DOI: 10.1590/1809-2950/20022028032021

ORIGINAL RESEARCH

Can electrotherapy improve the effect of kinesio-functional exercises in the treatment of chronic non-specific low back pain?

A eletroterapia pode aprimorar o efeito de exercícios cinesiofuncionais no tratamento da dor lombar inespecífica crônica?

¿Puede la electroterapia mejorar el efecto de los ejercicios kinesiofuncionales en el tratamiento del dolor lumbar crónico inespecífico?

Allex Maldonado Silveira[1], Letícia Torres Santos[2], Anna Yasmin Bertão Marques Rodrigues[3], Francielle de Oliveira Brum[4], Eloá Ferreira Yamada[5], Morgana Duarte da Silva[6]

ABSTRACT | This study aimed to compare the effect of a Kinesio-functional exercise protocol (KFE) isolated or associated with Interferential Current (IC) or Aussie Current (AC) on pain intensity, mobility/flexibility, functionality, and quality of life (QoL) of individuals with chronic non-specific low back pain. This is a non-randomized clinical trial, in which 42 individuals were randomly divided into three groups: GI (KFE; n=14), GII (KFE+IC; n=14) and GIII (KFE+AC, n=14). The individuals underwent 10 treatment sessions (five weeks). The individuals were evaluated before and after the intervention, using the Pain visual analog scale (VAS); the assessment of QoL was conducted using the SF-36 questionnaire; the assessment of lumbar mobility/flexibility, by the modified Schober test and the Wells Bank; the assessment of functional disability, using the Oswestry Index; and for depressive aspects, the Beck Depression Inventory (BDI) was used. In the reassessment, we observed a significant improvement in all experimental groups regarding pain intensity (p <0.0001) and mobility/flexibility. In SF-36, we found that only individuals treated with exercises associated with electrical current improved their physical capacity, physical aspects, and pain domains. The BDI assessment did not show any changes before or after the intervention. We conclude that the association of therapeutic techniques showed greater benefit to the individuals in the sample since it improved the evaluated variables, such as pain, mobility/flexibility, and quality of life.
Keywords | Physical Therapy Specialty; Electric Stimulation; Exercise Therapy; Low Back Pain.

RESUMO | O presente estudo teve como objetivo comparar o efeito de um protocolo de exercícios cinesiofuncionais (ECF) isolados ou associados a corrente interferencial (CI) ou corrente *aussie* (CA), sobre a intensidade da dor, a mobilidade/flexibilidade, a funcionalidade e a qualidade de vida (QV) de indivíduos com dor lombar inespecífica crônica. Trata-se de um ensaio clínico não randomizado, em que foram selecionados 42 sujeitos aleatorizados em três grupos: GI (treinamentos cinesiofuncional; n=14), GII (treinamentos cinesiofuncional + CI; n=14) e GIII (treinamento cinesiofuncional + CA; n=14). Os indivíduos foram submetidos a dez sessões de tratamento ao longo de 5 semanas e foram avaliados pré e pós-intervenção, usando escala visual analógica de dor (EVA); avaliação da QV pelo questionário SF-36; avaliação da mobilidade/flexibilidade lombar pelo teste de Schober modificado e o teste de sentar e alcançar com o banco de Wells; avaliação da incapacidade funcional através do índice Oswestry; e, para os aspectos depressivos, inventário de depressão de Beck (IDB). Na reavaliação, percebeu-se que houve melhora significativa em

[1]Universidade Federal do Pampa – Uruguaiana (RS), Brazil. E-mail: alex_ms15@hotmail.com. ORCID-0000-0002-6032-9217
[2]Universidade Federal do Pampa – Uruguaiana (RS), Brazil. E-mail: leticialts@hotmail.com. ORCID-0000-0003-2125-7959
[3]Universidade Federal do Pampa – Uruguaiana (RS), Brazil. E-mail: yasminmarques_r@hotmail.com. ORCID-0000-0002-9493-4685
[4]Universidade Federal do Pampa – Uruguaiana (RS), Brazil. E-mail: francielle_brum@gmail.com. ORCID-0000-0003-2131-7923
[5]Universidade Federal do Pampa – Uruguaiana (RS), Brazil. E-mail: eloayamada@unipampa.edu.br. ORCID-0000-0002-8824-3378
[6]Universidade Federal do Pampa – Uruguaiana (RS), Brazil. E-mail: dasilvamdbrazil@gmail.com. ORCID-0000-0002-2487-236X

