Comparison of the effectiveness of high-intensity laser therapy and Extracorporeal Shockwave in the treatment of myofascial pain syndrome: a randomized single-blind controlled study

Reda Kotb Abdelrazik[1*], Waleed Talat Mansour [2], Samah Mohamed Abd El Azem El Sadany[3], Mostafa A Abdelhameed[4], El Sayed Mohammed Hanoura[5], Wafaa Atef Abd Allah[6], Sarah A. Fetoh[7], Sara Mohamed Samir[8]

[1]Assistant Professor at Department of Physical Therapy for Musculoskeletal Disorders and its Surgery, Faculty of Physical Therapy, Benha University, Qaluybia, Egypt, E-mail: reda.gad@fpt.bu.edu.eg
[2]Professor at Department of Physical Therapy for Neurological Disorders and its Surgery, Faculty of Physical Therapy, Benha University, Benha, Egypt.
[3]Consultant of Physical Therapy Cairo University Hospital Lecturer of Physical Therapy Merit University, drsamahm2025@gmail.com
[4]Lecturer of Physical Therapy for surgery and burn, Faculty of Physical Therapy, Nahda University, Egypt Mostafa.awad@nub.edu.eg
[5]Lecture of physical therapy for internal medicine Faculty of physical therapy, Kafr elsheikh University sayedatwa24@gmail.com
[6]Lecturer - Department of Physical Therapy for Diseases and Surgeries of the Musculoskeletal System, College of Physical Therapy - Misr university for Science and Technology (MUST), P.O.Box77, Giza, Egypt. Orchid no.0000-0003-2417-7663, wafaa.abdallah@must.edu.eg
[7]Sara Abd Elwahab Fetoh, Lecturer at basic Sciences department, Faculty of Physical Therapy, October 6 University, Egypt., 0009-0008-1284-5787, sara.abdelwaha.pt@o6u.edu.eg
[8]Assistant Prof Physical therapy department of Musculoskeletal disorders and it's surgery .Faculty of Physical Therapy.Cairo univ. Egypt
[8]Associate Prof Physical therapy , department of Medical Rehabilitation.Faculty of Applied Medical sciences.Najran univ. KSA

Abstract

Objectives: The purpose of this study was to compare the effects of extracorporeal shock wave therapy (ESWT) and high-intensity laser therapy (HILT) on patients with myofascial pain syndrome (MPS) in terms of neck pain, pain pressure threshold, neck disability index, and active range of motion (AROM).

Methods: Forty eligible patients were randomly assigned into two groups: Group A received (HILT three times per week for four weeks). and Group B received (one session of ESWT, once a week for four weeks) Patients in both groups received the same traditional physical therapy program

Results: Both therapies significantly improved all outcomes within groups ($p < 0.001$). Between groups, no statistically significant difference for pain ($p = 0.49$), pressure pain threshold ($p = 0.55$), or disability ($p = 0.78$). HILT demonstrated superior improvements in cervical flexion ($p = 0.003$) and bilateral rotation ($p = 0.008$ and $p = 0.001$).

Conclusions: HILT and ESWT When combined with conventional physical therapy produced similar results in terms of pain and disability. While ESWT had comparable effects in less sessions, HILT showed greater increases in cervical mobility.

Keywords: Myofascial Pain Syndrome, Extracorporeal Shock Wave Therapy, high power laser, Neck Disability, pain pressure threshold

Introduction

Myofascial pain syndrome (MPS) is a type of regional pain condition that occurs when specific areas in one or more muscle groups, called trigger points, become irritated or overactive. These trigger points can hurt various sections of the body in addition to the affected muscle when they are touched or squeezed.[1] 74–85% of people may suffer MPS at some point in their lives, making it the most prevalent cause of musculoskeletal pain. [2, 3]. A person's quality of life can be severely diminished by MPS-related pain, which can range from small discomfort to severe incapacitating pain. [4].

Tight bands of muscle that may be felt during a physical examination and sensitive areas in the muscles that react to gentle pressure are two key indicators that aid in the diagnosis of MPS. These locations are crucial for determining the condition and are referred to as trigger points. [5]. There are different ways to treat MPS, including both medication-based and non-medication-based approaches. Non-medication treatments often involve hands-on techniques. Other options include physical therapy methods like heat packs, ultrasound, or electrical stimulation (TENS), as well as procedures like injections, acupuncture, dry needling, HILT or ESWT [6].

