Immediate analgesic effect of 2KHz interferential current in chronic low back pain: randomized clinical trial

Efeito analgésico imediato da corrente interferencial de 2KHz na dor lombar crônica: ensaio clínico randomizado

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ABSTRACT

BACKGROUND AND OBJECTIVES: Interferential current is widely used in clinical practice for the treatment of low back pain, but there is no literature consensus regarding its parameters. The objective of this study was to analyze the immediate effect of the 2KHz interferential current in chronic low back pain.
METHODS: This randomized controlled clinical trial was previously approved by the Research Ethics Committee of the Federal University of Paraná, with the participation of 105 individuals with chronic low back pain (>12 weeks) of both genders. Participants were randomized in 3 groups: placebo group (PG, n=35), electrical stimulus off; interferential current1 (IG1, n=35), carrier frequency 2KHz, AMF of 2Hz, motor intensity level and IG2, n=35, carrier frequency 2KHz, AMF of 100Hz, sensory intensity level. All groups were subjected to a single application for 30 minutes with 4 electrodes in a crossed-shape position in the lumbar region.
RESULTS: The visual analog scale, McGill pain scale, Oswestry Low Back disability questionnaire, Roland Morris disability questionnaire and Algometria of pressure were used for evaluation and revaluation.
CONCLUSION: It may be noticed that by the visual analog scale and questionnaires, the interferential current provided an immediate analgesic effect in chronic lumbar pain regardless of the mode of stimulation.
Keywords: Analgesia, Chronic pain, Electric stimulation therapy, Low back pain.

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RESUMO

JUSTIFICATIVA E OBJETIVOS: A corrente interferencial é amplamente utilizada na prática clínica para o tratamento da dor lombar, porém não há consenso na literatura sobre seus parâmetros. O objetivo deste estudo foi analisar o efeito imediato da corrente interferencial de 2KHz na dor lombar crônica.
MÉTODOS: Ensaio clínico, controlado randomizado, foi previamente aprovado pelo Comitê de Ética em Pesquisa da Universidade Federal do Paraná. Participaram 105 indivíduos com dor lombar crônica (>12 semanas), de ambos os sexos. Os participantes foram randomizados em 3 grupos: grupo placebo (GP, n=35), estímulo elétrico desligado, grupo interferencial1 (GI1, n=35), frequência portadora de 2KHz, AMF de 2Hz, intensidade a nível motor e grupo interferencial2 (GI2, n=35), frequência portadora de 2KHz, AMF de 100Hz, intensidade a nível sensorial. Todos os grupos foram submetidos a uma única aplicação durante 30 minutos, com 4 eletrodos posicionados de maneira cruzada na região lombar.
RESULTS: Para avaliação e reavaliação, foi utilizada a escala analógica visual, escala da dor de McGill, Questionário de dor lombar de Oswestry, Questionário de Incapacidade de Roland-Morris e Algometria de Pressão.
CONCLUSÃO: Pode-se perceber que, pela escala analógica visual e pelos questionários, a corrente interferencial proporcionou efeito analgésico imediato na dor lombar crônica independentemente do modo de estimulação.
Descritores: Analgesia, Dor crônica, Dor lombar, Terapia por estimulação elétrica.

INTRODUCTION

Lower back pain (LBP) is a multifactorial clinical condition, related to biopsychosocial, sociodemographic and economic factors[1-3], affecting approximately 84% of the world population. Around 30 to 33% of the population presenting acute episodes of LBP end up developing chronic lower back pain (CLBP)[4], i.e., persistent pain for more than 12 weeks[3]. Most of CLBP causes are non-specific and may be associated with increased central sensitization[5] and inefficiency in the control of pain endogenous[6]. Prolonged pain may increase the excitability of afferent neurons (hypersensitivity) which may lead to changes in their plasticity, resulting in an exaggerated response to pain[7].

Identifying effective non-invasive and non-pharmacological treatments for CLBP can lead to significant gains and substantial results in morbidity and costs related to this population[8]. Treatments for CLBP primarily aim to reduce pain and disability[9]. The analgesic approaches used in CLBP raise a lot of discussions and sometimes are controversial. However, it is known that physiotherapy is an excellent support in its treatment through therapeutic exercises, health education and also by means of electrotherapy[2,10].

Electrotherapy uses electrical currents for therapeutic purposes, such as analgesia[11]. Interferential current (IC) is an electric current of medium frequency, modulated at low-frequency, capable of penetrating deeper in tissues compared to other low-frequency currents.

