis for acupuncture

The largest number of patients in acupuncture treatments are cases of musculo-skeletal pain ((Filshe,2002), such as; low back pain and neck pain. 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. 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 (Côté et al.,2004). Neck pain can have several sources, such as postural changes, mechanical traumas, spine rectifications, and others. 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 (Qing et al.,2000 ;Vas et al.,2006).

To the extent that there is an unquestionable clinical applicability of electroacupuncture in pain,there is no standardization in the physical parameters that should contain stimulators (Silvério-Lopes et al.,2006).It noted the growing interest of health professionals by the use of electrical stimulation for therapeutic,as the technological resource. Even in places with in Chine, surrender in the new electroacupuncture as an additional resource in classic systemic acupuncture was for thousand years the basis of Traditional Chinese Medicine (TCM).

We propose a classification by electrical stimulation of Equipments for acupuncture according to their therapeutic purpose and types of electrodes in:

1. Electrical stimulation equipment for energetic diagnosis,are based on variations of bioimpedance skin(Voll electrical diagnosis, electrical diagnosis Ryodoraku, detectors acupoints).
2. Electrical stimulation equipment with needle electrodes (electroacupunture).
3. Electrical stimulation equipment with pen electrode (electropuncture) is indicated for use in children and painful anatomical regions.

Older equipments electrical stimulation used analog system and lasted until the decade of 90, being replaced by digital technology. The growing expansion of the use of acupuncture in Brazil and abroad. Coupled with the technology have made it come to attention for stimulus devices that replace needles, such as laserpuncture and eletropuntura and others that can augment the analgesic effects, adding to the electricity. However, the extent to which the interest of traders grows in using electroacupuncture, grows along the arsenal of new equipments by electrical stimulation. It is necessary to have electronic stability, safety for the operator and the user, and technical specifications to be used, ensuring adequate therapeutic effects. The repeatability in the quality of the stimulus generated in the apparatus of electro stimulation to acupuncture is an important premise, because you must keep the same parameters programmed independent of the patient, stimulated region or time of generation. Knihs (2003), recommends using a circuit must be reliable for the generation of times and frequencies, beyond the range, and that this is accomplished through the use of electronic micro processor controlled.Another aspect that goes along with this reality is the gap in physical parameters such as electro stimulation equipment should contain to fulfill their therapeutic role. It is widely recognized that the physical parameters are important and appropriate, but the recommendations of what is appropriate do not converge.The controversies begin to work as a source of constant current or constant voltage source. To Amestoy (1998) and Knihs (2003), the stimulators for use in acupuncture should be output with constant current, because they would be less influenced by fluctuations in the impedance of the tissue where it is being applied, and any instability or at the interface electrode / tissue, making programmed with the intensity does not change.There is a consensus not to use alternating current for electrical stimulation as well as the galvanic current, the latter causes electrolysis and tissue injury.As for polarity, the consensus among Brazilian authors to claim that it is important to the proper combination of negative electrode (cathode) and positive (anode), with respect to the region and the acupuncture points stimulated. It starts from the assumption that the negative electrode is where the electrons migrate toward the positive electrode and that this motion should be ordained in order to favor the direction of meridian acupuncture (Costa, 2002). Amestoy (1998) also emphasizes the cathode as the one that has effect "more stimulating"and suggests a combination of acupuncture points, where it would be more interesting, for example, keeping the needle on the stimulation of the cathode closest to the origin of the meridian, and stimulus from the anode to the needle more equidistant from this source. Currently in

Chine, the clinical practice that is found in 8 hospitals that we could follow, where the electroacupuncture is widely used, there was no relevance or consideration by the polarity of electric stimulation equipment. Knihs (2003) suggests the development and the need for more research on electroacupuncture, which could establish with certainty the influence of the combination wave analysis, stimulus duration, frequency and duration of application, the use of this source therapeutic.Of all the physical parameters of electroacupuncture, it is believed that the frequency has a stimulatory relevance and need for clinical studies. Currently there is still disagreement on what is the best stimulatory frequencies to be used in analgesia by electroacupuncture.The objective of this research and this chapter is to contribute to the definition of what is the best stimulatory frequency used in electroacupuncture. For that was selected volunteers with chronic neck pain source tension.

