

Effect of extracorporeal shockwave therapy on myofascial pain syndrome of upper trapezius: A systematic review

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ABSTRACT


Neck pain is highly prevalent condition, with myofascial pain syndrome (MPS) affecting 95% of people. Extracorporeal shockwave therapy (ESWT) being novel idea for this condition provides non-intrusive, less time consuming and tolerable sound electro physical therapy. The aim of the systematic review was to find and summarize the effectiveness of ESWT associated with different parameters on MPS of upper trapezius. Data were extracted from e-search engine, PubMed, research gate, semantic scholar, magonlinelibrary, Cochrane Library, Google scholar, and MedlinePlus. Systematic review design was done according to Problem, Intervention, Comparison, outcome, and time format, and systematic review was conducted according to PRISMA statement. List of keywords were searched and definite inclusion criteria were developed prior. Total 15 studies met the inclusion criteria. Descriptive analysis was done to find effectiveness of ESWT. Significant effectiveness of ESWT is found for the patients with MPS of upper trapezius. High-density focused ESWT is more significant results than others with pulses delivered minimum of 1000 per session. However, more high quality studies need to be done to conclude effectiveness of radial and combined ESWT.

KEY WORDS: Myofascial Pain Syndrome; Trigger Points; Trapezius; Extracorporeal Shortwave Therapy

INTRODUCTION

Neck pain is prevalent in 10–24% of the total population.^[1] Formation of hypersensitive nodules (myofascial trigger points-MTrPs) is called, myofascial pain syndrome (MPS) affecting up to 95% of people with chronic pain disorders.^[2] MPS also known as “Muscular rheumatism”, gives diffused pain affecting mainly deep somatic tissue.^[3] MPS of the upper trapezius has prevalence of 93.75% in neck pain participants, demonstrating MTrPs located right side (prevalence 82.1%) and left side (prevalence 79%) identified in the nearly-horizontal fibers of the upper trapezius muscle.^[4] A MTrPs is composed of numerous so-called contraction knots.^[5]

Physical mechanism of shockwave is having higher velocity than the speed of sound wave in the medium it propagates and then sudden, discontinuous change in pressure. On a general note, shockwave has up to 150 MPa pressure amplitude, up to –25 MPa low tensile wave, wide frequency ranging from approx. 150 kHz up to 100 MHz which is delivered with single pulse, small pulse width and a short rise time (few milliseconds).^[6] Two different types of extracorporeal shockwave therapy (ESWT) — focused ESWT (F-ESWT) and radial shockwaves (R-ESWT), differing in their mechanism of action, physical characteristics, and generation devices. However they share several indications. Principles of generation of F-ESWT are Electro-hydraulic sources, Electromagnetic sources, and Piezoelectric sources.^[7] In R-ESWT generators a pressure wave is produced and radically expands into the target tissue. Because of the too long rise times of the pressure pulses are too long and the too low pressure outputs, R-ESWTs do not produce shockwaves, but they may induce acoustic cavitation. Large areas are ideally treated by R-ESWT and Deep areas can be focused by using F-ESWT.^[7]

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Only one meta-analysis to our knowledge has studied the effect of ESWT effect on MPS. The five studies reviewed in this meta-analysis were analyzed for changes in pain intensity. Lee *et al.* compared F-ESWT in MPS which proved to be effective in reducing the pain scores (visual analog scale [VAS]), and concluded that the very low level of evidence that F-ESWT is effective for short-term relief of neck pain in MPS.^[8] However, other studies do exist. Hence, the aim of this systematic review was find and summarize effectiveness of ESWT associated with different parameters on MPS of the upper trapezius.

METHODOLOGY

Population/ Problem, Intervention, Comparison, Outcome, Time/Prognosis format was used to design the systematic review.^[9] Systematic review analysis was done according to PRISMA Checklist of items.^[10]

Literature Search

Following e-search databases were accessed while extracting the data: PubMed, Research gate, Semantic Scholar, Magonlinelibrary, Cochrane Library, Google Scholar, and MedlinePlus.

Keywords used for data search were trapezius pain, MPS (Disorder)/MPS, myalgia, Myofascial trigger point/trigger point/ MTrPs/TrP, shockwave, ESWT, focused shockwave therapy, and radical shockwave therapy. Screening of citations done accordingly and reports of potentially relevant studies were retrieved.

Inclusion and Exclusion Criteria

Databases which were found eligible during analyses included if the participants from the study were diagnosed with MPS, study used extracorporeal shockwave (radial/focused) in their treatment protocol, and article was published in peer-reviewed journal.