HILT is regarded as one of the phototherapeutic devices that have become popular for treating both acute and chronic inflammatory pain, as well as the impairments. [7] research has shown that HILT has deeper effects on inflammation and edema, analgesic effects, and deeper joint stimulation.[8] HILT works by encouraging tissue healing, aiding muscular relaxation, of tight bands of muscle fibers connected to myofascial trigger points ,It reduces the amounts of neurotransmitters linked to pain in the affected tissue, including Substance P ,It helps in tissue regeneration by enhancing local microcirculation and encouraging angiogenesis, or the formation of new blood vessels.. [9] Therefore, using HILT for MPS can decrease discomfort, increase range of motion, and improve function. [10] ESWT is a type of acoustic wave therapy that is commonly used to treat a variety of musculoskeletal conditions. [11] It is characterized by a precise wave form, high energy, and short duration that act on a specific, well-defined spot. shockwaves cause cells to create growth factors, increase fibroblastic activity, and encourage the production of collagen, it promotes the growth of new blood vessels, which enhances the flow of nutrients and blood to tissues like tendon-bone junctions, accelerating the healing process.it decrease pain as Endorphins can be released in response to high-energy waves. It also reduces Substance P's concentration. [12] ESWT has demonstrated efficacy as a treatment option for myofascial pain syndrome patients [13,14]. Although both HILT and ESWT have demonstrated promising outcomes in managing MPS, their relative clinical efficacy when integrated into a standardized, evidence-based physiotherapy protocol has not been directly examined. This knowledge gap is clinically significant, as HILT and ESWT operate through fundamentally different mechanisms—photo biomodulation versus mechanical acoustic stimulation—and entail distinct treatment burdens (commonly 3 sessions for HILT versus 1 weekly session for ESWT). Without head-to-head comparative data, clinicians lack evidence-based guidance to optimize modality selection based on treatment efficiency, pain reduction magnitude, and functional recovery. Thus, the purpose of this study was to directly assess the effects of HILT and ESWT on neck pain, pain pressure threshold, neck disability index, and active range of motion (AROM).

Methods

Study Design and Ethics

This single-blind randomized controlled trial was conducted at Faculty of Physical Therapy Benha university Egypt, between [October, 2025] and [April, 2026]. The study protocol was approved by the Institutional Review Board of Benha University approval number:(PT.BU.EC.23) and registered in a clinical trials registry ClinicalTrials.gov ID: (NCT07176039). All participants provided written informed consent prior to enrollment. The trial was conducted in accordance with the Declaration of Helsinki and reported following the CONSORT 2010 guidelines.

Participants

40 adults (20–45 years) diagnosed by orthopedic surgeon with myofascial pain syndrome (MPS) of the upper trapezius/cervical region were recruited from outpatient physiotherapy clinics of Benha university. Diagnosis was confirmed according to Travell and Simons' criteria requiring: presence of a taut band in accessible muscle, hypersensitive spot within the taut band, referred pain pattern typical of the trigger point, restricted range of motion due to muscle stiffness, and pain reproduction upon trigger point palpation [15].

patients included in the study if they had: ≥ 3 months of unilateral/bilateral neck/shoulder pain with active myofascial trigger points (MTrPs) in upper trapezius, pain intensity ≥4/10 on Numeric Pain Rating Scale (NPRS), presence of referred pain pattern upon MTrP palpation.

Patients excluded from study if they had cervical radiculopathy or disc herniation confirmed by MRI, fibromyalgia or systemic inflammatory disorders, cervical trauma/surgery, pregnancy, contraindications to laser/shockwave therapy (malignancy, coagulopathy, implanted electronic devices), ongoing analgesic/anti-inflammatory medication changes during the study period.

Sample Size Calculation

Based on a pilot study showing a mean difference of 2.1 points (SD=1.8) in NPRS between HILT and ESWT groups

, a sample size of 18 participants per group was required to achieve 80% power (α=0.05, two-tailed). Anticipating a 10% dropout rate, 40 participants were recruited (20 per group).

Randomization and Blinding

Using computer-generated block randomization (block size=4), participants were randomly assigned to either the HILT or ESWT groups. The allocation was hidden in opaque, sealed envelopes with sequential numbers that were opened by a separate researcher who was not involved in the evaluations. Group allocation was hidden from outcome assessors and data analysts. Participants were advised not to reveal the type of treatment during assessments, although therapists and participants could not be blinded due to the nature of physical therapies.

Interventions
A standardized conventional program was administered to all subjects, which included: (1) ischemia compression to active MTrPs (90 seconds × 3 repetitions); (2) upper trapezius/levator scapulae stretching exercises (3 sets × 30 seconds hold); (3) complete three sets of ten repetitions of scapular stabilization exercises three times a week for four weeks under the guidance of a physiotherapist [16].
HILT Group: received high-intensity laser therapy with a Class IV Nd:YAG laser(wavelength 1064 nm) that had the following characteristics: peak power of 3000 W, average power of 10 W, frequency 1000 Hz (pulsed mode), energy density 12–15 J/cm² per point, treatment of 4–6 trigger points per session, and a total treatment duration of 8–10 minutes. applied three times a week for four weeks, for a total of twelve sessions. [17]
ESWT Group: ESWT Group: Using a pneumatic device (Gymna-Uniphy NV, Pasweg 6A, B-3740 Bilzen, Belgium), participants underwent radial extracorporeal shockwave therapy. Energy flux density of 0.08–0.12 mJ/mm², frequency of 8–10 Hz, and approximately 1500 pulses per session administered to active myofascial trigger sites (500 pulses per trigger point) were the treatment parameters. For four weeks (a total of four sessions), treatment was given once a week [18,19]. With enough coupling gel, the applicator was held perpendicular to the skin, and the intensity was changed according to the participant's tolerance.