1.3.1 The electrodes for electro stimulation equipment

According to Webster (1998) and Cameron (2003), surface electrodes are devices that are intended to serve as an interface between the patient and equipment for electro stimulation (contact through the skin), whose purpose is to spread on the biological tissue to electrical stimuli therapeutic benefits There are different types of electrodes, and are classified or divided by the type of interface that provides: surface electrodes, which may be plates, electrodes such as acupuncture needles, and others also invasive, but for use as an implant. The implanted electrodes are usually used for diagnosis, many of them needle-shaped, while the surface electrodes in the shape of plates are used in physiotherapy stimulators for analgesia tipo Transcutaneous Electrical Nerve Stimulation (TENS) or interferential currents for strengthening muscle. The acupuncture needles can be electrodes when the insertion into the skin is associated with the electrical stimulus. (electroacupuncture).The plate-type electrodes, as in the TENS used for analgesia musculoskeletal, has an area of skin contact, ranging from 5 cm^2 to about 100 cm^2, where the electrical stimulus is conducted through the skin surface. In the case of needle-type electrode, there is less contact with the surface stimulated, and its invasive character, the conduct of the stimulus has an easier access to conductive elements such as blood and nerves. From the perspective of physics, the effect of current intensity is inversely proportional to the area. Remember that the acupuncture needle has a small contact area with the location that is being stimulated in skin. This feature is that there is less resistance to the passage of electrical stimulation by the electrode, but also a higher current density in a smaller surface skin. According Gerleman (2003) the area of the electrodes affects the current density, for an electrode with large surface area delivers a larger region of the stimulus driving through the skin. The current density in turn is an important factor in determining the responses of biological tissues. The ease of conducting an electrical stimulus to the needle-electrodo used for electroacupuncture, is in fact conducive to an analgesic effect, but at the same time we must take care with the equipment that is used with this electrical stimulation. In the needle electrode, the contact surface is extremely small, high intensity and could take a large concentration of electrons (high current density) below the surface of the electrode on the stimulated tissue and lightning reactions (AMESTOY, 1998).The Figures 3A and 3B are schematically distributional effects of electric current in two cases involving the plate-type electrodes (3A), used for example in the TENS and needle type (3B), used in electro-acupuncture.

Reported these special features from the perspective of physics, as well as our clinical practice with electroacupuncture, we recommend caution when purchasing equipment for an electrical stimulation to acupuncture. Equipment for electrical stimulation that has been

built to work only with plate electrodes (surface) is not suitable for use with needle electrodes.
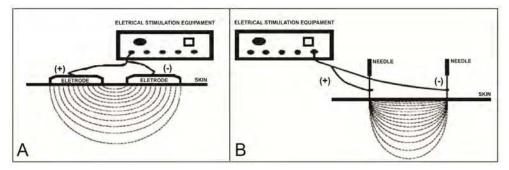

Fig. 3. Distribution of electric current under the electrodes. (A) plate type electrode, where there are more dispersed distribution of electric charges, (B) needle-type electrode, which had the highest concentration of electric charge at the same point. Source: Adapted from AMESTOY (1998).

1.4 Evaluation and measurement of pain

Pain perception has individual characteristics, idiosyncratic and culturally associated in which the individual is immersed. Ferreira (2001), as described in the original semantics of the English word pain, which in its Latin origin, poena meaning "penalty or punishment", with the pain, so in the Greco-Christian Western culture, associated with guilt. After that science began to describe the pain as a neurophysiological phenomenon, some questions were proposed in an attempt to measure it and bring more rational and cartesian parameters possible. To evaluate the pain has always been a challenge for science and a very logical importance. As analgesics seek medical sciences resources, it is necessary to know whether they are effective, in what proportion and how long. Pain perception involves two components:the perceptual-discriminative, known as nociception and the affective-emotional aspects involved in perception and experience of pain (Ferreira, 2001). In an attempt to create tools for the evaluation of pain, many authors proposed questionnaires, inventories and scales For exemple: BDI (Beck Depression Inventory) or Depression Inventory of Dr. Beck, who tried to assess depressive symptoms in patients with chronic pain; The MIQ (Meaning of llness Questionare) or Significant Illness Questionnaire to assess cognitive changes involving chronic pain and BPI (Brief Pain Inventory) and Short Pain Inventory, which assesses pain in patients with arthritis or cancer pain. Other authors have proposed questionnaires to consider the subjective aspects of pain, such as the MPQ(McGill Pain Questionnaire), by Melzack, which is the most extensive scale multidimensional tested for verbal assessment of pain. The questionnaire or inventory, as originally described, presupposes an explanatory theoretical model of pain considers his three-dimensional nature:

Sensory-discriminative, affective-motivational and evaluative-cognitive.