The guidelines on CLBP treatment mention IC as a non-pharmacological treatment for pain reduction[3], and may be advantageous in relation to other types of procedures, such as surgery[10,12]. However, they highlight the low evidence level in the studies, suggesting the need for more research related to the topic[1,3,10,11,13,14]. Fuentes et al.[15] found in their systematic review that despite the musculoskeletal pain reduction observed after IC, these results are inconclusive due to the reduced number of studies and the methodological heterogeneity.

IC equipment allows the adjustment of the medium frequency (carrier frequency) according to the therapeutic objective. The literature indicates that carrier frequencies (CF) of 2KHz are more appropriate for muscle contraction and 4KHz for analgesia[16,17]. However, these data are only found in books and are not evidenced in scientific studies[10]. There is still a lot of controversies in the literature regarding adequate IC parameters for both CF and frequency modulation to promote analgesia[18,19].

Only two studies evaluated the immediate IC effects on pain. Fuentes et al.[20] studied the IC acute effect associated or not to the therapist interaction in CLBP. They observed greater analgesia in the IC-treated groups but did not indicate the CF used, only the 0Hz frequency modulation and the treatment time (30 min). Corrêa et al.[12] measured the CF analgesic effect between 1 and 4KHz of IC in individuals with CLBP after the first session, after 12 sessions and after 4 months, and saw that IC provided an immediate analgesic effect after the first session, regardless of CF. These two studies show that the 2KHz CF was not used, despite the more satisfactory analgesic results with lower carrier frequencies showed in the literature[10,12].

So, this study aimed at analyzing the immediate analgesic effect of 2KHz IC in CLBP through the subjective and objective perception of pain, as well as evaluating the functional capacity of these individuals.

METHODS

A randomized, controlled clinical trial in which were selected male and female participants older than 18 years with CLBP (longer than 12 weeks)[3], of non-specific origin and with visual analog scale (VAS) pain greater than 1. After oral invitation, those who accepted to participate signed the Free and Informed Consent Form (FICT) (Resolution 466/2012 of National Health Council).

Exclusion criteria were: disc herniation or another disc disease, no lower back pain on the evaluation day, use of drugs within 24 hours before the instrument application and surgical procedure in the abdominal and lumbar regions.

The data was collected at the Physiotherapy laboratory of the Federal University of Paraná and Prevention and Functional Rehabilitation Service of the Hospital de Clínicas in Curitiba from March 2017 to March 2018.

Intervention

Participants were randomized in 3 groups, into blocks of 5: low-frequency interferential group (IG1), high-frequency interferential group (IG2) and placebo group (PG).

For IC application, the participant was positioned in the prone position. Four silicone electrodes (9x5cm) with conductor gel were arranged crosswise, fixed by adhesive tape, 3cm away from the L3 and L5 spinous processes, to the right and the left.

CF of IC used was of 2KHz and frequency variation (ΔF) of 0Hz. In IG1, the chosen amplitude modulation frequency (AMF) was 2Hz and motor level intensity. In IG2, the AMF was 100Hz and sensory level intensity. AMF selection was based on the frequencies used in Transcutaneous Electrical Neural Stimulation (TENS). According to Robertson et al.[21] high-frequency and low-intensity electrical pulses produce an analgesic effect through the theory of pain gates while those of low frequency and high intensity stimulate the endorphin release. PG was subjected to the equipment application but in the off mode. All groups received a single application lasting 30 minutes.

Evaluation

Participants were assessed through a specific record containing data of identification, anamnesis, pain evaluation (VAS and McGill Pain Questionnaire), pressure algometry and Oswestry Low Back Pain Questionnaire (OLBPQ) and Roland Morris Disability Questionnaire (RMDQ), validated in Portuguese.

VAS consists of a horizontal line with 10cm in length, numbered from zero to 10, with zero indicating no pain and 10 maximum pain. Participants indicated the point representing the intensity of their pain at the time of evaluation[22].

The McGill Pain Questionnaire (MPQ) validated in Portuguese[23] evaluates several aspects of pain through words (descriptors) chosen by the participant to express his/her pain. The 78 descriptors (words qualifying pain) are divided into four categories: sensory-discriminative, affective-motivational, evaluative-cognitive and mixed, and also in 20 subcategories each containing 4 to 6 words. The individual should choose none or a word from each subcategory. The numerical index of the descriptors was calculated by the number of words chosen by the participants to characterize their pain, being 20 the maximum value[23].