Any article or hypotheses based on relevant keywords were excluded if they did not show any data or statistical outcome. They were also excluded if the experiment was done on animal subjects. More above any literature reviews (systematic/ narrative/ meta-analysis) or case-reports were excluded even if they found relevant articles related to fibromyalgia or were published in language other than English were excluded.

Study Selection and Data Extraction

Independent screening of each article was done to eliminate chances of duplicity by the author. Each article was checked for inclusion and exclusion criteria. Full text analysis was done for the potentially relevant articles, abstracts providing

unclear results to avoid exclusion of the same. Variance in data extraction was resolved after discussing with other author. Eligible articles were selected according to the inclusion and exclusion criteria by doing full text analysis. Authors from this systematic review were single blinded to authors, institutions, or the publications. Manual checking for the references of the included articles was also done; among which one study found to be relevant to the inclusion criteria of the study which was assured that it is not from the previously listed databases.

Each study was analyzed thoroughly by the corresponding author and extracted the following data from each included article into predesigned data collection forms on Microsoft Excel sheet.

Microsoft Excel sheet on predesigned data collection was made by analyzing and extracting the following data from the selected articles by the corresponding author.

1. Study identification: First author's name, year of publication, study design, and country
2. Participants characteristics: Sample size, mean age, and numbers of male and female participants; diagnosis; and duration of symptom
3. Intervention group: Details of ESWT interventions such as intensity and frequency with control group, follow-up details
4. Primary outcome measures
5. Conclusion
6. Limitations.

Collected data were reviewed by second author. Any discrepancies found were resolved by second author. Fifteen studies which were found relevant and met the inclusion criteria were studied for analysis. Ji *et al.*,^[11] Gür *et al.*,^[12] Yanga *et al.*,^[13] Park *et al.*,^[14] Gezginaslan *et al.*,^[15] Lee and Han,^[16] Sukareechai *et al.*,^[17] Manafnezhad *et al.*,^[18] Luan *et al.*,^[19] Cho *et al.*,^[20] Khalil and Abdulla,^[21] Gur *et al.*,^[22] Aktürk *et al.*,^[23] Taheri *et al.*,^[24] Király *et al.*^[25]

Risk of bias in individual studies: Pedro scale was used to assess the bias in individual studies.^[26]

Summary measures are shown in Table 1.

Syntheses of results are shown in table.

Risk of bias across the studies was managed by blinding of the authors.

RESULTS

Study Selection

Selection of data was based on the 2029 digital literature search. After elimination, by checking title, abstract and

Table 1: Characteristics of study

Study	Study design, country, year	Sample size total (GRP1+2+3)	Age (years)		Treatment		Outcome measures	
			GRP1	GRP2	GRP3	Group 1		Group 2
Ji <i>et al.</i> ^[11]	Experimental study, Korea, 2012,	20 (9+11)	32.82±12.71	34.00±15.56		ESWT 700 impulses (taut band) 300 impulses (surrounding area) 0.056 mJ/mm ² (low energy) Total four sessions 2 sessions/week (for 2 weeks)	ESWT 700 impulses (taut band) 300 impulses (surrounding area) 0.001 mJ/mm ² (ineffective level) Total four sessions 2 sessions/week (for 2 weeks)	VAS, PPT. Follow-up duration pre and after attending four session
Gür <i>et al.</i> ^[12]	Experimental study, Turkey, 2014	62 (30+32)	35.90±11.57	37.00±11.51		ESWT Energy Density=0.25 mJ/mm ² 1000 impulses single session ESWT 10 min	ESWT Energy Density=0.25 mJ/mm ² 1000 impulses 3 sessions ESWT with 1 week interval between each session	PGA, MDGA, NPDS, NHP, VAS, PGA, HAM-A. follow-up duration Pre, 3 weeks, 12 weeks (3 months)
Lee <i>et al.</i> ^[13]	RCT, Korea, 2014	52 (26+26)	29.27 ±5.65	25.96±3.56		High ESWT 4Hz Intensity Level 10 (0.351 mJ/mm ²) 500 ant and post. Side (1000 pulses)	Low ESWT 4Hz Intensity Level 1 (0.092 mJ/mm ²) 500 ant and post. Side (1000 pulses)	VAS, PPT. Follow up duration. immediate pre and post data collection
Park <i>et al.</i> ^[14]	RCT, Korea, 2018	30 (15+15)	32.60±6.62	32.07±12.58		High ESWT 0.210 mJ/mm ² 1500 pulses. Once a week for 2 weeks	Low ESWT 0.068 mJ/mm ² 1500 pulses Once a week for 2 weeks	Vitiligo noticeability scale, PPT, routine outcome monitoring, NDI. Follow-up duration pre and post
Gezginaslan <i>et al.</i> ^[15]	RCT, Turkey, 2019	94(49+45)	45.0±12.0	43.3±11.9		0.26 mJ/mm ² (7 sessions) 500 pulses per trigger point 1500-4500 pulses + trapezius stretching	Traditional modalities (hot pack, Tens, US) (5 days/week for 2 weeks) + trapezius stretching	VAS, SF36, PSQI, FACIT, NDI, and BDI. Follow up duration pre and post
Lee and Han ^[16]	Experimental study, Korea, Experimental School, 2012	33 (11+11+11)	51.61±8.3	51.92±7.53	52.67±7.58	20 min hot pack + 5 min US, ESWT 5 Hz 1000 impulses Using 17-mm gun and low power Twice per week for 4 weeks 8 sessions	20 min hot pack+ 5 min US Twice per week for 4 weeks for a total of 8 treatment sessions	VAS, PPT, NDI, CMS follow-up duration pre and 4 week (1 month) twice per week for 4 weeks for a total of 8 treatment sessions