Outcome Measures
At baseline (T0) and just after the intervention (T1: week 4), the main outcomes were evaluated.
Pain intensity during rest and movement is measured using an 11-point Numeric Pain Rating Scale (NPRS), where 0 represents no pain and 10 represents the worst possible pain. [20]
Pressure pain threshold (PPT): Determined by applying a digital algometer (FPIX Wagner Instruments; 1 cm² probe tip) perpendicularly over MTrPs at a ramp rate of 1 kg/s. Three measurements were made at 30-second intervals, with the mean value expressed in kPa. [21]
The validated 10-item Neck Disability Index (NDI) measures functional limits; a score of 0–50 indicates a worse disability. [22]
Active cervical range of motion (AROM) is measured in degrees for flexion, extension, lateral flexion, and rotation using a cervical range of motion (CROM) device. [23]

Statistical analysis
Descriptive statistics were shown as mean ±standard deviation and counts for scale and categorical data, respectively. Shapiro-Wilk test was used to verify the normal distribution of the data and showed that almost all data were normally distributed ($p>0.05$). Levene̓s test was used to assess homogeneity of variances and showed $p>0.05$ for all comparisons. Given that skewness of PPT values were within 1 and -1, therefore no transformation is required. Unpaired and paired t tests were used for between and within group comparisons, respectively. Analysis of covariance (ANCOVA) [using pre-test scores as covariate] was used for between group comparisons post-treatment when pre-test comparisons were significant, while paired t test was used for within group comparisons. Given the exploratory nature of secondary outcomes and limited number of primary comparisons, un adjusted p-values are reported with emphases on effect sizes and confidence interval. Chi-square test was used to compare gender distribution among the three groups. Cohen̓s d effect sizes can be interpreted as; small=0.2, medium=0.5, and large=0.8 (Cohen, 1988). SPSS version 27 were used for all analyses.

Results

Baseline characteristics:
Descriptive statistics for demographic and clinical data of both groups were shown in table (1). There were no significant differences between groups in baseline characteristics ($p>0.05$).

Table (1): Descriptive statistics for demographic and clinical data of the three groups.

Variable	Group A (LPLT) Mean±SD	Group B (ESWT) Mean±SD	P value
Age (year)	34.8±7.27	35.05±7.24	0.91
Weight (kg)	78.4±4.8	79.2±6.06	0.65
Height (cm)	171.7±7.31	173.35±6.46	0.45
BMI (kg/m^2)	26.55±3.07	26.3±2.39	0.78
Gender (M/F)	12/8	11/9	0.75
Pain	7.55±0.95	7.15±1.18	0.24
Tenderness	174.95±35.13	186.95±24.25	0.22
Disability	29.05±3.86	29.4±5.27	0.81

SD: Standard deviation, P: Probability, BMI: Body mass index, M: Male, F: Female.
Within and between group comparisons in pain, tenderness, disability, and ROM:

Descriptive statistics for pain (NPRS), tenderness, disability (NDI), and ROM (cervical flexion, extension, rotation [Rt and Lt], and side-bending [Rt and Lt]) were shown in table (2).

Within group:

There were significant improvements in all outcomes within both groups post-treatment (p<0.05) except cervical extension ROM in group A and cervical rotation (RT and Lt) in group B. (Table 2).

Between groups:

There were no significant differences between groups at pre-treatment except Lt rotation and side-bending (for which ANCOVA were done for post-treatment comparisons). There were non-significant differences between groups at post-treatment except in flexion and rotation (Rt and Lt) (p<0.05) in favor of group A that had higher ROM (MD=3.46, 5.08, and 7.2, respectively) post-treatment (Table 2).

Table (2): Descriptive and analytical statistics for pain, tenderness, disability, and ROM within and between the three groups.

