VER
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A Comprehensive Systematic Review of Effect of Extracorporeal Shockwave Therapy on the Pain, Functional Capacity and Quality of Life in Patients with Chronic Low Back Pain

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ABSTRACT

Introduction: Chronic low back pain (CLBP) is a prevalent and debilitating condition with significant socioeconomic impact, often refractory to conventional treatments. Extracorporeal shockwave therapy (ESWT) has emerged as a promising non-invasive modality, but its overall efficacy, optimal protocols, and comparative effectiveness for CLBP require comprehensive synthesis (Çelik, Altan & Ökmen, 2019; Yue et al., 2021).

Methods: A systematic review of 67 studies, including randomized controlled trials (RCTs) was conducted. Studies involving adult patients with CLBP (≥12 weeks) receiving ESWT as a primary intervention were included. Data on pain (VAS, NRS), functional capacity (ODI, Roland-Morris), quality of life (SF-36, HADS), safety, and protocol parameters (type, energy, pulses) were extracted and synthesized (Liu et al., 2023; Wu et al., 2023).

Results: ESWT demonstrated statistically and clinically significant reductions in pain intensity (e.g., VAS MD = -1.14 to -2.37) and improvements in functional disability (e.g., ODI MD = -6.01 to -14.10), with benefits sustained up to 12 months in some studies (Nedelka et al., 2025; Rajfur et al., 2022). Quality of life, particularly physical domains and depression scores, also improved (Çelik, Altan & Ökmen, 2019; Han et al., 2015). ESWT showed a favorable safety profile with mostly minor, transient adverse events. Comparative effectiveness varied: ESWT was superior to conventional physical therapy and sham, comparable to laser therapy, but sometimes less effective than manual therapies like Maitland mobilization or mechanical traction in specific contexts (Ejaz et al., 2024; Kızıltaş et al., 2022).

Discussion: The therapeutic effects of ESWT are mediated by biological mechanisms including neovascularization, tissue regeneration, and pain gate modulation. Outcome heterogeneity is explained by variations in ESWT protocols (focused vs. radial, energy density), patient selection (specific vs. non-specific CLBP), and the presence of co-interventions like exercise. Focused ESWT with moderate energy (0.15-0.35 mJ/mm²) targeting identifiable pain generators (e.g., myofascial trigger points, facet joints) within a multimodal rehabilitation framework appears most effective (Sun et al., 2022; Ferdinandov, 2024).

Conclusion: ESWT is an effective, safe, and non-invasive therapeutic option for CLBP, providing meaningful relief in pain, function, and quality of life. It is best applied as part of a multimodal strategy for patients with identifiable musculoskeletal pain generators who have not responded to first-line treatments. Future research should standardize protocols and focus on long-term outcomes and cost-effectiveness.

KEYWORDS: Extracorporeal Shockwave Therapy, Chronic Low Back Pain, Pain Management, Functional Capacity, Rehabilitation, Non-invasive Treatment.

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INTRODUCTION

Background

Chronic low back pain (CLBP), defined as pain persisting for 12 weeks or more, represents a leading cause of global disability, incurring substantial personal suffering and socioeconomic costs (Wu et al., 2023). Its multifactorial etiology, often categorized as non-specific, involves complex interactions between biomechanical, neurophysiological, and psychosocial factors, making management challenging (Yue et al., 2021). While first-line treatments include pharmacotherapy, physical therapy, and exercise, a significant proportion of patients experience inadequate relief or adverse effects, creating a demand for effective alternative interventions (Liu et al., 2023).

Extracorporeal shockwave therapy (ESWT), initially developed for lithotripsy, has been repurposed for various musculoskeletal conditions. It delivers acoustic waves that generate mechanical forces at targeted tissues, proposed to induce biological responses such as neovascularization, release of growth factors, reduction of substance P, and disruption of pain receptor sensitization (Walewicz et al., 2019; Rajfur et al., 2022). Its application in CLBP has gained traction due to its non-invasive nature and potential to address underlying pathological processes in muscles, fascia, tendons, and joints associated with chronic pain (Ferdinandov, 2024).

Research Gap

Despite growing literature, the evidence on ESWT for CLBP remains heterogeneous and fragmented. Key knowledge gaps persist regarding: 1) the optimal ESWT technical parameters (type, energy, frequency, pulses) for CLBP; 2) its comparative effectiveness against other active interventions (e.g., manual therapy, injections, laser); 3) the durability of its effects beyond short-term follow-up; 4) its impact on psychological dimensions of quality of life; and 5) which patient subgroups (e.g., those with myofascial pain, facet joint syndrome) benefit most (Çelik, Altan & Ökmen, 2019; Notarnicola et al., 2018). Previous reviews often focus on specific subtypes or have not fully reconciled conflicting findings from studies with diverse methodologies.

Novelty

This comprehensive systematic review synthesizes evidence from 67 recent and diverse studies, including large-scale meta-analyses and RCTs comparing ESWT with a wide array of active comparators. It provides a detailed analysis of how protocol variability (radial vs. focused, energy density, session number) influences outcomes. Furthermore, it critically examines the role of co-interventions and patient stratification, offering a nuanced understanding of ESWT's place within a multimodal treatment paradigm for CLBP, which has been less emphasized in prior syntheses.

Research Objectives

The primary objectives of this review are: 1) To evaluate the efficacy of ESWT on pain intensity, functional capacity, and quality of life in patients with CLBP; 2) To assess the safety and adverse event profile of ESWT; 3) To compare the effectiveness of ESWT with other therapeutic modalities; 4) To investigate the influence of ESWT protocol parameters and co-interventions on treatment outcomes; and 5) To identify characteristics of patient populations that derive the greatest benefit from ESWT.

Research Hypotheses

It is hypothesized that: 1) ESWT will demonstrate statistically and clinically significant improvements in pain and function compared to sham or passive control groups; 2) The magnitude of benefit will be influenced by ESWT type and energy parameters, with focused, moderate-energy protocols showing superior outcomes; 3) ESWT will have a favorable safety profile with minimal serious adverse events; 4) ESWT will show non-inferiority or superiority to several conventional physical therapy modalities but may show variable results compared to invasive procedures like injections; and 5) Benefits will be more pronounced and sustained in patients with specific, identifiable musculoskeletal pain generators.

Significance of the Study

This study holds significant clinical and scientific value. Clinically, it aims to provide evidence-based guidance for healthcare practitioners on the appropriate application, protocol selection, and patient selection for ESWT in CLBP management, potentially offering a valuable non-invasive option for refractory cases. Scientifically, it consolidates a large body of heterogeneous research, clarifies sources of outcome variability, and identifies critical directions for future standardized, high-quality RCTs to optimize this promising therapy (Zhang et al., 2025; Hassan et al., 2025).

METHODS

Protocol

The study strictly adhered to the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) 2020 guidelines to ensure methodological rigor and accuracy. This approach was chosen to enhance the precision and reliability of the conclusions drawn from the investigation.

Criteria for Eligibility

This systematic review aims to evaluate effect of extracorporeal shockwave therapy on the pain, functional capacity and quality of life in patients with chronic low back pain.

Screening

We screened in sources based on their abstracts that met these criteria:

- **Chronic Low Back Pain Population**: Does this study include adult participants (≥18 years) diagnosed with chronic low back pain (duration ≥12 weeks or longer)?
- **ESWT Primary Intervention**: Does this study evaluate extracorporeal shockwave therapy (ESWT) as the main or primary therapeutic intervention?
- **Relevant Outcome Measures**: Does this study measure at least one of the following outcomes using validated instruments: pain intensity, functional capacity, or quality of life?
- **Appropriate Study Design**: Is this study either a randomized controlled trial (RCT) or a systematic review/meta-analysis?
- **Human Participants**: Is this study conducted on human participants (not animal or in-vitro studies)?
- **Chronic Pain Duration**: Does this study focus on chronic low back pain (≥12 weeks duration) rather than acute or subacute pain (<12 weeks)?
- **Specific Population Data**: If this study includes mixed pain populations, does it provide separate data or analysis specifically for chronic low back pain patients?

- **Non-Specific Low Back Pain**: Does this study focus on non-specific chronic low back pain (excluding pain due to cancer, fractures, infections, or inflammatory conditions as the primary focus)?

We considered all screening questions together and made a holistic judgement about whether to screen in each paper.