(Contd...)

Table 1: (Continued)

Study	Study design, country, year	Sample size total (GRP1+2+3)	Age (years)		Treatment			Outcome measures	
			GRP 1	GRP 2	GRP3	Group 1	Group 2		Group 3
Sukareechai and Sukareechai ^[17]	Experimental study, Thailand, 2019	42 (21+21)	38.2±11.9	42.7±12		Radial ESWT 12 Hz and peak pressure of 1–2 bar for 300 pulses at each trigger point (Self-stretch of Trap, rhomboids, infraspinatus muscle twice a day for 3 weeks) once a week for three weeks	Dry needling 0.25 × 50 Dong Bang needle, (multiple needle entry technique) (self-stretch of trap, rhomboids, infraspinatus muscle twice a day for 3 weeks) once a week for 3 weeks	NPRS, PPT. Follow-up duration pre and weeks 1, 2, and 3	
Manafnezhad et al. ^[18]	Single blind RCT, Iran, 2019	70 (35+35)	37±9.1	39.2±7.2		Radial ESWT 1000 impulses power of 60 mj/mm ² , fre-172 quency of 16 Hz, a 15-mm applicator. Once a week for 3 weeks	deep DN and fast-in and fast-out needling technique (0.03–50 mm – Dung Bang) Once a week /3 weeks	NPRS, PPT, NDI. Follow-up duration NPRS after each session NPRS, PPT, NDI pre and after 4 week	
Luan et al. ^[19]	Randomized trial, China, 2019	62 (30+32)	32.47±10.58	33.09±12.78		Radial ESWT 0.10 mj/mm ² 2000 shocks (1500 trigger point 500 surrounding). Once a week for 3 weeks	Dry needling needle of 0.30 mm in diameter and 50 mm. Once a week for 3 weeks	VAS, NDI, PPT, sonoelastograph. Follow up duration Pre, post, 1 month, 3 month	
Khalil et al. ^[21]	Experimental study, Korea, 2012	36 (12 Combination group + 12 ESWT group + 12 stabilization group)	48.08±12.24	47.06±13.53	47.67±10.49	ESWT + Stabilization (combine group). 3 times a week for 4 weeks	ESWT group low level of 0.12 mj/mm ² energy (1000 impulses). 3 times a week for 4 weeks	Shoulder stabilization exs 3 sets of 10 repetitions with 10 s hold. 3 times a week for 4 weeks	VAS, NDI, PPT, CMS, follow up duration Pre, post, 1 month ,3 month
Khalil et al. ^[21]	Randomized controlled, UAE, Egypt, 2018	60 (30+30)	41.5±8.46	39.77±8.88		Focus ESWT trigger point 4 Hz 0.25mj/mm ² 1000 shocks Radial shockwave :surrounding + trigger point 15 Hz 2.5 bar pressure 0.1 mj/mm ² 4000 shocks (once a week) 4 weeks	US 1.5 watt/cm2 1 MHz cont. mode 8 min 3 times a week (12 sessions) 4 weeks	Number of trigger points, VAS (local, referred), NDI, tenderness grading scale, CMS, HAM-A Follow up duration. pre and post	

(Contd...)

