

Advancing Rehabilitation: A Scoping Review on High-Power Laser Therapy and Its Role in Targeted Therapeutic Delivery

Anjali Raghuwanshi¹, Dr. Adarsh Kumar Srivastav², Dr. Shweta Sharma³, Dr. Aakanksha Bajpai⁴, Dr. Jayantika Bhardwaj⁵

¹PhD Scholar, Department of Physiotherapy, School of Health Sciences, Chhatrapati Shahu Ji Maharaj University, Uttar Pradesh, India,

²Assistant Professor, Department of Physiotherapy, School of Health Sciences, Chhatrapati Shahu Ji Maharaj University, Uttar Pradesh, India

³Associate Professor, School of Physiotherapy, Shree Guru Gobind Tricentenary University, Gurugram Haryana, India

⁴Assistant Professor, School of Physiotherapy, Shree Guru Gobind Tricentenary University, Gurugram Haryana, India

⁵Assistant Professor, School of Physiotherapy, Shree Guru Gobind Tricentenary University, Gurugram Haryana, India

Correspondence Author: anjaliraghuwanshi99@gmail.com

^{1*}ORCID: <https://orcid.org/0000-0003-4484-8225>

¹anjaliraghuwanshi99@gmail.com, ²adarshsrivastava13@gmail.com, ³shwetasharmamph27@gmail.com

⁴aakankshabajpai2403@gmail.com and ⁵Jayantika.bhardwaj@gmail.com

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ABSTRACT

Background

Athletes undergo intensive training routines and face competitive pressures that demand effective recovery strategies to maintain peak performance and mitigate injury risk. Musculoskeletal injuries remain prevalent in athletic populations, resulting in performance impairment and substantial economic burden. Conventional recovery approaches present inherent limitations, including prolonged recovery timelines and adverse effect profiles. High-Intensity Laser Therapy (HILT) has emerged as a non-invasive therapeutic modality utilizing high-intensity light for tissue interaction, offering potential advantages in accelerating recovery, alleviating pain, and enhancing tissue regeneration. However, current evidence regarding HILT application in athletes remains insufficient, with existing studies demonstrating methodological constraints in design rigor, sample adequacy, and parameter standardization.

Objective

This scoping review sought to identify and evaluate optimal treatment parameters for HILT application in athletic populations, thereby informing evidence-based clinical practice and future research directions.

Methods

The review followed PRISMA extension for scoping reviews i.e., PRISMA-ScR guidelines. Systematic database searches identified relevant literature published between 2014 and 2024. Eligibility criteria encompassed studies involving athletes with musculoskeletal injuries receiving HILT interventions and reporting specified outcome measures. Retrieved studies underwent systematic screening, quality appraisal, and data extraction procedures.

Results

Three studies met the inclusion criteria, comprising one clinical trial and two case studies. The included investigations examined chronic patellar tendinopathy, post-training recovery, and proximal hamstring tendinopathy. Findings indicated favourable HILT effects on pain reduction, functional restoration, and muscular strength enhancement. Nevertheless, a limited sample size constrains the generalizability of these outcomes.

Conclusion

HILT demonstrates therapeutic potential for managing musculoskeletal injuries in athletes. However, definitive efficacy determination requires additional rigorous randomised controlled trials employing standardised treatment protocols and larger participants.

Keywords: LASER, HILT, non-invasive, Therapeutic, Athletes, injuries

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*Author for Correspondence: anjaliraghuwanshi99@gmail.com

1. INTRODUCTION

Elite athletes live in a persistent pursuit, always pushing themselves towards their potential boundaries.¹ Their carefully planned training schedules required athletes to practice physically and psychologically, especially in competitive settings.² This clarifies recovery is very essential for maintaining the best performance and decreasing the risk of injury. Although traditional methods such as rest, cryotherapy, and massage therapy are not without limitations, they include extended recovery periods and potential side effects.³ Therefore, exploring alternative approaches becomes a requirement. Several athletes suffer from musculoskeletal injuries annually. Studies indicate more than 50% of athletes experience injuries every year and even certain sports report alarmingly high rates exceedingly around 70%.^{4,5} In addition to weakening performance, these injuries can cost players and teams a significant amount. The pressure to return to competition quickly adds to the need for effective and efficient evidence-based recovery strategies.⁶