In our clinical experience as a researcher, we recommend the MPQ questionnaire for longitudinal studies and others that include emotional components, such as in the case of fibromyalgia and cancer pain. In this chapter we cover the pain instruments to evaluate used in this research: the visual analogue scale (VAS) and the algometry.

1.4.1 Visual Analogue Scale (VAS)

Some scales for assessing pain present quantitative scores, alpha-numeric or mixed (quantitative and qualitative). The best known is the scale VAS (Visual Analogy Scale) where, throughout, a ruler, is coded 0 (zero) as no pain and 10 (ten) as the greatest pain that the patient has experienced (Cameron, 2003)It is requested that the individual expresses his opinion of "how"of pain is feeling at that moment. Although being widespread and simple to use, this scale does not allow subdivisions of graduation from pain, and involves a subjective aspect of pain perception. Hertogh et al. (2006) conducted a study seeking to assess the VAS as a resource for examinations of patients with cervical pain and the results it is concluded to be effective for the purpose of our research.

1.4.2 Algometry pressure

The algometry is based on principles of physics governing the dynamic forces applied to a surface. Expressed in units of pressure kgf/ cm ², in Newtons (N) or Kpa Also known as dolorimetry, correlating an indirect way of quantitative evaluation of pain sensitivity. In the process of evaluation with the algometer, is measured in fact, the tolerance threshold of pressure and indirectly the threshold of pain perception. The pressure algometry is recommended by the American Society of Rheumatology to assess musculoskeletal pain such as fibromyalgia and myofascial pain and has been used in several researches. The perception of pain recorded in the pressure algometer is directly associated with quality of response to pressure and consequent sensitization of nociceptors, neurons that are specialized primary. The threshold of perception and pain tolerance of a nociceptor is also involved in more complex responses of ascending pathways, descending from the central and painful process. Pain receptors (nociceptors) located on the skin almost never respond to usual stimuli of touch or pressure, but become intensely active at the time that a tactile stimulus is sufficiently strong as to damage the tissues (Guyton, 2002). The threshold of pain perception has been the purpose of research using algometry. Some authors such Piovesan et al. (2001), sought in their investigations to quantify the tolerance threshold pressure in individuals healthy. A great utility of this research is to establish parameters of normality scores for use in situations involving pain diseases. However we observed in our studies are scarce references to standards of pain tolerance, and / or perception in musculoskeletal pain. We believe that this difficulty is linked to differences of gender, race, age, and culture, involving tolerance to such one perceives the pain. Although there is no pattern of tolerance to pain in different body regions and pathologies that can be used in research, the pressure algometry can be used to evaluate the moments before-after therapeutic intervention. In this case not be compared with standard values of tolerance to pressure, but with the sensitivity threshold and tolerance of the pressure borne own research subject or patient. We recommend algometry pressure for experimental human clinical research involving musculoskeletal pain, as a means of to evaluate therapeutic interventions. Our experience in forms of therapeutic evaluation involving musculoskeletal pain, proposes the use of algometry in studies of "short time" between moments of the evaluation pre and post-intervention. We think it would be inappropriate to evaluate pain and analgesia of the intervention to be tested through the use of algometry, having passed much time between readings algometry before-after. Our justification is that there is external interference of mechanical origin, such as posture and physical efforts, drugs, food, tobacco and alcohol use, and stress and emotional factors. Even if in research that can control some of these variables would not be possible to control all in a longitudinal study for a long time. In our

paper this chapter we chose this instrument and form of evaluate the therapeutic intervention to be tested. In our paper this chapter we chose this instrument (algometry) such a resource of evaluate the therapeutic intervention to be tested. Also recommend that when using this equipment, the operator should be trained about the position and pressure control in the rubber tip of the algometer. It is necessary that the patient also receives orientation in form of a test, and how quickly to verbalize expression of his pain threshold. The pressure algometer currently has mechanical-analog version and electronic-digital version. Such equipments are dynamometers containing strain gauge type sensors and connected to a load cell, amplifier and a digital display. They have a metal rod in the manner of ejecting a disc-shaped rubber in 2 to 3 mm, which is the place to connect the device with the skin. The assessment of pain sensitivity using the algometer is a need for voice response by the subject that is being subjected to the tests. The device needs to receive the touch of the evaluator for the command block (stop) or the immediate withdrawal of the pressure to be blocked. Some algometer with most advanced technology resources that have the answer when verbalized by the patient, is replaced by a "push of a button, " a device in which the subject himself hand-held fire so soon perceive the painful discomfort. In the search for forms evaluation, experienced mechanical -analog algometer that was not appropriate because he had little sensitivity to variations in pain perception. The digital algometer, as used in this research, the display registers the tolerance threshold of pressure at the point tested (Figure 4).