Variable	Time	Group A (HILT) Mean±SD	Group B (ESWT) Mean±SD	Between groups MD (SE), Cohen's d, P value
Pain	Pre	7.55±0.95	7.15±1.18	0.4 (0.34), 0.24
	Post	3.1±1.90	2.9±0.85	0.2 (0.29), 0.22, 0.49
Within group MD (SD), Cohen's d, P value		4.45 (0.76), 5.9,<0.001	4.15 (1.07), 3.97,<0.001	
Tenderness	Pre	174.95±35.13	186.95±24.25	-12 (9.55), 0.22
	Post	249.68±80.12	265.5±87.09	-15.83 (26.46), -0.19, 0.55
Within group MD (SD), Cohen's d, P value		-74.73 (61.76), -1.2,<0.001	-78.55 (82.31), -0.95,<0.001	
Disability	Pre	29.05±3.86	29.4±5.27	-0.35 (1.46), 0.81
	Post	16.7 ±3.3	17.1±5.55	-0.4 (1.45), 0.09, 0.78
Within group MD (SD), Cohen's d, P value		12.35 (2.58), 4.79,<0.001	12.3 (4.53), 2.7,<0.001	
Cervical flexion ROM	pre	41.09±2.56	40.2±1.35	0.89 (0.65), 0.18
	post	51.64±3.72	48.19±3.12	3.46 (1.09), 1.01, 0.003
Within group MD (SD), Cohen's d, P value		-10.56 (3.5), -3.01,<0.001	-8 (3.54), -2.26,<0.001	
Cervical extension ROM	pre	58.16±8.02	60.79±6.77	-2.24 (2.39), 0.35
	post	59.05±6.96	62.37±6.4	-3.32 (2.17), -0.5, 0.14
Within group MD (SD), Cohen's d, P value		-0.9 (1.9), -0.46, 0.06	-1.58 (1.26), -1.25,<0.001	
Cervical Rt rotation ROM	pre	56.83±5.63	55.08±5.45	1.75 (1.75), 0.32
	post	60.28±4.68	55.2±6.61	5.08 (1.81), 0.89, 0.008
Within group MD (SD), Cohen's d, P value		-3.45 (4.32), -0.8, 0.002	-0.13 (1.13), -0.03, 0.91	
Cervical Lt rotation ROM	pre	54.68±5.07	48.6±4.9	6.08 (1.58),<0.001
	post	57.78±4.08	50.58±4.17	7.2 (1.3), 1.75, 0.001[a]
Within group MD (SD), Cohen's d, P value		-3.1 (3.67), -0.85, 0.001	-1.98 (1.24), -0.36, 0.13	
Cervical Lt side-bending ROM	pre	29.15±3.83	31.8±4.3	-2.65 (1.29), 0.047
	post	31.3±3.18	33.35±5.22	-2.05 (1.37), -0.47, 0.53[a]
Within group MD (SD), Cohen's d, P value		-2.15 (0.33), -1.47,<0.001	-1.55 (0.56), -0.63, 0.012	
Cervical Rt side-bending ROM	pre	29.65±3.88	30.1±4.49	-0.45 (1.33), 0.74
	post	31.05±2.72	31.2±4.17	-0.15 (1.11), -0.04, 0.89
Within group MD (SD), Cohen's d, P value		-1.4 (0.46), -0.69, 0.006	-1.1 (0.36), -0.68, 0.007	

Range of motion, MD: Mean difference, SD: Standard deviation, SE: Standard error, P: Probability, *ANCOVA p value, Negative values of pain and disability indicate improvement/reduction, Positive values of tenderness and ROM indicate improvement/increase.

Discussion

The effectiveness of HILT and ESWT as supplemental treatments for MPS affecting the upper trapezius and cervical region was examined in this randomized single-blind controlled experiment. When paired with a standardized conventional physiotherapy program, both modalities showed statistically significant within-group improvements in all assessed outcomes, including Pain intensity, pressure pain threshold (tenderness),

The ESWT group's analgesic effect is consistent with A recent meta-analysis of 10 controlled studies (n=571) found a mean difference of −1.34 points on pain scales preferring ESWT over alternative therapies in myofascial pain syndrome. [24]

shockwave therapy's known neurophysiological principles, by delivering high-energy acoustic waves, ESWT stimulates neovascularization, modulates the release of substance P and calcitonin gene-related peptide (CGRP), activates endogenous opioid systems, and causes controlled microtrauma at myofascial trigger sites. [12,25]

These mechanisms likely explain the substantial reduction in both spontaneous pain and mechanical hyperalgesia observed in our ESWT participants. The ability of ESWT to normalize peripheral and central nociceptive processing at myofascial trigger points is particularly supported by the significant within group difference in pressure pain threshold, which is consistent with other researchers' findings showing ESWT's effectiveness in lowering pain intensity and raising pressure pain thresholds in patients with myofascial trigger points. [24-26].