Table 1: (Continued)

Study	Study design, country, year	Sample size total (GRP1+2+3)	Age (years)		GRP3	Treatment		Outcome measures
			GRP1	GRP2		Group 1	Group 2	
Gur <i>et al.</i> ^[22]	RCT; Turkey, 2013	59 (30+29)	37.00±11.51	35.07±12.23		ED=0.25 mJ/mm ² , 1000 shock wave (3 days interval) (3 sessions)	US=1.5 Wt/cm ² , pulsed, 1 MHz, 5 min, 5 days a week for 2 weeks (10 sessions)	Number of trigger points, PGA, MDGA, NPAD, HAM-A, NHP. Follow-ups pre, 3 weeks, 12 weeks (3 month)
Aktürk ^[23]	randomized, sham-controlled study, Turkey, 2018	60 (20+20+20)	33.45±8.02	35.45±8.07	35.65 ± 11.03	ESWT:1.6–3.0 bar, 200–400 shocks/trigger point, total of 2,000–3,000 shock/session, maximum 3 min/ (3 days interval) (traction+ stretching + isometric exs)	4 sessions sham ESWT 1.0–1.3 bar for 3 min/session (3 days interval) (traction + stretching + isometric exs)	US: 2 weeks for 5 days a week for a total of 10 sessions, 5 min, 1.5 W/cm ² (traction + stretching + isometric exs)
Taheri <i>et al.</i> ^[24]	Experimental study, Iran, 2018	46 (26+20)	45.3±7.7	42.3±10.4		Three session of radial shock wave therapy in addition to stretching exercises, and medication. 1000 impulse and 3 J/m ² and 10 Hz frequency drug therapy + upper trapezius stretching 30 s 3 repetitions for 3 times a day) 2 weeks	10 sessions of LLLT in addition to stretching exercises and medication 6 J/cm ² , average power 100 mW, 3 min on each spot (drug therapy + upper trapezius stretching 30 s 3 repetitions for 3 times a day) 2 weeks	VAS, NDI, and shoulder pain and disability index Follow up duration was pre, post and 4 weeks after the treatment
Király <i>et al.</i> ^[25]	Experimental study, Hungary, 2018	61 (30+31)	57.26±14.31	62.62±9.62		Once weekly, altogether 3 times, 1000 impulses in around the region of the trigger point, 1.5 bar, 10 Hz, energy density: 0.25 mJ/mm ² followed by 1000 impulses, 2 bar, 10 Hz, energy density: 0.25 mJ/mm ²	Once daily, altogether 15 times (on 15 work days) 2000 Hz (800 mW), 3 J/cm ² around the trigger point for 2 min, 5000 Hz (2000 mW), 9 J/cm ² , for 2 min) on trigger point	100 mm VAS, NDI, SF-36, need for painkiller medication, follow up duration at pre, post and week 15

PGA: Patient global assessment, MDGA: Physician global assessment, NPDS: Neck pain and disability scale, NHP: Nottingham health profile, HAM-A: Hamilton anxiety scale, FACIT: Functional Assessment of Chronic Illness Therapy-Fatigue Scale, VAS: Visual analog scale, SF-36: Short form-36; PSQI: Pittsburgh sleep quality index, BDI: Beck depression inventory, HADS: Hospital anxiety and depression scale, NDI: Neck disability index, CMS: Constant-Murley score

keywords 24 studies were included; nine of these were eliminated which did not meet the inclusion/ exclusion criteria; total 15 studies were selected for Systematic Review Analysis. Selection of studies is presented in Figure 1 by prisma flow.^[10]

Study Characteristics

Table 1 shows characteristics of 15 included studies below. Included studies were published in between year of 2013 and 2019. Studies were randomized control trial, experimental study, randomized, or clinical trial. Total participants in these 15 studies were 787. Among them patients undergone ESWT were 459 (58.32%), 31 (3.94%) received placebo/sham ESWT, and 297 (37.74%) patients were treated as conservative group. Among 459 persons who received ESWT 267 (58.17%) patients received F-ESWT and 162 (35.3%) patients received R-ESWT and 30 (6.54%) patients received combined R-ESWT and F-ESWT. Total 18 different outcome measures were used in selected 15 studies. Each study has minimum one outcome measure for pain intensity VAS, numerical pain rating scale (NPRS), Vitiligo Noticeability Scale (VNS), patient global assessment, and physician global assessment. Only one study has neck routine outcome monitoring (ROM) as their outcome measure. Besides these, there were Nottingham Health Profile, Pittsburgh sleep quality index, Hamilton anxiety scale, neck disability index (NDI), Constant-Murley score (CMS), neck pain and disability scale, short form-36, hospital anxiety and depression scale, shoulder pain, and disability index, trigger point pain score, tenderness grading scale, and number of TPs as outcome measures. However, pain pressure threshold (PPT) was also one of the frequently used outcome measure for MPS in 15 studies.