The pressure algometer (EMG System do Brasil) is a mechanical device to apply point-pressure to cause pain, with

an indication of the force exerted (known pressure exerted, constant area). It has a display showing mean value and maximum peak, V/Kgf/cm^2 calibration report with signal conditioning, power supply, analog output via BNC connector allowing the external synchronism with other signal acquisition systems and with a system of integrated signal acquisition. It was applied before and immediately after the IC application to compare the intensity of pain in kilograms/force (KgF) by the same previously trained examiner (ICC=0.95). For the evaluation, 2 points were marked for control in the anterior tibial, one in the right and the other in the left, 4 points in the lumbar region: 5cm away from the third and fifth lumbar vertebra, both on the right and the left side. The algometer tip (1cm in diameter) was pressed at each point perpendicularly to the participant's skin, which was instructed to warn when he/she could no longer withstand the pressure. The development rate was 0.3kgf/s[12]. Three collections were performed at each point with a 1-minute interval. Then, the arithmetic mean was taken to define the pressure pain threshold (PPT).

OLBPQ is the most recommended instrument to measure the functional impact of LBP and has been translated and validated into Portuguese[24]. It consists of 10 sessions referring to daily activities that can be interrupted or impaired due to LBP. Each of them contains six statements, which progressively describe a greater degree of difficulty in activity than the preceding statement. The statements are scored from zero to five, resulting in a maximum score of 50. The dysfunction degree given by OLBPQ was classified as no dysfunction (0%), minimal dysfunction (1 to 20%), moderate dysfunction (21 to 40%), severe dysfunction (41 to 60%) and disability (above 60%)[23]. For results comparison, the total questionnaire score and the dysfunction degree were used.

The Brazilian RMDQ[25], which is widely used to evaluate the functional performance associated with LBP, is composed of 24 questions related to activities of daily living, pain, and function. For each affirmative question, 1 point was assigned. The score is the sum of the values, being possible to get a minimum score of "0" and a maximum score of "24". The individuals assessed with a score equal to or greater than "14" were classified as functionally disabled[25]. The reassessment began shortly after the application.

The sample calculation was defined taking a difference of two points in the pain intensity through VAS, using the *Gpower* 3.0 program. The statistical power of 0.95 was considered; alpha of 0.05 and effect of 0.4; totaling 102 participants, being 34 per group. This study selected 105 participants, being above the desired sample size.

The randomization was performed in blocks[22]. Nine blocks were established with 15 participants in each, that is, in the draw envelope, there were 5 pieces of paper with IG1 written on them, 5 with IG2 and 5 with PG. The draw was blind to the participant.

The Ethics and Research Committee in Human Beings of the Health Sciences Department of the Federal University of Paraná approved this study under number 1145540 and registered in the clinical trial records with number RBR 59YGR8.

Statistical analysis

For statistical analysis, the results were expressed as mean ± standard deviation and submitted to the normality analysis and variances homogeneity using the Shapiro Wilk and Levene tests, respectively. For parametric variables, paired t Student test was performed in the pre- and post-comparison, and Tukey's *post hoc* ANOVA in the comparison between the groups. The study adopted $p<0.05$ value for statistical significance.

RESULTS

One hundred and five patients were evaluated, divided into 3 groups: IG1 (n=35), IG2 (n=35) and PG (n=35) (Figure 1). There was no sample loss. The recruitment period comprised between March and November 2017.

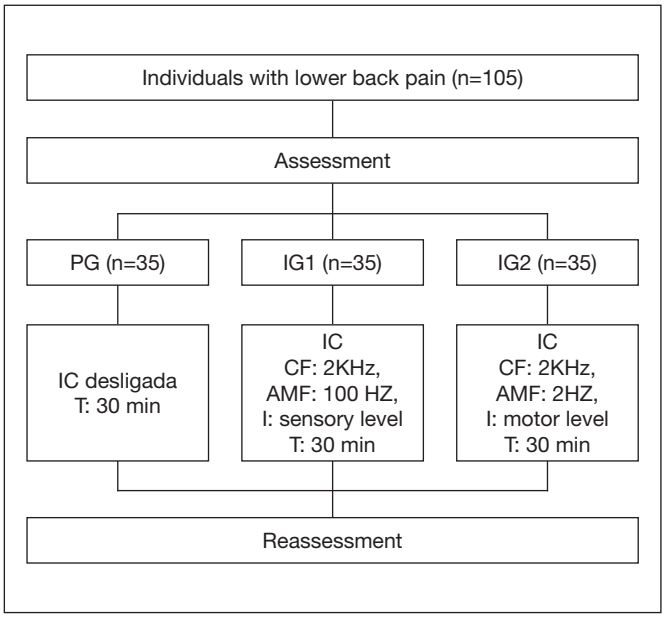

Figure 1. Study Design
IC = interferential current; CF = carrier frequency; AMF = amplitude modulation frequency.

