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Effect of Interferential Current on Pain, Pressure Pain Threshold, and Cervical Range of Motion in Myofascial Pain Syndrome: A Randomized Clinical Trial

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Abstract

Introduction: Interferential current (IFC) is a medium-frequency alternating current that is widely used for pain modulation. Myofascial pain syndrome (MPS) is a common form of chronic musculoskeletal pain characterized by the development of myofascial trigger points (MTrPs). Till date the effect of IFC on pain modulation has not been confirmed

Objective: To examine the effect of IFC on pain, pressure pain threshold (PPT), and active cervical lateral flexion range of motion (ROM) in participants with latent MTrPs in the upper trapezius.

Material and methods: Thirty-four MPS participants with latent MTrPs in the upper trapezius were recruited in the study, and randomly assigned into two equal groups. Group A received IFC and standard treatment, while group B received placebo IFC and standard treatment three sessions per week for four consecutive weeks. Pain intensity using visual analogue scale, PPT using pressure gauge algometer, and active cervical lateral flexion ROM using smart phone inclinometer application were assessed before and after the treatment.

Results: There were statistically significant improvements in pain intensity, PPT, active cervical lateral flexion ROM in both directions in groups A & B post-treatment compared with pretreatment (p values were 0.001).

There were statistically significant improvements in pain intensity, PPT and active cervical lateral flexion ROM to the contralateral side in group A as compared to group B in favor to group A (P values were 0.001).

Conclusion: IFC may improve pain intensity, PPT, and active cervical lateral flexion ROM to the contralateral side in the management of latent MTrPs in the upper trapezius.

Key words: electrical stimulation, neck pain, myofascial pain syndrome

INTRODUCTION

Interferential current (IFC) utilizes two asynchronous interfering medium-frequency alternating currents (1 to 10 KHz) to produce a low-frequency current that has unique properties. The frequency of the resultant current is equal to the difference between the frequencies of the two original currents [(1)].

As it exhibits the advantageous features of facing less skin impedance, deep penetration, and high levels of comfort compared to other pain-modulating currents [(1)], IFC is commonly used in treating musculoskeletal pain and injuries [(2)]. It has been used previously in the treatment of chronic muscular pain [(2-4)] and myofascial pain syndrome (MPS) [(5,6)].

Myofascial pain syndrome is a common form of chronic musculoskeletal pain that contributes to a significant financial burden and job-related disability [(7)]. According to Ezzati et al., MPS represents the most common disorder in patients with chronic non-specific neck pain (NSNP) [(8)].

The presence of a palpable hyperirritable nodule in a taut band of skeletal muscle fiber, known as myofascial trigger points (MTrPs), is the main characteristic feature of MPS. MTrPs are typically accompanied with tenderness, spasms, restricted movement and referred pain [(7)]. MTrPs that can be clinically categorized according to the characteristics of pain as either active or latent [(9)] are usually seen or observed in the upper fibers of the trapezius muscle [(10)]. The active MTrPs refer pain during activity and rest without any pressure, while the latent MTrPs are painful only when palpated. Both active and latent MTrPs prevent full muscle lengthening, and induce muscle weakness, pain, and discomfort in the cervical and shoulder regions [(9)]. Evidence regarding the effectiveness of IFC on pain modulation has not been confirmed up till now. This might be attributed to multiple factors, such as a limited number of studies, inappropriate use of the parameters, or improper study design, such as the absence of a control group that receives standard treatment in many clinical trials [(2)]. According to Hussein et al. [(2)], further researches are needed to establish the evidence regarding the effectiveness of IFC in pain management.

Objective

The aim of the current study was to investigate the effect of IFC on pain intensity, pressure pain threshold (PPT) and active cervical lateral flexion range of motion (ROM) on upper trapezius latent MTrPs in participants with MPS.

MATERIAL AND METHODS

Study design

A double-blind, randomized, controlled study design was utilized to investigate the aims of the study. The current study was approved by the Research Ethical Committee of the Faculty of Physical Therapy, Cairo University (approval no: P.T. REC/012/003591), and the study was prospectively registered at the Clinical Trial Registry (NCT05275634). The study was conducted between June 2022 and January 2023 at the outpatient clinic of the Faculty of Physical Therapy, Cairo University, Egypt.