High-power laser therapy (HPLT) or high intensity laser therapy (HILT) is a new addition to the toolkit of athletic recovery. It is also known as class IV laser therapy, becoming increasingly popular in physiotherapy as a non-invasive treatment modality.⁷ Originally recognized for its effectiveness in treating different musculoskeletal conditions,⁸ HPLT is now catching the interest of sports physiotherapists. Athletes and sports enthusiasts are increasingly turning to HPLT to speed up healing from injuries like muscle strains and ligament sprains, which helps athletes get back to peak performance faster.⁹ Unlike low-power laser therapy, which primarily focuses on biostimulation, HPLT utilizes higher power densities to induce both photochemical and thermal effects on targeted tissues.^{9,10} HPLT has been effective in treating musculoskeletal conditions in athletes, particularly PHT (P: Proximal, H: hamstring, T: Tendinopathy).⁹ A previous study found that HPLT significantly improved pain scores by 61.26% and increased the isokinetic peak torque of the muscle (hamstring) 13.18% in athletes with PHT after 3 weeks of treatment. In comparison, a standard or traditional physical therapy program, including ultrasound therapy (UST), moist heat pack, and home-based exercises, only reduced pain scores by 41.14% with no significant improvement in IPT.⁹ The clinical biostimulation of HPLT are primarily due to biostimulation, a process that enhances cellular function, which leads to the significant pain relief and more rapid tissue repair after any injury.¹¹ The 808-810 nm wavelength is strongly absorbed by mitochondrial cytochromes, activating the respiratory chain and increasing ATP production.^{4,9,11-14}

While suggestive of potential benefits, the existing literature on HPLT in athletes are hampered by several limitations that need a scoping and critical evaluation. Future research should prioritize rigorous study designs with standardized protocols, HPLT parameters used in studies (wavelength, power density, treatment duration, and frequency), and adequate statistical analysis to

increase the reliability and applicability of the discoveries. Assessing the efficacy of HILT for athletes with musculoskeletal injuries in athletes, the null hypothesis (H0) posits that HILT does not lead to improved pain, recovery, and tendinopathy in athletes. Conversely, the alternative hypothesis (H1) suggests that HILT will improve athletes' musculoskeletal injuries. This framework will guide the investigation into the potential benefits of HILT in enhancing athletic recovery and performance. By precisely analyzing the extant literature, this review also aims to provide clinicians and the young researchers with a comprehensive understanding of the potential benefits and limitations of HPLT in managing musculoskeletal injuries in athletes. This information can lead to evidence-based clinical decision-making and guide future research directions in a rapidly evolving field.

Consequently, the research questions (RQ) for this scoping review are:

- Does the HPLT effectively improve athletes pain, function, and recovery times?
- Does the HPLT demonstrate differential effectiveness for various types of athletic injuries?
- What are the optimal treatment parameters for HPLT in athletes considering different injury types and desired outcomes?

2. MATERIALS AND METHODS

A scoping review was conducted to identify, synthesize, and map the aspects of the existing information regarding the impact of HPLT on athletes; however, the methodological quality of the work was not critically evaluated.¹⁵ The approach and structure of the methodology supplied by Arksey and O'Malley, as well as the procedural breakthrough by Levac and colleagues, were utilized for this analysis.^{16,17} The reporting of this systematic scoping review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-sCr) guidelines.¹⁶ This framework's planned steps are as follows: (1) defining the RQ; (2) locating pertinent studies; (3) choosing studies; (4) plotting the data; and (5) compiling, analyzing, and reporting.¹⁶ This review did not entail direct engagement with patients or healthcare professionals. Instead, it involved an examination and synthesis of pre-existing published data, thus removing the requirement for ethical approval.

2.1. Formulating RQ

The goal of the present review questions is to summarize the relevant evidence that is currently accessible in a broad manner.¹⁸ The following queries were chosen for the current investigation based on the overarching project goals: (1) What are the characteristics of HPLT on athletic injuries worldwide? (2) What are interventional tactics have been used in the rehabilitation of athletes with HPLT globally? (4) for what kind of injuries HPLT is mostly effective worldwide?