Table 1 shows the clinical and sociodemographic characteristics of the studied population.

Pain intensity decreased significantly in the three groups, and in IG1 and IG2 there was a decrease of more than 3 points on the scale (zero to 10). In intergroup comparison, a difference was found between IG1 and IG2 with PG, but with no difference between IG1 and IG2 (Table 2).

Regarding the algometry result in the lumbar region, significance was only found in L3R and L3L in the IG2 intragroup (Table 3).

Table 4 refers to the results found through the questionnaires applied. Regarding MPQ, the pain index was reduced in the three groups during the analysis of intragroup data. In OLBPQ and RMDQ, there was a significant reduction in the three groups when compared to the initial evaluation. However, when the groups were compared, no difference was found between IG1 and IG2 and placebo.

Table 5 presents the results of the intergroup differences.

Table 1. Clinical and sociodemographic characteristics

Variables	IG1 (n=35)	IG2 (n=35)	PG (n=35)
Age (mean±SD) (years)	43.3 ± 15.3	42.2 ± 14.3	32.9 ± 15.6
Gender (n, %)			
Female	23 (65.7)	23 (65.7)	21 (60)
Male	12 (34.3)	12 (34.3)	14 (40)
Education (n, %)			
Incomplete elementary school	1 (2.9)	0 (0)	1 (2.9)
Complete elementary school	0 (0)	2 (5.7)	1 (2.9)
Incomplete secondary school	7 (20)	6 (17.1)	3 (8.6)
Complete secondary school	9 (25.7)	7 (20)	3 (8.6)
Incomplete higher education	11 (31.4)	10 (28.6)	20 (57.1)
Complete higher education	7 (20)	10 (28.6)	7 (20)
Lifestyle habits			
Smoker (n, %)	2 (5.7)	4 (11.4)	2 (5.7)
Alcohol consumption (n, %)	7 (20)	1 (2.9)	4 (11.4)
Sedentary (n, %)	17 (48.6)	14 (40)	17 (48.6)
Time of pain (years) (mean, min, max, median)	5.81; 3; 34; 3	6.54; 3; 31; 3	4.46; 3; 17; 3
Location of pain (n, %)			
Centralized	12 (34.3)	8 (22.9)	10 (28.6)
On the right	7 (20)	9 (25.7)	5 (14.3)
On the left	1 (2.9)	1 (2.9)	4 (11.4)
Bilateral	15 (42.9)	17 (48.6)	16 (45.7)
Period of the day when pain worsens (n, %)			
Morning	14 (40)	12 (34.3)	8 (22.9)
Afternoon	6 (17.1)	7 (10)	7 (10)
Night	15 (42.9)	16 (45.7)	20 (57.1)
Activities that exacerbate pain (n, %)			
Walking	9 (25.7)	14 (40)	12 (34.3)
Sitting	13 (37.1)	17 (48.6)	11 (31.4)
Getting down	9 (25.7)	19 (54.3)	15 (42.9)
Standing up	8 (22.9)	11 (31.4)	10 (28.6)
Climbing stairs	5 (14.3)	12 (34.3)	11 (31.4)
Effort/lifting object	31 (88.6)	28 (80)	31 (88.6)

IG1 = low-frequency interferential group; IG2 = high-frequency interferential group; PG = placebo group.

Table 2. Evaluation of pain by visual analog scale

	IG1 (n=35)		IG2 (n=35)		PG (n=35)	
VAS (mean ± SD)	Before	After	Before	After	Before	After
	5.3 ± 2.1	2.0 ± 1.9*#	4.7 ± 1.8	1.0 ± 1.4*#	4.9 ± 2.3	3.0 ± 2.0*

IG1 = low-frequency interferential group; IG2 = high-frequency interferential group; PG = placebo group; VAS = visual analog scale. *p<0.05 - intragroup (paired t test). # p<0.05 comparing with PG.