Participants and randomization

Thirty-four participants (23 female and 11 male) with MPS presenting nonspecific mechanical neck pain, referred by a physician, were recruited in the current study after being tested for recruitment eligibility. The inclusion criteria were as follows: 1) age from 18-29 years old, 2) normal Body Mass Index (from18.5-24.9 kg\m^2), 3) latent MTrPs in upper trapezius muscle for at least three months duration, 4) pain elicited with pressure, local twitch response, jump sign, limited ROM and referred pain over the lateral aspect of the upper trapezius fibers and superiorly to the ipsilateral occiput. The exclusion criteria were as

follows: 1) onset of neck pain less than 3 months, 2) history of a whiplash injury, 3) cervical radiculopathy and/or cervical disc lesion, 4) cervical spondylolisthesis, 5) fractures of the cervical spine, 6) history of cervical spine surgery, 7) multiple sclerosis, 8) thyroid dysfunction, 9) rheumatologic condition as rheumatoid arthritis, poly-articular osteoarthritis, and advanced cervical spine degenerative diseases, 9) physical therapy intervention during the previous six months, 10) skin disease and impaired sensation, 11) phobia of using electrical current, 12) pregnancy, thrombosis, tumor and pacemaker, 13) administration of regular analgesic drugs or any medications that affect skin sensation. Eligible participants signed a consent form before being formally recruited in the study.

Participants were randomly and equally assigned into two groups using random number generator, and the group codes were concealed within consecutively numbered, closed, and opaque envelopes. The randomization was executed by a researcher who was not involved in participant recruitment, treatment, or evaluation of participants. Both groups received standard MTrPs treatment in the form of active cervical ROM, stretching and postural correction exercises. They received 12 sessions, 3 sessions/ week for 4 weeks. In addition to the standard treatment, group A, (10 females and 7 males), received IFC with carrier frequency 4 KHz, while group B, (13 females and 4 males), received placebo IFC. A flowchart (Figure 1) illustrates the process of participants' recruitment and randomization.

Outcome measures

Demographic data (age, height, weight, and BMI) were measured and recorded for all participants before enrollment in the treatment sessions. The study participants underwent assessment twice. The first assessment was performed just before stating the treatment sessions and the second assessment was carried out just after finishing the treatment sessions. Both participants and the evaluator were blinded to the treatment throughout the study. Pain intensity, the primary outcome, was measured using visual analogue scale which is valid and reliable for pain assessment [(11)]. VAS is made up of a scaled line; one end of the line refers to no pain and the other end refers to the most severe pain. The participants were instructed to put a vertical mark on the point that indicates their pain intensity level and the examiner measures the distance from the mark to the left side. The secondary outcome measures were PPT and active cervical lateral flexion ROM.

Pressure pain threshold

Pain pressure threshold, as indicator of muscle tenderness and MTrPts sensitivity, was assessed using pressure gauge algometer (Baseline®, FEI Inc., White Plains, NY, USA), that is valid to identify the force and /or pressure eliciting a PPT and has a high inter-examiner reliability. The ICC was 0.91 (95% CI 0.82, 0.97) [(12, 13)].

With the participant in a relaxed sitting position, the latent MTrP in the upper trapezius was localized by pincer palpation and marked with a pen mark. The tip of the algometer's probe was applied over the MTrP perpendicularly, and the therapist applied a gradually increasing pressure until the patient started to perceive pain. The algometer's reading was recorded as the PPT over this point. The procedure was repeated three times with 30 seconds interval in between. The mean of the three measurements was calculated and recorded as the final value of PPT [(14)].

Active cervical lateral flexion ROM

Active cervical lateral flexion ROM was assessed by smart phone clinometer application. The Clinometer application is a valid instrument for measuring active cervical ROM and has moderate to excellent reliability, with ICC ranging between 0.774 and 0.928 [(15)]. The smart phone was kept steady by using a strap attached to the phone cover. The strap was used to secure the smartphone on participant's head and prevent unwanted errors or drifts when being held by the therapist.

With the patient comfortably seated on a back chair and both hands resting on his/her thighs, the smartphone was securely fixed to the patient's forehead with a strap at the level of the forehead. The phone was positioned and adjusted to ensure that the indicator of the application was aligned with the patient's tip of nose and is currently reading zero. The patient's trunk was stabilized to the back of the seat using a strap to prevent trunk movement during the test.