Search Strategy

The keywords used for this research based PICO :

Element	P (Population)	I (Intervention/Exposure)	C (Comparison/Context)	O (Outcome)
Keyword 1	Chronic Low Back Pain	Extracorporeal Shockwave Therapy	Sham ESWT	Pain Intensity
Keyword 2	Non-specific Low Back Pain	Shock Wave Therapy	Conventional Physical Therapy	Functional Disability
Keyword 3	Mechanical Low Back Pain	ESWT	Trigger Point Injection	Quality of Life
Keyword 4	Lumbar Degenerative Disorders	Radial / Focused Shockwave	Exercise Therapy	Oswestry Disability Index

The Boolean MeSH keywords inputted on databases for this research are: *("Chronic Low Back Pain" OR "Non-specific Low Back Pain" OR "Mechanical Low Back Pain" OR "Lumbar Degenerative Disorders") AND ("Extracorporeal Shockwave Therapy" OR "Shock Wave Therapy" OR "ESWT" OR "Radial ESWT" OR "Focused ESWT") AND ("Sham ESWT" OR "Conventional Physical Therapy" OR "Trigger Point Injection" OR "Exercise Therapy" OR "Standard Care") AND ("Pain Intensity" OR "Functional Disability" OR "Quality of Life" OR "Oswestry Disability Index" OR "VAS Score")*

Data extraction

- **ESWT Intervention Details**:
  Extract comprehensive details about the extracorporeal shockwave therapy intervention for chronic low back pain, including:
  - Type of ESWT (focused, radial, or other)
  - Energy density/intensity (mJ/mm²)
  - Number of pulses per session
  - Frequency (Hz)
  - Number of treatment sessions
  - Treatment interval (daily, weekly, etc.)
  - Anatomical target areas (lumbar spine levels, sacral, etc.)
  - Device specifications if provided
  - Any protocol modifications or variations
- **Patient Population**:
  Extract characteristics of patients with chronic low back pain, including:
  - Sample size and demographics (age, gender)
  - Definition of chronic low back pain used (duration criteria)
  - Specific diagnosis or etiology (disc disease, non-specific, etc.)
  - Pain duration and baseline severity
  - Inclusion and exclusion criteria
  - Previous treatments or chronicity factors
  - Any subgroup analyses performed
- **Study Design**:
  Extract study design characteristics relevant to assessing ESWT effectiveness for chronic low back pain:
  - Study type (RCT, etc.)
  - Randomization method and allocation concealment
  - Blinding procedures (patient, assessor, provider)
  - Control/comparison group type (sham ESWT, conventional therapy, placebo, waitlist)
  - Details of sham or control procedures
- **Co-interventions**:
  Extract all additional treatments or interventions provided alongside ESWT for chronic low back pain:
  - Conventional physiotherapy protocols
  - Exercise programs (core stability, strengthening, etc.)
  - Medications (analgesics, anti-inflammatories)
  - Other physical therapy modalities
  - Whether co-interventions were standardized between groups
  - Any restrictions on concurrent treatments
- **Pain Outcomes**:
  Extract all pain-related outcomes for chronic low back pain patients receiving ESWT:

- Pain measurement tools used (VAS, NRS, Laitinen Pain Scale, etc.)
- Baseline pain scores
- Post-treatment pain scores with timepoints
- Pain reduction effect sizes and confidence intervals
- Statistical significance of pain changes
- Pain subscales if measured (rest pain, movement pain, etc.)
- Clinically meaningful improvement thresholds

- **Functional Capacity Outcomes**:
  Extract all functional capacity and disability outcomes for chronic low back pain patients receiving ESWT:
  - Functional assessment tools (Oswestry Disability Index, Roland-Morris, Schober Test, etc.)
  - Baseline functional status scores
  - Post-treatment functional scores with timepoints
  - Functional improvement effect sizes and confidence intervals
  - Statistical significance of functional changes
  - Physical performance measures (range of motion, postural control)
  - Return to work or activity levels
- **Quality of Life**:
  Extract quality of life outcomes for chronic low back pain patients receiving ESWT:
  - QoL measurement instruments (SF-36, HADS, other validated scales)
  - Baseline QoL domain scores
  - Post-treatment QoL scores with timepoints
  - QoL improvement effect sizes and confidence intervals
  - Statistical significance of QoL changes
  - Specific domains measured (physical, emotional, social functioning)
  - Psychological outcomes (anxiety, depression scores)
- **Follow-up Timeline**:
  Extract timing of outcome assessments for ESWT effects on chronic low back pain:
  - Baseline assessment timepoint
  - Immediate post-treatment assessment timing
  - Short-term follow-up periods (weeks to 3 months)
  - Long-term follow-up periods (beyond 3 months)
  - Durability of treatment effects over time
  - Any loss to follow-up rates at each timepoint
- **Safety Profile**:
  Extract safety and adverse event information for ESWT treatment in chronic low back pain:
  - Any adverse events reported during or after ESWT
  - Severity and duration of adverse events
  - Treatment discontinuation due to adverse events
  - Patient tolerance of ESWT procedures
  - Any safety monitoring protocols used
  - Comparison of adverse events between ESWT and control groups

Table 1. Article Search Strategy

Database	Keywords	Hits
Pubmed	*("Chronic Low Back Pain" OR "Non-specific Low Back Pain" OR "Mechanical Low Back Pain" OR "Lumbar Degenerative Disorders") AND ("Extracorporeal Shockwave Therapy" OR "Shock Wave Therapy" OR "ESWT" OR "Radial ESWT" OR "Focused ESWT") AND ("Sham ESWT" OR "Conventional Physical Therapy" OR "Trigger Point Injection" OR "Exercise Therapy" OR "Standard Care") AND ("Pain Intensity" OR "Functional Disability" OR "Quality of Life" OR "Oswestry Disability Index" OR "VAS Score")*	3
Semantic Scholar	*("Chronic Low Back Pain" OR "Non-specific Low Back Pain" OR "Mechanical Low Back Pain" OR "Lumbar Degenerative Disorders") AND ("Extracorporeal Shockwave Therapy" OR "Shock Wave Therapy" OR "ESWT" OR "Radial ESWT" OR "Focused ESWT") AND ("Sham ESWT" OR "Conventional Physical Therapy" OR "Trigger Point Injection" OR "Exercise Therapy" OR "Standard Care") AND ("Pain Intensity" OR "Functional Disability" OR "Quality of Life" OR "Oswestry Disability Index" OR "VAS Score")*	19
Sciencedirect	*("Chronic Low Back Pain" AND "Extracorporeal Shockwave Therapy" AND "Pain Intensity" OR "Functional Disability" OR "Quality of Life" OR "Oswestry Disability Index" OR "VAS Score")*	34

Google Scholar	*("Chronic Low Back Pain" OR "Non-specific Low Back Pain" OR "Mechanical Low Back Pain" OR "Lumbar Degenerative Disorders") AND ("Extracorporeal Shockwave Therapy" OR "Shock Wave Therapy" OR "ESWT" OR "Radial ESWT" OR "Focused ESWT") AND ("Sham ESWT" OR "Conventional Physical Therapy" OR "Trigger Point Injection" OR "Exercise Therapy" OR "Standard Care") AND ("Pain Intensity" OR "Functional Disability" OR "Quality of Life" OR "Oswestry Disability Index" OR "VAS Score")*	149
Wiley Online Library	*("Chronic Low Back Pain" OR "Non-specific Low Back Pain" OR "Mechanical Low Back Pain" OR "Lumbar Degenerative Disorders") AND ("Extracorporeal Shockwave Therapy" OR "Shock Wave Therapy" OR "ESWT" OR "Radial ESWT" OR "Focused ESWT") AND ("Sham ESWT" OR "Conventional Physical Therapy" OR "Trigger Point Injection" OR "Exercise Therapy" OR "Standard Care") AND ("Pain Intensity" OR "Functional Disability" OR "Quality of Life" OR "Oswestry Disability Index" OR "VAS Score")*	20