Table 3. Results of pressure pain threshold

PPT (mean ± SD)	IG1 (n=35)		IG2 (n=35)		PG (n=35)	
	Before	After	Before	After	Before	After
ATL	4.6 ± 2.7	4.5 ± 2.6	5.5 ± 1.8	5.3 ± 1.6	5.6 ± 1.9	5.1 ± 2.1
ATR	4.7 ± 2.4	4.5 ± 2.4	5.9 ± 1.8	5.6 ± 1.6	4.4 ± 1.7	5.3 ± 1.9
L3L	4.6 ± 2.8	4.9 ± 2.9	4.8 ± 1.4	5.3 ± 1.7*	4.4 ± 1.7	4.5 ± 1.8
L3R	4.8 ± 2.9	4.8 ± 2.9	4.6 ± 1.4	5.1 ± 1.4*	4.4 ± 1.8	4.7 ± 1.8
L5L	4.6 ± 2.6	4.9 ± 3.0	4.7 ± 1.5	5.1 ± 1.6	4.5 ± 1.8	4.6 ± 1.8
L5R	4.7 ± 2.9	5.1 ± 2.7	4.7 ± 1.8	5.1 ± 1.4	4.9 ± 2.4	4.9 ± 2.3

PPT = pressure pain threshold; IG1 = low-frequency interferential group; IG2 = high-frequency interferential group; PG = placebo group; AT = anterior tibial; L3 = 3rd lumbar vertebra; L5 = 5th lumbar vertebra; L = left; R = right. *p<0.05.

Table 4. Results from the McGill, Oswestry pain questionnaires for lower back pain assessment and Roland Morris Disability Questionnaire

	IG1 (n=35)		IG2 (n=35)		PG (n=35)	
	Before	After	Before	After	Before	After
MPQ (mean±SD)						
Sensory	7.7 ± 2.6	4.0 ± 3.3*	8.5 ± 2.2	4.0 ± 3.3*	8.3 ± 3.3	5.4 ± 2.7*
Affective	3.0 ± 1.8	0.7 ± 1.3*	3.8 ± 1.7	0.9 ± 2.1*	3.5 ± 1.9	1.8 ± 1.5
Evaluative	1.4 ± 0.7	0.4 ± 0.7	1.1 ± 0.3	0.4 ± 0.6*	1.2 ± 1.3	0.9 ± 1.4
Miscellaneous	3.0 ± 1.7	1.4 ± 1.3*	3.5 ± 1.6	1.1 ± 1.5*	3.2 ± 1.1	2.0 ± 1.4*
Total	15.2 ± 4.9	6.6 ± 6.0*	17 ± 4.7	6.4 ± 6.8*	16.2 ± 6.1	10.2 ± 4.9*
OLBPQ	Before	After	Before	After	Before	After
Total	11.4 ± 4.4	5.2 ± 3.9*#	13.7 ± 6.0	5.6 ± 5.7*#	11.1 ± 5.7	7.0 ± 4.5*
Dysfunction level n (%)						
No dysfunction	0 (0)	3 (8.6)	0 (0)	5 (14.3)	0 (0)	2 (5.7)
Minimal dysfunction	17 (48.6)	28 (80)	12 (34.3)	24 (68.6)	17 (48.6)	28 (80)
Moderate dysfunction	17 (48.6)	4 (11.4)	17 (48.6)	4 (11.4)	16 (45.7)	4 (11.4)
Severe dysfunction	1 (2.9)	0 (0)	6 (17.1)	2 (5.7)	2 (5.7)	1 (2.9)
RMDQ	Before	After	Before	After	Before	After
Total	9 ± 4.2	5.1 ± 3*#	11.2 ± 5.3	4.6 ± 4.4*#	9.9 ± 6.0	6.9 ± 5.1*
FD (n, %)						
Yes	4 (11.4)	0 (0)	9 (25.7)	1 (2.9)	10 (28.6)	3 (8.6)

IG1 = low-frequency interferential group; IG2 = high-frequency interferential group; PG = placebo group; MPQ = McGill Pain Questionnaire; OLBPQ = Oswestry Low Back Pain Questionnaire; RMDQ = Roland Morris Disability Questionnaire; FD = functional disability. *p<0.05 - intragroup (paired t test). # p<0.05 - comparing with PG.

Table 5. Intergroup difference (IG1, IG2 and PG) of the analyzed variables after the interferential current application

