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Comparing the effectiveness of high- and low-intensity laser therapy in enhancing conventional treatment for frozen shoulder: A systematic review, meta-analysis, and meta-regression

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ABSTRACT

Introduction: This study reviews the efficacy of high-intensity laser therapy (HILT) and low-level laser therapy (LLLT) for frozen shoulders, including a meta-regression to identify variables affecting treatment outcomes.

Methods: Eight randomized controlled trials (RCTs) with 444 participants with frozen shoulders received HILT or LLLT, combined with conventional therapies. Outcomes measured visual analogue scale (VAS)-pain scores, shoulder pain and disability index (SPADI), short form health survey questionnaire (SF-36), and shoulder range of motion (ROM). The bias was analyzed with risk of bias version 2 and the analysis was performed with JAMOVI 2.4.14 and RevMan 5.4.

Results: Laser therapy showed significant improvements in outcomes: VAS scores (risk ratio [RR] -1.36, 95% confidence interval [CI] -1.95, -0.76), SPADI-pain (RR -10.20, 95% CI -15.95, -4.44), shoulder abduction ROM (RR 8.74, 95% CI 1.37, 16.11), and SF-36 role limitation due to physical health (RR 28.55, 95% CI 9.99, 47.12). The intensity of laser therapy influenced outcomes, with confounding factors affecting follow-up time and SF-36 emotional well-being.

Conclusion: Laser therapy, especially HILT, significantly reduces pain, improves shoulder range of motion, and enhances quality of life.

Keywords: laser therapy, pain, range of motion, functional status, frozen shoulder

INTRODUCTION

Frozen shoulder, also known as adhesive capsulitis, is a common musculoskeletal disorder characterized by pain and restricted range of motion (ROM) in the shoulder joint. It affects approximately 2% to 5% of the general population, with a higher prevalence observed among individuals aged 40 to 60 years, particularly women [1]. This condition significantly impacts daily activities and quality of life. While the etiology of frozen shoulder remains unclear, it is often associated with conditions such as diabetes, thyroid disorders, and prolonged immobility [2].

Various therapeutic interventions have been explored to manage the symptoms of frozen shoulder, including physical therapy, corticosteroid injections, and surgical interventions. While physical therapy remains a cornerstone of treatment, it often requires prolonged adherence and may yield limited improvement in patients with severe pain or restricted motion. Corticosteroid injections, although effective in providing short-term pain relief, are associated with potential side effects such as tissue atrophy and joint infection, and their benefits tend to diminish over time. Surgical interventions, including capsular release, are typically reserved for refractory cases but carry inherent risks such as infection, nerve injury, and prolonged rehabilitation. In light of these limitations, laser therapy has gained attention as a non-invasive alternative with promising potential to promote tissue healing and reduce inflammation [1]. Laser therapy is broadly classified into high-intensity laser therapy (HILT) and low-intensity laser therapy (LILT), each believed to exert therapeutic effects through distinct mechanisms. HILT delivers higher energy in short pulses, allowing deeper tissue penetration and is proposed to accelerate pain relief and functional recovery.

Conversely, LILT provides continuous low energy, which may enhance cellular repair and modulate inflammatory responses over extended treatment periods [3]. Despite the theoretical advantages of both approaches, a lack of consensus remains regarding their comparative efficacy in treating frozen shoulders.

Table 1. Literature search strategy

Database	Search strategy
PubMed	("Frozen shoulder" OR "adhesive capsulitis" OR "bursitis" OR "subacromial shoulder pain" OR "glenohumeral joint" OR "rotator cuff tendinitis") AND ("laser" OR "photobiomodulation") AND ("treatment" OR "therapy")
Scopus	
Springer Link	
Epistemonikos	
Cochrane	
ProQuest	

The present study aims to fill this gap by systematically reviewing and meta-analyzing the existing literature on the efficacy of HILT and LILT for frozen shoulder treatment. Specifically, this study aims to compare the effectiveness of HILT and low-level laser therapy (LLLT) in enhancing conventional treatment for frozen shoulder.

Additionally, a meta-regression analysis will be conducted to explore potential factors influencing treatment outcomes. This comprehensive analysis will provide evidence-based insights to guide clinical decision-making and optimize therapeutic strategies for patients suffering from frozen shoulders. Furthermore, this research also aims to assess the comparative benefit of integrating laser therapy with conventional treatment versus conventional therapy alone in improving pain, function, and quality of life.