Furthermore, five studies were assessed as having longest follow-up duration of 3 months after the completion of the last treatment sessions, which is helpful to note long-lasting effect of ESWT.^[12,19,20,22,25] Three studies have 1 month period of follow-up duration after taking baseline data,^[18,23,24] six studies reported no follow-up data collection, only post-treatment statistics were reported.^[11,14-17,21] However, one study reported immediate effect of ESWT on MPS after one session.^[13]

Risk of bias with in the studies: It is demonstrated by Pedro scaling in Table 2.^[26]

Results of individual studies are shown in Table 1.

Synthesis of results

Ji *et al.* stated that effect of ESWT on myofascial pain relief of trapezius showed lowering in VAS and increase in PPT. However, no significant difference between groups before therapy and significant difference after therapy was also stated.^[11] Treatment showed significant difference within the group when compared which shows effectiveness of the ESWT.^[11] Gür *et al.* reported reduction in the number of TPs and improved QOL, anxiety scores in two different protocols. However, triple session group showed high significance at week 3 comparing it to another group in pain alleviation, reducing number of TPs with improving scores in QOL.^[12]

HIGH VERSUS LOW ENERGY ESWT

Lee *et al.* reported that effect of high and low ESWT was significant within the group but values were not significant

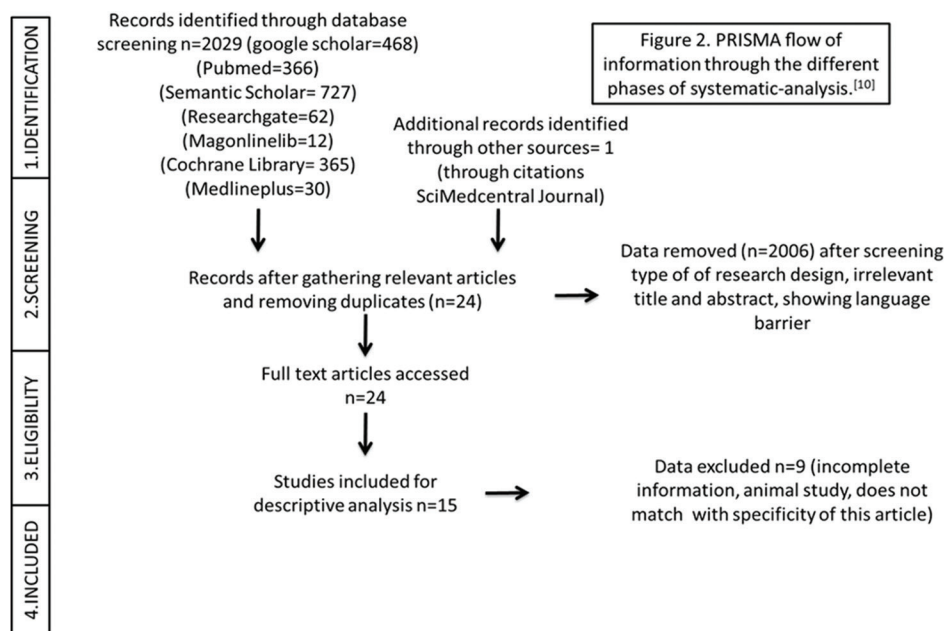


Figure 1: Selection of studies

Table 2: Pedro scale

Study/Qt	1	2	3	4	5	6	7	8	9	10	11
Ji <i>et al.</i> ^[11]	Y	Y	N	Y	Y	N	N	Y	N	Y	Y
Gür <i>et al.</i> ^[12]	Y	Y	N	N	N	N	N	Y	N	N	Y
Lee <i>et al.</i> ^[13]	Y	Y	N	Y	Y	N	N	Y	Y	Y	Y
Park <i>et al.</i> ^[14]	Y	Y	Y	Y	N	Y	Y	Y	N	Y	Y
Gezginaslan <i>et al.</i> ^[15]	Y	Y	Y	N	N	N	Y	Y	N	Y	Y
Lee and Han ^[16]	Y	Y	N	Y	N	N	N	Y	Y	Y	Y
Sukareechai and Sukareechai ^[17]	Y	Y	N	Y	N	N	N	Y	Y	Y	Y
Manafnezhad <i>et al.</i> ^[18]	Y	Y	N	Y	N	Y	Y	Y	N	Y	Y
Luan <i>et al.</i> ^[19]	Y	Y	Y	Y	N	Y	Y	Y	N	Y	Y
Cho <i>et al.</i> ^[20]	Y	Y	Y	N	N	N	N	Y	Y	Y	Y
Khalil <i>et al.</i> ^[21]	Y	Y	N	Y	N	Y	Y	Y	Y	Y	Y
Gur <i>et al.</i> ^[22]	Y	Y	N	Y	N	Y	Y	Y	N	Y	Y
Aktürk ^[23]	Y	Y	N	Y	N	N	N	Y	Y	Y	Y
Taheri <i>et al.</i> ^[24]	Y	Y	N	Y	N	N	N	Y	N	Y	Y
Király <i>et al.</i> ^[25]	Y	Y	Y	Y	N	Y	Y	Y	N	Y	Y

1. Eligibility criteria were specified, 2. Subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated an order in which treatments were received), 3 Allocation was concealed, 4. The groups were similar at baseline regarding the most important prognostic indicators, 5. There was blinding of all subjects, 6. There was blinding of all therapists who administered the therapy, 7. There was blinding of all assessors who measured at least one key outcome, 8. Measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups, 9. All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analyzed by “intention to treat”, 10. The results of between-group statistical comparisons are reported for at least one key outcome, 11. The study provides both point measures and measures of variability for at least one key outcome