Outcomes	Differences between interventions with a 95% confidence interval					
	IG1 versus PG	p-value	IG2 versus PG	p-value	IG1 versus IG2	p-value
VAS (0-10)	1.4 (0.5 to 2.3)	0.02*	1.7 (0.8 to 2.6)	0.00*	-0.3 (-1.2 to 0.5)	0.40
MPQ						
Sensory (0-10)	-1.0 (-2.1 to 0.1)	0.56	-0.6 (-1.7 to 0.5)	0.56	-0.4 (-1.5 to 0.7)	0.56
Affective (0-5)	-0.7 (-1.5 to -0.0)	0.04*	-0.3 (-1.0 to 0.4)	0.44	-0.4 (-1.2 to 0.2)	0.20
Evaluative (0-1)	-0.1 (-0.4 to 0.1)	0.27	-0.3 (-0.6 to -0.0)	0.01	0.2 (-0.0 to 0.4)	0.15
Miscellaneous (0-4)	-0.4 (-1.0 to 0.2)	0.17	-0.3 (-0.9 to 0.3)	0.32	-0.1 (-0.72 to 0.5)	0.32
Total (0-20)	-2.3 (-4.6 to 0.0)	0.05	-1.5 (-3.8 to 0.8)	0.20	-0.8 (-3.1 to 1.5)	0.50
OLBPQ (0-50)	-2.1 (0.2 to 4.0)	0.03*	4.0 (2.2 to 5.9)	0.00*	1.9 (-0.0 to 3.83)	0.06
RMDQ (-24)	2.9 (1.0 to 4.8)	0.02*	3.4 (1.5 to 5.3)	0.00*	0.5 (-1.3 to 2.3)	0.59
Algometry						
ATR	0.86 (-0.5 to 0.6)	0.77	0.6 (-0.5 to 0.6)	0.82	0.0 (-0.5 to 0.6)	0.94
ATL	0.8 (-0.5 to 0.6)	0.77	0.1 (-0.4 to 0.7)	0.70	-0.0 (-6.6 to 0.5)	0.92
L3R	-0.3 (-0.8 to 0.2)	0.29	-0.2 (-0.7 to 0.3)	0.40	-0.5 (-1.0 to 0.0)	0.06
L3L	0.2 (-0.3 to 0.7)	0.45	0.3 (-0.1 to 0.9)	0.17	-0.1 (-0.7 to 0.3)	0.54
L5R	-0.1 (-0.7 to 0.5)	0.74	-0.04 (-0.7 to 0.6)	0.88	-0.7 (-0.7 to 0.5)	0.82
L5L	0.1 (-0.4 to 0.7)	0.61	0.14 (-0.4 to 0.7)	0.61	-0.0 (-0.6 to 0.5)	0.99

IG1 = low-frequency interferential group; IG2 = high-frequency interferential group; PG = placebo group; AT = anterior tibial; L3 = 3rd lumbar vertebra; L5 = 5th lumbar vertebra; L = left; R = right. *Significant difference (p<0.05). MPQ = McGill Pain Questionnaire; OLBPQ = Oswestry Low Back Pain Questionnaire; RMDQ = Roland Morris Disability Questionnaire.

DISCUSSION

This study showed that the IC caused a decrease in the subjective perception of pain and also an improvement in the functionality in relation to PG.

Assessing the short-term (immediate) analgesic effect, not only long-term after IC application, is essential for clinical practice. Often CLBP-patients are unable to perform kinesiotherapy because of the high pain or, in some cases, kinesiotherapy may lead to the exacerbation of this condition. So, IC can be used to minimize or suppress pain before or after exercise.

Few studies have evaluated the immediate analgesic effects after IC application in CLBP[12,15,20]. Most studies evaluated the long-term effects of this equipment on healthy individuals[10,27], CLBP-individuals[12,27]; or associated with other therapies and currents[29,30]. This study is the first one to evaluate the frequency of 2KHz in CLBP-individuals with two different AMF, one of high frequency (AMF=100Hz) and one of low frequency (2KHz).

The results found in the subjective measurement of pain presented strong effects of 2KHz IC treatment, regardless the AMF chosen. This result is reinforced by Corrêa et al.[12], who found more significant effects on the immediate reduction of pain after IC application with lower frequencies (1KHz), and also by Fuentes et al.[20] who found satisfactory results of IC in relation to placebo, but did not indicate the CF used, only the frequency modulation of 0Hz. Only the study by Pereira et al.[31] evaluated the IC immediate effects in the frequency of 2KHz and found no significant results in changing the pain threshold for cold and heat. However, this study evaluated healthy individuals and not CLBP ones. It was emphasized that there was no difference between the groups that applied IC, i.e., there was no interference of the chosen AMF. Johnson and Tabasam[32] and Claro et al.[27] also found no difference in the groups treated with different AMFs in healthy subjects.

It was observed that in the objective pain evaluation, through algometry, no immediate analgesic results were found (only in L3R and L3L of IG2), unlike the study by Corrêa et al.[12] and Venancio et al.[10], who observed PPT increase immediately after the intervention, but at the frequency of 1KHz. It was expected that, along with the significant decrease in VAS, the PPT increase occurred, but this did not happen. Perhaps this was due to the IC electrical stimulus that have momentarily blocked the mechanoreceptors stimulus through the Abo fibers excitability which may have decreased the PPT, or by the interference of the individual himself who may not want to feel the strong pressure (as much as he/she could) of the algometer after having his/her lumbar region pain diminished by the treatment.

