International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 17s, 2025
https://www.theaspd.com/ijes.php

Influence Of Adding Interferential Current Stimulation To Conventional Treatment And Abdominal Draw-In Exercises In The Treatment Of Chronic Non-Specific Low Back Pain: A Randomized Controlled Trial

Mohamed H. El Gendy[1], Ghady Y. Mohamed[2], Doaa R. Elazab[1], Mohammed A Abd El-Naeem[3], Yasser Ramzy Lasheen[1]
[1] Department of Physical Therapy for Basic Science, Faculty of Physical Therapy, Cairo University, Cairo, Egypt.
[2] Department of Physical Therapy for Basic Science, Faculty of Physical Therapy, Deraya University, EL Minia, Egypt.
[3] Department of Radio diagnosis, Faculty of Medicine, El Minia University, El Minia, Egypt.

Abstract
Introduction: *Chronic non-specific low back pain is a high-impact disorder. The study aimed to determine the influence of adding interferential current stimulation to conventional treatment and draw-in exercises on abdominal muscle thickness, transverse abdominis endurance, pain, and disability in chronic non-specific low back pain patients.* ***Methods:*** *Sixty patients with chronic non-specific low back pain were diagnosed and referred by an orthopedist recruited in the current study. The patients were divided equally into two groups in a random manner; group (A) was given interferential stimulation, draw-in exercises and conventional treatment (ultrasound, hot pack, knee to chest and strengthening exercises) and group (B) was given draw-in exercises, and conventional treatment. Both groups were assessed by ultrasound imaging, prone test, visual analogue scale, and Oswestry disability index to evaluate transverse abdominis, internal and external oblique thickness, transverse abdominis endurance, pain and disability before and after the intervention.* ***Results:*** *In each group, there was a significant increase in abdominal thickness and transverse abdominis endurance after treatment (p = 0.001). Also, the pain and disability scores of each group significantly declined after treatment (p = 0.001). Comparing the groups revealed a significant difference in all measured outcomes in favor of group A (p=0.001).* ***Conclusions:*** *Adding interferential stimulation to conventional treatment and draw-in exercises would have great value in improving abdominal muscle thickness, transverse abdominis endurance, pain and disability in those suffering from CNSLBP.*

Keywords: *Abdominal Draw-In Exercises, Abdominal Thickness, Interferential Stimulation, Non-Specific Low Back Pain, Ultrasound Imaging.*

INTRODUCTION

Low back pain (LBP) is identified as a serious medical condition as well as the primary reason for work absence in industrialized countries. A family center in Egypt has registered a lifetime prevalence of LBP among Egyptian patients of 48%, which suggests that LBP is a common condition that requires greater attention [1]. Chronic Non-specific low back pain (CNSLBP) is a significant global socioeconomic healthcare issue. The lifetime prevalence of CNSLBP is estimated approximately to be 23%. After headache, it is regarded as the second most prevalent health problem [2, 3].

LBP is associated with physical conditions such as muscular shortening, lumbar spinal stiffness, and a decline in the multifidus as well as deep abdominal muscular strength and endurance [4] so, strengthening of these muscles is related to activating superficial trunk muscles that serve as shock absorbers for loads, and strengthening the global trunk muscles and could reduce the pain and disability level [5].

Interferential Current Stimulation (IFC) can improve deep muscle contraction and blood circulation and achieve uniform stimulation with high reproducibility [6]. Also, in clinical practice, motor control exercises such as abdominal draw-in, an essential exercise for treating LBP patients based on the coactivation of trunk muscles that preserve spine stability [7].

Most studies have shown that IFC is effective in treating painful conditions, such as chronic LBP [3], and may be effective when used in conjunction with other therapy methods [8]. Also, an earlier investigation looked at the effect of combining IFC with lumbopelvic stability exercises in the treatment of discogenic LBP, focusing only on immediate IFC analgesic effects on the pain and disability score, revealed a significant improvement [9]. But, to our knowledge, no multiple research studies have discussed the effects of adding IFC stimulation to therapeutic exercises in chronic LBP patients [10].

Additionally, the only study that discussed the impact of IFC on abdominal thickness focusing only on the left deep abdominal musculature's thickness, states only that compared to various IF stimulation conditions, the amount of change for all abdominal musculature's thickness was significantly higher under IFC 2.5 kHz and 20 Hz condition and recommended for further research [6]. Yet, this effect has not been established in patients with CNSLBP.

In the available literature, there are lack of studies that used IFC stimulatory effect for lateral abdominal muscles (LAM) thickness including transverse abdominis (TrA), external oblique (EO) and internal oblique (IO) in the treatment of those suffering from chronic non-specific low back pain. So, the goal of the study was to determine the influence of adding interferential current stimulation to conventional treatment and draw-in exercises on abdominal muscle thickness, transverse abdominis endurance, pain, and disability in CNSLBP patients.

SUBJECTS AND METHODS

Study design: A randomized controlled clinical trial. The patients were enrolled from Deraya University's outpatient physical therapy clinic, Elmenia governorate. From September 2023 to June 2024, patients were assessed, and their demographic data were recorded, including gender, age, height, and weight, and their body mass index (BMI) was calculated using the already recorded data.

Informed consent: A written informed consent form was signed by each patient after they were informed of the study's contents, purpose, and the benefits and risks associated with it.

Ethical approval: The Ethical Committee of the Faculty of Physical Therapy, Cairo University gave its approval to this study (NO.P.T.REC/012/004618) and was registered on ClinicalTrials.gov with Identifier NO: (NCT06066567).

Subjects: Sixty patients suffering from CNSLBP, were diagnosed and referred to physical therapy outpatient clinic (Deraya University) by an orthopedist. Patients were included if their ages were from 18 to 40 years, BMI from 25 to 29.9 (kg/m2), with 19% or greater disability score as evidenced by the Oswestry Disability Index (ODI). Patients had a history of back surgery, spinal fracture or deformities, neurological radiating pain with lumbar disc bulge, unable to do abdominal muscle contraction, symptoms of cauda equina, individuals with BMI> 30, uncontrolled diabetic patients, cancer patients, those with a peacemaker, and females during pregnancy were not included. Patients received instructions not to participate in any other physical therapy intervention throughout the period of the trial. Fig. (1) shows the CONSORT flow chart of the study.