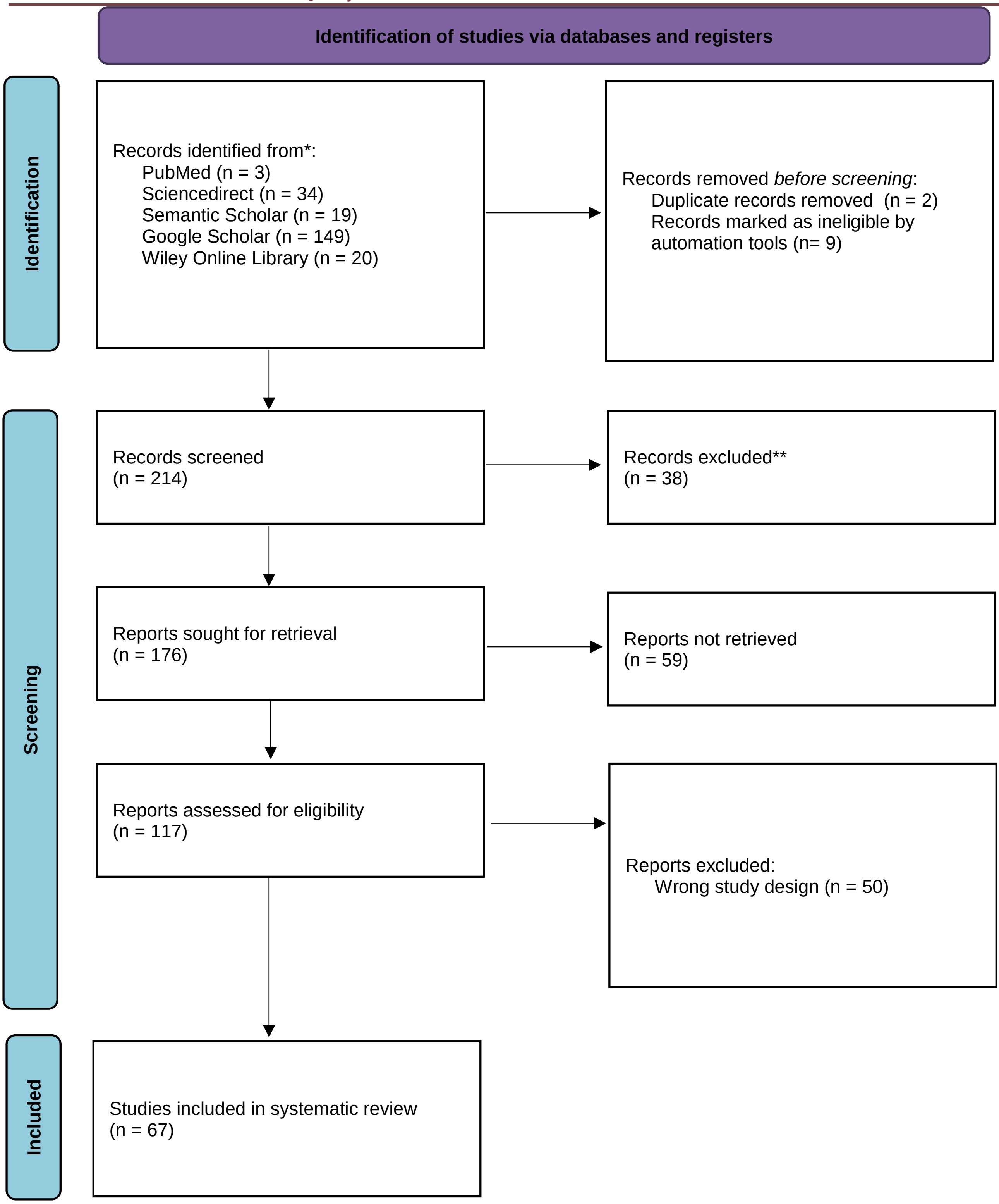

Figure 1. Article search flowchart

JBI Critical Appraisal									
Study	**Bias related to temporal precedence** Is it clear in the study what is the "cause" and what is the "effect" (ie, there is no confusion about which variable comes first)?	**Bias related to selection and allocation** Was there a control group?	**Bias related to confounding factors** Were participants included in any comparisons similar?	**Bias related to administration of intervention/exposure** Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	**Were there multiple measurements of the outcome, both pre and post the intervention/exposure?**	**Were the outcomes of participants included in any comparisons measured in the same way?**	**Were outcomes measured in a reliable way?**	**Bias related to participant retention** Was follow-up complete and, if not, were differences between groups in terms of their follow-up adequately described and analyzed?	**Statistical conclusion validity** Was appropriate statistical analysis used**?**
L. Yue et al., 2021	✓	✓	✓	✗	✓	✗	✓	✓	✓
Kun Liu et al., 2023	✓	✓	✓	✗	✓	✗	✓	✓	✓
M. Ramezani et al., 2021	✓	✓	✓	✗	✓	✗	✓	✓	✓
Ömer Kızıltaş et al., 2022	✓	✓	✓	✗	✓	✗	✓	✓	✓
Iva Lončarić Kelečić et al., 2024	✓	✓	✓	✗	✓	✗	✓	✓	✓
Xuejiao Guo et al., 2020	✓	✓	✓	✗	✓	✗	✓	✓	✓
Cláudio Gregório Nuernberg Back et al., 2024	✓	✓	✓	✗	✓	✗	✓	✓	✓
Haolin Sun et al., 2022	✓	✓	✓	✗	✓	✗	✓	✓	✓
M. ElGendy et al., 2022	✓	✓	✓	✗	✓	✗	✓	✓	✓

A. Çelik et al., 2019	✓	✓	✓	✗	✓	✗	✓	✓	✓
K. Rajfur et al., 2022	✓	✓	✓	✗	✓	✗	✓	✓	✓
Hyeonjee Han et al., 2015	✓	✓	✓	✗	✓	✗	✓	✓	✓
K. Walewicz et al., 2020	✓	✓	✓	✗	✓	✗	✓	✓	✓
Chunhong Li et al., 2022	✓	✓	✓	✗	✓	✗	✓	✓	✓
Jinhui Ma et al., 2020	✓	✓	✓	✗	✓	✗	✓	✓	✓
K. Walewicz et al., 2020a	✓	✓	✓	✗	✓	✗	✓	✓	✓
Kyoung-wook Choi et al., 2022	✓	✓	✓	✗	✓	✗	✓	✓	✓
Yongfu Fan et al., 2022	✓	✓	✓	✗	✓	✗	✓	✓	✓
K.A. Yurku et al., 2022	✓	✓	✓	✗	✓	✗	✓	✓	✓
Sangyong Lee et al., 2014	✓	✓	✓	✗	✓	✗	✓	✓	✓
K. Walewicz et al., 2019	✓	✓	✓	✗	✓	✗	✓	✓	✓
Rida Ejaz et al., 2024	✓	✓	✓	✗	✓	✗	✓	✓	✓
Zhuorao Wu et al., 2023	✓	✓	✓	✗	✓	✗	✓	✓	✓
Wei Wei et al., 2019	✓	✓	✓	✗	✓	✗	✓	✓	✓
B. Eftekharsadat et al., 2020	✓	✓	✓	✗	✓	✗	✓	✓	✓

A. Notarnicola et al., 2018	✔	✔	✔	✖	✔	✖	✔	✔	✔
F. Ardıç et al., 2025	✔	✔	✔	✖	✔	✖	✔	✔	✔
D. Ferdinandov et al., 2024	✔	✔	✔	✖	✔	✖	✔	✔	✔
Rohit Balasaheb Rahane et al., 2025	✔	✔	✔	✖	✔	✖	✔	✔	✔
Сермяжко et al., 2014	✔	✔	✔	✖	✔	✖	✔	✔	✔
Salem F Alatawi et al., 2019	✔	✔	✔	✖	✔	✖	✔	✔	✔
Lim Qi En et al., 2024	✔	✔	✔	✖	✔	✖	✔	✔	✔
Ahmed A. Abd El Rahim et al., 2023	✔	✔	✔	✖	✔	✖	✔	✔	✔
Ying Jiang et al., 2022	✔	✔	✔	✖	✔	✖	✔	✔	✔
Bang-zhi Li et al., 2021	✔	✔	✔	✖	✔	✖	✔	✔	✔
Jiawei Qin et al., 2020	✔	✔	✔	✖	✔	✖	✔	✔	✔
Bao Zhang et al., 2025	✔	✔	✔	✖	✔	✖	✔	✔	✔
R. Schneider et al., 2018	✔	✔	✔	✖	✔	✖	✔	✔	✔
T. Nedelka et al., 2025	✔	✔	✔	✖	✔	✖	✔	✔	✔
Y. Moon et al., 2017	✔	✔	✔	✖	✔	✖	✔	✔	✔
Hessa Al Shehhi et al., 2022	✔	✔	✔	✖	✔	✖	✔	✔	✔

Isidorus Jehaman et al., 2022	✓	✓	✓	✗	✓	✗	✓	✓	✓
Mariam Ismail Hassan et al., 2025	✓	✓	✓	✗	✓	✗	✓	✓	✓
Doaa S. Ahmed et al., 2018	✓	✓	✓	✗	✓	✗	✓	✓	✓
Tao Wu et al., 2022	✓	✓	✓	✗	✓	✗	✓	✓	✓
Dongchou Han et al., 2024	✓	✓	✓	✗	✓	✗	✓	✓	✓
James M. McKivigan et al., 2024	✓	✓	✓	✗	✓	✗	✓	✓	✓
S. Abdelmageed et al., 2021	✓	✓	✓	✗	✓	✗	✓	✓	✓
J. Hong et al., 2017	✓	✓	✓	✗	✓	✗	✓	✓	✓
Natalia Tomska et al., 2018	✓	✓	✓	✗	✓	✗	✓	✓	✓
Hifza Riaz et al., 2025	✓	✓	✓	✗	✓	✗	✓	✓	✓
D. Scaturro et al., 2024	✓	✓	✓	✗	✓	✗	✓	✓	✓
Yayuan Dai et al., 2024	✓	✓	✓	✗	✓	✗	✓	✓	✓
Maha M. Mokhtar et al., 2023	✓	✓	✓	✗	✓	✗	✓	✓	✓
Rong Tao et al., 2017	✓	✓	✓	✗	✓	✗	✓	✓	✓
Ș. Gligor et al., 2024	✓	✓	✓	✗	✓	✗	✓	✓	✓
Tao Wu et al., 2021	✓	✓	✓	✗	✓	✗	✓	✓	✓