MATERIAL AND METHOD

Eligibility Criteria

The preferred reporting items for systematic reviews and meta-analyses (PRISMA) statement and the handbook criteria were followed in this review. We included the following studies:

(1) patients at the age of 18-60 years old with the diagnosis of frozen shoulder (derived terms such as adhesive capsulitis, bursitis, subacromial shoulder pain, glenohumeral joint, rotator cuff tendinitis) (population),

(2) compare between efficacy of laser therapy energy ("HILT," "LILT," and "photobiomodulation") as an add-ons for conventional therapy ("passive stretching," "strengthening," "active assisted ROM," and "codman/pendulum exercises") (intervention and control),

(3) provided data on the outcome for visual analogue scale (VAS)-pain, shoulder pain and disability index (SPADI), short form health survey questionnaire (SF-36), and shoulder ROM (outcome), and

(4) presented in the form of randomized clinical trials in 2014 until 2024 (study design).

However, our analysis did not include the following criteria:

(1) patients that have no outcome data,

(2) limited access to studies, and

(3) in the forms of review articles, case reports, and case series.

Literature Search and Study Selection

We have search six international databases: Scopus, PubMed, Cochrane, Springer Link, Epistemonikos, and ProQuest between May 26, 2024, and July 28, 2024. To gather all possibly relevant literature, we combined the following keywords: as indicated in **Table 1** "(frozen shoulder) AND (laser OR photobiomodulation) AND (treatment OR therapy)". Duplicated articles form the identified ones were first eliminated, and the remaining articles were then reviewed according to their titles and abstracts. Articles with titles and abstracts that met the pre-determined inclusion/exclusion criteria underwent a secondary stage of evaluation, where they were fully read through. The selected articles were determined by three authors through discussion.

Data Extraction

For analytical reasons, we extracted the following information: study ID, publication year, country, study design, sample size, participant mean age, participant per intervention and control group, intervention, time to follow up, the baseline and outcome of each desired intervention. All of the authors separate the data using Microsoft Excel 2019.

The baseline and outcome therapy that were provided in this research include: VAS, SPADI-pain, SPADI-total, SPADI-disability, abduction, external rotation, flexion, internal rotation, SF-36 (general health, emotional well-being, physical functioning, role limitation due to physical health, role limitation to emotional, social functioning) (outcome).

Risk of Bias Assessment

Using a validated method, three independent authors assessed the risk of bias. We applied a method from Cochrane collaborations, called risk of bias version 2 (RoB v2) to analyze the quality of included randomized controlled trials (RCTs). This application comprises a methodological assessment of five different domains:

(a) randomization process,

(b) deviations from intended interventions,

(c) missing outcome data,

(d) measurement of the outcome, and

(e) selection of the reported results.

The outcome is presented. The evaluations were classified as "low risk," "high risk," or "some concerns" of biased statistical analysis.

We applied mean difference combined with 95% confidence intervals (CIs) by using the inverse-variance formula for the analytical polling of continuous variable results. Dichotomous variables outcomes were combined into risk ratio (RR) with 95% CI by using the calculation of Mantel-Haenszel. Random-effect models were chosen in this review due to anticipated significant heterogeneity arising from various population characteristics and follow-up durations. The I-squared (I^2) statistic was used to evaluate heterogeneity between studies, treating I^2 values above 50% as significant heterogeneity. To convert data expressed as median and interquartile range or as median, minimum, and maximum into mean and standard deviation for pooled analysis, we use a combination formula from [4].