SAMPLE SIZE CALCULATION:

The sample size was determined prior to the study was started. Using an allocation ratio N2/N1 = 1, $\alpha = 0.05$, $\beta = 0.2$, and an effect size of 0.8, G*POWER statistical software (version 3.1.9.2; Franz Faul, Universitat Kiel, Germany,) showed that the required sample size for this study was 26 patients with CNSLBP per group, However, the sample size was determined to be 60 after taking the dropouts into account.

Randomization:

Sixty patients with CNSLBP were randomly assigned to two groups (A and B), maintaining a balanced 1:1 ratio. Groups were assigned at random through a computerized random number generator using the Research Randomizer Program online (https://www.randomizer.org/).

Outcome measures:

At baseline, all measurable outcomes were assessed, and after four weeks later.

International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 17s, 2025
https://www.theaspd.com/ijes.php

-Abdominal muscular thickness was measured by a real-time B-mode Ultrasonography Imaging (UI) **(Mindray DP-10, convex probe 5 MHz, SN: bn-75013216, China).** It is a noninvasive method that does not expose patients to ionizing radiation, a valid and reliable imaging tool **[11].** UI reliability for measuring LAM thickness on both sides in chronic LBP patients exhibited good to high interrater reliability (ICC= 0.80–0.98) (ICC= 0.81–0.97). Also, the study results stated that the reliability values of UI are better at rest than under contraction **[12].**

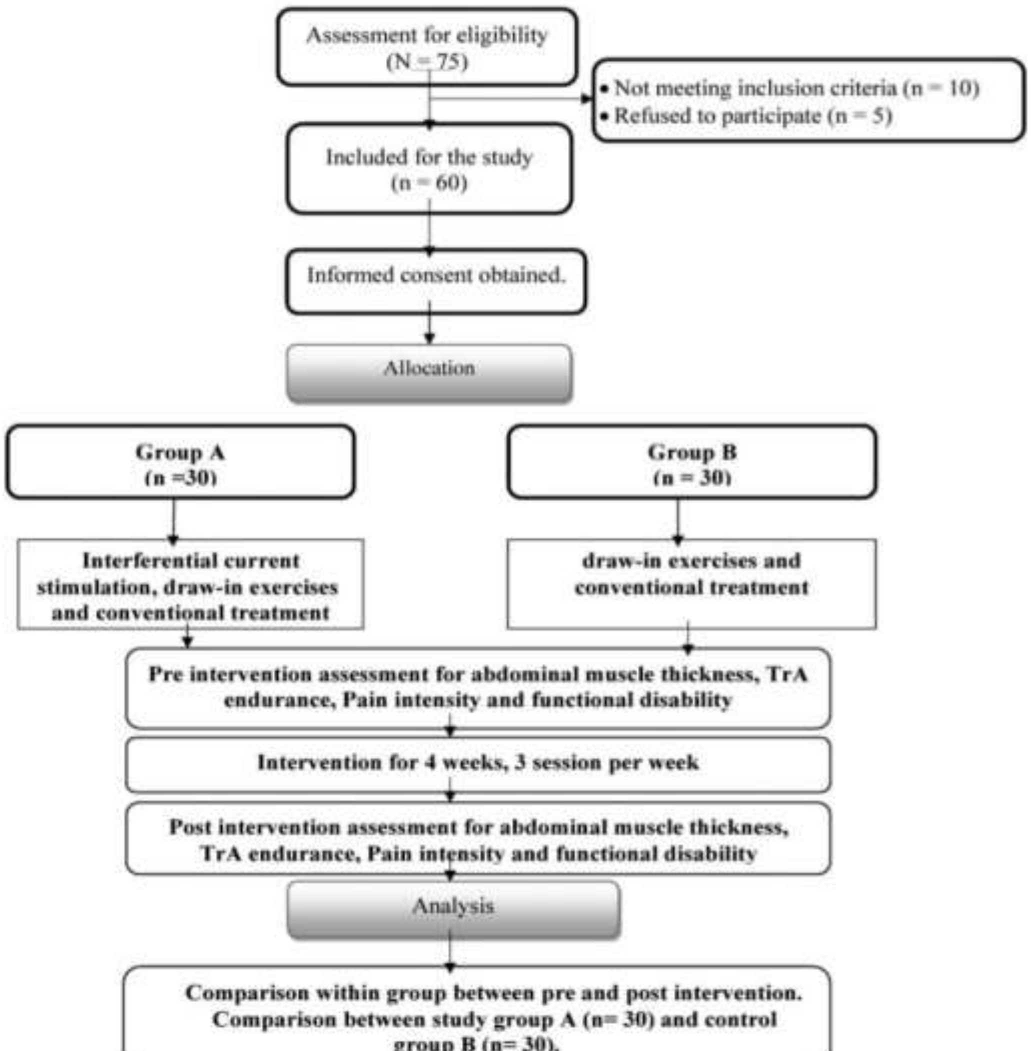
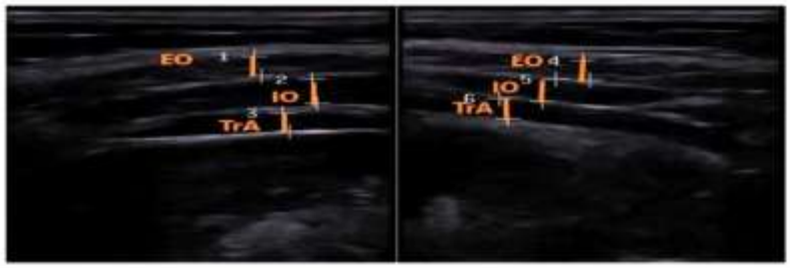


Fig (1) Flow chart showing the experimental design of the study.