Fig. 4. Digital Pressure Algometer used at work.

2. 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 (2003). 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 (Associação Brasileira de Normas Técnicas-ABNT 1977; ABNT 1997).The subjects were recruited at the outpatient clinics of Instituto Brasileiro de Terapias e Ensino (IBRATE) at Curitiba -Brazil. 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.(2001) 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 (Filshe & White,2002); 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 and registered in the Australian New Zealand Clinical Trials Registry (ANSCTR)under the number 083456.All the volunteers signed a consent form. With the intention of partially blinding the study, a physiotherapist examiner 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/cm2). 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, according is ilustred in the Figure 4. 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 5. These points were chosen based on the literature because they are painful points in myofascial syndromes (Stux & Pomeranz, 2004; Silvério-Lopes, 2007).
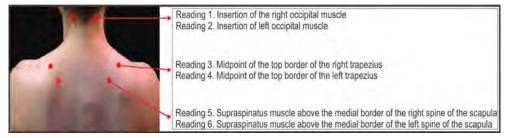

Fig. 5. Algometry points and anatomical/topographical references.

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: BL10 (*tianzhu*), GB21 (*jianjing*), SJ15 (*tianliao*), LI4 (*hegu*) and SI3 (*houxi*) (Stux & Pomeranz, 2004; Lian et al., 2007). The needles used on points SJ15 and GB21 (trapezius muscle, bilaterally) were selected to receive electrical stimulus, acting as needle-electrode (Figure 6A and 6B).

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 SI3 (on the hand), where the depth was about 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, and based on the electroacupuncture technique (Knihs, 2003;

Filshe, 2002).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).
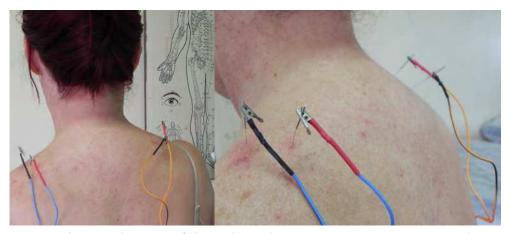

Fig. 6A and 6B – A- Ilustration of electrical stimulation on acupuncture points SJ15 and GB21 in the region of the trapezius muscle. 6 B- Details of the electrodes being stimulated.

2.2 Selection of data and statistical analysis

For comparison of groups regarding the results of the percentage changes between before and after applying the experimental protocol for the tolerance level of pressure was applied to analysis of covariance (ANCOVA), with an initial level of tolerance as a co-variable, to take the influence of initial levels of the volunteers. The ANCOVA and test *student t* are parametric analysis. Was applied the Kruskal-Wallis and Wilcoxon tests for studies of variable pain scores by Visual Analogic Scale (VAS), since they are nonparametric data. The changes follow a VAS scale with a variation occurs by ordinal assessment (from least to most) expressed by a score (a note). Thus, requiring treatment based on these tests.In all tests, p values <0.05 indicate statistical significance. For statistical calculations, we used the software Statistica/w.We performed the arithmetic mean of three measurements, each time (pre and post-intervention) taking an initial value for each of the anatomical regions 1,2,3,4,5 and 6 (Figure 5). From these data, we calculated the arithmetic means of regions 1 and 2 (base of the skull in the occipital muscle), regions 3 and 5 (right trapezius and supraspinatus) and regions 4 and 6 (left trapezius muscle and supraspinatus). These were the figures that fueled the statistical treatment of pressure algometry. The selection criterion is to group these regions to calculate the arithmetic average, was due to neck pain that have features of tension lateralized to the right and / or left, through the trapezius / supraspinatus. This follows the path of the innervation of brachial plexus nerve roots

emerging from the cervical vertebrae, and also often associated with postural imbalances, one of the possible causes of neck pain (Hoppenfeld, 2005).