Corresponding address: Morgana Duarte da Silva – Universidade Federal do Pampa, Campus Uruguaiana, Adress: BR 472, Km 592, Prédio 700. Uruguaiana (RS), Brazil – ZIP Code: 97500-970 – E-mail: dasilvamdbrazil@gmail.com – Financing source: nothing to declare – Conflict of interest: nothing to declare – Presentation: August 19th, 2021 – Accepted for publication: September 21st, 2021 – Ethics Committee Approval: No 2.117.371.

todos os grupos experimentais na intensidade da dor (p<0,0001) e na mobilidade/flexibilidade. No SF-36, verificamos que apenas os indivíduos tratados com exercícios associados à corrente elétrica apresentaram melhora dos domínios capacidade física, aspectos físicos e dor. A avaliação do IDB não apresentou modificações pré e pós-intervenção. Conclui-se que a associação das técnicas terapêuticas apresentou maior benefício aos indivíduos da amostra, uma vez que produziu melhora sobre as variáveis avaliadas, como dor, mobilidade/flexibilidade e qualidade de vida.
Descritores | Fisioterapia; Estimulação Elétrica; Terapia por Exercício; Dor Lombar.

RESUMEN | El presente estudio tuvo por objetivo comparar el efecto de un protocolo de ejercicios kinesiofuncionales (ECF) aislados o asociados con corriente interferencial (CI) o corriente *aussie* (CA) sobre la intensidad del dolor, la movilidad/flexibilidad, la funcionalidad y la calidad de vida (CV) de las personas con dolor lumbar crónico inespecífico. Este es un ensayo clínico no aleatorizado en el que participaron 42 individuos y se los dividieron al azar en tres grupos: GI (entrenamientos kinesiofuncionales; n=14), GII (entrenamientos kinesiofuncionales + CI; n=14) y GIII (entrenamiento kinesiofuncional + CA; n=14). Se sometieron a los participantes a diez sesiones de tratamiento, durante 5 semanas, y estos pasaron por una evaluación antes y después de la intervención por medio de una escala visual de dolor analógica (EVA); evaluación de la CV por el cuestionario SF-36; evaluación de la movilidad/flexibilidad lumbar utilizando la prueba de Schober modificada y la prueba de sentarse y llegar al banco Wells; evaluación de la incapacidad funcional empelando el índice de Oswestry; y, para los aspectos depresivos, el Inventario de Depresión de Beck (BDI). En la reevaluación, la intensidad del dolor (p<0,0001) y la movilidad/flexibilidad tuvieron una mejora significativa en todos los grupos experimentales. En el SF-36, solo los individuos tratados con ejercicios asociados con corriente eléctrica mejoraron la capacidad física, los aspectos físicos y los dominios del dolor. La evaluación del BDI no cambió antes ni después de la intervención. Se concluye que la asociación entre técnicas terapéuticas tuvo un efecto positivo para los individuos de la muestra por la mejora producida en las variables evaluadas, como el dolor, la movilidad/flexibilidad y la calidad de vida.
Palabras clave | Fisioterapia; Estimulación Eléctrica; Terapia por Ejercicio; Dolor de la Región Lumbar.

INTRODUCTION

Chronic non-specific low back pain is defined as persistent pain for at least 12 weeks, located below the costal margin and above the gluteal folds[1-3]. It is considered a significant health problem responsible for changing quality of life (QoL)[1], being one of the main causes of the absence of individuals from work and almost 84% of people may be affected by this condition at some point in life[4].

Low back pain causes a decrease in muscle strength, which reduces the protective capacity of joint structures[5]. Thus, exercises to activate the abdominal, superficial, transverse abdominal, and multifidus muscles are essential for stabilization of the lumbar spine and reduction of pain[6,7].

Electrotherapy is another resource indicated for the treatment of low back pain. The interferential (IC) and Aussie (AC) currents are alternating currents of medium-frequency modulated at low frequency[8], which are characterized by deep penetration into tissues[9], in addition to promoting pain relief and increasing blood flow[1,9,10]. The IC has a sine wave shape; and AC, symmetrical, biphasic, and rectangular wave. AC, unlike other alternating currents, has its burst adjusted in a short duration, then, it is considered more comfortable compared to other analgesic currents[11,12].