2.2. Data Sources and Literature Search Strategy

The following electronic databases, registries, and search engines were searched for eligible articles from the inception of the database to August 2024, a systematic search was followed for published articles from the last fourteen years (i.e. 2010-2024) was conducted in electronic databases such as PUBMED, EMBASE, Cochrane Library, Litmaps, Research rabbit, connected papers, and PEDro. Search terms included words related to ‘high-power laser therapy’, ‘class IV laser therapy’,

‘athletes’, ‘pain’, ‘injury’, ‘physiotherapy’, and ‘physical therapy’, combined with the Boolean operators like ‘AND’, ‘NOT’, and ‘OR’. Titles, Headings, and abstracts were screened to identify relevant literature. Full-text copies of relevant peer-reviewed scientific papers were retrieved, and their reference lists were screened to identify additional relevant studies within the predetermined area.

Table 1 Search Constraints

Population	Concept
High-intensity laser therapy, Athletes’ injury, and risk factors block keywords, laser therapy for athletes, laser therapy athletic training, laser therapy sports injuries, HILT, high power laser therapy, tendinopathy, sports injury, sports condition	Physiotherapy Or Physical Therapy block keywords, Physiotherapist(s), physical therapist(s), kinesiotherapy, physiotherapy assistant. Health advancement block keywords: Athlete instruction, health advancement, health instruction, health behavior, advanced technology, educational technology, individual, sports person, the activity of daily living, the activity of daily living improvement, HILT, HPLT, advance technology, physical activity, exercise promotion, goal setting, brief counseling, motivational prompts, nutrition, weight management

2.3 Eligibility Criteria

Both types of studies were included, either they reported or evaluated with sports injuries for HILT, were led by physical therapists, and were published in English

language. Studies focusing on specific clinical and therapeutic outcomes were included, while those related to health promotions were excluded. Details on inclusion and exclusion criteria are presented in Table 2.

Table 2 Inclusion and Exclusion Criteria

Participants/Population	Concept/Intervention	Context	Study Types and Design
Inclusion Criteria			
<ul style="list-style-type: none"> • Injured Athletes with risk or occurred injury • Studies Conducted, Organized, or implemented by Physiotherapists or Physiotherapy Assistants 	<ul style="list-style-type: none"> • High Power Laser Therapy or High-Intensity Laser Therapy 	<ul style="list-style-type: none"> • Primary, Secondary, and Tertiary care • Rural and Urban Settings • Low-and high-income countries 	<ul style="list-style-type: none"> • All eligible primary studies • Both qualitative and quantitative studies published literatures
Exclusion Criteria			
<ul style="list-style-type: none"> • Studies with low-intensity laser therapy or low-power laser therapy • Intervention initiated and implemented by clinicians other than physiotherapists 	<ul style="list-style-type: none"> • Studies with high-power laser therapy on musculoskeletal or neurological conditions 		<ul style="list-style-type: none"> • Incomplete research data • Unpublished Articles • Letters to the editor, commentaries, notes, reviews • Studies in a language other than English

2.4 Study Selection (Screening)

Studies recognized through searches were introduced through Mendley. Both independent reviewers (AR, AKS) individually screened literatures using a three-step process: First, step is screening the titles were screened,

then the abstracts, and finally, the full text based on inclusion and exclusion criteria as presented in Table 2. Full texts of selected literature were reviewed in detail based on the inclusion criteria by independent reviewers (AR, and AKS). Any reasons for excluding scientific studies that did not meet the inclusion criteria are

described on the PRISMA flowchart. Any disagreements between the reviewers at any stage of the study performance selection process were resolved through a detailed discussion.

2.5 Data Charting (Data Extraction)

Data charting (DC) is one of the methods for extracting data for scoping reviews.¹⁶ The chart included detailed evidence about the study involved participants and the study’s design. Data about the nature of the intervention were extracted based on the Template for Intervention Description and Replication (TIDeR) outline, involve the theoretical framework (why), type of the intervention (what), duration of the intervention provider (who), the delivery format (how), the intervention location (where), the number of intervention sessions (how much), modified intervention according to the individual (tailoring), and the fidelity (how well).¹⁹ In cases where the missing data process was sufficiently described, the corresponding author was communicated to clarify or provide the missing information. Screening and DC were completed in Mendley.