3. Results

3.1 Tolerance to pressure

This study was a comparative nature, in order to assess whether there is a stimulatory often more effective for analgesia, using techniques of electroacupuncture on patients with neck tension. After the readings with the algometer was done a register of individual values by anatomical region studied, before and after the intervention of electroacupuncture. Was done statistical studies the following: a) the performance of the average individual variability of tolerance to pressure, expressed in Kgf/cm2, b) mean tolerance variability in each region of lectures expressed in Figure 5, c) variability between groups A comparative , B, C, D and E (with different frequencies stimulatory) grouping them by region. It was considered that the anatomical differences in local reading algometry would not be appropriate to average data from different regions. An evaluation   by anatomical region (Figure 5) found statistical significance between pre- and post-intervention in 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 3 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.

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	Time	n	Mean	Median	Low	High	Standard deviation	P value
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	Time	n	Mean	Median	Low	High	Standard deviation	P value
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	Time	n	Mean	Median	Low	High	Standard deviation	P value
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	Time	n	Mean	Median	Low	High	Standard deviation	P value
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
	After	14	2,91	2,38	1,08	7,81	1,78	

Table 2. Variations in the pressure tolerance measurements and statistical significance (kgf/cm2) before and after the intervention within groups A (2500Hz), B (2Hz), C (1000Hz), D (100Hz) and E (without electrical stimulation).

3.2 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.

3.3 Heart rate

This study compared the average percentage change in heart rate measured in the moments pre and post-intervention with the purpose of observing whether there are differences between the groups and the nature of this difference we tested the hypothesis that the

results of the percentage change in heart rate between before and after treatment is same to the five groups.

Grup	Time	n	Mean	Median	Low	High	Standard deviation	P value
A	Before	13	5,08	5	3	8	1,38	0,003
	After	13	2,46	2	0	7	1,90	
B	Before	13	4,96	5	0	8	2,47	0,028
	After	13	2,54	2	0	6	2,11	
C	Before	13	5,58	5	2	8	1,96	0,002
	After	13	3,15	2	0	8	2,79	
D	Before	13	5,73	6	4	7	1,13	0,013
	After	13	3,35	3	0	9	2,72	
E	Before	14	5,93	5,5	3	10	1,90	0,002
	After	14	2,11	1	0	9	2,83	

Table 3. Mean, median, standard deviation and significance level (p value) of pain scores (VAS) in group A (2500 Hz), B (2 Hz), C (1000 Hz), D (100 Hz) and E (without electrical stimulation).

This hypothesis was confirmed. The percentage variation between pre and post-intervention heart rate had no significant difference between groups (p=0.716).The Although it had no statistical differences between groups with respect to variation in the frequency of stimulatory pre and post intervention, it was observed that heart rates increased in some volunteers, some are not changed and decreased in others. This observation led us to construct the Figure 7.The figure clearly demonstrates that in group E (without electrical stimulation) had the highest number of cases of increased heart rate (43%) represented by the red column.
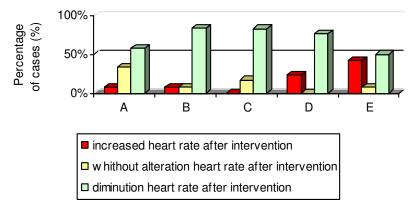

Fig. 7. Comparison of groups regarding the incidence of cases where the heart rate had increased, not changed and decreased after the intervention. Groups A (2500Hz), B (2Hz), C (1000Hz), D (100Hz) and E (without electrical stimulation).