Ultrasonography imaging measurement of abdominal thickness at rest performed from supine to crook-lying position with cushions beneath their knees and head. Both the lower border of the rib cage and the iliac crest were represented as bony landmarks during the measurement. Conducting gel was placed between the probe of the UI and the abdomen to increase the contact area **[13].**

The probe of the UI was situated on the abdominal wall transversely on the anterior axillary line, halfway between the lower border of the rib cage and iliac crest, and every image was taken at the end of the expiration to get a clear image of the abdominal musculature including (TrA, IO, EO). At rest, 3 images of each muscle were captured, and the mean of the 3 measures was utilized in the statistical analysis. The images of abdominal muscles were shown in Fig. (2) &Fig. (3). Measurements of UI were recorded both before and after the treatment **[14].**



A **B**

Fig (2) Pre-treatment ultrasound imaging for right lateral abdominal wall muscles (A) and for left lateral abdominal wall muscles(B).

C **D**

Fig (3) post-treatment ultrasound imaging for right lateral abdominal wall muscles (C) and for left lateral abdominal wall muscles(D).

-Transverse abdominis endurance was measured by a prone test guided by a Pressure Biofeedback Unit (PBU). Prone endurance test was performed from a prone position. The PBU cuff was placed horizontally beneath the abdomen with the umbilicus in the middle of the unit. The lower border of the cuff is positioned below the anterior superior iliac spines (ASIS). The therapist initiated the use of the PBU by inflating the pressure to 70 mmHg then the patients were instructed to pull the lower abdomen in, and keep relaxed breathing, without any movement in the spine or the pelvis until the pressure declined by 6 to 10 mmHg and hold the abdominal contraction (draw-in) for ten seconds. Every contraction (10sec hold) was separated by a 20 sec rest. TrA muscle endurance (holding capacity) was measured by counting how many times the patient could hold the draw-in for ten seconds with the pressure declined by 6 to 10 mmHg (up to 10 times) **[15].**

The stabilizer pressure biofeedback device was manufactured by the **Chattanooga Stabilizer Group Inc. (Hixson, TN37343, USA)**. It consists of 3 chambers cuff, a catheter, and a manometer. The cuff is made of non-elastic material, its size is 6.7–24 cm, and the manometer's scale starts from zero to 200 mmHg with 2 mmHg measuring intervals as shown in Fig (4). The pressure readings displayed on the manometer vary depending on different movements and positions on the cuff **[7].** The inter-rater and intra-rater reliability were assessed, and the results showed good to excellent intra-class correlation coefficients of 0.89 and 0.87 for them, respectively. It is utilized for assessment of the abdominal muscles, as well as giving feedback to subjects who are participating in motor control exercises. The same stabilizer was utilized, and the device was calibrated to prevent bias throughout the study. Also, 0.5 mmHg was the accepted difference before using it **[16, 17].**

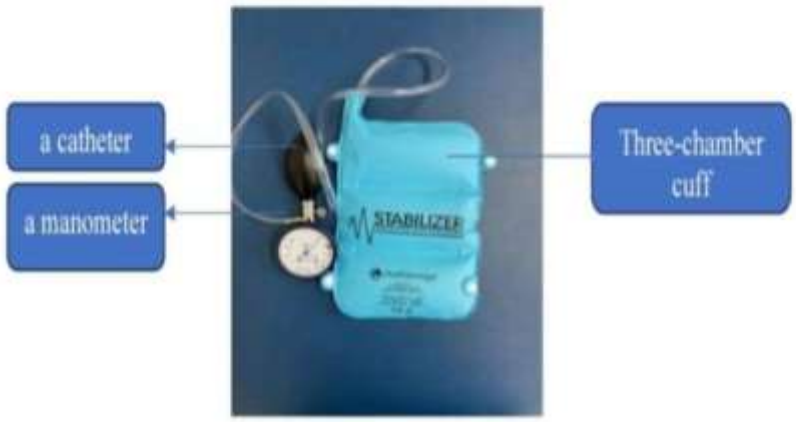


Fig (4) Pressure biofeedback unit.

-Pain intensity was measured through a Visual Analog Scale (VAS). It is a valid, reliable method and has very high test-retest reliability for pain assessment and reassessment in rehabilitation **[18].** The patients were instructed to mark perpendicularly on the scale 100 millimeters(mm) long to express their degree of pain as none, mild, moderate, or severe **[3].**

- Functional disability level was evaluated through the Arabic version of the ODI with strong test-retest reliability, and Cronbach's alpha was 0.87 **[19].** Patients were asked about how back pain affects managing their everyday life. The ODI total score is determined by the summation of all scores of applied items, dividing the obtained score by the maximum possible score (50), and multiplying the result by 100 to obtain a percentage score. It used to categorize individuals as either slightly impaired (0–20%), moderately impaired (20–40%), extremely disabled (40–60%), crippled (60–80%), or bedridden (80–100%) **[20]**

Intervention: Two groups of patients were randomly and equally selected; group (A) was given IFC stimulation, and draw-in exercises from prone lying, three times a week, four weeks in total, guided by PBU to obtain visual biofeedback on pressure changes during the exercises, and conventional treatment (ultrasound, hot pack, knee to chest and strengthening exercises). Also, group (B) was given draw-in exercises from a prone position, and conventional treatment.