2.6 Quality Appraisal

According to the current guidelines for conducting scoping reviews, a quality appraisal was not required to meet the objectives of this study.²⁰

2.7 Consultation

We consulted relevant stakeholders, experts in the field, and key informants in the later stages of this review to clarify missing information, identify relevant ongoing studies, or identify interventions/concepts not considered in the review.²¹

2.8 Collating, Summarizing, and Reporting

Outcomes are been synthesized narratively and documented in a tabular format based on elements of the TIDier framework.

3. RESULTS

3.1 The Literature Exploration and Included Studies

Figure 1 presents the PRISMA flow diagram illustrating the study selection process. Systematic database searches yielded 69 articles, with individual database contributions detailed in the diagram. After excluding non-article records, the remaining literature underwent systematic screening. Based on the titles, and abstract review, 7 articles met the criteria for full text assessment. Final evaluation of these articles led to the inclusion of the full-text of 3 studies in the systematic review. Exclusion rationale at each screening phase is been documented in the PRISMA flow diagram.

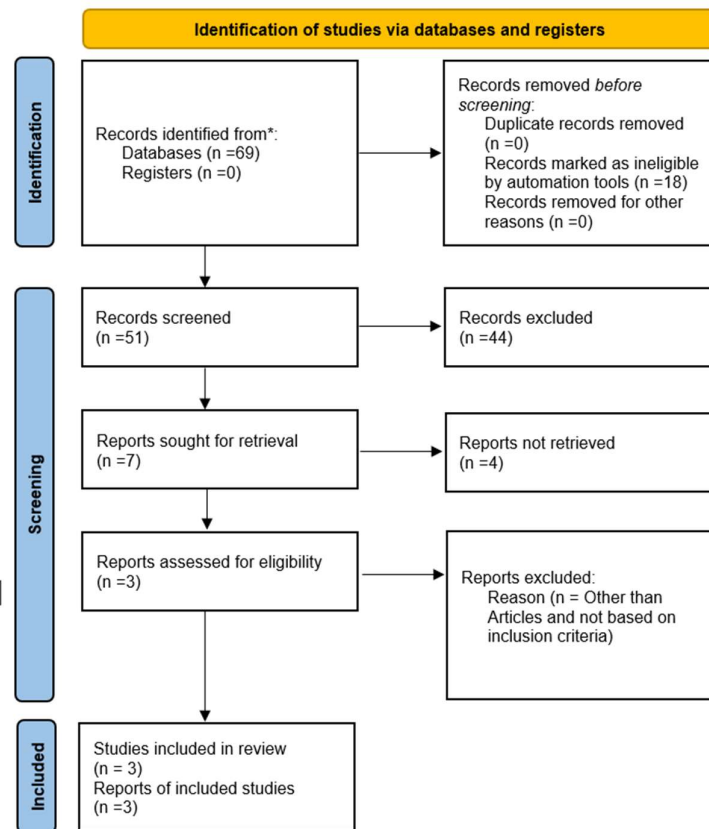


Figure Error! No text of specified style in document..1 PRISMA Flow Chart

3.2 Features of Included Studies

Table 3, summarizes the features of the included studies. Of the three studies, one was randomized control trial

(RCT),^{22,23}, one was a clinical trial^{22,23}, and one was a case study²⁴. All the included studies were published between 2019 and 2024. Studies were conducted on injured athletes with chronic patellar tendinopathy,²³ post-training recovery,²⁴ and proximal hamstring tendinopathy²². The sample size of the performed research ranged from 2

to 36 participants. The included study was conducted in Ukraine,²³ Vietnamese,²⁴ and Saudi Arabia.²² One study was from a lower middle-class economic country and Europe continent²³. The other two studies were from Asia, one from a middle-income economy country,²⁴ and one from a high-income country.²²

Table 3 Components and characteristics of the interventions in the included studies for HILT