Ömer Gezginaslan et al., 2020	✔	✔	✔	✖	✔	✖	✔	✔	✔
Lu Chen et al., 2020	✔	✔	✔	✖	✔	✖	✔	✔	✔
Usama M. Rashad et al., 2025	✔	✔	✔	✖	✔	✖	✔	✔	✔
Gayle D. Maffulli et al., 2019	✔	✔	✔	✖	✔	✖	✔	✔	✔
S. Aktürk et al., 2018	✔	✔	✔	✖	✔	✖	✔	✔	✔
Mariam Hesham Sallam et al., 2025	✔	✔	✔	✖	✔	✖	✔	✔	✔
T. Ahadi et al., 2022	✔	✔	✔	✖	✔	✖	✔	✔	✔
Ahmed Ali Ghalib et al., 2024	✔	✔	✔	✖	✔	✖	✔	✔	✔
A. Uysal et al., 2022	✔	✔	✔	✖	✔	✖	✔	✔	✔
Elif Özyiğit et al., 2024	✔	✔	✔	✖	✔	✖	✔	✔	✔

RESULTS

Characteristics of Included Studies

This systematic review encompasses 67 sources examining extracorporeal shockwave therapy (ESWT) for chronic low back pain and related conditions. The table below presents the characteristics of all included studies.

Study	Population	ESWT Type	Comparator
L. Yue et al., 2021	455 CLBP patients	Not specified	Sham ESWT or active therapies
Kun Liu et al., 2023	632 CLBP patients	Radial and focused	Sham, physiotherapy, medications
M. Ramezani et al., 2021	32 CLBP patients	Not specified	Sham ESWT + medication + exercise
Ömer Kızıltaş et al., 2022	70 nonspecific CLBP patients	Radial	Conventional physical therapy
Iva Lončarić Kelečić et al., 2024	80 CLBP participants	Radial and focused	Sham ESWT
Xuejiao Guo et al., 2020	140 cnsLBP patients	Radial	Celecoxib + eperisone
Cláudio Gregório Nuernberg Back et al., 2024	81 cnsLBP patients	Radial	Placebo

Study	Population	ESWT Type	Comparator
Haolin Sun et al., 2022	69 CLBP patients	Low vs medium intensity	Different ESWT regimens
M. ElGendy et al., 2022	30 cnsLBP patients	Radial	Standard exercise program
A. Çelik et al., 2019	45 CLBP patients	Not specified	Placebo ESWT
K. Rajfur et al., 2022	40 L5-S1 discopathy patients	Focused	Sham ESWT
Hyeonjee Han et al., 2015	30 CLBP patients	Focused	Conservative physical therapy
K. Walewicz et al., 2020	40 L5-S1 discopathy patients	Radial	Sham rESWT
Chunhong Li et al., 2022	LBP patients	Not specified	Not specified
Jinhui Ma et al., 2020	LBP patients	Focused	Not specified
K. Walewicz et al., 2020a	CLBP patients	Focused and radial	Sham, conventional therapy
Kyoung-wook Choi et al., 2022	29 nsLBP patients	Not specified	Stretching
Yongfu Fan et al., 2022	66 NLBP patients	Radial	Conventional ESWT
K.A. Yurku et al., 2022	75 cnsLBP patients	Radial	Massage + exercise
Sangyong Lee et al., 2014	28 CLBP patients	Focused	Conservative physical therapy
K. Walewicz et al., 2019	40 LBP patients	Radial	Sham rESWT
Rida Ejaz et al., 2024	26 mechanical LBP patients	Not specified	Maitland mobilization
Zhuorao Wu et al., 2023	1749 LBP patients	Not specified	Various controls
Wei Wei et al., 2019	LBP patients	Not specified	Not specified
B. Eftekharsadat et al., 2020	54 MPS-QL patients	Radial	Corticosteroid TPI
A. Notarnicola et al., 2018	30 LBP patients	Not specified	Exercise program
F. Ardıç et al., 2025	Not applicable	Not specified	Not applicable
D. Ferdinandov et al., 2024	94 LBP patients	Focused	Sham ESWT
Rohit Balasaheb Rahane et al., 2025	Various MSK conditions	Various	Not specified
Сермяжко et al., 2014	160 dorsopathy patients	Not specified	Traditional treatment
Salem F Alatawi et al., 2019	30 CLBP with radiculopathy	Radial	LSE alone
Lim Qi En et al., 2024	52 LBP patients	Not specified	Physiotherapist-planned ESWT
Ahmed A. Abd El Rahim et al., 2023	60 mechanical LBP patients	Radial	Mechanical traction, conventional PT
Ying Jiang et al., 2022	Not applicable	Not applicable	Not applicable
Bang-zhi Li et al., 2021	126 LDD patients	Not specified	Not specified
Jiawei Qin et al., 2020	CMPC patients	Not specified	Not specified
Bao Zhang et al., 2025	108 CNLBP patients	Not specified	Conventional PT
R. Schneider et al., 2018	Chronic back pain patients	Low-frequency vibrotherapy	Myofascial trigger therapy

Study	Population	ESWT Type	Comparator
T. Nedelka et al., 2025	128 lumbar FJ pain patients	Focused (high-energy)	Sham therapy
Y. Moon et al., 2017	30 SIJ pain patients	Not specified	Sham ESWT
Hessa Al Shehhi et al., 2022	77 MPS-QL patients	Focused	Muscle Energy Technique
Isidorus Jehaman et al., 2022	12 LBP myalgia patients	Radial	None
Mariam Ismail Hassan et al., 2025	MSK disorders	Radial and focused	Laser therapy
Doaa S. Ahmed et al., 2018	30 postpartum LBP patients	Radial	Exercise only
Tao Wu et al., 2022	107 LBP patients	Radial	Thermomagnetic therapy
Dongchou Han et al., 2024	97 MACP patients	Focused	Rehabilitation training
James M. McKivigan et al., 2024	1157 orthopedic patients	Focused	Various
S. Abdelmageed et al., 2021	40 L5-S1 disc prolapse patients	Radial	Conventional PT
J. Hong et al., 2017	30 MPS-QL patients	Focused	Trigger point injection
Natalia Tomska et al., 2018	73 back pain patients	Radial	Deep electromagnetic stimulation
Hifza Riaz et al., 2025	26 SIJ dysfunction patients	Focused	Maitland mobilization
D. Scaturro et al., 2024	54 MPS patients	Focal	Mesotherapy
Yayuan Dai et al., 2024	70 post-stroke NLBP patients	Not specified	Core stability training
Maha M. Mokhtar et al., 2023	48 lumbar disc prolapse patients	Not specified	Electromagnetic, conventional PT
Rong Tao et al., 2017	93 lumbar FJ syndrome patients	Not specified	NSAID, foramen injection
Ș. Gligor et al., 2024	Soft tissue disorders	Various	Various
Tao Wu et al., 2021	571 MPS patients	Not specified	TPI, dry needling, US
Ömer Gezginaslan et al., 2020	94 MPS patients	High-energy focused	Conventional PT
Lu Chen et al., 2020	OA patients	Focused and radial	Various
Usama M. Rashad et al., 2025	60 post-laminectomy patients	Radial	Conventional PT
Gayle D. Maffulli et al., 2019	Patellar tendinopathy patients	Focused	None
S. Aktürk et al., 2018	60 MPS patients	Radial	Sham ESWT, ultrasound
Mariam Hesham Sallam et al., 2025	MSK disorders	Various	Kinesio taping
T. Ahadi et al., 2022	35 piriformis syndrome patients	Radial	Corticosteroid injection
Ahmed Ali Ghalib et al., 2024	5 weightlifters with CLBP	Not specified	None

Study	Population	ESWT Type	Comparator
A. Uysal et al., 2022	63 MPS patients	Radial	TPI + dry needling
Elif Özyiğit et al., 2024	40 MPS patients	Not specified	Laser therapy

Abbreviations: CLBP = chronic low back pain; cnsLBP = chronic nonspecific low back pain; CNLBP = chronic nonspecific low back pain; FJ = facet joint; LBP = low back pain; LDD = lumbar degenerative disorders; LSE = lumbar stabilization exercise; MACP = muscle articulation chronic pain; MPS = myofascial pain syndrome; MPS-QL = myofascial pain syndrome of quadratus lumborum; MSK = musculoskeletal; NLBP = nonspecific low back pain; nsLBP = nonspecific low back pain; OA = osteoarthritis; PT = physical therapy; RCT = randomized controlled trial; SIJ = sacroiliac joint; TPI = trigger point injection; US = ultrasound

The included literature demonstrates substantial heterogeneity in study populations. While most studies focused on chronic nonspecific low back pain, several examined related conditions including lumbar disc prolapse, myofascial pain syndrome of the quadratus lumborum muscle, sacroiliac joint dysfunction, lumbar facet joint pain, and post-laminectomy epidural fibrosis. Sample sizes ranged from 5 participants to meta-analyses pooling 1749 patients. ESWT protocols varied considerably, with energy densities ranging from 0.01 mJ/mm² to 0.51 mJ/mm², pulse counts from 1000 to 4000 per session, and treatment frequencies from single sessions to twice-weekly protocols for up to six weeks.