between the groups post-treatment. Difference between the averages of the PPT was higher in the high energy group and eventually they calculated effect sizes which were 0.45 (low effect size) and 0.61 (medium effect size) for low and high energy group. According to medium effect size they stated that the high energy group is more effective.^[13] Park *et al.* reported improvement in the both group neck ROM (lateral bending to the affected side and sound side, and rotation to the sound side), VNS, NDI, and PPT. Except for low energy group, high energy group had improvement in Neck ROM of flexion and extension with statistical significance. Post-treatment significant effectiveness was reported between the groups on neck flexion ROM and NDI.^[14]

ESWT versus electromodalities

Gezginaslan *et al.* stated significant relationship between the changes in the VAS scores and changes in the NDI, functional assessment of chronic illness therapy, Pittsburgh sleep quality index, and beck depression inventory scores after the treatment in the ESWT group.^[15]

Peripheral neuromuscular facilitation (PNF), ESWT, trigger point injection (TPI)

Lee and Han reported no significant differences for pre-treatment measures VAS, PPT, NDI, and CMS among both groups no significant differences among the groups for PPT, but VAS, CMS, and NDI were statistically significant among the groups. They again reported that the there is no statistical

difference between ESWT and TPI.^[16] However, Gezginaslan *et al.* and Lee and Han reported remarkable effect of H-ESWT on pain and functional outcome measure.^[15,16]

Shockwave versus dry needling

Sukareechai and Sukareechai stated no significant between-group difference in PPT pre-treatment at the three trigger points. Radial shockwave therapy was significant for upper trapezius and infraspinatus trigger point post-treatment, whereas significant values for only upper trapezius TPs were found. However, they stated that overall pain alleviation was less significant for both the groups post-treatment. They reported high pain reduction for deep needling, which was not statistically significant. Moreover, author mentioned that no complications were reported for ESWT group while deep needling group reported many complications.^[17]

Manafnezhad *et al.* reported that outcome measures PPT, NPRS, and NDI between the groups have no statistically significant difference. However, PPT increased and NPSP decreased and NDI improved in the group. They concluded that the dry needling and ESWT are same for pain reduction and functional ability.^[18] Luan *et al.* reported long-term effectiveness of ESWT and DN treatment on the upper trapezius MTrPs. Positive effects on observation of VAS, PPT, NDI, and sonoelastography of MTrPs for both treatment groups were noted. They concluded that the ESWT and DN both have similar effects on MPS of upper trapezius.^[19]

ESWT, stabilization exercises, combined approach

Cho *et al.* reported statistically significant improvements. CMS evaluation item of pain was improved significantly in the ESWT group, stating pain reduction in MPS. They concluded their studies by stating that the more positive effects can be produced by combining ESWT and shoulder stabilization exercises for reduction in pain and improving functional outcomes.^[20]