Interferential Current Stimulation: IFC stimulation pulses are generated using an electric therapy device (ES-5200, ITO PHYSIOTHERAPY & REHABILITATION-SN/201711500024). Both sides of abdominal muscles including TrA, EO, and IO muscles were stimulated by IFC. IFC electrical stimulation for abdominal muscles is delivered from a supine position **[5]** through the quadripolar technique, adhesive electrodes are placed on either side of the midline covering the muscles. These are applied to the cleaned skin**.** Parameters of IFC applied as follows: carrier frequency 2 kHz, beat frequency 30Hz, auto sweep five seconds, treatment duration15 minutes, the current with dynamic vector field **[21],** applied three days a week for four weeks **[22]** and the current amplitude gradually increased until a light rhythmic contraction was seen in abdominal muscles **[21].**

Abdominal Draw-In Exercise: It is an exercise method applied by pulling the abdomen inward as the oblique abdominal and TrA contracts increase the abdominal pressure **[23].** It is applied from a prone position. A PBU was placed under the pubis symphysis with the lowering edge in line with the ASIS and set at 70 mmHg. The patients were taught how to carefully pull the lower abdominal wall in and hold for ten seconds while keeping the pelvis and the spine in a neutral position. Additionally, the upper abdominal wall movement was limited so that the pressure declined by nearly ten mmHg **[24]** and applied in the form of 10 reps,10 sets, 3/a week, four weeks in total, guided by PBU **[23].** The patients rested for 5 s between contractions and one minute between the practice sets **[24]**

Therapeutic Ultrasound: (US-751, ITO PHYSIOTHERAPY & REHABILITATION, TOKYO 176-0014, JAPAN). It was applied to the lumbar area at an amplitude of 1.5 Watts/cm^2, frequency of 1 MHz, and continuous mode with a 100% duty cycle for five minutes **[25,21].**

Electric Hot Pack: (ORTHOPEDIC HEAT BELT, HC-1002, INDIA). From a prone position. First, place the hot pack over the back region, then cover the pack with a folded towel to prevent heat loss. Hot packs were applied for 20min, and their intensity was based on individual tolerance **[21]**

Knee to Chest Exercise: For improving flexibility of the lumbar extensor **[26],** it was applied in the form of 3 sets, each consisting of a thirty-second hold and thirty-second rest, performed in three sessions a week for four weeks, and repeated three times **[27]**

Strengthening Exercise (STE) Program: It was modified from that discussed by **Koumantakis et al**. **[28],** with the period of the program being shortened to four weeks for activating the trunk extensors and flexors, respectively. It advanced from lying to the quadruped position, which increased the muscular load**,** three sessions per week. Patients maintained each exercise for ten seconds and repeated it ten times, which represented 1 set, followed by a five-minute rest in between sets. All patients received the exercise instructions at the end of the first session **[5].**

Week (1): Specific abdominal and back exercises in a lying position

Exercises for the upper abdominals were performed from a crook lying position (knees bent), patients were instructed to perform a partial sit-up (flex the trunk partially) with the hands extended towards the knee until clearance of the inferior angle of the scapula from the plinth. Exercises for the back extensors were performed by active back extension as patients were instructed to raise their trunk to neutral from lying prone, with a pillow beneath their stomach and their arms by their sides. The exercise was maintained for ten seconds with ten repetitions **[5].**

Week (2): Abdominal and back exercise with limb movement in lying position

Exercises for the lower abdomen were performed from a lying position as the patients were instructed to pull the lower abdomen in, then slowly slide their heel and sustain the draw-in for ten seconds, then relax. Exercises for the back extensors were performed from a supine position with flexed knees as the patients were instructed to raise the pelvis up and sustain the raised pelvis for ten seconds; then the patients lowered the pelvis **[5].**

Week (3): Abdominal exercise in a side-lying position and back exercise in a 4-point kneeling position.

Exercises for the oblique abdominis were performed from a side-lying position as the patients were instructed to lift their hips up and keep the raised hip posture for ten seconds and then return to neutral. Exercises for back extensors were performed from a four-point kneeling position as patients were instructed to do single-leg extensions **[5].**

Week (4): Abdominal exercise in a supine lying position and back exercise in 4-point kneeling position.

Exercises for the abdominals were performed from a supine position as the patients were instructed to do full abdominal crunches keep this posture for ten seconds. Back extensors were exercised from a four-point kneeling position as the patients were instructed to perform alternate arm and leg lifting and keep this posture for ten seconds **[5].**

Statistical Analysis

The analyses were conducted using the statistical package for the social studies (SPSS) version 25 on Windows (IBM SPSS, Chicago, IL, USA). The unpaired t-test was used to compare the subject characteristics between groups. The chi-square test was utilized to compare sex distribution. Shapiro-Wilk test was utilized to verify that the data was distributed normally. The homogeneity between groups was checked using Levene's test. The treatment effects on abdominal muscle thickness, transverse abdominis endurance, VAS, and ODI were compared within and across groups using mixed MANOVA. Bonferroni corrections were performed for subsequent multiple comparisons. For all statistical analyses, the significance level was fixed at $p < 0.05$.

RESULTS:

Table (1) demonstrated subjects' characteristics of each group regarding age, weight, height, BMI, and distribution of sexes, there was no significant difference between groups ($p > 0.05$).

Table (2) demonstrated that there was a significant interaction effect of treatment and time ($p = 0.001$), a significant main effect of time ($p = 0.001$) and a significant main effect of treatment ($p = 0.001$). Also, Mixed MANOVA revealed a significant treatment X time interaction ($F = 38.78$, $p = 0.001$, $\eta 2 = 0.87$), a significant main effect of time ($F = 457.27$, $p = 0.001$, $\eta 2 = 0.98$) and a significant main effect of treatment ($F = 4.11$, $p = 0.001$, $\eta 2 = 0.42$).

Table 1. Comparison of subject characteristics between group A and B:

	Group A	Group B			
	Mean ±SD	**Mean ±SD**	**MD**	**t- value**	**p-value**
Age (years)	22.07 ± 3.07	23.17 ± 2.86	-1.1	-1.43	0.15
Weight (kg)	67.63 ± 9.79	65.90 ± 9.95	1.73	0.68	0.49
Height (cm)	162.23 ± 8.33	160.83 ± 6.43	1.4	0.72	0.46
BMI (kg/m²)	25.63 ± 2.84	25.38 ± 2.90	0.25	0.33	0.73
Sex, n (%)					
Female	21 (70%)	19 (63%)		($\chi^2 = 0.30$)	0.58
Male	9 (30%)	11 (37%)			

SD, Standard deviation; MD, mean difference; χ^2, Chi squared value. p value, Probability value.