The significant within-group reduction in pain intensity and pain pressure threshold observed in our HILT group aligns with prior randomized trials demonstrating comparable analgesic effects of high-intensity laser therapy in upper trapezius myofascial pain syndrome [8, 10]. HILT functions via photo biomodulation pathways, in which photons enter tissue to increase ATP generation, decrease pro-inflammatory cytokines, stimulate mitochondrial cytochrome c oxidase, and regulate oxidative stress, these processes contribute to analgesia and tissue repair. [27]

At the four-week endpoint, a between-group examination of pain intensity showed no statistically significant difference between HILT and ESWT (mean difference = 0.20 points on NPRS, 95% CI: −0.29 to 0.69, p = 0.49, Cohen's d = 0.22) and pressure pain threshold (MD = −15.83 kPa, p = 0.55, Cohen's d = −0.19), in agreement with [13, 25,28-29]. Our results which suggest that both modalities had similar analgesic benefits in individuals with upper trapezius myofascial pain syndrome when paired with a structured supplementary physiotherapy regimen. The observed numerical difference is unlikely to be noticeable or significant to patients, significant within-group gains lends credence to the idea that the traditional physiotherapy component which includes scapular stability, stretching, and ischemia compression may have significantly reduced pain in both arms and possibly obscuring modality-specific benefits so in cervical MPS, both HILT and ESWT may be equally valid supplementary alternatives for pain modulation; however, the choice of modality may be influenced by factors other than differential analgesic efficacy, such as treatment efficiency, patient preference, or contraindications.

Neck Disability Index (NDI) scores after the intervention showed no significant between group difference (MD = −0.40, p = 0.417, Cohen's d = 0.09).Clinically significant within-group improvements were attained by both groups (HILT: −12.35 points; ESWT: −12.30 points). This pattern is in line with previous research showing that when incorporated into structured rehabilitation p rotocols, photobiomodulation and acoustic wave therapy both successfully reduce neck-related disability [10, 13].

This convergence is consistent with data from systematic reviews showing that advanced physical mod alities, in conjunction with manual therapy and standardized exercise, result in similar functional impro vements in myofascial pain syndrome, since the adjunctive program is frequently the main factor reduc ing disability [13, 16].

On the other hand, a number of recent studies have found that one modality outperforms comparators i n terms of NDI improvements.

For example, RCTs have demonstrated that ESWT significantly reduces neck impairment compared to manual treatment or mesotherapy [18, 30], whereas other studies revealed that HILT provided better fu nctional gains than traditional physiotherapy alone [31, 32].

Numerous methodological and clinical reasons could be responsible for these disparities.

First, the NDI evaluates multidimensional dimensions that go beyond pain intensity, such as lifting, rea ding, driving, sleeping, and concentration. These domains are significantly impacted by posture correct ion, neuromuscular re-education, and patient self-efficacy.

By offering a strong baseline of mechanical and proprioceptive input, the standardized co-intervention in our experiment (ischemic compression, stretching, and scapular stabilization) probably concealed modality-specific functional differences [33, 34]. Second, because of ingrained fear avoidance behaviors, altered motor control patterns, and psychosocial issues that necessitate longer inte rvention periods or focused cognitive-behavioral treatments to properly resolve, impairment in chronic MPS frequently lags behind pain redu ction [33, 35].

In terms of cervical range of motion, HILT outperformed ESWT in bilateral rotation (right: MD = 5.08°, p = 0.008, d = 0.89; left: MD = 7.20°, p = 0.001, d = 1.75) and cervical flexion (MD = 3.46°, 95% CI:

1.23 to 5.69, p = 0.003, Cohen's d = 1.01). these finding in same line with. **[17, 36]** These significant flexion and rotation effect sizes suggest that HILT has clinically significant advantages for reestablishing dynamic cervical mobility in the sagittal and transverse planes. This pattern is consistent with the known anti-inflammatory and anti-edematous mechanisms of HILT, in which photon absorption by mitochondrial cytochrome c oxidase increases ATP production, decreases pro-inflammatory cytokines (TNF-α, IL-1β), and controls oxidative stress in deep cervical musculature [27, 37]. In contrast to the primarily neuro modulatory effects of ESWT, these biochemical cascades may preferentially increase tissue elasticity and decrease fascial adhesions surrounding the atlanto-axial (C1–C2) and suboccipital joints structures primarily responsible for cervical rotation thereby enabling greater gains in rotational range of motion. [34, 37]

On the other hand, there may be a number of reasons for the lack of significant between-group differences in lateral side-bending and cervical extension (p = 0.14). First, compared to the more superficial upper trapezius and levator scapulae targeted in our protocol, extension and lateral flexion involve more complex multi-joint kinematics and a greater contribution from deep cervical extensors (semispinalis, multifidus), which may be less accessible to superficial photobiomodulation. Second, both groups' uniform supplementary program (stretching, scapular stabilization) probably supplied significant mechanical input for side-bending and extension, potentially mitigating modality-specific variations in these planes [16, 29]. Third, ANCOVA adjustment was required for post-treatment comparisons due to baseline imbalances in side-bending and left rotation, which may have decreased statistical power to identify minor between-group effects in these outcomes.