Considering the aforementioned, we hope that the association of medium-frequency currents with kinesio-functional exercises (KFE) will result in better outcomes compared to isolated KFE therapy. Thus, this study aimed to compare the effect of KFE isolated and associated with the currents and to verify which treatment provided better results regarding pain intensity, functionality, and QoL of individuals with non-specific low back pain.

METHOLOGY

This is an interventional, non-randomized clinical trial study. The convenience sample was composed of individuals who have inespecific chronic low back pain complaints that sought therapeutic care at the Campus Uruguaiana of Universidade Federal do Pampa (Unipampa) from January 2018 to May 2019. All participants were previously informed about the study and then signed an informed consent form. The assessment and reassessment were performed by the participants, who were previously and equally trained by the same instructors, seeking to reduce the intra-rater variability. The rater referred the participants to the

therapists. Four therapists worked in the protocols of this study and they were previously and equally trained.

The inclusion criteria were: non-specific chronic low back pain complaints, individuals aged over 18 years, being a resident of the municipality of Uruguaiana (RS), and not presenting restrictions regarding physical capacity. Exclusion criteria were: contraindications of the protocols and cognitive deficits.

The participants undergone an initial assessment and a reassessment at the end of the procedures, which consisted of:

- Anamnesis: personal and clinical data of the individual.
- Pain assessment: the visual analog pain scale (VAS) was used. The scale is numbered from 0 (no pain) to 10 (maximum pain), according to the degree of pain reported by the participant in the last 24 hours and the reassessment.
- QoL assessment: the SF-36 questionnaire was used. It assesses functional capacity, physical aspects, pain, general condition, vitality, social aspects, emotional aspects, and mental health[13,14].
- Lumbar spine mobility/flexibility assessment: it was performed by the Schöber test and the sit-and-reach test with the Wells bank. The first test was performed with the individual in an orthostatic position; reference points were demarked in the lumbosacral transition and 10cm above this point. Then, the individual performed maximum flexion of the trunk. The test is considered normal when ≥5cm variation occurs. In the second test, the individual was seated, with knees in extension, feet resting on the bank, shoulders flexed, forearms extended and pronated, and hands overlapped. The individuals moved forward with the trunk, moving on the graduated scale of the Wells bank, The total distance reached represents the final score[15]. Three attempts were made in each test and the mean value was used as a result..
- Disability assessment: the Oswestry Disability Index was used, containing 10 items that score from 0 to 5. The questions assess the intensity of pain and the consequences of pain in daily life. The points are added, obtaining a minimum of zero and a maximum of fifty points. The score achieved is multiplied by two, obtaining a percentage, used to classify the level of low back pain incapacitation. The score ranges from 0 (absence of disability) to 100 (maximum disability)[16].
- Assessment of depressive aspects: Beck depression inventory (BDI) was used. This inventory consists of 21 items, with answers classified from 0 to 3. Scores inferior to 10 indicate no depression or minimal depression; from 10 to 18, mild to moderate depression; from 19 to 29, moderate to severe depression; and 30 to 63, severe depression[17,18].

Treatment protocols were performed in 10 sessions twice a week. The individuals available for the study were randomly divided into three groups, initially randomized into blocks of 10 participants, on a first-come, first-served basis of groups: Group I (GI) - Kinesio-functional Training (KFE); Group II (GII) - KFE+IC; and Group III (GIII) - KFE+AC. Thus, 10 individuals from each group were attended and each added participant was distributed among the groups, neatly (31st for GI, 32nd for GII, and so on).

In each session, the individuals undergone a KFE protocol for strengthening and stabilizing the core muscles, composed of the exercises: front plank, lateral plank, abdominal crossed, abdominal rower, bridge, crunch, and superman exercise (hyperextension of the spine). The exercises were performed in three sets of 10 repetitions, except for the frontal and lateral plank, performed in three sets of 10 repetitions (Figure 1).