Table (2). Mixed MANOVA for the effect of treatment on abdominal muscle thickness, transverse abdominis endurance, pain intensity and functional disability:

	Mixed MANOVA					
	Wilks' Lambda	F-value	Hypothesis df	Error df	p-value	Partial Eta Squared
Interaction effect (treatment * time)	0.125	38.78	9	50	0.001	0.87
Effect of time	0.012	457.27	9	50	0.001	0.98
Effect of treatment (group effect)	0.575	4.11	9	50	0.001	0.42

F value: Mixed MANOVA F value; df: degree of freedom; p value: Probability value

WITHIN GROUP COMPARISON

Both right and left TrA, IO, and EO thickness of each group significantly increased after treatment compared with before ($p < 0.01$). (Table 3). The percentage of change in right and left TrA thickness in group A posttreatment was (60.71%), (71.42%) and in group B was (22.22%) (16%) respectively, IO thickness in group A posttreatment was (33.33%) (34.54%) and in group B was (13.72%) (10.20 %) and EO thickness in group A posttreatment was (28.26%), (33.33%), in group B was (6.97%), (7.14%.) respectively.

Additionally, TrA endurance of both groups significantly increased after treatment as compared to before ($p < 0.001$) as well as VAS and ODI scores of each group significantly declined after treatment as compared to before in each group A and B ($p = 0.001$). (Table 4). Also, the percent of change in TrA endurance in groups A and B post-treatment was (125.69%) (81.16%), VAS was (73.27%) (65.51%.) and ODI was (54.04%) (45.54%) respectively.

BETWEEN-GROUP COMPARISON

Each side of the TrA, EO and IO thickness of group A had a significant increase in comparison to that of group B after treatment (p < 0.01) (Table 3), and transverse abdominis endurance of group A had a significant increase in comparison to that of group B after treatment (p < 0.01) (Table 4). Also, the VAS and ODI scores of group A had a significant decline in comparison to that of group B after treatment. (Table 4).

Table 3. Mean abdominal muscles thickness pre and post treatment of groups A and B:

Thickness (cm)	Group A	Group B				
	Mean ±SD	Mean ±SD	MD	95% CI	p value	EF
Right transverse abdominis						
Pre treatment	0.28 ± 0.11	0.27 ± 0.09	0.01	-0.04: 0.07	0.65	
Post treatment	0.45 ± 0.12	0.33 ± 0.09	0.12	0.07: 0.18	0.001	1.13
MD	-0.17	-0.06				
95% CI	-0.19: -0.15	-0.07: -0.03				
	p = 0.001	***p = 0.001***				
Left transverse abdominis						
Pre treatment	0.28 ± 0.10	0.25 ± 0.10	0.03	-0.03: 0.08	0.36	
Post treatment	0.48 ± 0.12	0.29 ± 0.09	0.19	0.13: 0.24	0.001	1.79
MD	-0.2	-0.04				
95% CI	-0.23: -0.18	-0.06: -0.02				
	p = 0.001	***p = 0.002***				
Right internal oblique						
Pre treatment	0.57 ± 0.23	0.51 ± 0.16	0.06	-0.04: 0.17	0.22	
Post treatment	0.76 ± 0.20	0.58 ± 0.16	0.18	0.09: 0.27	0.001	0.99
MD	-0.19	-0.07				
95% CI	-0.22: -0.15	-0.10: -0.04				
	p = 0.001	***p = 0.001***				
Left internal oblique						
Pre treatment	0.55 ± 0.22	0.49 ± 0.18	0.06	-0.04: 0.17	0.30	
Post treatment	0.74 ± 0.21	0.54 ± 0.18	0.2	0.10: 0.31	0.001	1.02
MD	-0.19	-0.05				
95% CI	-0.22: -0.17	-0.08: -0.03				
	p = 0.001	***p = 0.001***				
Right external oblique						
Pre treatment	0.46 ± 0.15	0.43 ± 0.13	0.03	-0.05: 0.11	0.41	
Post treatment	0.59 ± 0.15	0.46 ± 0.13	0.13	0.05: 0.20	0.002	0.93
MD	-0.13	-0.03				
95% CI	-0.14: -0.11	-0.05: -0.01				
	p = 0.001	***p = 0.002***				
Left external oblique						
Pre treatment	0.45 ± 0.16	0.42 ± 0.11	0.03	-0.04: 0.11	0.32	

Post treatment	0.60 ± 0.15	0.45 ± 0.12	0.15	0.07: 0.21	0.001	1.1
MD	-0.15	-0.03				
95% CI	-0.16: -0.12	-0.06: -0.02				
	p = 0.001	***p = 0.001***				

SD, Standard deviation; MD, Mean difference; CI, Confidence interval; p value, Probability value; within group A p<0.001, within group B p<0.01; EF, Effect size.

Table 4. Mean transverse abdominis endurance, VAS and ODI pre and post treatment of groups A and B:

	Group A	**Group B**				
	Mean ±SD	**Mean ±SD**	**MD**	**95% CI**	**p value**	**EF**
Transverse abdominis endurance						
Pre treatment	3.93 ± 1.04	3.77 ± 1.07	0.16	-0.38: 0.71	0.54	
Post treatment	8.87 ± 0.93	6.83 ± 1.17	2.04	1.48: 2.58	0.001	1.93
MD	-4.94	-3.06				
95% CI	-5.29: -4.58	-3.42: -2.71				
	p = 0.001	***p = 0.001***				
VAS						
Pre treatment	71.83 ± 7.77	71.63 ± 9.39	0.2	-4.26: 4.66	0.93	
Post treatment	19.20 ± 9.29	24.70 ± 6.74	-5.5	-9.70: -1.30	0.01	0.68
MD	52.63	46.93				
95% CI	49.06: 56.21	43.36: 50.51				
	p = 0.001	***p = 0.001***				
ODI (%)						
Pre treatment	23.61 ± 3.05	23.80 ± 3.55	-0.19	-1.90: 1.53	0.82	
Post treatment	10.85 ± 2.41	12.96 ± 1.99	-2.11	-3.25: -0.97	0.001	0.95
MD	12.76	10.84				
95% CI	11.76: 13.76	9.84: 11.84				
	p = 0.001	***p = 0.001***				