Although no therapeutic exercises have been performed in this protocol, significant improvement in the functional performance of the individuals could be observed through OLBPQ and RMDQ with a substantial treatment effect in IG2 and moderate in IG1. These data are reinforced by Facci et al.[29], who used IC as an intervention form, but with CF of 4KHz. However, Corrêa et al.[12] also used the RMDQ to evaluate the functional performance of their participants after applying the 1KHz and 4KHz IC and did not find satisfactory results. Albornoz-Cabello et al.[28], on the other hand, used 4000Hz IC, 65Hz frequency modulation, 95Hz frequency variation, and 1/1 slope during ten sessions and saw improvement in the functional capacity of the individuals with CLBP.

Venancio et al.[10] emphasized that lower frequency carrier currents, such as 1 and 2KHz, are more uncomfortable, but have higher analgesic effects than higher CF, such as 8 and 10kHz. This study corroborated these data since there were significant improvements after IC application with 2KHz CF. Despite this assertion, most studies used the 4KHz frequency[12,15,27,29].

It should be emphasized that the study has some limitations, such as failure to perform it double-blinded and the lack of functional tests in the evaluation instruments.

However, it should be noted that the study was carried out with a large number of participants, in a blinded way and with all the evaluation instruments validated and culturally adapted for the Brazilian population. Moreover, pressure algometry is considered the gold standard for measuring pain sensitivity by pressure[33].

CONCLUSION

It was found that the IC provided an immediate analgesic effect in CLBP. However, further studies should be performed with other protocols to define the best parameter of this current for CLBP treatment.

REFERENCES

1. Chou R, Huffman LH. Medications for acute and chronic low back pain: a review of the evidence for an American Pain Society/American College of Physicians clinical practice guideline. Ann Intern Med. 2007;147(7):505-14.
2. Chou R, Huffman LH. Nonpharmacologic therapies for acute and chronic low back pain: a review of the evidence for an American Pain Society/American College of Physicians clinical practice guideline. Ann Intern Med. 2007;147(7):492-504.
3. Delitto A, George SZ, Van Dillen LR, Whitman JM, Sowa G, Shekelle P, et al. Low back pain. J Orthop Sports Phys Ther. 2012;42(4):A1-57.
4. Ladeira CE. Evidence based practice guidelines for management of low back pain: physical therapy implications. Rev Bras Fisioter. 2011;15(3):190-9.
5. Nijs J, Apeldoorn A, Hallegraeff H, Clark J, Smeets R, Malfliet A, et al. Low back pain: guidelines for the clinical classification of predominant neuropathic, nociceptive, or central sensitization pain. Pain Physician. 2015;18(3):E333-46.
6. Mlekusch S, Schliessbach J, Cámara RJ, Arendt-Nielsen L, Jüni P, Curatolo M. Do central hypersensitivity and altered pain modulation predict the course of chronic low back and neck pain? Clin J Pain. 2013;29(8):673-80.
7. Kuner R, Flor H. Structural plasticity and reorganisation in chronic pain. Nat Rev Neurosci. 2016;18(1):20-30. Erratum in: Nat Rev Neurosci. 2017;18(2):113.
8. Thiese MS, Hughes M, Biggs J. Electrical stimulation for chronic non-specific low back pain in a working-age population: a 12-week double blinded randomized controlled trial. BMC Musculoskeletal Disord. 2013;14:117.
9. Searle A, Spink M, Ho A, Chuter V. Exercise interventions for the treatment of chronic low back pain: a systematic review and meta-analysis of randomised controlled trials. Clin Rehabil. 2015;29(12):1155-67.
10. Venancio RC, Pelegrini S, Gomes DQ, Nakano EY, Liebano RE. Effects of carrier frequency of interferential current on pressure pain threshold and sensory comfort in humans. Arch Phys Med Rehabil. 2013;94(1):95-102.
11. Corrêa JB, Costa LO, de Oliveira NT, Sluka KA, Liebano RE. Effects of the carrier frequency of interferential current on pain modulation in patients with chronic nonspecific low back pain: a protocol of a randomised controlled trial. BMC Musculoskelet Disord. 2013;14(1):195.
12. Corrêa JB, Costa LO, Oliveira NT, Lima WP, Sluka KA, Liebano RE. Effects of the carrier frequency of interferential current on pain modulation and central hypersensitivity in people with chronic nonspecific low back pain: a randomized placebo-controlled trial**.** Eur J Pain. 2016;20(10):1653-66.
13. Qaseem A, Wilt TJ, McLean RM, Forciea MA. Noninvasive treatments for acute, subacute, and chronic low back pain: a clinical practice guideline from the American