4. Discussion

4.1 Sample

The musculoskeletal pain always afflicted humans since it became a biped, transferring to the spinal mechanical loading of the body. Among the main complaints of painful musculoskeletal nature, are the pain in the neck and cervical vertebrae. According Borghouts et al (1998) and Cote et al. (2004), 30% to 43% of adults, have pain in this region, showing a higher prevalence in women. Among the various therapeutic approaches for treatment of neck pain, are: myo-relaxing drugs, anti-inflammatory, physical therapy, massage therapy, osteopathy and acupuncture. The therapeutic option, when chosen by the physician, is considered the probable source of neck pain and chronic conditions or acute that met in these patients. The experimental protocol was administered to volunteers with neck tension. Willich (2006) warned in its work the importance of seeking relief from this symptom, noting be an important factor of removal work, as also the high financial cost to the Government. However, it is known that the neck is not a disease in itself but a symptom. Based on this assumption was justified for the need to standardize the study population. In the inclusion criteria, were opened to the possibility that the sample was composed of both sexes. However, there was a predominance of extremely higher female volunteers (88,4%) than males (10.6%), confirming findings by Côté et al.(2004) and Bourghouts et al. (1999), pointing to a trend of higher incidence of neck pain in women. Hoppenfeld (2005) and Bau (2002) argue that complaints of neck pain with possible origins have tension component associated with repetitive stress, physical stress, and static posture, often linked to work and / or stress and emotional factors. The musculoskeletal pain always afflicted humans since it became a biped, transferring to the spinal mechanical loading of the body. Among the main complaints of painful musculoskeletal nature, are the pain in the neck and cervical vertebrae. According Borghouts et al (1998) and Côté et al. (2004), 30% to 43% of adults, have pain in this region, showing a higher prevalence in women. Among the various therapeutic approaches for treatment of neck pain, are: myo-relaxing drugs, anti-inflammatory, physical therapy, massage therapy, osteopathy and acupuncture. The therapeutic option, when chosen by the physician, is considered the probable source of neck pain and chronic conditions or acute that met in these patients. In our research results agree with the statements of these authors demonstrated by the profile of professional activities of the sample and 89,5% of volunteers who claimed to have involvement of repetitive stress and / or static-posture. The distribution of the activities of professional volunteers from the sample of this research were: Teachers(19,5%),administration assistant (25,5%), physiotherapists (13,0%),call center (13,5%), cleaning auxiliary (9,00%), designer(6,00%), and others professionals(13,5%). It is perceptible the large number of people who have no clinical diagnosis for their pain. The sample surveyed, 73.0% of volunteers, have not confirmed the clinical diagnosis and / or physical therapy of the origin of his neck pain. Of those diagnosed, 68.0% of total causes of Repetitive Strain Injury (RSI), muscular tension and stress, followed by 16.0% of causes postural, and only a small proportion of 16.0% of joint pathologies, agree with Hoppenfeld (2005), which suggests these possibilities as the source of neck pain. The causes postural, shortening and retraction of the musculature of the shoulder girdle, although reported with clinical diagnosis only in 16.0% of volunteers, the physical therapy evaluation of this work was evidenced by the large presence of these pathologies in volunteers: decreased range of motion in the region cervical in 79.0% and 88.0% in muscle shortening, consistent with the literature, according Hoppenfeld (2005). The

study characterized therefore as muscle tension, neck pain main feature of the volunteers of the sample, where the interview guide designed to characterize the same was adequate. There were statistically homogeneous between groups, with regard to socio-demographic profile.

4.2 Technical and selection of acupuncture points

In a routine clinical practice of acupuncture, the selection of acupuncture points to a specific complaint meets the criteria that are grounded in the philosophical basis of the known energy diagnosis of Traditional Chinese Medicine, where they are considered, among other factors, the nature of the syndrome, wrist and tongue, energy meridian pathway involved, featuring a need to individualize treatment. However, when the objective is to compare the physical parameters in the case of this research, it is necessary to standardize some variables such as: acupuncture points, such as the manner and sequence of puncture, anatomical localization, terminology and choice of points referenced. This research adapted this line as a standardized methodology, consistent with the literature of Pomeranz (2005) and Sator (2003). For this research, we chose classical points of acupuncture, recognized as analgesics for neck pain. Among the few selected points are muscle relaxation in this region, noting the need for methodological adequacy of the population referred to as "the most time with muscles tense and hard / contraction" (74.0%). With adding, "sometimes tense and hard" (23.0%), totaling no less than 97.0% of volunteers. MacDonald (2002) argues that the analgesic effects of acupuncture can be understood and studied as the distance from the local effects puncture, such as using a point on the leg as master point of the tendons (GB34) to treat tendonitis in one elbow, and effects analgesics near the site of puncture, as the region of the GB21 trapezius muscles to relax this region. The points selected for this study proved to be methodologically adequate and attended the two approaches; segmental level with BL10, GB21 and SJ15 (the latter two received electrical stimulation, being closer to the painful region of the trapezius and the local assessment algometry pressure) and non-target, or far, with LI4 and SI3 in hand.