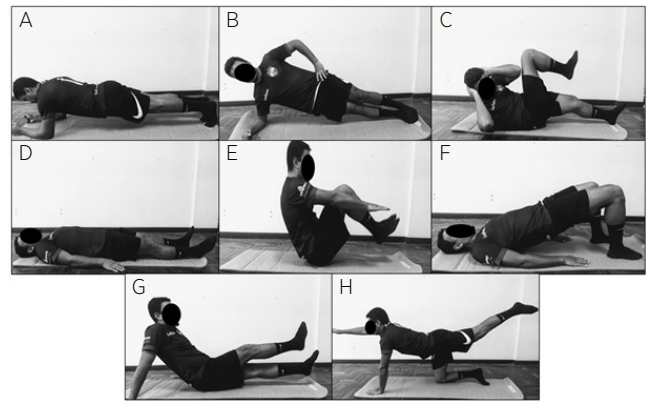

Figure 1. Kinesio-functional exercise protocol (KFE) to strengthen the core
A: front plank; B: side plank; C: cross crunch; D and E: V-crunch, with an initial position in D and final position in E; F: bridge; G: scissor crunch; H: bird-dog exercise (hyperextension of the spine).

After performing the exercises, the vital signs and VAS of the individuals of GI were verified and they were discharged. The individuals of GII and GIII were led to sit in the quick massage chair for the application of IC and AC, using the Neurodyn Ruby Line (Ibramed®). Four self-adhesive electrodes (5x10cm) were used, positioned in the equivalent distance (3cm and 4cm) next to the first vertebrae of the lumbar and sacral spine (L1 and S1), bilaterally, in two canals. In canal 1, the electrodes were arranged laterally to the right L1 and the left S1; and in canal 2, the electrodes were arranged laterally to the left L1 and the right S1. Parameters of the currents: IC – 2000Hz,

frequency modulated by amplitude (FMA) 10Hz, Slope 1:1, Sweep 10Hz; AC – 4000Hz, modulated frequency 20Hz and a burst of 4ms; both with 30min duration[19,20]. The intensity was strong throughout the session, adjusting it according to the sensitivity of the patient. In the end, the vital signs and VAS of the individuals were measured.

The Kolmogorov-Smirnov test was used to verify the sample distribution. Intragroup results were analyzed by the t-test for paired parametric data (pain, Schöber, and Wells bank), which were presented as ± standard deviation. The Wilcoxon test was used in the nonparametric data (SF-36, Oswestry, and depression inventory). The analyses among the groups were performed in the same way, comparing the delta of the values before and after treatment in the groups (GIxGII, GIxGIII, GIIxGIII). Results were expressed as mean and standard deviation. Statistical analysis was performed using GraphPad Software. The significance level in all cases was considered $p<0.05$.

RESULTS

In total, 42 individuals were included in the study and the distribution of the groups was heterogeneous, performed by convenience (Table 1), so that 14 individuals were randomly allocated in each of the three experimental groups.

Table 1. Sample characteristics

Clinical data	Number of individuals	%
Sex		
Female	28	66.7
Male	14	33.3
Age group		
<20	1	2.4
20-29	21	50
30-39	17	40.5
40-49	3	7.1

The proposed treatments significantly reduced low back pain in all groups, according to the first and last intervention (Figure 2A), presenting $p<0.0001$. The evaluation of QoL by the SF-36 presents statistical differences before and after GII and GIII in the following domains: physical capacity, physical aspects, and pain (Figure 2B). When we performed the statistical analysis of the delta (Δ), we observed differences (delta Δ) in the comparison of the domains between GI and GII, and between GI and GIII (Table 2).