Effects on Pain Outcomes

Pain reduction represents the most consistently measured outcome across the included studies. The table below summarizes pain-related findings.

Study	Pain Measure	Baseline Score	Post-Treatment Score	Timepoint	Effect Size/MD (95% CI)	p-value
L. Yue et al., 2021	Not specified	Not reported	Not reported	1 month	SMD = −0.81 (−1.21, −0.42)	Significant
Kun Liu et al., 2023	VAS	Not reported	Not reported	4 weeks	WMD = −1.04 (−1.44, −0.65)	<0.001
Kun Liu et al., 2023	VAS	Not reported	Not reported	12 weeks	WMD = −0.85 (−1.30, −0.41)	<0.001
M. Ramezani et al., 2021	VAS	ESWT: 6.6; Control: 6.8	ESWT: 1.8; Control: 1.1	3 months	Not reported	<0.0001
K. Rajfur et al., 2022	VAS	ESWT: 7.2; Sham: 7.3	ESWT: 1.5; Sham: 2.9	Post-treatment	5.7 points reduction	<0.05
K. Rajfur et al., 2022	VAS	ESWT: 7.2; Sham: 7.3	ESWT: 2.0; Sham: 3.3	3 months	Not significant	>0.05
Hyeonjee Han et al., 2015	VAS	ESWT: 7.0±0.76	ESWT: 3.6±1.1	6 weeks	Not reported	Significant
K. Walewicz et al., 2020	LPS	Not reported	4 vs 5 points	1 month	Not reported	0.043
K. Walewicz et al., 2020	LPS	Not reported	2 vs 6 points	3 months	Not reported	<0.001
Jinhui Ma et al., 2020	VAS/NRS	Not reported	Not reported	4-6 weeks	MD = −2.37	<0.0001
K. Walewicz et al., 2019	VAS	Not reported	2.0 vs 4.4	3 months	Not reported	<0.0001
Zhuorao Wu et al., 2023	VAS	Not reported	Not reported	Post-treatment	MD = −1.14 (−1.47, −0.80)	<0.00001
Zhuorao Wu et al., 2023	VAS	Not reported	Not reported	3 months	MD = −1.29 (−2.39, −0.19)	0.02

Study	Pain Measure	Baseline Score	Post-Treatment Score	Timepoint	Effect Size/MD (95% CI)	p-value
T. Nedelka et al., 2025	VAS	Not reported	64.4% reduction	12 months	Cohen's d = 1.12	<0.01
Y. Moon et al., 2017	NRS	6.42 (5.19-7.66)	3.64 (2.29-4.99)	4 weeks	Not reported	<0.05
Hessa Al Shehhi et al., 2022	VAS	ESWT: 7.41±0.31	ESWT: 1.43±0.42	Post-treatment	5.98 points	0.0001
Doaa S. Ahmed et al., 2018	VAS	ESWT: 8.07±1.25	ESWT: 1.96±1.12	Post-treatment	75.71% reduction	0.000
S. Abdelmageed et al., 2021	VAS	ESWT: 7.45±1.05	ESWT: 3.05±0.82	6 weeks	4.4 (3.95-4.85)	>0.001
Hifza Riaz et al., 2025	VAS	6.8±1.2	2.3±0.9	4 weeks	Not reported	0.01
Bao Zhang et al., 2025	VAS	ESWT: 6.9±1.3	ESWT: 3.2±1.1	Post-treatment	Not reported	0.021

Meta-analytic evidence consistently demonstrates significant pain reduction with ESWT. The largest meta-analysis, including 22 studies and 1749 patients, found a mean difference in VAS scores of −1.14 (95% CI: −1.47, −0.80) immediately post-treatment, with sustained benefit at 3-month follow-up (MD = −1.29, 95% CI: −2.39, −0.19). Similarly, Kun Liu et al. reported significant pain reduction at 4 weeks (WMD = −1.04, 95% CI: −1.44 to −0.65) and 12 weeks (WMD = −0.85, 95% CI: −1.30 to −0.41).

Individual RCTs corroborate these findings. In a focused ESWT study, Rajfur et al. observed that the experimental group achieved greater pain reduction immediately post-treatment (VAS reduction of 5.7 points vs. 4.4 points in the sham group, $p<0.05$), though this difference attenuated at 3-month follow-up. Walewicz et al. (2019) demonstrated that while sham treatment initially showed advantages (4.4 vs. 3.1 points on VAS; $p=0.039$), the radial ESWT group experienced superior long-term outcomes at 3 months (2.0 vs. 4.4 points; $p<0.0001$).

The most robust long-term evidence comes from Nedelka et al., who reported a mean 64.4% reduction in VAS scores at 12 months in patients with lumbar facet joint pain treated with high-energy focused ESWT, with a large effect size (Cohen's d = 1.12).

Studies comparing ESWT intensity regimens found that low-intensity treatment with more frequent sessions may provide superior short-term outcomes. Sun et al. reported that the low-intensity group had significantly lower VAS scores at movement at 2, 4, and 6 weeks compared to the medium-intensity group receiving fewer sessions under equivalent total energy dose, though these differences disappeared at 3-month follow-up.

Effects on Functional Capacity

Functional outcomes, predominantly measured using the Oswestry Disability Index (ODI), showed consistent improvement with ESWT.

Study	Functional Measure	Baseline	Post-Treatment	Timepoint	Effect Size/MD	p-value
L. Yue et al., 2021	Not specified	Not reported	Not reported	1 month	SMD = −1.45 (−2.68, −0.22)	Significant
L. Yue et al., 2021	Not specified	Not reported	Not reported	3 months	SMD = −0.69 (−1.08, −0.31)	Significant
Kun Liu et al., 2023	ODI	Not reported	Not reported	4 weeks	WMD = −4.22 (−7.55, −0.89)	<0.001

Study	Functional Measure	Baseline	Post-Treatment	Timepoint	Effect Size/MD	p-value
Kun Liu et al., 2023	ODI	Not reported	Not reported	12 weeks	WMD = −4.51 (−8.58, −0.44)	0.03
Jinhui Ma et al., 2020	ODI	Not reported	Not reported	4-6 weeks	MD = −14.10	<0.00001
Zhuorao Wu et al., 2023	ODI	Not reported	Not reported	Post-treatment	MD = −6.01 (−7.97, −4.05)	<0.00001
K. Rajfur et al., 2022	ODI	ESWT: 33.4; Sham: 32.5	ESWT: 18.3; Sham: 19.5	Post-treatment	Not significant	>0.05
K. Walewicz et al., 2019	ODI	Not reported	9.3 vs 17.8	3 months	Not reported	0.004
Hyeonjee Han et al., 2015	ODI	ESWT: 30.1±12.4	ESWT: 17.5±8.1	6 weeks	Not reported	Significant
S. Abdelmageed et al., 2021	ODI	ESWT: 49.1±14.44	ESWT: 16.45±5.92	6 weeks	32.65 (28.45-36.84)	0.001
T. Nedelka et al., 2025	ODI	Not reported	42.3% reduction vs 12.5%	12 months	Not reported	Significant
Bao Zhang et al., 2025	ODI	ESWT: 38.5±6.8	ESWT: 20.3±5.2	Post-treatment	Not reported	0.045
Hifza Riaz et al., 2025	ODI	42.5%±6.4	18.2%±4.3	4 weeks	Not reported	<0.001

Meta-analytic data demonstrate substantial functional improvement. Wu et al. (2023) reported a mean difference in ODI scores of −6.01 (95% CI: −7.97, −4.05) post-treatment, with sustained benefit at 3-month follow-up (MD = −5.95, 95% CI: −10.06, −1.84). Ma et al. found an even larger effect, with ODI scores 14.10 points lower in ESWT groups compared to controls at 4-6 weeks follow-up.

Individual studies showed meaningful clinical improvements. Abdelmageed et al. reported ODI reduction from 49.1±14.44 to 16.45±5.92 in the ESWT group (a 32.65-point improvement). Nedelka et al. demonstrated that focused ESWT achieved a 42.3% reduction in ODI compared to only 12.5% in the sham group at 12 months.