ESWT versus US

Khalil *et al.* reported positive results in functional outcomes, pain, and anxiety for both groups (four sessions of ESWT and 12 sessions of US). ESWT group reported more significant level of improvement and patients' satisfaction.^[21] Gur *et al.* concluded the same results in their studies stating ESWT to be effective and reliable than US in patients with trapezius MPS.^[22] Aktürk *et al.* reported US and ESWT to be more effective than sham-ESWT; however, they concluded US and ESWT having same effectiveness, which is conflicting with the above two studies.^[23]

ESWT versus low-level laser therapy (LLLT)

Taheri *et al.* concluded that LASER has quick and ideal results but overall ESWT and LLLT provide similar effect in long-term for pain reduction.^[24] Király *et al.* reported significant measures for both group; resting pain, PPT, NDI, and SF-36 demonstrated comparatively high significant improvements for shockwave group which is again conflicting with the previous included study with reporting no side-effects.^[25]

Risk of bias across the studies was avoided by blinding.

Sensitivity or subgroup analysis was not done.

DISCUSSION

This systematic review article has mainly focused on the current available data for implications of ESWT on MPS of upper trapezius. Our aim was to provide data for pain reduction as well as effect on functional ability, ROM, and QOL. Table for different doses and treatment protocol was also created to highlight the use of effective ESWT protocol for MPS of trapezius [Table 3].

To summarize all the findings, ESWT is more effective than PNF, shoulder stabilization exercises and ultrasound. ESWT is equally effective to TPI and dry needling. Effectiveness of ESWT was reported in two placebo/sham treatments; high energy density ESWT was more effective for MPS in trapezius than low energy ESWT. Increased frequency of sessions with appropriate gap in between is more beneficial than single session treatment.^[12] However, long-term effect (3 months) of ESWT has also been reported in five studies out of 15 (other ten studies did not follow-up for a duration of

3 months); among them four studies used F-ESWT produced more significant effect, while one study had used R-ESWT produced similar significant effect with other conventional therapy. Above all Cho *et al.* reported ESWT combined with traditional exercise therapy will significantly improve muscle property function when checked through CMS scale.^[20] Gleitz also gave statement that ESWT is beneficial in refractory cases having MPS, with 5–10 cm penetration capacity of F-ESWT.^[27]

However, ultrasound and LASER were found to have conflicting results. Significant effect of ESWT compared with LLLT might be because of parameters used by Király *et al.*^[25] who showed more bar pressure with quite more pulses delivery, as all other parameters were same between both studies.^[24,25] Furthermore, use of R-ESWT by Aktürk *et al.* might be the reason behind conflicting results, as other two studies had used F-ESWT and combined ESWT.^[21,22] Up to date, this is the first systematic review conducted to find effectiveness of both type of ESWT on all available parameters.

Inconsistent and heterogenic results for ESWT might be on account of lack of proper evidences for different parameters as ESWT follows dose-dependent effectiveness. Moreover, the Conjoint Physics Working Group of International Society for Medical Shockwave Treatment (ISMST) and DIGEST have recommended on ESWT study design and publication, to mention all necessary parameters with model details. In our review, we found that the penetration depth details of head and pulses repetition rates were the two parameters which were not mentioned in few studies.^[28]

ESWT produces changes within the cells due to transformation of the mechanical signal into molecular biological signal. (Principal: mechanotransduction)^[29] There are mainly three hypothesis proposed behind principle of ESWT stating increase in circulation of blood vessels and reduction in overstimulation of nociceptors and nerves helps to reduce stiffness and tension of muscle fibers,^[29] specific destruction of non-myelinated muscle fibers and producing a transient dysfunction in excitability of nerve fiber at the neuromuscular junction, resulting in reduction of pain, effectivity in reducing substance P level in target tissue increasing synthesis of substance in dorsal root ganglia,^[30,31] perpendicular propagation of ESWT waves break up links formed between actin-myosin.^[32]

ISMST has given guidelines for treatment protocols which states that the MPS can be treated by ESWT.

- F-ESWT: EFD: 0.05–0.35 mJ/mm² Interval: 1–2 × week Frequency: 4–5 Hz 2000–4000 pulses per session, 300–400 pulses per MTrP 3–8 treatments
- R-ESWT: Energy up to 2.5 bar Interval: 1–2 × week Frequency: Up to 10 Hz 2000–4000 pulses per session 3–8 treatments
- Coupling medium: Ultrasound gel no local anesthesia