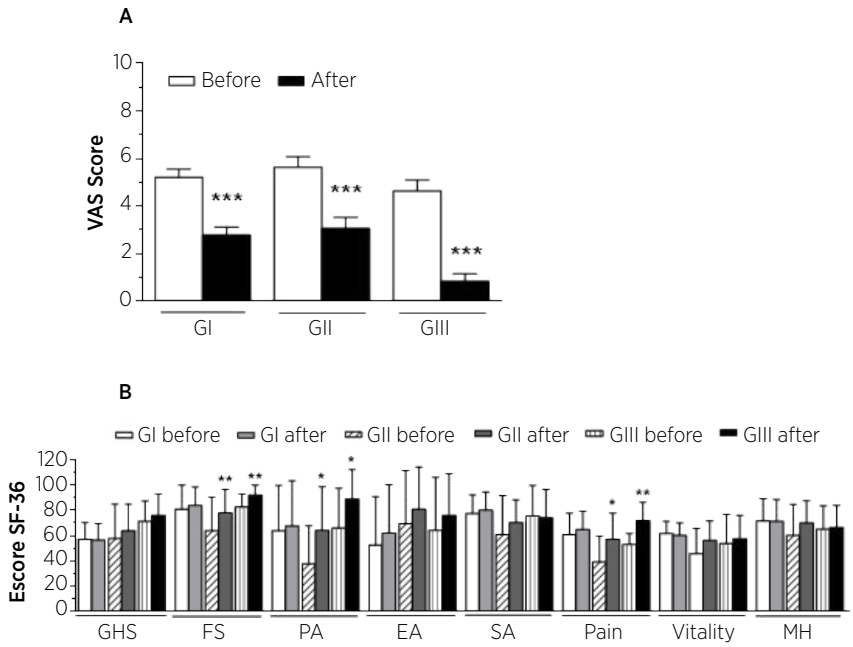

Figure 2. Pain score and quality of life questionnaire SF-36

A: represents VAS, at the beginning and the end of treatments in GI, GII, and GIII; B: represents the domains of the SF-36 questionnaire, before and after treatments in GI, GII, and GIII; GHS: general health status; FC: functional capacity; PA: physical aspect; EA: emotional aspect; SA: social aspect; MH: pain, vitality, and mental health; * statistically significant results.

Table 2. Evaluation of the difference in pre- and post-intervention data (Δ) between the groups

Evaluation	Δ GI x Δ GII	Δ GI x Δ GIII	Δ GII x Δ GIII
VAS	0.7022	<0.0001***	0.0059**
SF-36			
GHS	0.0497*	0.0793	1.0000
FC	0.0402*	0.0344*	0.5270
PA	0.1159	0.1052	0.6506
EA	1.0000	0.9438	1.0000
SA	0.4697	0.4406	0.5519
Pain	0.3277	0.0133*	1.0000
Vital	0.0686	0.1230	0.2304
MH	0.2995	0.5013	0.2883
Schöber	0.0193*	0.3055	0.0005***
Wells Bank	0.7085	0.0853	0.0392*
Oswestry	0.1002	0.0078**	0.1788
Beck	0.7085	0.0853	0.0392*

VAS: visual analog scale; GHS: general health status; FC: functional capacity; PA: physical aspect; EA: emotional aspect; SA: social aspect; MH: pain, vitality, and mental health; * statistically significant results.

In lumbar spine mobility, all groups showed statistical difference at the end of the evaluations (means: pre-GI 14.57±1.39 and post-GI 15.93±1.68, p=0.0001; pre-GII 15.07±1.58 and post-GII 15.71±1.82, p=0.0006; pre-GIII 14.21±0.97 and post-GIII 15.92±0.62, p<0.0001). Table 2 shows the difference between the groups of post-intervention values.

In the evaluation of lumbar spine flexibility, we observed a significant difference in GI and GII at the end of the interventions (mean: pre-GI 20.49±7.45 and post-GI 23.91±7.21cm, p=0.0018; pre-GII 23.49±12.45 and post-GII 27.39±10.99cm, p=0.0011; pre-GIII 26.33±6.93 and post-GIII 28.10±6.69cm). After the interventions, we observed a significant difference between GII and GIII (Table 2).

Regarding disability (Table 3), the GI showed no significant difference between the initial (4.50±3.73) and final (4.50±2.70) values. In GII, we found a significant difference between the initial and final values (11.00±6.91 and 8.50±5.50, p=0.097); as well as in GIII (7.00±2.46 and 4.00±2.02, p=0.0067). We observed a significant difference between the results after the interventions between GI and GIII (Table 2).

Table 3. Oswestry disability index, pre- and post-interventions in the three groups

Oswestry Index	Pre-GI	Post-GI	Pre-GII	Post-GII	Pre-GIII	Post-GII
	N-%					
Minimal disability	12-86	13-93	6-43	10-72	11-79	14-100
Moderate disability	2-14	1-7	7-50	3-21	3-21	
Severe disability				1-7		
Amputee			1-7			
Disabled						
TOTAL	14-100	14-100	14-100	14-100	14-100	14-100

N: number of individuals; % indicates the percentage of individuals concerning the total experimental group.