Cervical lateral flexion was performed in the frontal plane while the head remaining in the sagittal neutral position. Participants were asked to move their head in lateral flexion movement to one side till the limit of pain, and the degree of lateral flexion of the neck was recorded. The same procedure was repeated for the other side. Level of shoulder must be unchanged during the assessment. This procedure was repeated thrice on either side to obtain the mean of the three trials.

Intervention

Initially, the participants received the following instructions: avoid prolonged fixed neck position, change neck position regularly, avoid bad posture of the neck and avoid heavy weightlifting over head or shoulders then participants were educated about IFC, active cervical ROM, stretching exercises and postural correction exercises [(16)].

The standard treatment was administrated prior to IFC. All treatment procedures in both groups were applied by the first investigator using the same electric stimulation unit (Gymna duo 400®, Gymna Uniphy N.V., Bilzen, Belgium).

Standard treatment

Active cervical ROM exercises

Cervical ROM exercises involved movements of the head in the three planes of motion. For cervical flexion, participants were asked to raise the head up while keeping the chin tucked in from supine lying position. For cervical extension, participants were asked to raise the head backwards from prone lying position. For cervical lateral flexion, participants were asked to raise the head sideways from pillow from side lying position and repeat the same for the other side. For cervical rotation, participants were asked to raise the head off from the bed and rotating it to one side and repeat the same for the other side. These exercises were performed three sets of ten repetitions [(17)].

Stretching exercises

The suboccipital muscles stretch

The participants were in sitting position and the therapist stood behind the participants. The therapist identified the spinous process of the second cervical vertebra and stabilized it with his thumb. The participants were asked to gradually nod their head. The therapist guided the movement by placing the other hand across the participants' forehead. The exercise was performed three times with holding 30 second for each time [(18)].

The pectoral muscles stretch

The participants were in sitting position with the hands clasped behind their head. The therapist stood behind the participants and grasped their elbows. The therapist asked the participants to breathe in and brought their elbows out to the side. The therapist held the elbows at the end point as the participants breathed out. As the participants repeated the inhalation, the therapist again moved the elbows up and out to the end of the available ROM and held as the participants breathed out. The exercise was performed three times for 30 second each time [(18)].

Postural correction exercises

The Participants were in proper sitting position and performed two major exercises. The first exercise was for the retraction of the cervical spine. Participants were asked to retract their head and neck into a position in which their head was positioned over the thorax and held this position for ten second. The second exercise was for the retraction of the scapulae.

Participants were asked to take a deep breath and expand their chest, retract their shoulders backward, draw their scapulae close to each other and hold for ten second. Posture correction exercises were performed three sets of ten repetitions. [19].

Interferential current application

Participants were lying in supine lying position to reduce tension in upper trapezius. Two self-adhesive silicon electrodes were applied on either side of the MTrP of the upper trapezius muscles, so that one was located on C7 spinous process and the other on the supraspinatus fossa [20].

Group A received IFC treatment with carrier frequency of 4 KHz, and beat frequency of 15 Hz for 45 minutes. The current amplitude was increased gradually until the patient felt strong comfortable tingling sensation throughout the session time. Participants in group B received placebo IFC with the same IFC parameters as group A, but the current amplitude wasn't raised and the participants was told that he/she may or may not feel any sensation at the application site of the electrodes. The screen of the equipment was kept hidden of the patient's eyes [21].

Statistical analysis

Data analysis was conducted by a statistician blinded to patients' allocation. Data were expressed as mean ± SD. Un-paired t-test was used to compare between participants demographic data of the two groups. MANOVA of mixed 2 x 2 design was performed to compare within and between groups' effects for all measured variables. Statistical package for the social sciences computer program (version 20 for Windows; SPSS Inc., Chicago, Illinois, USA) was used for data analysis. The *p* less than or equal to 0.05 was considered significant.

Results

In the current study, no cases of dropouts were reported. None of the participants crossed over groups during the study. Additionally, after the IFC application, no adverse effect was noted in any case.

Demographic data showed non-significant differences between both groups in terms of age, height, weight, and BMI (Table 1).

Table (1): Participants' demographic characteristics at baseline.