SD, Standard deviation; MD, Mean difference; CI, Confidence interval; p value, Probability value; within group A p<0.001, within group B p<0.001; EF, Effect size

DISCUSSION:

The current study aimed to determine the influence of adding interferential current stimulation to conventional treatment and draw-in exercises on abdominal muscle thickness, transverse abdominis endurance, pain, and disability in CNSLBP patients. The current study results found significant improvement in abdominal muscle thickness, transverse abdominis endurance, pain, and disability post-treatment in each group ($p<0.05$). After treatment, a significant difference between groups A and B has been found in abdominal muscle thickness, transverse abdominis endurance, pain, and disability in favor of group A ($p<0.05$). The findings of the current study regarding abdominal thickness could have many explanations. Firstly, IFC has the ability to selectively activate the deeper abdominal muscles, as IFC has 2 medium-frequency current crosses over and produces the low-frequency effect that is believed to be less stressful and has low skin resistance to penetrate deeper tissue. This allows for more targeted stimulation of the TrA muscle compared with superficial muscles [6, 29]. Secondly, draw-in exercises from a prone position guided by the use of a biofeedback device may have a role in the improvement of the TrA thickness, as the prone posture can stimulate the stretching receptor by producing deep abdominal muscular stretching that can raise the TrA muscle's motor neurons' excitation [24,30]. Also, Park., et al., stated that draw-in exercise from the prone lying showed more improvement in the thickness of abdominal muscles compared to that in the crook and supine lying positions, which induces the contraction of TrA muscle [30].

Endo et al., 2022[6] agree with the findings of the current study as reported a significant improvement in abdominal muscle thickness, including TrA, EO, and IO, under different IFC stimulation conditions in favor of the under 2.5 kHz and 20 Hz condition versus resting muscle thickness. Additionally, Yoo et al., 2023 [31] showed that when adding electrical muscle stimulation to strengthening exercises, the contracted TrA, EO and IO muscular thickness was greater compared to that received strengthening exercises alone in healthy individuals; however, their thickness at rest didn't significantly differ.

Regarding the effect of draw-in exercises on abdominal muscular thickness, many studies [32,23] discussed the impact of draw-in exercises on muscular thickness as Park and Yu, [23] reported that draw-in exercise alone significantly increases the TrA and EO's muscular thickness in chronic LBP patients, while IO thickness showed significant improvement following 4 weeks of core exercises. While, Kim et al., 2017 showed that the draw-in can be motivated by the combination of it with other stimulating factors [32].

In contrast to this study's findings, Atli et al., 2020 [33] revealed that adding neuromuscular stimulation to core exercises did not significantly alter the abdominal and lumbar muscular thickness in either group which owing to the variations in current parameters and patients' tolerance. Also, Batistella et al., 2020 [34] stated that no large increase in multifidus thickness and increased resistance of trunk muscle in CLBP females after 4 weeks of Russian current stimulation in comparison to the control group, and there was an equal difference between groups which is logically to be in contrast to the current study results owing to the difference in muscle structure, depth and nature of function, but the treated group's effect sizes were more than those of the controls.

A possible explanation of the present study results regarding transverse abdominis endurance improvement after adding IFC stimulation to conventional treatment and draw-in exercises perhaps due to enhancements in motor control and adding stimulatory effects of IFC, that produce amplitude-modulated currents with low frequency deeply in the treated region to stimulate muscles and other tissues, including ligaments as well as nerves [10].

Zuo et al. 2024[10] reported that for enhancing functional parameters of core muscle, specifically strength and endurance, the adding of IFC stimulation to targeted core exercise was superior to IFC alone and had benefits for enhancing TrA endurance. Also, Hwang et al., 2020[35] stated a significant increase in endurance of the abdominal muscles as trunk flexion (29.1%), side bridge (24.6–28.9%) after neuromuscular electrical stimulation training. Additionally, Bueno et al., 2017[36] stated that Russian current stimulation was successful in maintaining multifidus muscular thickness in CLBP females resulting in improved endurance of the spinal extensor muscle.

A possible rationale for the present study findings regarding pain intensity and functional disability improvement posttreatment in both groups compared with pretreatment in favor of the IFC group when comparing between groups is attributed to its analgesic effect rather than its effect on muscle contraction or change in muscle thickness [8]. Also, other authors attributed the pain reduction to its ability to activate TrA, as well as the improvement of circulation [8]. These were among the theories [37]. The significant decline in pain and significant increase of abdominal thickness posttreatment in both groups may be a direct rationale for increasing stability of the lumbar spine and functional disability improvement.

Many studies agree with the current study results regarding pain intensity as Batistella et al., 2020 [34] stated a significant decrease in pain intensity with a large effect size in females with CLBP after receiving Russian current stimulation as same as IF medium frequency stimulation indicating a higher tolerance to pressure. Also, Döhnert, 2016[9] stated that the level of pain and disability significantly reduced in each group in discogenic LBP patients after combining IFC with lumbar stabilizing exercises may be due to the activation of the core muscles, decreasing the compression on the innervated structures during movements of the lumbar spine and increased strength of the trunk muscles, however, the study results showed that the stabilizing exercises more be effective both alone and in combination with IFC.

Along with the current study's findings da Luz et al., 2019 [38] stated that pain severity and disability significantly reduced after receiving neuromuscular stimulation with core exercises compared to the neuromuscular stimulation alone. Also, Jain et al., 2024[39] discuss the effect of abdominal draw-in exercises on pain intensity in subjects with LBP and demonstrate that the level of pain has decreased and differed significantly between before and after intervention.

The present study results were confirmed by the results of Atli et al., 2020 [33] that stated pain severity level and disability scores of the initial measurement significantly differ compared to the scores of the fourth and eighth weeks after adding neuromuscular stimulation to core exercises. These changes show a significant improvement in the patient's ability to manage daily activities suggesting the effectiveness of the combined intervention.