Table 3: Different doses and treatment protocol of ESWT

Study	Type of ESWT	Energy density	Pulses	Frequency
Ji <i>et al.</i> ^[11]	Focused	0.056 mJ/mm ²	700 (taut band) 300 (surrounding)	2 times a week for 2 weeks (4 sessions)
	Focused (sham protocol)	0.001 mJ/mm ²	700 (taut band) 300 (surrounding)	2 times a week for 2 weeks (4 sessions)
Gür <i>et al.</i> ^[12]	Focused	0.25 mJ/mm ²	1000	10 min once
	Focused	0.25 mJ/mm ²	1000	10 min once for three sessions between the 1 week gap for each
Lee <i>et al.</i> ^[13]	PiezoWave focused	4 Hz 0.351 mJ/mm ²	1000	Single session
	PiezoWave focused	4 Hz 0.092 mJ/mm ²	1000	Single session
Park <i>et al.</i> ^[14]	Focused	0.210 mJ/mm ²	1500	Once a week for 2 weeks
	Focused	0.068 mJ/mm ²	1500	Once a week for 2 weeks
Gezginaslan <i>et al.</i> ^[15]	Focused	0.26 mJ/mm ² 1.5–3 bar pressure	500 pulses per trigger point (1500–4500 pulses in one session)	7 sessions with 3 days gap in between of each session
Lee and Han ^[16]	Focused	Low energy density 5 Hz	1000 TPs	Twice per week for 4 weeks 8 sessions
Sukareechai and Sukareechai ^[17]	Radial pneumatic	12 Hz and peak pressure of 1–2 bar	300 per each TPs (did not exceeded 6000)	Once a week (3 weeks) 3 sessions
Manafnezhad <i>et al.</i> ^[18]	Radial	60 mJ, frequency of 16 Hz	1000	Once a week (3 weeks) 3 sessions
Luan <i>et al.</i> ^[19]	Radial	0.10 mJ/mm ²	2000(1500 TPs+500 surrounding)	Once a week (3 weeks) 3 sessions
Cho <i>et al.</i> ^[20]	Focused	0.12 mJ/mm ²	1000	3/week for 4 weeks (12 sessions)
Khalil <i>et al.</i> ^[21]	Focus+radial	0.25 mJ/mm ² 4 Hz (focus) (TPs) 15 Hz 2.5 bar pressure	1000 (focus) (TPs) 4000 (radial) (surrounding)	4 weekly
Gur <i>et al.</i> ^[22]	Focused	0.25 mJ/mm ²	1000	3 sessions in between the gap of three days for each session
Aktürk ^[23]	Radial	1.6–3.0 bar	200-400 per RPs(total 2000-3000)	4 sessions for 3 min with gap of 3 days between each session
	Sham ESWT	1.0–1.3 bar	No application of waves	4 sessions for 3 min with gap of 3 days between each session
Taheri <i>et al.</i> ^[24]	Radial	3 J/m ² and 10 Hz frequency	1000	3 sessions (upper trapezius stretching+ medication)
Király <i>et al.</i> ^[25]	Radial	1.5 bar, 10 Hz, 0.25 mJ/mm ² (surrounding) 2 bar, 10 Hz(TPs)	1000(surrounding) 1000(TPs)	3 session , once a week

- No other side effects can be produced by ESWT beside vegetative reaction (e.g., sweating, and circulatory reaction).^[33]

Limitations

Heterogeneity of data and lack of availability for appropriate parameter details used by studies was the major limitation of our systematic review. Inclusion of only English written articles was the other limitation; some studies written in other languages may be missed because of language barrier. Inclusion of non-RCT studies was another factor. However, for this, we performed quality assessment of all included studies to overcome risk of bias. Another limitation was

to fail to summarize effect on disease duration. This study included studies having effects of ESWT combined with drug therapies, which might have given overlapping results with effect of drug therapies.

Future Studies

Studies can be done for particular treatment parameters (energy density, number of pulses per session, pulse repetitions rates, penetration depth, and number of sessions) to check more accurate effectiveness of ESWT on MPS. Other outcome measures can be included which conclude effect on ROM and muscle strength.

CONCLUSION

We found ESWT to be effective in patients with MPS in the upper trapezius, more beneficial when used with high energy density F-ESWT, minimum of 700–1000 pulses delivered. Effect of R-ESWT showed similar effects; however, further studies needed to eliminate heterogeneity (on outcome measures and treatment parameters and results reporting) and conclude more reliable results. Only one study was found which compared combined effect of R-ESWT and F-ESWT, further research needs to be done for this protocol also. Long-term effect of ESWT has been reported up to 3 months. ESWT might be more beneficial modality when it is used in place of other traditional electro modalities; however, effect of modern techniques and modalities might walk parallel with ESWT.

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