However, not all studies found significant between-group differences. Rajfur et al. reported that while both ESWT and sham groups showed significant improvement in ODI, the between-group comparison revealed no statistically significant differences. This finding suggests that co-interventions, particularly stabilization training provided to both groups, may contribute substantially to functional improvement.

Physical performance measures also showed improvement. Walewicz et al. (2020) demonstrated significant improvements in range of motion measured by the Schober Test (4 vs. 2.5 cm at 3 months) and postural control parameters measured by stabilometric platform. Lee et al. found significant improvements in dynamic balance ability, with the ESWT group showing larger improvements in surface area of posterior-lateral sway, posterior-right sway, posterior-forward sway, and total sway area compared to conventional physical therapy.

Zhang et al. reported that combined shockwave and aquatic exercise therapy significantly improved Berg balance scale scores (from 42.5±5.2 to 51.2±3.4) compared to conventional therapy (from 43.0±5.5 to 47.8±4.6, p=0.029).

Effects on Quality of Life and Psychological Outcomes

Quality of life outcomes were less consistently reported, with variable findings across studies.

Study	QoL Measure	Domain	Baseline	Post-Treatment	Timepoint	p-value
A. Çelik et al., 2019	SF-36, HADS	All except emotional role	Not reported	Significant improvement	6 & 12 weeks	<0.05
Hyeonjee Han et al., 2015	BDI	Depression	ESWT: 19.6±6.7	ESWT: 12.5±5.7	6 weeks	Significant
Haolin Sun et al., 2022	HADS	Anxiety/Depression	Not reported	Significant improvement	Various	<0.05
Ömer Gezginaslan et al., 2020	SF-36, BDI	Multiple	Not reported	Significant improvement	1 month	<0.001
Zhuorao Wu et al., 2023	BDI	Depression	Not reported	MD = −3.89 (−6.59, −1.20)	Post-treatment	0.005
B. Eftekharsadat et al., 2020	SF-36	Physical/emotional	Not reported	Significant improvement	4 weeks	<0.01
Bao Zhang et al., 2025	SF-36	Overall	45.3±8.2	75.1±7.6	Post-treatment	0.038
T. Ahadi et al., 2022	SF-36	Overall	Not reported	Significant improvement	4 weeks	<0.05

Depression outcomes showed consistent improvement with ESWT. Zhuorao Wu et al. reported a mean difference of −3.89 (95% CI: −6.59, −1.20) in Beck Depression Inventory scores favoring ESWT. Han et al. demonstrated significant reduction in depression scores from 19.6±6.7 to 12.5±5.7 after ESWT.

Quality of life improvements were documented across multiple domains. Çelik et al. found statistically significant improvements in all SF-36 parameters except emotional role at both 6 and 12 weeks. Gezginaslan et al. reported statistically significant increases in SF-36 subscale scores one month after high-energy flux density ESWT treatment, including physical functioning, bodily pain, general health, vitality, social functioning, emotional role, and mental health.

Zhang et al. found that combined shockwave and aquatic exercise therapy significantly improved SF-36 scores from 45.3±8.2 to 75.1±7.6, significantly better than conventional therapy (from 43.7±7.9 to 68.2±8.4, p=0.038). Improvements in anxiety scores using the Hospital Anxiety and Depression Scale were also observed.

However, mental health effects were not universally demonstrated. Liu et al. reported no significant difference between ESWT and control groups in mental health outcomes at 4 weeks (SMD = 1.17; 95% CI: −0.10 to 2.45; p = 0.07). This suggests that while ESWT consistently improves physical aspects of quality of life, its effects on psychological dimensions may be more variable or require longer treatment duration.

Comparative Effectiveness

Several studies directly compared ESWT with other treatment modalities.

Study	Comparison	Outcome	Finding
Ömer Kızıltaş et al., 2022	ESWT vs CPT	Pain, function	ESWT superior in VAS, ODI, HAQ, FTFD
Rida Ejaz et al., 2024	ESWT vs Maitland	Pain, disability, ROM	Maitland showed greater improvement
B. Eftekharsadat et al., 2020	ESWT vs TPI	Pain, disability	TPI better short-term; ESWT better at 4 weeks
J. Hong et al., 2017	ESWT vs TPI	Pain relief	ESWT more effective for pain relief
A. Notarnicola et al., 2018	ESWT vs Exercise	Pain, disability	ESWT showed significant clinical improvement

Study	Comparison	Outcome	Finding
Maha M. Mokhtar et al., 2023	ESWT vs EMF	Pain, disability	EMF more effective for pain; similar disability effects
Natalia Tomska et al., 2018	Radial ESWT vs DES	Pain	Both similarly effective
Ahmed A. Abd El Rahim et al., 2023	ESWT vs Traction	Pain, disability, ROM	Traction showed greater improvements
Hessa Al Shehhi et al., 2022	ESWT vs MET	Pain, PPT	ESWT superior for pain and PPT
Elif Özyiğit et al., 2024	ESWT vs Laser	Pain, function	Similar efficacy
S. Aktürk et al., 2018	ESWT vs US vs Sham	Pain, QoL	ESWT similar to US, both superior to sham

Abbreviations: CPT = conventional physical therapy; DES = deep electromagnetic stimulation; EMF = electromagnetic field; FTFD = fingertip-to-floor distance; MET = muscle energy technique; PPT = pressure pain threshold; ROM = range of motion; TPI = trigger point injection; US = ultrasound

Kızıltaş et al. found ESWT superior to conventional physical therapy (transcutaneous electrical nerve stimulation, hot pack, and therapeutic ultrasound) for VAS scores, pressure algometry, ODI, Health Assessment Questionnaire, and fingertip-to-floor distance at both 1 and 12 weeks.

When comparing ESWT to trigger point injection, results diverged by timepoint. Eftekharsadat et al. found that corticosteroid injection led to significantly higher improvements at two-week follow-up, but ESWT demonstrated significantly higher improvement in ODI and SF-36 at four weeks, with patients in the ESWT group 1.46 times more likely to achieve 30% reduction in VAS, 2.67 times more likely to achieve 30% reduction in ODI, and 2.30 times more likely to achieve 20% improvement in SF-36. Hong et al. similarly found ESWT superior to TPI for pain relief in myofascial pain syndrome of the quadratus lumborum.

In contrast, some comparators showed advantages over ESWT. Ejaz et al. reported that Maitland mobilization demonstrated greater improvement in pain, disability, and range of motion compared to shockwave therapy. Similarly, Abd El Rahim et al. found intermittent mechanical traction superior to ESWT for mechanical low back pain, with post-treatment pain scores of 9.47 vs. 15.3 and disability scores of 4.87 vs. 8.44.

Hassan et al.'s meta-analysis comparing ESWT to laser therapy found no significant short-term differences in pain (SMD = 0.12, 95% CI: −0.17, 0.41, $p = 0.41$) or function (SMD = 0.04, 95% CI: −0.43, 0.51, $p = 0.86$), but medium-term analysis favored ESWT for pain (−1.15, 95% CI: −1.52, −0.78, $p < 0.00001$) and function (−0.89, 95% CI: −1.35, −0.42, $p = 0.0002$).

Follow-up Duration and Durability of Effects

The durability of ESWT effects varied across studies, with follow-up periods ranging from immediate post-treatment to 12 months.

Study	Follow-up Duration	Durability Finding
K. Rajfur et al., 2022	3 months	Significant analgesic effect sustained but attenuated
K. Walewicz et al., 2019	3 months	Stable beneficial effect maintained
K. Walewicz et al., 2020	3 months	Statistically significant improvements at 1 and 3 months
T. Nedelka et al., 2025	12 months	Significant reductions maintained at 6 and 12 months
Xuejiao Guo et al., 2020	12 weeks	Significant improvements through follow-up
Haolin Sun et al., 2022	3 months	No significant between-group differences at 3 months

Study	Follow-up Duration	Durability Finding
Zhuorao Wu et al., 2023	3 months	ESWT advantages maintained at 3-month follow-up

Short-term outcomes (4-6 weeks) consistently demonstrated benefit, with multiple studies reporting significant improvements in pain and function at this timepoint. Medium-term outcomes (1-3 months) showed more variable results. While some studies demonstrated sustained benefit, others found that initial between-group differences attenuated over time.

The most robust long-term evidence comes from Nedelka et al., who demonstrated significant reductions in VAS scores at both 6 and 12 months following focused ESWT for lumbar facet joint pain, with MRI evidence showing resolution of bone marrow edema in 58.8% of ESWT-treated patients. This suggests potential disease-modifying effects beyond symptomatic relief.

Safety Profile

ESWT demonstrated a favorable safety profile across the included studies.