In the results of the depression inventory, we observed no difference in the pre- and post-intervention data (initial median: 4.50±7.79; 8.00±9.08; 7.00±6.36; and final 4.50±7.3; 7.00±7.99; 5.00±3.70, for GI, GII, and GIII, respectively). Comparing the deltas of the groups, a statistical difference was observed only between GII and GIII (Table 2).

DISCUSSION

In this study, after 10 sessions of treatment with Kinesio-functional exercises – isolated or associated with electrotherapy, IC or AC – we observed a decrease in pain perception, as well as improvement in the functional capacity of individuals with non-specific low back pain.

Patients with low back pain restrict the movement of the trunk, reducing the strength of the core and increasing joint instability, which accentuates the pain[21]. The treatment of low back pain performed through the stability of the lumbo-pelvic region is thought to increase intra-abdominal pressure, in addition to activate superficial abdominal muscles, transverse abdominal, and multifidus muscles, which also stabilize this area and can help to reduce pain [7,8]. Although this relationship is not fully understood, central stability exercises are more effective to reduce pain and increase the functional status of patients with low back pain than non-specific exercises[7], which corroborates the data observed in this study. In addition to pain reduction, we observed improvement in mobility and flexibility in all individuals who underwent KFE (GI, GII, and GIII).

The use of IC reduced the pain of individuals, which may be related to FMA at low frequency, which can penetrate deeper into tissues [22] and promote vasodilation and improvement of blood flow[23], causing analgesic effects[24]. The analgesic effect is partially attributed to the gate control theory, which asserts that the impulses transmitted transcutaneously stimulate A-beta fibers, covered with a myelin sheath, which conducts ascending information sensitive to biphasic waves[25,26]. Karvat, Antunes, and Bertolini[27] showed a reduction in pain after CI application. In this study, IC associated with KFE reduced pain perception and improved functional capacity and QoL, more prominently than in individuals who performed only exercises, especially in the functionality parameter.

Ward and Lucas-Toumbourou[28] developed a type of modulated alternating current in a rectangular shape with short bursts (2-4ms). They wanted to produce a more adequate current for sensory and motor stimulation. This type of electrotherapy became commercially known as Aussie current (AC). We found few studies on AC, some of which show a potential analgesic effect[11,28,29]. However, the low methodological rigor and the high risk of bias limit a more precise interpretation of the results. The authors suggest that the average frequency and burst (4000Hz and 4ms) generate less discomfort and greater effect on pain reduction due to lower impedance, which can more easily stimulate nerves in the underlying tissue[11,12,30]. Although the exact mechanism of AC analgesia is unknown, this therapy seems to be as effective as other currents, such as transcutaneous electrical nerve stimulation (TENS)[29]. In this study, individuals treated with AC presented greater pain reduction when compared to other groups, as well as improvement in functional capacity and quality of life.

Individuals with low back pain have high levels of disability[31,32]. The data of this study show that there was an improvement in the functionality of individuals treated with electrotherapy associated with KFE, proving the benefits of the combination of both therapies. The individuals who performed exercises associated with electric current (GII and GIII) showed improvement in quality of life, and in physical capacity, physical aspects, and pain domains. Gonçalves et al.[33] observed that 82% of the individuals with low back pain complaints presented decrease in lumbar flexion, which was also observed in our findings. We also verified that the treatment protocols of this study promoted an increase in mobility and trunk flexibility, corroborating the findings from Briganó and Macedo,[15] who demonstrated significant improvement in lumbar mobility after intervention with kinesiotherapy.

We suggest that further studies with a greater number of participants, intervention time, and instruments, such as the algometer to assess the pain, be conducted in the field.

CONCLUSION

The association of medium-frequency electric currents with Kinesio-functional exercises showed greater therapeutic benefit when compared to treatment with isolated exercises. In the association of exercises with the Aussie current, a higher effect is observed concerning pain relief. Thus, the associated use of physical therapy techniques – exercises and medium-frequency electrotherapy – reduced pain intensity as well as improved mobility/flexibility, functionality, and quality of life of individuals with non-specific low back pain.