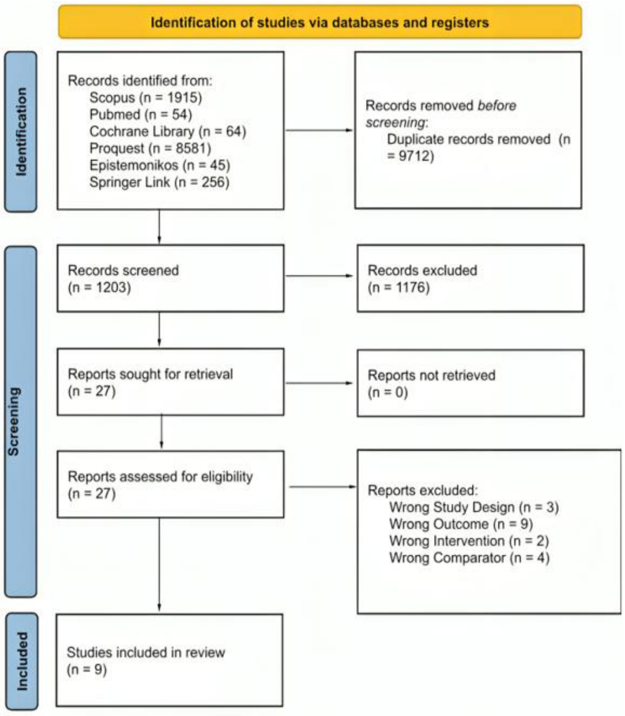

Figure 1. PRISMA diagram of the detailed process of selection of studies for inclusion in the systematic review and meta-analysis [5-13]

In cases where each outcome of interest had more than 10 studies, publication bias analysis was conducted. Upon finding funnel plot asymmetry, we intended to review PICO and outcome characteristics to determine if the asymmetry was due to publication bias or other factors like methodological heterogeneity. All of the statical analyses used review manager 5.4, an application from the Cochrane collaboration. Sensitivity meta-analyses were used to test the robustness outcome, including only studies with an overall low risk of bias.

Regression analysis is a statistical technique that is commonly used in data analysis to clarify the relationship between dependent and one or various independent variables.

Linear regression is applied to focus on the dependent variables such as sample size, age and length of follow-up and whether or not they showed an impact on those identified connections. Theoretical consideration and their relevance to the studies includes in the selection of variables. The regression analysis is performed using JAMOVI 2.4.14 to ensure robust data interpretation.

RESULTS

Study Selection and Characteristics

A literature search on 6 international databases yielded a total of 10,915 studies. After removing duplicates and screening studies based on year and design study, there were 1,203 remaining studies. After removing studies based on their titles and abstracts, leaving 27 studies. These 27 studies were assessed in a full-text form where 18 studies did not meet our eligibility criteria as follows: 3 study was only review article, 9 studies did not have data on the outcome of interest, 2 study did not mention the dose of laser therapy as a treatment for frozen shoulder, 4 studies did not have any control group. Thus, only 9 studies remain [5-13] were included in the final analysis **Figure 1**. These 9 studies were prospective RCTs and the number of samples ranged from 36 to 70.

A summary of the baseline characteristics of the included studies can be found in **Table 2**.

Quality of Study Assessment

The risk of bias assessment using the RoB v2 tool revealed that none of the RCTs were found to have a "high risk" of bias across all six assessment domains. However, one RCTs were identified as having "some concerns" regarding potential bias. Specifically, these concerns arose due to the use of single-blinding and the minimization method for randomization which can increase the risk of bias. Nevertheless, the participant baseline characteristics were similar between intervention groups, indicating no major randomization issues. The summary of the risk of bias assessment for all RCTs is detailed in **Figure 2**.

Table 2. Characteristics of included studies

Study ID				Population		Study
A	STD	Country	Type of participants	Age	SS	Follow-up
[5]	RCT	Saudi Arabia	Patients with adhesive capsulitis after their diagnosis and referral from professional orthopedists	56.70 ± 9.20	55	8 weeks
[6]	RCT	Turkey	Adult subjects aged 18 to 65 years who were clinically diagnosed with adhesive capsulitis for at least 1 month	58.50 ± 7.29	36	3 months
[7]	RCT	Turkey	Adult patients aged 18-65 years with complaints of shoulder pain, had been diagnosed with AC, and had severe pain also shoulder limitation for at least 3 months.	55.60 ± 7.90	45	3 weeks
[8]	RCT	Egypt	Adult patients aged 25-65 years suffering from shoulder AC after neck dissection surgeries	39.00 ± 14.09	40	8 weeks
[9]	RCT	Turkey	Adult patients aged 30 to 75 and having shoulder pain for more than 3 months.	52.30 ± 8.70	59	1 month
[10]	RCT	Turkey	Adult patients with an age range of 40 to 75 years, having shoulder pain for 3 months prior to admission and diagnosed with SAIS	51.10 ± 14.30	70	15 days
[11]	RCT	Turkey	Adult patients with age range of 30-75 years, having shoulder pain for at least 6 weeks and being diagnosed with SAIS	48.00 ± 7.70	63	3 weeks
[12]	RCT	Egypt	Adult patients with painful, restricted active and passive ROM of the shoulder, capsular pattern of motion restriction, and absence of radiologic evidence of glenohumeral joint arthritis with the duration of symptoms from 3 to 8 months.	49.50 ± 4.60	45	4 weeks
[13]	RCT	South Korea	Adult patients with shoulder pain for at least 1 month, prior to presentation at the clinic and limitation of passive movement of the shoulder joint compared to the contralateral asymptomatic shoulder and internal rotation at back	55.60 ± 7.90	66	3 weeks