Author and year of publication	Objectives of the Study	Study Design	Intervention Used	Sampling Size and Sex	Treatment Characteristics and Duration	Assessment Tool Used	Follow-Up	Result
Olexandrs, stepanenko et al., ²³ 2022	To evaluate the effectiveness of a comprehensive rehabilitation program combining laser therapy and therapeutic exercises for athletes with chronic patellar tendinopathy	Clinical Trial	Laser Therapy (HILT) and therapeutic exercises	22 athletes (main group: 11, control group: 11)	Duration: 2 Months, 4 Stages <i>Stage 1:</i> Pain Management <i>Stage 2:</i> Biostimulation <i>Stage 3 & 4:</i> Exercise Therapy	Visual Analogue Scale (VAS) and VISA-P scale	The effectiveness of the rehabilitation program was assessed before and after the intervention period of 2 months	At the end of the intervention, pain significantly decreased in both groups. The Main Group's VAS score decreased to 2.0 points (71.01% reduction), while the Control Group's score dropped to 3.5 points (50% reduction). Functional capacity of the knee joint improved more in the main group compared to a 12.0-point increase (21%) in the control group.
Verma S et. AL, ²² 2022	To evaluate the effectiveness of HPLT on pain relief and isokinetic peak torque (IPT) in athletes with proximal hamstring tendinopathy	A Randomized Control Trial	HPLT for the experimental group and conventional therapy (Ultrasound therapy and Moist heat pack) for the control group	A total of 36 participants (18 in each group), aged 18-35 years, all of whom were male athletes participating in national level competitive track and field events	The intervention on the lasted for three weeks, with specific treatment sessions detailed in the study protocol Dosage Calculation The average output power of the laser was set at 5 watts The dose was specified as 50joules/cm ² The total treatment area was calculated as 6cm x6 cm = 36 cm ² The total energy was calculated to be 6 minutes, in continuous mode for this duration. Applied Areas Around the ischial tuberosity, where the hamstring tendons originate.	Numeric Pain Rating Scale (NPRS) for pain assessment and isokinetic dynamometer for measuring IPT of the hamstring muscle	Post-intervention assessments were conducted immediately after the completion of the treatment to evaluate changes in NPRS scores and IPT values.	The experimental group showed a significant decrease in NPRS scores (61.26%) and an increase in IPT (13.18%) after HPLT, while the conventional group showed a decrease in NPRS scores (41.14%) and a marginal increase in IPT (1.49%)

<p>Hanh LEHI MY et. Al.,²⁴</p>	<p>To evaluate the effect of embedded post-training recovery services on muscular strength in para powerlifting athletes.</p>	<p>Quasi-experimental case study with pre-test and post-test assessments</p>	<p>Resistance training followed by post-training recovery services including sport massage, sauna & Jacuzzi, and HILT</p>	<p>Two male powerlifting athletes from the Vietnam National Team, aged 36-38 years</p>	<p>The intervention consisted of four exercises and HILT for recovery after each training session HILT Dosage Calculation <i>HILT Power</i></p> <ul style="list-style-type: none"> • 20W for io-stimulation (8101J) for 5 minutes per position • 16 W for pain relief (8101J) for another 5 minutes per position <p><i>Applied areas</i> <u>Targeted Areas for Treatment</u></p> <ul style="list-style-type: none"> • Right and left shoulder muscles • Chest Muscles • Upper back muscles <p><i>Total Treatment Duration</i> Each session included 20 minutes of HILT treatment after sauna bathing</p>	<p>Bench Press Strength Test and Dominant Hand grip (dynamometer) test</p>	<p>Post-intervention data collected one day after the intervention period</p>	<p>The muscular strength of the bench press showed significant enhancement between pre-intervention and post-intervention assessment. Study also shows a significant difference in dominant handgrip difference in dominant (M=31.25±0.35) to post-intervention (M=55.00±2.83), with a t-value of t(1)= -13.57, p=0.047, and an effect size of d = 9.62, indicating a large effect. The HILT also proved the effect of reducing pain and inflammation, which contributed to the overall improvement in strength performance during the post-intervention tests.</p>
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3.3 Features of the Included Interventions

The physiotherapist implemented all the studies.²²⁻²⁴ or in blend with other healthcare professionals. The recognized interventions were heterogeneous and documented

according to the TIDeR outline in table 4, studies also used the multimodal intervention strategies, and studies using only a single (HILT) intervention strategy.