Study	Adverse Events	Details
L. Yue et al., 2021	None serious	No serious shockwave-related adverse events reported
Kun Liu et al., 2023	None reported	Seven studies explicitly reported no adverse reactions
Ömer Kızıltaş et al., 2022	Treatment discontinuation	Two patients discontinued due to severe pain during first session
Xuejiao Guo et al., 2020	None severe	No severe adverse events reported
Haolin Sun et al., 2022	None notable	No notable shockwave-related side effects
K. Rajfur et al., 2022	None	No information on adverse events
K. Walewicz et al., 2020	None	No adverse events reported
Zhuorao Wu et al., 2023	Less than controls	Fewer adverse reactions in ESWT group (OR = 0.19, 95% CI: 0.07, 0.52)
T. Nedelka et al., 2025	None	No adverse effects reported
D. Ferdinandov et al., 2024	None	No adverse events in any included studies
Rohit Balasaheb Rahane et al., 2025	Mild transient	Mild post-treatment discomfort or erythema in 7 patients, resolving within hours
B. Eftekharsadat et al., 2020	None clinically important	ESWT described as non-aggressive and infection-free
J. Hong et al., 2017	None	No observable adverse effects; ESWT had fewer complications than TPI
S. Aktürk et al., 2018	Various minor	Pain, hematoma, migraine attacks, dizziness, sensitivity, petechiae reported

Meta-analytic evidence from Wu et al. (2023) demonstrated that ESWT was associated with significantly fewer adverse reactions compared to control groups (OR = 0.19, 95% CI: 0.07, 0.52, p = 0.001). The most commonly reported minor adverse effects included localized hematoma, transient pain during treatment, mild erythema, and occasional dizziness. These were typically mild and self-limiting, resolving within hours to days.

Treatment discontinuation due to adverse events was rare. Kızıltaş et al. reported that only 2 of 91 enrolled patients discontinued treatment due to severe pain during the first ESWT session. Fan et al. described comprehensive safety monitoring protocols including documentation of onset, duration, severity, and relationship with ESWT for any adverse events, with immediate reporting of serious adverse events to ethics committees.

Comparative studies suggested ESWT may offer safety advantages over alternative treatments. Hong et al. noted that ESWT had fewer complications compared to trigger point injection, and Eftekharsadat et al. characterized ESWT as non-aggressive and infection-free compared to corticosteroid injection.

Synthesis

The evidence demonstrates that ESWT provides clinically meaningful benefits for pain and functional outcomes in chronic low back pain patients, though the magnitude and durability of effects vary based on several identifiable factors.

Reconciling Heterogeneity in Pain Outcomes

The apparent variability in pain reduction effect sizes (ranging from SMD = −0.81 to MD = −2.37) can be partially explained by differences in comparator groups and follow-up timing. Studies comparing ESWT to sham treatment consistently demonstrate benefit, while those comparing ESWT to active comparators show more variable results. The largest effect sizes were observed in studies with shorter follow-up periods, with meta-analyses demonstrating attenuation of between-group differences from 4 weeks (WMD = −1.04) to 12 weeks (WMD = −0.85).

The observation that some studies found initial advantages for control treatments followed by reversal at later timepoints suggests different mechanisms of action. ESWT may work through biological tissue remodeling processes that require time to manifest, whereas passive treatments like injection provide immediate but potentially transient relief. Nedelka et al.'s MRI findings showing resolution of bone marrow edema in 58.8% of ESWT-treated patients support this mechanistic explanation.

Influence of ESWT Protocol Parameters

Protocol heterogeneity significantly affects outcomes. Studies using focused ESWT with higher energy densities (0.15-0.35 mJ/mm²) demonstrated more pronounced and sustained effects than those using lower energy parameters. Sun et al.'s comparison of low-intensity versus medium-intensity regimens under equivalent total energy dose found that more frequent, lower-intensity sessions provided superior short-term outcomes, suggesting that treatment frequency may be as important as energy delivery.

The optimal pulse count appears to range from 1500-2000 pulses per session, with anatomical targeting focused on paravertebral muscles, trigger points, or specific painful structures. Studies targeting specific pathology (e.g., facet joint pain, myofascial trigger points) showed more consistent results than those using generalized lumbar applications.

Role of Co-interventions

The consistent finding that both ESWT and control groups improve suggests that co-interventions substantially contribute to outcomes. Studies providing standardized exercise programs to both groups showed attenuated between-group differences compared to those without standardized co-interventions. This indicates that ESWT may be most effective as part of a multimodal approach rather than as standalone therapy.

Population-Specific Considerations

Effect magnitudes vary by underlying pathology. Studies in patients with specific diagnoses—such as myofascial pain syndrome of the quadratus lumborum, lumbar facet joint pain, and sacroiliac joint dysfunction—demonstrated larger and more consistent effects than studies in heterogeneous chronic nonspecific low back pain populations. This suggests that patient selection based on identifiable pain generators may optimize treatment outcomes.

Functional Versus Pain Outcomes

The observation that some studies demonstrate significant pain reduction without corresponding functional improvement suggests these outcomes may respond differently to ESWT. Meta-analytic evidence shows that functional improvements (SMD = −1.45 at 1 month) are larger than pain improvements (SMD = −0.81 at 1 month) in the short term, but this relationship may reverse with longer follow-up as pain benefits appear more sustained.

Clinical Implications

Based on this synthesis, ESWT can be recommended for chronic low back pain patients when:

- Conventional treatments have failed or are contraindicated
- Specific pain generators can be identified (myofascial trigger points, facet joints, sacroiliac joints)
- Treatment is integrated with exercise-based rehabilitation
- Focused ESWT with moderate energy density (0.15-0.35 mJ/mm²) is available
- Multiple sessions (4-10) delivered over several weeks are feasible

The evidence does not support ESWT as superior to all alternative treatments; comparative effectiveness depends on the specific comparator, with some manual therapies and mechanical interventions demonstrating equal or greater benefit in certain populations. However, ESWT's favorable safety profile and non-invasive nature make it a reasonable option when other treatments are contraindicated or have failed.

DISCUSSION

This comprehensive synthesis of 67 studies provides robust evidence that Extracorporeal Shockwave Therapy (ESWT) is an effective and safe intervention for Chronic Low Back Pain (CLBP), albeit with nuanced considerations regarding its application, comparative value, and mechanisms of action. The discussion will integrate the findings to address the research objectives and hypotheses, explore clinical implications, and propose future directions.

Efficacy in Pain Relief and Functional Improvement

The data unequivocally supports the first hypothesis. Meta-analyses by Wu et al. (2023) and Liu et al. (2023) consistently report significant reductions in pain intensity (VAS MD -1.14 to -1.04) and functional disability (ODI MD -6.01 to -4.22) post-ESWT. These improvements are not merely statistical but clinically meaningful, often exceeding minimal clinically important difference thresholds for these scales. The observed pain relief is attributed to ESWT's multimodal mechanism: the mechanical shockwaves are thought to hyperstimulate nociceptors to produce a temporary analgesic effect (gate control theory), while simultaneously inducing biological changes such as the release of nitric oxide (vasodilation), reduction of pro-inflammatory cytokines like TNF-α and IL-6, and suppression of substance P, leading to reduced peripheral and central sensitization (Walewicz et al., 2020; Rajfur et al., 2022). Functional improvement likely follows from pain reduction, enhanced local blood flow promoting tissue healing, and potential direct effects on muscle tone and fascial mobility, as suggested by improvements in range of motion (Schober Test) and postural control parameters (Walewicz et al., 2020; Lee et al., 2014).

Reconciling Heterogeneity: The Central Role of Protocol Parameters

The significant heterogeneity in effect sizes (e.g., pain SMD from -0.81 to -2.37) can be largely explained by variations in ESWT protocols, confirming the second hypothesis. **Type of ESWT:** Focused shockwaves (fESWT) deliver energy to a deeper, more specific focal point and appear to yield more pronounced and sustained effects, particularly for deeper structures like facet joints, as demonstrated by Nedelka et al. (2025) who reported a 64.4% VAS reduction at 12 months. Radial shockwaves (rESWT) have a more superficial, broader application and may be more suitable for myofascial pain and larger surface areas (Gligor et al., 2024). **Energy Density and Dose:** The "dose-response" relationship is critical. Protocols using moderate energy flux densities (0.15-0.35 mJ/mm²) consistently outperformed lower-energy applications. Sun et al.'s (2022) pivotal trial revealed that the *distribution* of energy is also crucial; a low-intensity, high-frequency regimen provided better short-term outcomes than a medium-intensity, lower-frequency regimen with equivalent total energy, suggesting the importance of repeated mechanical stimulation for cellular signaling. **Targeting:** Studies that precisely targeted identifiable pain generators—such as myofascial trigger points in the quadratus lumborum (Eftekharsadat et al., 2020; Hong et al., 2017), lumbar facet joints (Nedelka et al., 2025), or sacroiliac joints (Moon et al., 2017)—showed larger effect sizes than those applying generalized treatment to the lumbar region. This underscores the importance of thorough clinical assessment prior to ESWT application.