Clinically, these results imply that HILT might be the best adjunctive modality for patients with cervical MPS whose main therapeutic objective is the restoration of dynamic neck mobility—especially those who have functional or occupational demands that necessitate frequent cervical rotation (e.g., driving, computer work, athletic activities). The idea that either technique can successfully address global cervical mobility deficits in myofascial pain management when combined with evidence-based manual therapy and exercise is supported by the same gains in extension and side-bending observed in both groups.

Future research

should look into: (1) the best order of treatments (e.g., ESWT for initial pain relief followed by HILT for tissue healing and mobility restoration); (2) dose-response relationships for both modalities in MPS, especially with regard to energy flux density for ESWT and energy density parameters for HILT; (3) predictors of differential treatment response based on trigger point characteristics (active versus latent), pain chronicity, or psychosocial factors; and (4) cost-effectiveness analyses contrast these cutting-edge modalities with traditional interventions in actual clinical settings.

Conclusion

when combined with a conventional physiotherapy program for upper trapezius myofascial pain syndrome, both high-intensity laser therapy (HILT) and extracorporeal shockwave therapy (ESWT) significantly reduced pain, improved pressure pain thresholds, and improved functional outcomes. Neck impairment, pain pressure threshold and pain intensity did not show statistically significant difference between groups, suggesting similar clinical efficacy for symptom management. Nevertheless, HILT showed better gains in bilateral rotation range of motion and cervical flexion, indicating a modality-specific advantage for dynamic mobility restoration. ESWT may be a more time- and resource-efficient choice for patients who prioritize quick symptom alleviation because it produced comparable analgesic and functional results with just four weekly sessions as opposed to twelve for HILT.

References

1. Ahi, E. D.,&Sirzai, H. (2022). Comparison of the effectiveness of dry needling and high-intensity laser therapy in the treatment of myofascial pain syndrome: a randomized single-blind controlled study. Lasers in medical science, 38(1), 3. https://doi.org/10.1007/s10103-022-03687-w
2. Bodine N. (2023). An overview of myofascial pain syndrome with a focus on trigger point injection. The Nurse practitioner, 48(11), 18–25. https://doi.org/10.1097/01.NPR.0000000000000110
3. Steen, J. P., Jaiswal, K. S.,&Kumbhare, D. (2025). Myofascial Pain Syndrome: An Update on Clinical Characteristics, Etiopathogenesis, Diagnosis, and Treatment. Muscle&nerve, 71(5), 889–910. https://doi.org/10.1002/mus.28377
4. Steen, J. P., Jaiswal, K. S.,&Kumbhare, D. (2025). Myofascial Pain Syndrome: An Update on Clinical Characteristics, Etiopathogenesis, Diagnosis, and Treatment. Muscle&nerve, 71(5), 889–910. https://doi.org/10.1002/mus.28377
5. Cao, Q. W., Peng, B. G., Wang, L., Huang, Y. Q., Jia, D. L., Jiang, H., Lv, Y., Liu, X. G., Liu, R. G., Li, Y., Song, T., Shen, W., Yu, L. Z., Zheng, Y. J., Liu, Y. Q.,&Huang, D. (2021). Expert consensus on the diagnosis and treatment of myofascial pain syndrome. World journal of clinical cases, 9(9), 2077–2089. https://doi.org/10.12998/wjcc.v9.i9.2077
6. Lam, C., Tieppo Francio, V., Gustafson, K., Carroll, M., York, A., & Chadwick, A. L. (2024). Myofascial pain – A major player in musculoskeletal pain. Best Practice & Research Clinical Rheumatology, 38(1), Article 101944 https://doi.org/10.1016/j.berh.2024.101944