Table 4 TIDIER components and the nature of HILT interventions on athletes of the included studies

Author Year	Country	N	Study Design	Population	Nature of the Intervention	Intervention Duration	Theory Use	Setting(s)	Educational Component	Delivery Format	Number of Sessions	Technology	Tailoring	Fidelity
Alexander s. stepanenko et al., ²³ 2022	Ukraine	22	Clinical Trial	Male athletes aged 20 to 35 years with chronic patellar tendinopathy	A comprehensive physical rehabilitation program combining HILT and various therapeutic exercises	2 months	The intervention was based on principles of pain management and tissue biostimulation, utilizing therapeutic laser protocols to enhance recovery and functional capacity	Clinical	Participants received education on the correct execution of therapeutic exercise and the importance of adherence to the rehabilitation program for optimal recovery	The intervention was delivered in a structured format, including both individual sessions for laser therapy and group or individual sessions for therapeutic exercises	Participants in the main group underwent a total of 16 sessions of laser therapy (8 sessions for pain management and 8 sessions for tissue biostimulation), along with therapeutic exercises conducted throughout the 2 months	Yes, the intervention utilized a HILT HIL-6000 laser (P6000/402) with maximum power of 12 W and a wavelength of 1064nm for laser therapy	The rehabilitation program was tailored to individual needs based on the severity of the condition, pain, levels, and functional capacity of each athlete, ensuring personalized treatment	Fidelity to the intervention was maintained through adherence to the established laser therapy protocols and supervision by qualified physical therapists to ensure correct application of therapeutic exercises
Verma S et. Al., ²² 2022	India	36	RCT	Athletes aged 18 to 35 years with proximal hamstring tendinopathy	The intervention involved HILT administered as monotherapy to the area around the ischial tuberosity, targeting the hamstring tendons	3 weeks	The intervention is based on principles of biostimulation, which suggests that specific wavelengths of light can promote healing and reduce pain by influencing cellular processes	Clinical	Participants were informed about the risks and benefit of study, and informed consent was obtained prior to participation.	The HPLT was delivered in a prone position, with the treatment area uncovered and prepared for laser application.	Each participant received a total of 9 sessions of HPLT over the 3-week period (3 sessions per week)	Laser device with parameters set at an average output power of 5W, a wavelength of 980/810nm, and a total energy delivery of 1800 joules	Yes, the intervention was tailored to target the specific area of pain (ischial tuberosity) based on the participants' diagnosis of posterior hamstring tendinopathy	Fidelity to the intervention was maintained by ensuring that the same laser parameters and protocols were followed for all participants, and the outcome assessors were blinded to group allocation.
Hanh LEHMY et. Al., ²⁴	Vietnamese	2	Case Study	Athletes aged 36 to 38 years of National Para Powerlifting Athletes	Sport Massage, Sutra Bathing, HILT, and Kines Taping	8 Weeks	The intervention was based on principles of exercise physiology and recovery strategies aimed at enhancing muscular strength and recovery from exercise-induced muscle damage	Clinical	No	The intervention was delivered in a structured format, combining resistance training sessions with recovery services immediately following the training	There are 24 sessions during 8-week intervention period, three resistance training sessions per week, and recovery services scheduled after each training session.	Yes, the intervention utilizes HPLT as a technological component for recovery, which involves the application of laser radiation for therapeutic benefit.	The intervention was tailored specifically for para athletes, considering their unique physical needs and the demands of their sport	The study adhered to established protocols for applying recovery methods, ensuring that the interventions were delivered consistently and according to the planned schedule.