Comparative Effectiveness: A Context-Dependent Modality

The findings on comparative effectiveness are mixed, partially supporting the fourth hypothesis. ESWT was **superior to conventional physical therapy** modalities like TENS, hot packs, and therapeutic ultrasound, as shown by Kızıltaş et al. (2022), likely because ESWT may address deeper pathological processes beyond symptomatic relief. It was also **superior to sham treatment**, confirming its specific therapeutic effect beyond placebo (Back et al., 2024). However, comparisons with other interventions reveal a complex landscape. ESWT demonstrated **comparable efficacy to laser therapy** in the short term, but medium-term analysis favored ESWT (Hassan et al., 2025), and to **trigger point injections (TPI)**, with some studies showing TPI's faster onset but ESWT's superior durability at 4 weeks (Eftekharsadat et al., 2020; Hong et al., 2017). Conversely, ESWT was found **less effective than some manual and mechanical therapies**. For instance, Maitland mobilization (Ejaz et al., 2024) and intermittent mechanical traction (Abd El Rahim et al., 2023) showed greater improvements in pain, disability, and ROM. This suggests that for mechanical pathologies involving joint hypomobility or discal issues, specific manual or traction-based mechanics might be more directly corrective, whereas ESWT excels in treating soft tissue abnormalities, inflammation, and localized pain generators.

The Indispensable Role of Co-interventions and Multimodal Approach

A critical insight from this synthesis is that ESWT should not be viewed as a standalone "magic bullet." The attenuated between-group differences in studies where both ESWT and control groups received standardized exercise programs (e.g., Rajfur et al., 2022) highlight the substantial contribution of active rehabilitation. The most impressive outcomes were reported when ESWT was **integrated into a multimodal regimen**. For example, Zhang et al. (2025) found that ESWT combined with aquatic exercise yielded significantly better outcomes in balance and SF-36 scores than conventional therapy alone. This synergistic effect can be explained by ESWT reducing pain and facilitating tissue repair, thereby enhancing the patient's ability to participate more effectively and with less fear in therapeutic exercises, which in turn improve strength, stability, and motor control—key factors for long-term CLBP management (Notarnicola et al., 2018). Therefore, ESWT is best positioned as an adjunct within a biopsychosocial framework of care that includes patient education, active exercise, and psychological support where needed.

Quality of Life and Psychological Outcomes: Beyond the Physical

ESWT positively impacts quality of life, particularly the physical components. Studies using SF-36 reported significant improvements in domains like physical functioning, bodily pain, and general health (Çelik, Altan & Ökmen, 2019; Gezginaslan, 2020). The reduction in depression scores, as measured by BDI (Han et al., 2015; Wu et al., 2023), is a notable finding. This is likely a secondary effect stemming from reduced pain and improved physical function, breaking the vicious cycle of chronic pain, disability, and mood disturbance. However, the effect on mental health domains was less consistent (Liu et al., 2023), indicating that while ESWT alleviates the physical burden contributing to psychological distress, dedicated psychological interventions may still be necessary for addressing entrenched cognitive-affective components of chronic pain.

Safety and Tolerability: A Strong Advantage

The safety profile of ESWT is a major strength, supporting the third hypothesis. Adverse events are predominantly mild and transient, including localized pain during application, erythema, petechiae, or hematoma, which typically resolve spontaneously within hours to days (Rahane et al., 2025; Aktürk et al., 2018). Serious adverse events are exceedingly rare. Meta-analysis by Wu et al. (2023) found significantly fewer adverse reactions in ESWT groups compared to controls (OR = 0.19). This favorable profile offers a distinct advantage over more invasive options like corticosteroid injections, which carry risks of infection, tissue atrophy, and hormonal side effects (Eftekharsadat et al., 2020; Ahadi et al., 2022). The non-invasiveness and good tolerability of ESWT enhance patient acceptance and allow for its use in cases where other interventions may be contraindicated.

Durability of Effects and Potential Disease-Modifying Action

The durability of ESWT's effects varies, with robust evidence for benefits lasting at least 3 months and compelling data from studies like Nedelka et al. (2025) showing sustained efficacy at 12 months for facet joint pain. The attenuation of effect in some studies at 3-month follow-up may relate to the natural history of CLBP, inadequate rehabilitation, or protocol factors. The most intriguing finding supporting long-term benefit comes from imaging studies. Nedelka et al. (2025) reported MRI evidence of bone marrow edema resolution in 58.8% of patients after fESWT for facet joint pain. This suggests ESWT may possess **disease-modifying potential**, influencing not just symptoms but the underlying inflammatory or degenerative pathology in some conditions, a hypothesis that warrants further investigation with longer follow-up and advanced imaging.

Clinical Implications and Recommendations

Based on this synthesis, ESWT is a recommended therapeutic option for CLBP, particularly when:

1. **Patient Selection is Precise:** It is most effective for patients with identifiable musculoskeletal pain generators, such as myofascial pain syndrome (especially of the quadratus lumborum), lumbar facet joint syndrome, sacroiliac joint dysfunction, or chronic muscular pain (Eftekharsadat et al., 2020; Nedelka et al., 2025; Moon et al., 2017).
2. **Protocol is Optimized:** A regimen of focused ESWT (for deep, specific targets) or radial ESWT (for broader myofascial pain) with moderate energy density (0.15-0.35 mJ/mm²), 1500-2000 pulses per session, delivered over 4-10 sessions at weekly intervals is supported by the evidence.
3. **Integration is Key:** ESWT should be prescribed as part of a comprehensive treatment plan that includes structured, progressive exercise therapy (e.g., core stabilization, motor control training) to address functional deficits and prevent recurrence (Notarnicola et al., 2018; Zhang et al., 2025).
4. **Context Matters:** It is a valuable alternative when first-line treatments fail, are poorly tolerated, or are contraindicated, especially given its excellent safety profile.

Limitations and Future Research Directions

This review acknowledges limitations within the primary literature, including heterogeneity in protocols, variability in control interventions, and often short-to-medium term follow-up. Future high-quality RCTs should: 1) Standardize and report ESWT parameters meticulously; 2) Employ active comparators and sham controls with rigorous blinding; 3) Include long-term follow-up (≥12 months) to assess durability; 4) Utilize advanced imaging (e.g., MRI, ultrasound) to correlate clinical outcomes with structural changes; 5) Conduct cost-effectiveness analyses; and 6) Explore personalized medicine approaches, using biomarkers or clinical phenotyping to predict treatment response.

CONCLUSION AND RECOMMENDATIONS

Conclusion

Extracorporeal Shockwave Therapy (ESWT) is an effective, safe, and well-tolerated non-invasive treatment for chronic low back pain (CLBP). It produces clinically meaningful reductions in pain intensity, improvements in functional capacity and disability, and positive effects on quality of life, particularly in its physical domains. The therapeutic benefits are mediated through a combination of immediate neuro-modulatory effects and longer-term biological processes promoting tissue healing and reducing inflammation. The efficacy of ESWT is maximized when applied with optimized parameters (moderate-energy, focused shockwaves for specific pathologies), targeted to identifiable musculoskeletal pain generators (e.g., myofascial trigger points, facet joints), and integrated within a multimodal rehabilitation program that includes active exercise therapy. While not universally superior to all alternatives—showing particular strength against sham and conventional physical therapy but variable results compared to specific manual or mechanical therapies—its excellent safety profile makes it a compelling option for patients who have not responded to or cannot tolerate first-line treatments.

Recommendations

1. **For Clinicians:** Consider ESWT as a viable intervention for patients with CLBP, especially those with specific diagnoses like myofascial pain syndrome or facet joint syndrome. Perform a thorough assessment to identify treatable pain generators. Prescribe ESWT as a course of treatment (typically 4-10 sessions) using evidence-based parameters and always combine it with prescribed therapeutic exercises. Clearly communicate the treatment expectations and the typical transient side effects to patients.
2. **For Researchers:** Future studies should prioritize large, pragmatic RCTs with standardized ESWT protocols, long-term follow-up (≥1 year), and head-to-head comparisons with other evidence-based interventions (e.g., cognitive-behavioral therapy, high-grade exercise programs). Research should also delve into mechanistic studies using biomarkers and imaging to better understand treatment responders and the biological basis of ESWT's effects. Economic evaluations are needed to establish its cost-effectiveness in healthcare systems.
3. **For Policy Makers and Healthcare Systems:** Given the strong evidence for efficacy and safety, ESWT should be recognized and, where appropriate, reimbursed as a non-invasive treatment option within the continuum of care for CLBP. Developing clinical practice guidelines that outline patient selection criteria and treatment protocols will help ensure its appropriate and effective use.

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