	Group A	Group B	t-value	p-value	Significance
Age (years)	20.8±1.6	20±1.2	1.325	0.194	N.S
Height (cm)	167.8±8.1	167±8.2	0.295	0.770	N.S
Weight (kg)	62.8±6.9	61.3±9.5	0.517	0.609	N.S
BMI (kg/m^2)	22.3±1.8	21.9±2.5	0.448	0.657	N.S
Sex Females Males	10 (59%) 7 (41%)	13(76.5%) 4 (23.5%)	χ^2 = 1.2	0.271	N.S

Data represented as mean ± standard deviation or number (percentage), χ^2: chi squared value, N.S: non-significant, p-value: probability value

Effects of IFC on pain intensity, pressure pain threshold and active cervical lateral flexion ROM

Within-group comparison of pain intensity showed a significant improvement between pre- and post-treatment values in both groups (p values were 0.001, 0.001). Between-groups comparison of pain intensity showed non-significant differences between the two groups in the pre-treatment measurement, while post-treatment showed significant differences in favor of group A (p values were 0.548, 0.001 respectively) (Table 2).

Within-group comparison of PPT showed a significant difference between pre- and post-treatment values in both groups (p values were 0.001, 0.001). Between-groups comparison of PPT showed non-significant difference between the two groups in the pre-treatment

measurement, while post-treatment showed significant difference in favor of group A (p values were 0.105, 0.001 respectively) (Table 2).

Within-group comparison of active cervical lateral flexion ROM to the same side showed significant difference between pre- and post-treatment values in both groups (p values were 0.001, 0.001). Between-groups comparison of active cervical lateral flexion ROM to the same side showed non-significant difference between the two groups in the pre- and post-treatment measurement (p values were 0.886, 0.291 respectively) (table 2).

Within-group comparison of active cervical lateral flexion ROM to the contralateral side showed significant difference between pre- and post-treatment values in both groups (p values were 0.001, 0.001). Between-groups comparison of active cervical lateral flexion ROM to the contralateral side showed non-significant difference between the two groups in the pre-treatment measurement, while post-treatment showed significant difference in favor of group A (p values were 0.226, 0.001 respectively) (table 2).

Table (2): Comparison between pre- and post-study mean values of pain, pressure pain threshold and active cervical lateral flexion between and within groups

Measured variables	Group A	Group B	P-value
Pain (mm) Pre-study	73 ± 13	76 ± 15	0.548
Post-study	14 ± 10	45 ± 13	0.001*
% of change	81%	41%	
(P-value)	0.001*	0.001*	
PPT (kg) Pre-study	0.9 ± 0.3	0.7 ± 0.3	0.105
Post-study	2.3 ± 0.77	1.4 ± 0.4	0.001*
% of change	155%	100%	
(P-value)	0.001*	0.001*	
Lateral flexion to the same side (degrees) Pre-study	36.6 ± 2.3	36.4 ± 4.5	0.886
Post-study	41.4 ± 3	40.2 ± 3.3	0.291
% of change	13%	10.4%	
(P-value)	0.001*	0.001*	
Lateral flexion to the contralateral side (degrees) Pre-study	32.6 ± 2.9	31.1 ± 4	0.226
Post-study	43 ± 1.7	37.3 ± 3.8	0.001*
% of change	31.9%	20%	
(P-value)	0.001*	0.001*	

Data is represented as mean ± standard deviation, P-value: probability value, *: significant, PPT: pressure pain threshold

Discussion

This study investigated the effect of IFC on pain intensity, PPT and active cervical lateral flexion ROM in participants with latent MTrPs of the upper trapezius muscle. Both groups showed significant improvements regarding all concerned measured outcomes, yet IFC was more effective in improving pain, PPT, and active cervical lateral flexion ROM to the contralateral side.

The findings of the current study could be explained as IFC induces stimulation of supraspinal level of pain killers that might lead to delayed onset but long-lasting pain relief [(1)]. The relaxation of muscle tension and consequently the improvement in ROM could be attributed to the secondary effects of pain relief. The reduction of pain could break the pain-spasm cycle and enhance normal pain-free movement. When the pain subsides, the patient could eventually move the neck in lateral flexion to the contralateral side without the burden of pain felt previously [(22,23)].