3.4 The Quality Assessment

The quality of all included RCT research literature is evaluated and designed by using the PEDro scale (P: Physiotherapy, E: Evidence, Dro: database). The PEDro scores of included articles are conveyed in Table 5. The quality of the included scientific proven literature was evaluated by obtaining the PEDro score from the Physiotherapy Evidence Database (www.pedro.org.au). This scale consists of 11-item scale designed for rating the trials' quality of methods followed (internal validity and the statistical knowledge). Except for item 1, each item contributes one point to the total score (range 0 to 10 points). An scientific paper with a PEDro score of more

than or equal to 6 out of 10 is considered good or excellent, and an article with a PEDro score of less than or equal to 4 out of ten is denoted as poor. The PEDro scores for the included studies were obtained from the official PEDro website (<https://www.pedro.org.au/>).²⁵ In any scenario, if the score for the included articles was not available on the websites, both reviewers (AR and AKS) scored the quality of the included article across the 10 items scale of PEDro scale independently (Box 2), and in case of any doubt or disagreement, the final decision was made through the detailed discussion.²⁵

The involved non-RCTs article quality is evaluated using the Methodological Index for Non-Randomized Studies (MINORS) scale. The scale scores of the included articles are in Table 6. It mainly consists of a group of eight items scale for non-comparative studies and a twelve-items scale for comparative studies, with a maximum score of sixteen for non-comparative studies and twenty-four for comparative studies. So, this scale is eligible to evaluate both comparative and non-comparative studies. In the evaluation of the MINORS items, each independent item

is assigned a score of 0, 1, or 2, reflecting its level of reporting. Specifically, a score of 0, which shows that the item was not reported, a result of 1 signifies that the item was reported but deemed inadequate, and if a score of 2 is obtained, it denotes that the item was reported appropriately. The maximum possible score is 16 for non-comparative studies and 24 for comparative studies, representing the ideal standard of reporting for each study type.²⁶

Table 5 Quality Assessment: PEDro Scale

Study	Eligibility criteria and sources	Random allocation	Concealed allocation	Base line comparability	Blind subjects	Blind Therapists	Blind Assessors	Adequate follow-up	Intention to treat analysis	Between-group comparisons	Point estimates and variability	Total Score (0 to 10)	Quality
<i>Olexandr S. Stepanenko et al.,²³</i>	Yes	0	0	1	0	0	0	0	1	1	1	4/10	Low
<i>Verma S et. Al.,²²</i>	Yes	1	0	1	0	0	1	0	0	1	1	5/10	Moderate

Table 6 Quality assessment- methodological index for non-randomized study (MINORS) score

Methodological items for non-randomized studies	Articles	Hanh LEHI MY et. Al., ²⁴
	1. A clearly stated aim	2
	2. Inclusion of consecutive participants	2
	3. Prospective Collection of Data	2
	4. Endpoints appropriate to the aim of the study	2
	5. Unbiased assessment of study endpoint	0
	6. Follow-up period appropriate to the aim of the study	2
	7. Loss to follow-up less than 5%	0
	8. Prospective calculation of the study size	0
	Total Score	10/16

3.5 Risk of Bias

The result of the risk of bias assessment for the overall risk of bias in the articles included is presented in Figure 2.

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Hanh LE EHI MY et. al,	-	-	?	?	+	+	?
Olexandr. S Stepanenko et. al,	+	-	-	-	?	-	?
Verma S et. al,	+	+	+	+	+	+	?

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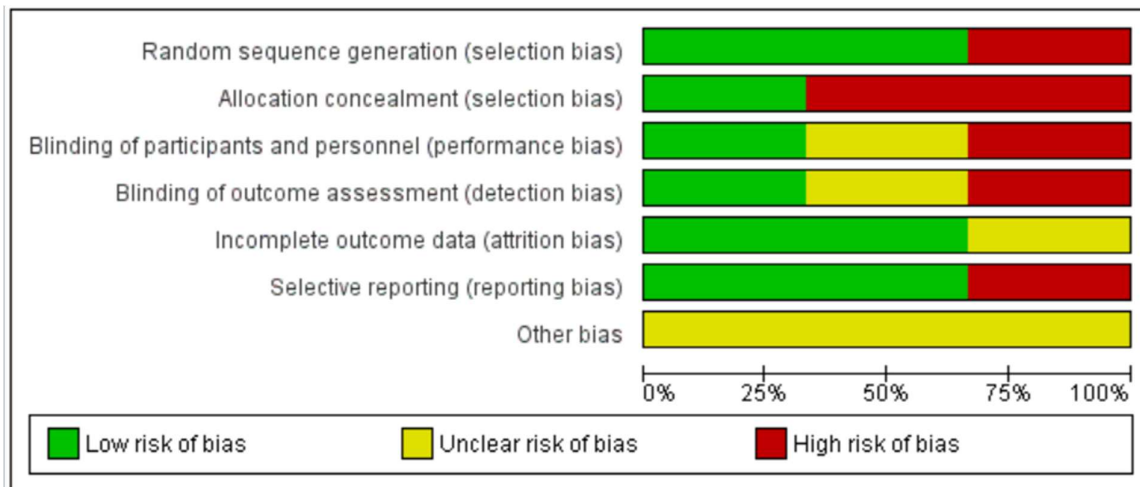