College of Physicians. Ann Intern Med. 2017;166(7):514-30.
14. Wong JJ, Côté P, Sutton DA, Randhawa K, Yu H, Varatharajan S, et al. Clinical practice guidelines for the noninvasive management of low back pain: A systematic review by the Ontario Protocol for Traffic Injury Management (OPTIMa) Collaboration. Eur J Pain. 2017;21(2): 201-16.
15. Fuentes JP, Armijo Olivo S, Magee DJ, Gross DP. Effectiveness of interferential current therapy in the management of musculoskeletal pain: a systematic review and meta-analysis. Phys Ther. 2010;90(9):1219-38.
16. Goats GC. Interferential current therapy. Br J Sports Med. 1990;24:87-92.
17. Prentice WE. Therapeutic modalities in rehabilitation. McGraw Hill Professional; 2017.
18. Ward AR, Robertson VJ, Makowski RJ. Optimal frequencies for electric stimulation using medium-frequency alternating current. Arch Phys Med Rehabil. 2002;83(7):1024-7.
19. Ward AR. Electrical stimulation using kilohertz-frequency alternating current. Phys Ther. 2009;89(2):181-90.
20. Fuentes J, Armijo-Olivo S, Funabashi M, Miciak M, Dick B, Warren S, et al. Enhanced therapeutic alliance modulates pain intensity and muscle pain sensitivity in patients with chronic low back pain: an experimental controlled study. Phys Ther. 2014;94(4):477-89.
21. Robertson V, Ward A, Low J, Reed A. Eletroterapia explicada: princípios e prática. 4ª ed. Rio de Janeiro: Elsevier; 2009.
22. Ludington E, Dexter F. Statistical analysis of total labor pain using the visual analog scale and application to studies of analgesic effectiveness during childbirth. Anesth Analg. 1998;87(3):723-7.
23. Pimenta CA, Teixeira MJ. Questionário de dor McGill: proposta de adaptação para a língua portuguesa. Rev Esc Enferm USP. 1996;30(3):473-83.
24. Vigatto R, Alexandre NM, Correa Filho HR. Development of a Brazilian Portuguese version of the Oswestry Disability Index: cross-cultural adaptation, reliability, and validity. Spine. 2007;32(4):481-6.
25. Nusbaum L, Natour J, Ferraz MB, Goldenberg J. Translation, adaptation and validation of the Roland Morris questionnaire- Brazil Roland-Morris. Braz J Med Biol Res. 2001;34(2):203-10.
26. Ferreira JC, Patino CM. Randomization: beyond tossing a coin. J Bras Pneumol. 2016;42(5):310. English, Portuguese.
27. Claro AD, Kanezawa BA, Camargo MD, Paes VM, Portolez JL, Bertolini GR. Pressure and cold pain threshold in healthy subjects undergoing interferential current at different amplitude modulated frequencies. Rev Dor. 2014;15(3):178-81.
28. Albornoz-Cabello M, Maya-Martín J, Domínguez-Maldonado G, Espejo-Antúnez L, Heredia-Rizo AM. Effect of interferential current therapy on pain perception and disability level in subjects with chronic low back pain: a randomized controlled trial. Clin Rehabil. 2017;31(2):242-9.
29. Facci LM, Nowotny JP, Tormem F, Trevisani VF. Effects of transcutaneous electrical nerve stimulation (TENS) and interferential currents (IFC) in patients with nonspecific chronic low back pain: randomized clinical trial. São Paulo Med J. 2011;129(4):206-16.
30. Shanahan C, Ward AR, Robertson VJ. Comparison of the analgesic efficacy of interferential therapy and transcutaneous electrical nerve stimulation. Physioter. 2006;92(4):247-53.
31. Pereira GD, Cassolato KM, Lazarin PH, Canto TO, Portolez JL, Bertolini GR. Efeito da corrente interferencial, 2000Hz, no limiar de dor induzida. Rev Bras Med Esporte. 2011;17(4):257-60.
32. Johnson MI, Tabasam G. An investigation into the analgesic effects of different frequencies of the amplitude modulated wave of interferential current therapy on cold--induced pain in normal subjects. Arch Phys Med Rehabil. 2003;84(9):1387-94.
33. Dagtekin O, König E, Gerbershagen HJ, Marcus H, Sabatowski R, Petzke F. [Measuring pressure pain thresholds. Comparison of an electromechanically controlled algometer with established methods]. Schmerz. 2007;21(5):439-44. German.