Also results of Park and Yu, 2013 [23] are in line with the current study results regarding the draw-in exercises, which stated when comparing the core training and draw-in technique, the disability level significantly decreased due to the effectiveness of abdominal drawing-in in the improvement of EO/Tra muscle thickness while training the core muscles is more successful in improving IO muscular thickness.

LIMITATIONS

The potential limitation of this study is: that the efficacy of intervention was assessed for thickness of abdomen musculature only, so researchers are required to include other trunk muscles. Additionally, it is recommended that longitudinal research be applied to explore the long-term impact of combined IFC stimulation with drawing-in exercises on the thickness of abdomen musculature, transverse abdominis endurance, intensity of pain, and disability scores.

CONCLUSION

Adding interferential stimulation to conventional treatment and draw-in exercises would have a great value in improving abdominal muscle thickness, transverse abdominis endurance, pain, and disability in those suffering from CNSLBP. Therefore, the combination of IFC stimulation and therapeutic exercises may be of great effect in the treatment of patients with CNSLBP.

Acknowledgments: The authors would give thanks to every patient who participated in the study.
Conflict of interest: No conflicts of interest were disclosed by the authors.
Funding: the authors did not receive any support for their research, authorship, or publication.

REFERENCES:

[1] Elshiwi AM, Mohammed AM. Influence of Electromagnetic Field Therapy Versus Acupuncture Dry Needle in Treatment of Nonspecific Low Back Pain Patients: Randomized Clinical Trial. Journal of Positive School Psychology. 2022 Dec 23;6(11):3014-31.

[2] Pourahmadi MR, Bagheri R, Jannati E, Takamjani IE, Sarrafzadeh J, Mohsenifar H. Effect of elastic therapeutic taping on abdominal muscle endurance in patients with chronic nonspecific low back pain: a randomized, controlled, single-blind, crossover trial. Journal of manipulative and physiological therapeutics. 2018 Sep 1;41(7):609-20.

[3] Tantawy SA, Kamel DM, Abdelbasset WK, Nambi G. A randomized controlled trial investigating the impact of interferential therapy on pain, range of motion and quality of life in patients with chronic non-specific low back pain. Arch Balk Med Union.2020 Mar;55(1):47-54.

[4] Sánchez Romero EA, Alonso Pérez JL, Muñoz Fernández AC, Battaglino A, Castaldo M, Cleland JA, Villafañe JH. Reliability of sonography measures of the lumbar multifidus and transversus abdominis during static and dynamic activities in subjects with non-specific chronic low back pain. Diagnostics. 2021 Apr 1;11(4):632.

[5] Hlaing SS, Puntumetakul R, Khine EE, Boucaut R. Effects of core stabilization exercise and strengthening exercise on proprioception, balance, muscle thickness and pain related outcomes in patients with subacute nonspecific low back pain: a randomized controlled trial. BMC musculoskeletal disorders. 2021 Dec; 22:1-3.
[6] Endo A, Yakabi A, Kubo A. Effect of interferential current on deep abdominal muscle thickness. Journal of Physical Therapy Science. 2022;34(4):306-10.
[7] Polat M, Demirsoy N, Tokgöz N. Association between abdominal muscle activity and lumbar muscle morphology, and their role in the functional assessment of patients with low back pain: A cross-sectional study. Journal of Musculoskeletal & Neuronal Interactions. 2022;22(3):37-384.
[8] Hussein HM, Alshammari R, Al-Barak S, Alshammari N, Alajlan S. Efficacy of interferential current on relieving pain of musculoskeletal origin-protocol of a systematic review and meta-analysis undertaken. Journal of Pre-Clinical and Clinical Research. 2020;14(3):69-72 (Doi:101097/PHM.0000000000001870).
[9] Döhnert MB. Interferential current combined with lumbopelvic stabilization exercises in patients with degenerative disc disease with symptoms of chronic low back pain. EC Orthopaedics. 2016;3:335-44.
[10] Zuo C, Zheng Z, Ma X, Wei F, Wang Y, Yin Y, Liu S, Cui X, Ye C. Efficacy of Core Muscle Exercise Combined with Interferential Therapy in Alleviating Chronic Low Back Pain in High-Performance Fighter Pilots: A Randomized Controlled Trial. BMC Public Health. 2024 Mar 5;24(1):700.
[11] Rahmani N, Mohseni‐Bandpei MA, Salavati M, Vameghi R, Abdollahi I. Comparative study of abdominal muscle thickness on ultrasonography in healthy adolescents and patients with low back pain. Journal of Ultrasound in Medicine. 2018 Apr;37(4):905-12.
[12] Abbasi S, Rasanani MR, Olyaei GR, Ghotbi N, Rasouli O. Reliability of ultrasound measurement of the lateral abdominal and lumbar multifidus muscles in individuals with chronic low back pain: A cross-sectional test-retest study. Journal of Bodywork and Movement Therapies. 2021 Apr 1; 26:394-400.
[13] Mannion AF, Pulkovski N, Gubler D, Gorelick M, O'Riordan D, Loupas T, Schenk P, Gerber H, Sprott H. Muscle thickness changes during abdominal hollowing: an assessment of between-day measurement error in controls and patients with chronic low back pain. European Spine Journal. 2008 Apr; 17:494-501.
[14] Tahan N, Khademi-Kalantari K, Mohseni-Bandpei MA, Mikaili S, Baghban AA, Jaberzadeh S. Measurement of superficial and deep abdominal muscle thickness: an ultrasonography study. Journal of physiological anthropology. 2016 Dec; 35:1-5.
[15] Jobalia AH, John S. Correlation between transversus abdominis muscle endurance and limits of stability in asymptomatic healthy young women. International Journal of Physiotherapy. 2018 Jun 1;5(3):123-31.
[16] Park DJ, Lee SK. What is a suitable pressure for the abdominal drawing-in maneuver in the supine position using a pressure biofeedback unit?. Journal of physical therapy science. 2013 May 25;25(5):527-30
[17] Rathod SR, Vyas NJ, Sorani DM. Relationship between double leg lowering test and core strength test of the lumbar spine in normal healthy individuals. Journal of Mahatma Gandhi Institute of Medical Sciences. 2021 Jan 1;26(1):23-7.
[18] Begum MR, Hossain MA. Validity and reliability of visual analogue scale (VAS) for pain measurement. Journal of Medical Case Reports and Reviews. 2019;2(11).
[19] Algarni AS, Ghorbel S, Jones JG, Guermazi M. Validation of an Arabic version of the Oswestry index in Saudi Arabia. Annals of physical and rehabilitation medicine. 2014 Dec 1;57(9-10):653-63.
[20] Lara-Palomo IC, Aguilar-Ferrándiz ME, Matarán-Peñarrocha GA, Saavedra-Hernández M, Granero-Molina J, Fernández-Sola C, Castro-Sánchez AM. Short-term effects of interferential current electro-massage in adults with chronic non-specific low back pain: a randomized controlled trial. Clinical rehabilitation. 2013 May;27(5):439-49.
[21] Mitra PK. Handbook of practical electrotherapy (First Edition). Jaypee Brothers Medical Publishers (P) Ltd; 2006;8: p.74.
[22] 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. European journal of pain. 2016 Nov;20(10):1653-66.
[23] Park SD, Yu SH. The effects of abdominal draw-in maneuver and core exercise on abdominal muscle thickness and Oswestry disability index in subjects with chronic low back pain. Journal of exercise rehabilitation. 2013 Apr;9(2):286-291.
[24] Lee HJ, Kim SY. Comparison of the effects of abdominal draw-in and expansion maneuvers on trunk stabilization in patients with low back pain and lumbar spine instability. Physical Therapy Korea. 2015;22(1):37-48.
[25] Çolak TK, Sert N, Sert B, Apti A. The effect of interferential currents and tens on pain and functionality in patients with chronic mechanical low back pain. J Turk Spinal Surg.2024; Jan;35(1):24-30.