Figure Error! No text of specified style in document..3 Risk of Bias Graph

4. DISCUSSION

4.1 Effectiveness of HPLT

The reviewed studies collectively suggest that HPLT may benefit significantly in managing athletic injuries and conditions. For instance, Verma et al.,²² reported a substantial reduction in pain and improvement in IPT among athletes with proximal hamstring tendinopathy following HPLT treatment. Similarly, Stepanenko et al., (2022)²³ found that combining HPLT with therapeutic exercises led to greater pain reduction and functional improvement compared to conventional therapy. Research

on the efficacy of various treatment methods for sports injuries and muscular strength in athletes is crucial for healthcare professionals and clinicians to make informed decisions for better athlete care and performance. To evaluate the efficacy of existing and innovative adjunct physiotherapy therapies, we gathered and critically appraised all relevant scientific literature on injury, pain, tendinopathy, muscle strength, and HILT, including case studies, clinical trials, and RCT. Based on the evidence shown in Table 1, it is clear that using both traditional and innovative HILT can improve treatment outcomes. However, past studies demonstrate multiple treatment

plans such as eccentric exercises are widely regarded as first-line treatment for tendinopathy in athletes due to their efficiency. HILT sessions typically require less time than exercise regimens, making it a more convenient option for athletes who need to manage their training schedules. Eccentric and isometric exercises often require consistent and prolonged engagement to yield results, which can be challenging during competitive seasons.²⁷

However, the variability in treatment protocols and outcome measures highlights a need for standardized approaches in future research. The differences in power settings, wavelengths, and treatment durations across studies underscore the challenge of establishing uniform treatment guidelines.

4.2 Differential effectiveness

The effectiveness of HPLT appears to vary depending on the type of injury and the specific parameters used. For example, while HPLT showed promising results in treating proximal hamstring tendinopathy²² and chronic patellar tendinopathy,²³ its impact on other athletic injuries requires further investigation—the case study by Hanh et al.²⁴ (2024) suggests that HPLT can also effectively enhance muscular strength and recovery. Still, the small sample size limits the generalizability of the findings.

4.3 Optimal Treatment Parameters

Determining the optimal parameters for HPLT is crucial for maximizing the therapeutic benefits. The reviewed studies utilized different power, wavelength, and dosage settings, reflecting a lack of consensus on the ideal treatment parameters. Future research should aim to standardize these parameters and explore their impact on various injury types and outcomes. Establishing clear protocols will facilitate more reliable comparisons and help refine treatment strategies. Further research is required to address the current gap in the literature regarding the application of HILT within the specialized field of sports physiotherapy.

5. LIMITATION

The current literature on the impact of HILT on athletes has notable limitations. One key issue is the variability in the design, where other methodologies make it difficult to compare results across studies. Sample sizes are often small, limiting the generalizability of the findings. Additionally, treatment parameters, such as the intensity, frequency, and duration of the HILT, vary significantly between studies, creating inconsistencies in the outcomes. More RCTs with larger sample sizes are needed to establish reliable evidence and identify optimal HILT parameters for athletic rehabilitation and performance enhancement.

6. CONCLUSIONS

HPLT shows potential for treating sporting injuries. According to studies, it can help reduce discomfort, improve function, and increase muscle strength. While the present study has limitations, HPLT's potential advantages are worth additional exploration. Future studies should focus on robust study designs, standardized criteria, and mechanism discovery to strengthen HPLT's place in

evidence-based sports training and rehabilitation. This review offers physicians and researchers a thorough grasp of HPLT's potential, which will inform future research and therapeutic decision-making in this quickly growing field.

6. FUNDING

The research has not received any external funding.

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