REFERENCES

1. Airaksinen O, Brox JI, Cedraschi C, Hildebrandt J, Klaber-Moffett J, Kovacs F, et al. European guidelines for the management of chronic nonspecific low back pain. Eur Spine J. 2006;15(Suppl 2):s192-s300. doi: 10.1007/s00586-006-1072-1.
2. O'Sullivan P. Diagnosis and classification of chronic low back pain disorders: maladaptive movement and motor control impairments as underlying mechanism. Man Ther. 2005;10(4):242-55. doi: 10.1016/j.math.2005.07.001.
3. Waddell G. 1987 Volvo award in clinical sciences: a new clinical model for the treatment of low-back pain. Spine J. 1987;12(7):632-44. doi: 10.1097/00007632-198709000-00002.
4. Global Burden of Disease Study 2013 Collaborators. Global, regional, and national incidence, prevalence, and years lived with disability for 301 acute and chronic diseases and injuries in 188 countries, 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013. Lancet. 2015;386(9995):743-800. doi: 10.1016/S0140-6736(15)60692-4.
5. Norris C, Matthews M. The role of an integrated back stability program in patients with chronic low back pain. Complement Ther Clin Pract. 2008;14(4):255-63. doi: 10.1016/j.ctcp.2008.06.001.
6. Amit K, Manish G, Taruna K. Effect of trunk muscles stabilization exercises and general exercises on pain in recurrent non specific low back ache. Int Res J Med Sci. 2013;1(1):23-6.
7. Coulombe BJ, Games KE, Neil ER, Eberman LE. Core Stability Exercise Versus General Exercise for chronic low back pain. J Athl Train. 2017 Jan;52(1):71-2. doi: 10.4085/1062-6050-51.11.16.
8. Franco YRS, Liebano RE, Moura KF, Oliveira NTB, Miyamoto GC, Santos MO, et al. Efficacy of the addition of interferential current to Pilates method in patients with low back pain: a

protocol of a randomized controlled trial. BMC Musculoskelet Disord. 2014;15:420. doi: 10.1186/1471-2474-15-420.