[26] Ghorbanpour A, Azghani MR, Taghipour M, Salahzadeh Z, Ghaderi F, Oskouei AE. Effects of McGill stabilization exercises and conventional physiotherapy on pain, functional disability and active back range of motion in patients with chronic non-specific low back pain. Journal of physical therapy science. 2018;30(4):481-5.
[27] Kachanathu SJ, Alenazi AM, Seif HE, Hafez AR, Alroumim AM. Comparison between Kinesio taping and a traditional physical therapy program in treatment of nonspecific low back pain. Journal of physical therapy science. 2014;26(8):1185-8.
[28] Koumantakis GA, Watson PJ, Oldham JA. Trunk muscle stabilization training plus general exercise versus general exercise only: randomized controlled trial of patients with recurrent low back pain. Physical therapy. 2005 Mar 1;85(3):209-25.
[29] Raja MP. A Comparative Study on Abdominal Strengthening Exercise with Interferential Therapy Versus Back Strengthening Exercise with Interferential Therapy in Acute Low Back Pain. IOSR Journal of Dental and Medical Sciences (IOSR-JDMS), 19(4), 2020, pp. 01-05.
[30] Park C, Cha Y, Kim K, Park I, Oh W, Kang S, Lee C, Yoon S. Differential effects of the abdominal draw-in maneuver in different positions on muscle thickness and balance ratio in non-symptomatic adults. Journal of Mechanics in Medicine and Biology. 2022 Apr 25;22(03):2240005.
[31] Yoo HJ, Park S, Oh S, Kang M, Seo Y, Kim BG, Lee SH. Effects of electrical muscle stimulation on core muscle activation and physical performance in non-athletic adults: A randomized controlled trial. Medicine. 2023 Jan 27;102(4): e32765.
[32] Kim JS, Seok CH, Jeon HS. Abdominal draw-in maneuver combined with simulated weight bearing increases transversus abdominis and internal oblique thickness. Physiotherapy Theory and Practice. 2017 Dec 2;33(12):954-8.
[33] Atli E, Coşkunsu DK, Taskıran OO, Turan Z. Does neuromuscular electrical stimulation have an effect on disabiliy, pain, abdominal and lumbar muscle thickness in chronic low back pain?. Gait & Posture. 2020 Sep 1; 81:13-4.
[34] Batistella CE, Bidin F, Giacomelli I, Nunez MA, Gasoto E, de Albuquerque CE, Flores LJ, Bertolini GR. Effects of the Russian current in the treatment of low back pain in women: a randomized clinical trial. Journal of bodywork and movement therapies. 2020 Apr 1;24(2):118-22.
[35] Hwang UJ, Kwon OY, Jung SH, Kim HA, Gwak GT. Effect of neuromuscular electrical stimulation training for abdominal muscles on change of muscle size, strength, endurance and lumbopelvic stability. The Journal of Sports Medicine and Physical Fitness. 2020 Feb 1;60(2):206-13.
[36] Bueno CR, Pereira M, Favaretto IA, Bortoluci CH, Santos TC, Dias DV, Daré LR, Rosa GM. Electrical stimulation attenuates morphological alterations and prevents atrophy of the denervated cranial tibial muscle. Einstein (Sao Paulo). 2017 Jan; 15:71-6.
[37] Dadalto TV, Souza CP, Silva EB. Neuromuscular electrical stimulation, exercises against resistance, muscle strength, pain, and motor function in patients with primary osteoarthritis of the knee. Fisioterapia em Movimento. 2013; 26:777-89.
[38] da Luz R, da Silva Santos M, Evaldt AS, da Silva Matos L, Daitx RB, Döhnert MB. Neuromuscular electrical stimulation associated with core stability exercises in nonspecific postural low back pain: a randomized clinical trial. Muscles, Ligaments & Tendons Journal (MLTJ). 2019 Jul 1;9(3): 446.
[39] Jain K, Goyal B, Singh R, Verma S, Bhandari Y, Sharma A, Sharma S. Evaluate the Impact of Core Exercise and Abdominal Draw-In Maneuver on Oswestry Disability Index in Subjects with Low Back Pain. Educational Administration: Theory and Practice. 2024 May 23;30(5):8139-43.