7. Starzec-Proserpio, M., Grigol Bardin, M., Fradette, J., Tu, L. M., Bérubè-Lauzière, Y., Paré, J., Carroll, M. S.,&Morin, M. (2022). High-Intensity Laser Therapy (HILT) as an Emerging Treatment for Vulvodynia and Chronic Musculoskeletal Pain Disorders: A Systematic Review of Treatment Efficacy. Journal of clinical medicine, 11(13), 3701. https://doi.org/10.3390/jcm11133701
8. Rahbar, S., Radinmehr, H., Talimkhani, A., Owliaee, P., Montazerlotf, H.,&Asadi, M. R. (2025). The Effects of High-Power Laser Therapy on the Treatment of Patients with Myofascial Trigger Points in the Upper Trapezius Muscle: A Randomized Controlled Trial. Journal of lasers in medical sciences, 16, e41. https://doi.org/10.34172/jlms.2025.41
9. Suschek, C. V., Feibel, D., von Kohout, M.,&Opländer, C. (2022). Enhancement of Nitric Oxide Bioavailability by Modulation of Cutaneous Nitric Oxide Stores. Biomedicines, 10(9), 2124. https://doi.org/10.3390/biomedicines10092124
10. Taleb, E. A., Ahmed, H. M., Ameen, F. H., Lasheen, Y. R., Albalawi, H. F.,&Eldesoky, M. T. (2022). Effect of high-intensity laser on upper trapezius myofascial pain syndrome: Single-blinded randomized control trial. International Journal of Health Sciences, 6(3), 1227–1239. https://doi.org/10.53730/ijhs.v6n3.11987
11. Ryskalin, L., Fulceri, F., D'Agostino, M. C., Vetrano, M., Vulpiani, M. C.,&Gesi, M. (2025). Recent Advances in Shockwave Therapy for Musculoskeletal and Soft-Tissue Disorders. Life (Basel, Switzerland), 15(12), 1912. https://doi.org/10.3390/life15121912
12. Simplicio, C. L., Purita, J., Murrell, W., Santos, G. S., Dos Santos, R. G.,&Lana, J. F. S. D. (2020). Extracorporeal shock wave therapy mechanisms in musculoskeletal regenerative medicine. Journal of clinical orthopaedics and trauma, 11(Suppl 3), S309–S318. https://doi.org/10.1016/j.jcot.2020.02.004
13. Avendaño-López, C., Megía-García, Á., Beltran-Alacreu, H., Serrano-Muñoz, D., Arroyo-Fernández, R., Comino-Suárez, N.,&Avendaño-Coy, J. (2024). Efficacy of Extracorporeal Shockwave Therapy on Pain and Function in Myofascial Pain Syndrome: A Systematic Review and Meta-analysis of Randomized Clinical Trials. American journal of physical medicine&rehabilitation, 103(2), 89–98. https://doi.org/10.1097/PHM.0000000000002286
14. Faramawy, M., Youssef, E., Ibrahim, M.,&Abdelrazik, R. (2024). INFLUENCE OF EXTRACORPOREAL SHOCKWAVE THERAPY IN PATIENTS OF MECHANICAL NECK PAIN. International Physical Therapy Conference - Cairo University, 3(1), 333-345. https://doi.org/10.21608/iptccu.2024.457147
15. Shah, J. P., Thaker, N., Heimur, J., Aredo, J. V., Sikdar, S.,&Gerber, L. (2015). Myofascial Trigger Points Then and Now: A Historical and Scientific Perspective. PM&R : the journal of injury, function, and rehabilitation, 7(7), 746–761. https://doi.org/10.1016/j.pmrj.2015.01.024
16. Takla M. K. N. (2018). Low-frequency high-intensity versus medium-frequency low-intensity combined therapy in the management of active myofascial trigger points: A randomized controlled trial. Physiotherapy research international : the journal for researchers and clinicians in physical therapy, 23(4), e1737. https://doi.org/10.1002/pri.1737
17. Alayat, M. S., Battecha, K. H., ELsodany, A. M.,&Ali, M. I. (2020). Pulsed ND:YAG laser combined with progressive pressure release in the treatment of cervical myofascial pain syndrome: a randomized control trial. Journal of physical therapy science, 32(7), 422–427. https://doi.org/10.1589/jpts.32.422
18. Avendaño-López, C., Megía-García, Á., Beltran-Alacreu, H., Serrano-Muñoz, D., Arroyo-Fernández, R., Comino-Suárez, N.,&Avendaño-Coy, J. (2024). Efficacy of Extracorporeal Shockwave Therapy on Pain and Function in Myofascial Pain Syndrome: A Systematic Review and Meta-analysis of Randomized Clinical Trials. American journal of physical medicine&rehabilitation, 103(2), 89–98. https://doi.org/10.1097/PHM.0000000000002286
19. Park, K. D., Lee, W. Y., Park, M. H., Ahn, J. K.,&Park, Y. (2018). High- versus low-energy extracorporeal shock-wave therapy for myofascial pain syndrome of upper trapezius: A prospective randomized single blinded pilot study. Medicine, 97(28), e11432. https://doi.org/10.1097/MD.0000000000011432
20. Karcioglu, O., Topacoglu, H., Dikme, O.,&Dikme, O. (2018). A systematic review of the pain scales in adults: Which to use?. The American journal of emergency medicine, 36(4), 707–714. https://doi.org/10.1016/j.ajem.2018.01.008
21. Zaidi, S., Aziz, R., Areeba, Khan, S. A.,&Fatima, N. (2026). Test-retest reliability of Wagner Pressure algometer in measuring pain Pressure threshold in patients with chronic neck pain: repeated-measures reliability study. The Journal of manual&manipulative therapy, 1–9. Advance online publication. https://doi.org/10.1080/10669817.2026.2646241
22. MacDermid, J. C.,&Walton, D. M. (2022). Development and validation of the ND10 to measure neck-related functional disability. BMC musculoskeletal disorders, 23(1), 605. https://doi.org/10.1186/s12891-022-05556-7
23. Tousignant, M., de Bellefeuille, L., O'Donoughue, S.,&Grahovac, S. (2000). Criterion validity of the cervical range of motion (CROM) goniometer for cervical flexion and extension. Spine, 25(3), 324–330. https://doi.org/10.1097/00007632-200002010-00011
24. Wu, T., Li, S., Ren, J., Wang, D., & Ai, Y. (2022). Efficacy of extracorporeal shock waves in the treatment of myofascial pain syndrome: A systematic review and meta-analysis of controlled clinical studies. Annals of Translational Medicine, 10(4), Article 165. https://doi.org/10.21037/atm-22-295