4.3 Assessment tools

A clinical trial in humans, it intends to evaluate the technology as a resource analgesic, have to worry about the ways to evaluate the results, especially the difficulties of measuring pain. The VAS is recommended by Cameron (2003) to evaluate technologies on procedures analgesics in musculoskeletal pain. There is, however, that if on one side there is an operational facility of its use by other collides with the subjective perception of a "note" that should be attributed to pain. We must also remember that the pain has an emotional and cultural component as already studied by Ferreira (2001). This research has shown to be consistent with the studies of Ferreira (2001), recording subjective factors, such as empathy or not with the researcher, the evaluator, with the technique, with the environment. It is noticed that some volunteers are apparent a need to express pain before and after improvements, as a host, or gratitude, as if to say, "Look I need this treatment, my pain is important", and then "I think I've improved a pain little" or "I'm much better". This perception, if it is something latent in the eyes of the clinical evaluator, the other is a probability factor that means being diluted and also influencing the groups, since the sample is homogeneous and the distribution of volunteer groups was systematic. Another source was used to evaluate the tolerance level pressure known as algometry pressure. The

choice of this technique was supported in the literature in researches with analgesia and was understood to be adequate initially. However, in the course of implementation of the method was difficult to read as standardized in anatomic regions 1 and 2 (Figure 5) in some volunteers for the volume of hair at the base of the occipital region. Was repeated some readings because the tip of the algometer rubber did not settle well, slipping a few times. Another factor was perceived in the occipital region a low nociceptive sensitivity. In the other anatomical regions and standardized as described 3, 4, 5 and 6, reading the algometer proved adequate. A study by Piovesan et al. (2001) describes the factors that may interfere with the reading of the algometer, by masking thresholds of pain perception, such as use of tobacco, alcoholic beverages, use of muscle relaxants, psychotropic medication, among others. When selecting volunteers, we adopted these as exclusion criteria. Backed by the need for sample homogeneity, given the comparative nature of goals, this study sought to rigor in the selection of volunteers. There was slow uptake of volunteers. Limiting factor which justified this fact is the basis of the criteria of sensitivity algometry, as reported by Piovesan et al (2001) which generated two exclusion factors: the individual smoker and the use of analgesics means "widespread" among the population.

It was also used to measure heart rate before and 10 min. after the intervention, noting that the volunteer received acupuncture or electroacupuncture stimulation for 20 min. No specific literature was found using this resource assessment procedures for pain relief in acupuncture. This research suggested this assessment, sustained by the theoretical understanding that acupuncture is an external stimulus and the sensitizer autonomic tone suggesting alter the heart rate. (Yang, 2002), and effects slow in Figure 7.

4.4 Results

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 (2003) and Filshe & White (2002) 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 is important because it is based on the analgesic effects of neurotransmitter release. In contrast, it does not take into account emotional, cultural and biomechanical variables experienced in human pain. Filshe & White (2002) 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. Yin (2000), Cui et al.(2004)and Tienyou (2000), 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. The justification of this result is based on the fact that possibility of passage an electrical current 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 (2001). 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 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 7). 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. Wall & Melzack (1999), and Fox (2007) discussed the influence of stress and external stimuli on heart rate modulation, as well as the anatomical and physiological pathways of that influence. Pomeranz (2005) 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.,(2002) 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.

5. Concluding remarks

Most the researches on electroacupuncture has predominance with guinea and rats with use of biochemical and immunohistological investigation bases. It was found a dearth of research controlled clinical trials with humans, and even more rare that proposes to comparative studies of physical parameters used in electroacupuncture. The methodology of this paper proved to be adequate from the standpoint of protecting the uniformity of the sample, assessment tools, and statistical analysis. There was convergence of results between the different features of evaluation used (algometry pressure, heart rate and VAS. It is recommended that future studies with algometry (tolerance to pressure) suitable for regions seeking to standardize the evaluation of analgesic effects of acupuncture and electroacupuncture, thus assisting the appropriate methodological support to encourage clinical research in humans. 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.

6. Acknowledgment

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Acupuncture - Concepts and Physiology

Edited by Prof. Marcelo Saad

Acupuncture and related techniques are useful tools for treating a spectrum of diseases. However, there are still many areas of controversy surrounding it. We hope this book can contribute to guide the advance of this ancient medical art. In the present work, the reader will find texts written by authors from different parts of the world. The chapters cover strategic areas to collaborate with the consolidation of the knowledge in acupuncture. The book doesn't intend to solve all the questions regarding this issue but the main objective is to share elements to make acupuncture more and better understood at health systems worldwide.

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