Electric stimulation is proposed to physiologically suppress the sympathetic nerve fibres in the tiny arterioles in the muscular belly, which would reduce sympathetic tonus and increase local blood flow. This process has been proposed as the primary contributor to elevated tissue oxygen levels and, as a result, to a clinical reduction in the pain-spasm-pain cycle [(24,25)].

The improvement in pain perception and active cervical lateral flexion to the contralateral side observed in the current study was supported by earlier findings reported by Dissanayaka et al., [(26)] where 105 patients with upper trapezius active MTrPs demonstrated significant improvement in pain intensity and cervical ROM in the group received IFC with standard physical therapy treatment compared to the group who received standard physical therapy treatment only.

Furthermore, Sutariya and Shukla [(17)] compared the effect of IFC versus shortwave diathermy on pain intensity; PPT and neck function in patients with mechanical neck pain and concluded significant improvement in the measured variables, with superiority in the outcomes in the IFC group.

In the same line, Takla [(27)] investigated the effect of TENS and IFC in the management of upper trapezius MTrPs. IFC group demonstrated more improvement in PPT and cervical ROM when compared to control group. It is worthy to mention that IFC used by Takla was applied in combination with ultrasound therapy.

Additionally, Acedo et al., [(20)] presented the efficacy of IFC therapy on the upper trapezius MPS. Sixty four females with NSNP were assigned into two groups: one receiving TENS and the other receiving IFC. The IFC group showed more significant improvement in terms of pain intensity and muscle tension.

Moreover, Kim et al., [(28)] studied the effects of TENS and IFC on MPS. Twenty patients with upper trapezius MTrPs demonstrated significant change in both groups with favor of the IFC group which indicates that IFC is more effective in pain control.

In line with the current study findings, the improvement in pain perception noted in the current study was supported by earlier findings reported by Albornoz-Cabello et al., [(29)], where 49 subjects with chronic NSNP demonstrated more decrease in pain intensity in the group received IFC with therapeutic exercises compared to the group who received therapeutic exercises only while, cervical side bending not significantly changed which is not in agreement with the current study. In this study the placement of the electrodes, beat frequency and the duration of IFC were different than those used in the current study.

On the other hand, Dhawan and Bhardwaj [(30)] found that IFC not significantly improve pain intensity and cervical contralateral side bending in 42 subjects with active MTrPs in the upper trapezius. However, their study differs from the current study in the placement of the electrodes and the duration of IFC. In addition, Dhawan and Bhardwaj used beat frequency (10Hz) to treat active MTrPs. According to guidelines, lower frequency currents are recommended when treating chronic pain such as the condition with latent MTrPs [(1, 31)].

Study limitations

The current study has encountered a number of limitations including; lack of long term follow up to confirm if the improvement was maintained after cessation of treatment sessions and for how long would it be still appreciated by the participants. Future work is needed to evaluate the long term effects of FC. The wide range of stimulation parameters that could be used with IFC makes the presented results of the current study limited to the parameters adopted by the authors. Research using other combination of parameters need to be conducted to clarify the best combination needed for better results. The present study used a unidimensional measurement of pain on a 100-mm visual analog scale, and this captures only a self-reported unidimensional assessment of pain.

Conclusions

Interferential current reduce pain intensity, improves PPT, and active cervical lateral flexion ROM when treating participants with latent MTrPs in upper trapezius muscle.

Clnical implications

Physical therapists who treat patients with latent MTrPs which inducing neck pain and affecting active cervical lateral flexion ROM are advised to add IFC with low beat frequency to their standard program of treatment to obtain better results.