25. Ryskalin, L., Morucci, G., Natale, G., Soldani, P., & Gesi, M. (2022). Molecular Mechanisms Underlying the Pain-Relieving Effects of Extracorporeal Shock Wave Therapy: A Focus on Fascia Nociceptors. Life (Basel, Switzerland), 12(5), 743. https://doi.org/10.3390/life12050743
26. Ryskalin, L., Morucci, G., Natale, G., Soldani, P.,&Gesi, M. (2022). Molecular Mechanisms Underlying the Pain-Relieving Effects of Extracorporeal Shock Wave Therapy: A Focus on Fascia Nociceptors. Life (Basel, Switzerland), 12(5), 743. https://doi.org/10.3390/life12050743
27. Hamblin M. R. (2018). Mechanisms and Mitochondrial Redox Signaling in Photo bio modulation. Photochemistry and photobiology, 94(2), 199–212. https://doi.org/10.1111/php.12864
28. Song, H. J., Seo, H. J., Lee, Y.,&Kim, S. K. (2018). Effectiveness of high-intensity laser therapy in the treatment of musculoskeletal disorders: A systematic review and meta-analysis of randomized controlled trials. Medicine, 97(51), e13126. https://doi.org/10.1097/MD.0000000000013126
29. Ahi, E. D.,&Sirzai, H. (2022). Comparison of the effectiveness of dry needling and high-intensity laser therapy in the treatment of myofascial pain syndrome: a randomized single-blind controlled study. Lasers in medical science, 38(1), 3. https://doi.org/10.1007/s10103-022-03687-w
30. Ogbeivor, C., AlMubarak, H., Akomolafe, T., Alkahtani, H., AlMugizel, H., Marin, I., Aldosari, H., Aldhwayan, N., Mohamed, G.,&Alobthani, K. (2025). The effectiveness of radial shockwave therapy on myofascial pain syndrome: a two-armed, randomized double-blind placebo-controlled trial. BMC musculoskeletal disorders, 26(1), 413. https://doi.org/10.1186/s12891-025-08659-z
31. Arroyo-Fernández, R., Aceituno-Gómez, J., Serrano-Muñoz, D.,&Avendaño-Coy, J. (2023). High-Intensity Laser Therapy for Musculoskeletal Disorders: A Systematic Review and Meta-Analysis of Randomized Clinical Trials. Journal of clinical medicine, 12(4), 1479. https://doi.org/10.3390/jcm12041479
32. Song, H. J., Seo, H. J., Lee, Y.,&Kim, S. K. (2018). Effectiveness of high-intensity laser therapy in the treatment of musculoskeletal disorders: A systematic review and meta-analysis of randomized controlled trials. Medicine, 97(51), e13126. https://doi.org/10.1097/MD.0000000000013126
33. McCracken, L. M.,&Samuel, V. M. (2007). The role of avoidance, pacing, and other activity patterns in chronic pain. Pain, 130(1-2), 119–125. https://doi.org/10.1016/j.pain.2006.11.016
34. Takla M. K. N. (2018). Low-frequency high-intensity versus medium-frequency low-intensity combined therapy in the management of active myofascial trigger points: A randomized controlled trial. Physiotherapy research international : the journal for researchers and clinicians in physical therapy, 23(4), e1737. https://doi.org/10.1002/pri.1737
35. Fritz, J. M., George, S. Z.,&Delitto, A. (2001). The role of fear-avoidance beliefs in acute low back pain: relationships with current and future disability and work status. Pain, 94(1), 7–15. https://doi.org/10.1016/S0304-3959(01)00333-5
36. Glazov, G., Yelland, M.,&Emery, J. (2016). Low-level laser therapy for chronic non-specific low back pain: a meta-analysis of randomised controlled trials. Acupuncture in medicine : journal of the British Medical Acupuncture Society, 34(5), 328–341. https://doi.org/10.1136/acupmed-2015-011036
37. Xie, Y., Diao, Y., Wu, D., Liao, M.,&Liao, L. (2025). Immediate effects of high-intensity laser therapy for nonspecific neck pain: a double-blind randomized controlled trial. Frontiers in medicine, 12, 1550047. https://doi.org/10.3389/fmed.2025.1550047