9. 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. doi: 10.2522/ptj.20090335.
10. Firmino T, Esteves J. Influência da corrente interferencial na dor induzida pelo alongamento dos músculos isquio-tibiais. Rev Port Fisiot Desport [Internet]. 2007[cited 2021 Sep 28];1(1):25-31. Available from: https://bit.ly/3uoa8GO
11. Ward AR, Chuen WLH. Lowering of sensory, motor, and pain-tolerance thresholds with burst duration using kilohertz-frequency alternating current electric stimulation: part II. Arch Phys Med Rehabil. 2009;90(9):1619-27. doi: 10.1016/j.apmr.2009.02.022.
12. Ward AR, Oliver WG, Buccella D. Wrist extensor torque production and discomfort associated with low-frequency and burst-modulated kilohertz-frequency currents. Phys Ther. 2006;86(10):1360-67. doi: 10.2522/ptj.20050300.
13. Adorno MLGR, Brasil-Neto JP. Avaliação da qualidade de vida com o instrumento SF-36 em lombalgia crônica. Acta Ortop Bras. 2013;21(4):202-7. doi: 10.1590/S1413-78522013000400004.
14. Ciconelli RM, Ferraz MB, Santos W, Meinão I, Quaresma MR. Tradução para a língua portuguesa e validação do questionário genérico de avaliação de qualidade de vida SF-36 (Brasil SF-36). Rev Bras Reumatol. 1999;39(3):143-50.
15. Briganó JU, Macedo CSG. Análise da mobilidade lombar e influência da terapia manual e cinesioterapia na lombalgia. Semina Cienc Biol Saude. 2005;26(2):75-82. doi: 10.5433/1679-0367.2005v26n2p75.
16. Vigatto R, Alexandre NMC, Correa Filho HR. Development of a Brazilian Portuguese version of the Oswestry Disability Index: cross-cultural adaptation, reliability, and validity. Spine J. 2007;32(4):481-6. doi: 10.1097/01.brs.0000255075.11496.47.
17. Gorestein C, Andrade LHSG. Inventário de depressão de Beck: propriedades psicométricas da versão em português. Rev Psiquiatr Clin. 1998;25(5):245-50.
18. Beck AT, Steer RA, Carbin MG. Psychometric properties of the Beck Depression Inventory: twenty-five years of evaluation. Clin Psychol Rev. 1988;8(1):77-100. doi: 10.1016/0272-7358(88)90050-5.
19. Facci LM, Nowotny JP, Tormem F, Trevisani VFM. Effects of transcutaneous electrical nerve stimulation (TENS) and interferential currents (IFC) in patients with nonspecific chronic low back pain: randomized clinical trial. Sao Paulo Med J. 2011;129(4):206-16. doi: 10.1590/s1516-31802011000400003.
20. Johnson MI, Ashton CH, Bousfield DR, Thompson JW. Analgesic effects of different frequencies of transcutaneous electrical nerve stimulation on cold-induced pain in normal subjects. Pain. 1989;39(2):231-6. doi: 10.1016/0304-3959(89)90010-9.
21. Danneels LA, Vanderstraeten GG, Cambier DC, Witvrouw EE, Cuyper HJ, Danneels L. CT imaging of trunk muscles in chronic low back pain patients and healthy control subjects. Eur Spine J. 2000;9:266-272. doi: 10.1007/s005860000190.
22. Agharezaee M, Mahnam A. A computational study to evaluate the activation pattern of nerve fibers in response to interferential currents stimulation. Med Biol Eng Comput. 2015;53(8):713-20. doi: 10.1007/s11517-015-1279-6.
23. Jin H-K, Hwang T-Y, Cho S-H. Effect of electrical stimulation on blood flow velocity and vessel size. Open Med. 2017;12(1):5-11. doi: 10.1515/med-2017-0002.
24. Artioli DP, Bertolini GRF. Corrente interferencial vetorial: aplicação, parâmetros e resultados. Rev Bras Clin Med [Internet]. 2012 [cited 20 Sep 28];10(1):51-6. Available from: https://bit.ly/3oi62Pk
25. Agharezaee M, Mahnam A. A computational study to evaluate the activation pattern of nerve fibers in response to interferential currents stimulation. Med Biol Eng Comput. 2015;53(8):713-20. doi: 10.1007/s11517-015-1279-6.
26. 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. doi: 10.1177/0269215516639653.
27. Karvat J, Antunes JS, Bertolini GRF. Corrente interferencial como forma de tratamento em pacientes com dor lombar. Pub UEPG Ci Biol Saude. 2016;22(1):7-13. doi: 10.5212/Publ.Biologicas.v.22i1.0001.
28. Ward AR, Lucas-Toumbourou S. Lowering of sensory, motor, and pain-tolerance thresholds with burst duration using kilohertz-frequency alternating current electric stimulation. Arch Phys Med Rehabil. 2009;88(8):1036-41. doi: 10.1016/j.apmr.2007.04.009.
29. Ward AR, Lucas-Toumbourou S, McCarthy B. A comparison of the analgesic efficacy of medium-frequency alternating current and TENS. Physiotherapy. 2009;95(4):280-8. doi: 10.1016/j.physio.2009.06.005.
30. Silva EPR, Silva VR, Bernardes AS, Matuzawa F, Liebano RE. Segmental and extrasegmental hypoalgesic effects of low-frequency pulsed current and modulated kilohertz-frequency currents in healthy subjects: randomized clinical trial. Physiother Theory Pract. 2021;37(8):916-25. doi: 10.1080/09593985.2019.1650857.
31. Lara-Palomo IC, Aguilar-Ferrándiz ME, Matarán-Peñarrocha GA, Saavedra-Hernández M, Granero-Molina J, Fernández-Sola C, et al. Short-term effects of interferential current electro-massage in adults with chronic non-specific low back pain: a randomized controlled trial. Clin Rehabil. 2013;27(5):439-49. doi: 10.1177/0269215512460780.
32. Koç M, Bayar B, Bayar K. A Comparison of Back Pain Functional Scale with Roland Morris Disability Questionnaire, Oswestry Disability Index, and Short Form 36-Health Survey. Spine J. 2018;43(12):877-82. doi: 10.1097/BRS.0000000000002431.
33. Gonçalves DIP, Souza JA, Santos ML, Ramos NE, Venturini C. Avaliação da mobilidade da coluna lombar e do desempenho funcional de indivíduos com lombalgia. Sinapse Mult. 2016;5(2):100.