References

1. Rampazo É.P., Liebano R.E. Analgesic effects of interferential current therapy: A narrative review. Medicina 2022; 58(1): 141- 155. doi: 10.3390/medicina58010141.
2. Hussein H.M., Alshammari R.S., Al-Barak S.S., Alshammari N.D., Alajlan S.N., Althomali O.W. A systematic review and meta-analysis investigating the pain-relieving effect of interferential current on musculoskeletal pain. Am J Phys Med Rehabil 2022; 101(7): 624-633. doi: 10.1097/PHM.0000000000001870.
3. Zahid R., Khan I., Anis R., Ahmad H.J., Riaz S. Role of Electrotherapy in Treating Chronic Musculoskeletal Conditions: A Narrative Review of the Last 5 Years. Int Health Rev 2022; 2(2): 47-60. doi: 10.32350/ihr.22.05.
4. De Almeida C.C., Da Silva V.Z., Júnior G.C., Liebano R.E., Durigan J.L. Transcutaneous electrical nerve stimulation and interferential current demonstrate similar effects in relieving acute and chronic pain: a systematic review with meta-analysis. Braz J Phys Ther 2018; 22(5): 347-354. doi: 10.1016/j.bjpt.2017.12.005.
5. Galasso A., Urits I., An D., Nguyen D., Borchart M., Yazdi C. et al. A comprehensive review of the treatment and management of myofascial pain syndrome. Curr Pain Headache Rep 2020; 24(43): 1-11. doi: 10.1007/s11916-020-00877-5.
6. Ofluoglu D., Bulak E.A., Kablan N., Akyuz G. Short-term effects of interferential currents on chronic myofascial pain syndrome. Turk J Phys Med Rehabil 2013; 59(3): 209-214. doi: 10.4274/tftr.87259.
7. Shah J.P., Thaker N., Heimur J., Aredo J.V., Sikdar S., Gerber L. Myofascial trigger points then and now: a historical and scientific perspective. PM&R 2015; 7(7): 746-761. doi: 10.1016/j.pmrj.2015.01.024.
8. Ezzati K., Ravarian B., Saberi A., Salari A., Reyhanian Z., Khakpour M. Prevalence of Cervical Myofascial Pain Syndrome and its Correlation with the Severity of Pain and Disability in Patients with Chronic Non-specific Neck Pain. Arch Bone Jt Surg 2021; 9(2): 230. doi: 10.22038/ABJS.2020.48697.2415.
9. Dommerholt J., Gerwin R.D., Courtney C.A. Pain Sciences and Myofascial Pain. [In:] Donnelly J.M., Fernandez-de-Las-Penas C., Finnegan M., Freeman J. Travell, Simons &

Simons' Myofascial Pain and Dysfunction: The trigger point manual. Wolters Kluwer, Philadelphia 2018: 59-121.
10. Cerezo-Téllez E., Torres-Lacomba M., Mayoral-del Moral O., Sánchez-Sánchez B., Dommerholt J., Gutiérrez-Ortega C. Prevalence of myofascial pain syndrome in chronic non-specific neck pain: a population-based cross-sectional descriptive study. Pain Med 2016; 17(12): 2369-2377. doi: 10.1093/pm/pnw114.
11. Begum M.R., Hossain M.A. Validity and reliability of visual analogue scale (VAS) for pain measurement. Med case rep rev 2019; 2(11): 394-402.
12. Chesterton L.S., Sim J., Wright C.C., Foster N.E. Interrater reliability of algometry in measuring pressure pain thresholds in healthy humans, using multiple raters. Clin J Pain 2007; 23(9): 760-766. doi: 10.1097/AJP.0b013e318154b6ae.
13. Kinser A.M., Sands W.A., Stone M.H. Reliability and validity of a pressure algometer. J Strength Cond Res 2009; 23(1): 312-314. doi: 10.1519/JSC.0b013e31818f051c.
14. Zamani S., Okhovatian F., Naimi S.S., Baghban A.A. Intra-examiner and between-day reliability of algometer for pressure pain threshold and pain sensitivity in upper trapezius muscle in asymptomatic young adult women. J Clin Physio Res 2017; 2(1): 15-20. doi: 10.22037/jcpr.v2i1.10382.
15. Monreal C., Luinstra L., Larkins L., May J. Validity and intrarater reliability using a smartphone clinometer application to measure active cervical range of motion including rotation measurements in supine. J Sport Rehabil 2020; 30(4): 680-684. doi: 10.1123/jsr.2019-0422.
16. Abd El-Azeim A.S., Ahmed S.E., Draz A.H., Elhafez H.M., Kattabei O.M. Integrated neuromuscular inhibition technique versus kinesiotape on upper trapezius myofascial trigger points a randomized clinical trial. Int J Physiother 2018: 105-12. doi: 10.15621/ijphy/2018/v5i3/173934.
17. Sutariya N., Shukla Y. Effect of Interferential Therapy versus Shortwave Diathermy on Pain and Function in Mechanical Neck Pain-A Comparative Study. Int J Sci Healthc Res 2020; 5(1): 279-288.
18. El-Gendy M.H., Lasheen Y.R., Rezkall W. K. Multimodal approach of electrotherapy versus myofascial release in patients with chronic mechanical neck pain: A randomized controlled trial. Physiother Q 2019; 27(4), 6-12. doi: https://doi.org/10.5114/pq.2019.87735.
19. Elkhateeb Y.S., Mahmoud A.G., Mohamed M.H., Abd El Azeim A.S. Influence of adding strain-counterstrain to standard therapy on axioscapular muscles amplitude and fatigue in mechanical neck pain; a single-blind, randomized trial. Eur J Phys Rehabil Med 2022; 58(4): 621–629. doi: 10.23736/S1973-9087.22.07194-5.
20. Acedo A.A., Antunes A.C., dos Santos A.B., de Olveira C.B., dos Santos C.T., Colonezi G.L. et al. Upper trapezius relaxation induced by TENS and interferential current in computer users with chronic nonspecific neck discomfort: an electromyographic analysis. J Back Musculoskelet Rehabil 2015; 28(1): 19-24. doi: 10.3233/BMR-140482.
21. Corrêa J., Costa L., Oliveira N., Lima W., Sluka K., Liebano R. 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): 1653-1666. doi: 10.1002/ejp.889.
22. Beinert H.C., Behrens B.J., Larkin S. Tissue response to injury. [In:] Behrens B.J., Beinert H. Physical agents theory and practice. FA Davis, Philadelphia 2014: 18-22.
23. Liebano R.E. Mechansms of pain and use of therapeutic modalities. [In:] Bellew J.W., Michlovitz S.L., Nolan Jr T.P. Michlovitz's modalities for therapeutic intervention. FA Davis, Philadelphia 2016: 346-348.

24. Noble G.J., Lowe A.S., Walsh D.M. Interferential therapy review. Part 1. Mechanism of analgesic action and clinical usage. Phys Ther Rev 2000; 5(4): 239-245. doi: 10.1179/108331900786166588.
25. Hou C.R., Tsai L.C., Cheng K.F., Chung K.C., Hong C.Z. Immediate effects of various physical therapeutic modalities on cervical myofascial pain and trigger-point sensitivity. Arch Phys Med Rehabil 2002; 83(10): 1406-1414. doi: 10.1053/apmr.2002.34834.
26. Dissanayaka T.D., Pallegama R.W., Suraweera H.J., Johnson M.I., Kariyawasam A.P. Comparison of the effectiveness of transcutaneous electrical nerve stimulation and interferential therapy on the upper trapezius in myofascial pain syndrome: a randomized controlled study. Am J Phys Med Rehabil 2016; 95(9): 663-672. doi: 10.1097/PHM.0000000000000461.
27. Takla M.K. Low frequency high intensity versus medium frequency low intensity combined therapy in the management of active myofascial trigger points: A randomized controlled trial. Physiother Res Int 2018; 23(4): 1737-1746. doi: 10.1002/pri.1737.
28. Kim M.J., Lee J.H., Choi W.H. Effects of transcutaneous electrical nerve stimulation and interferential current on myofacial pain syndrome. J Korean Acad Clin Electrophysiol 2004; 2(1): 1-8.
29. Albornoz-Cabello M., Barrios-Quinta C.J., Espejo-Antunez L., Escobio-Prieto I., Casuso-Holgado M.J., Heredia-Rizo A.M. Immediate clinical benefits of combining therapeutic exercise and interferential therapy in adults with chronic neck pain: a randomized controlled trial. Eur J Phys Rehabil Med 2021; 57(5): 767-774. doi: 10.23736/S1973-9087.21.06688-0.
30. Dhawan A., Bhardwaj P. The relative efficacy of high-power pain threshold static ultrasound technique versus interferential currents in the treatment of active myofascial trigger points of upper trapezius. Physiother Occup Ther 2010; 4(4): 12-17.
31. Fuentes J., Armijo-Olivo S., Magee D.J., Gross D. Does amplitude-modulated frequency have a role in the hypoalgesic response of interferential current on pressure pain sensitivity in healthy subjects? A randomised crossover study. J Physiother 2010; 96(1): 22-29. doi: 10.1016/j.physio.2009.06.009.