Note. A: Authors; STD: Study design; & SS: Sample size

Figure 2. Risk of bias assessment of the included studies using RoB v2 tool [14]

Data Synthesis

Primary outcome

VAS score: Our analysis of 8 studies (n = 444) revealed that laser therapy is considerably effective in lowering VAS score compared to conventional physical therapy for patients with frozen shoulders (RR -1.36 [95% CI -1.95,-0.76], p < 0.00001, I^2 = 89%) as displayed in **Figure 3**. Subgroup analysis according to the intensity of laser therapy indicated both HILT (RR-1.74 [95% -2.69, -0.79], p = 0.0003, I^2= 90%) and LILT (RR -0.90 [95% CI -1.72,-0.07], p = 0.03, I^2= 90%) showed a significant reduction in VAS scores with lower RR found in LILT as shown in **Figure 3**.

SPADI-pain score: The pooled analysis of 6 studies (n=363) demonstrated that laser therapy is significantly more effective in reducing SPADI-pain (RR -10.20 [95% CI -15.95, -4.44], p = 0.0005, I^2= 86%) than conventional physical therapy within patients diagnosed with frozen shoulder. Subgroup analysis considering the intensity showed that HILT proved to have significant reduction on SPADI-pain (RR-14.17 [95% CI -23.21, -5.13], p = 0.002, I^2 = 91%) , while LILT did not prove to have a significant reduction (RR -5.85 [95% CI -12.46, 0.76], p = 0.08, I^2 = 69%), as shown in **Figure 4**.

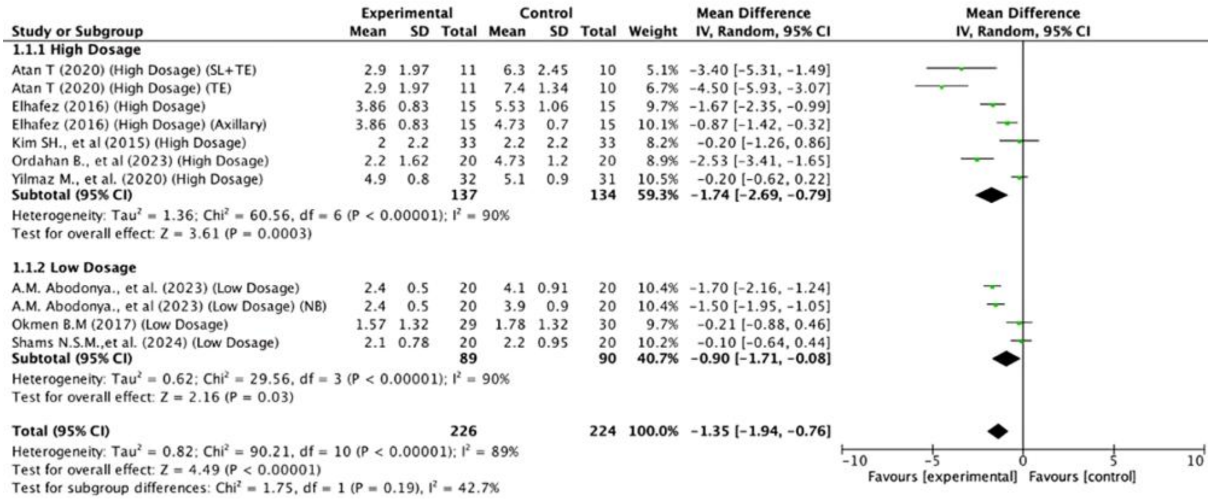

Figure 3. Forest and funnel plots displaying the comparison of VAS scores between HILT and LLLT with conventional physical therapy for patients with frozen shoulders in RCTs [5-9, 11-13]

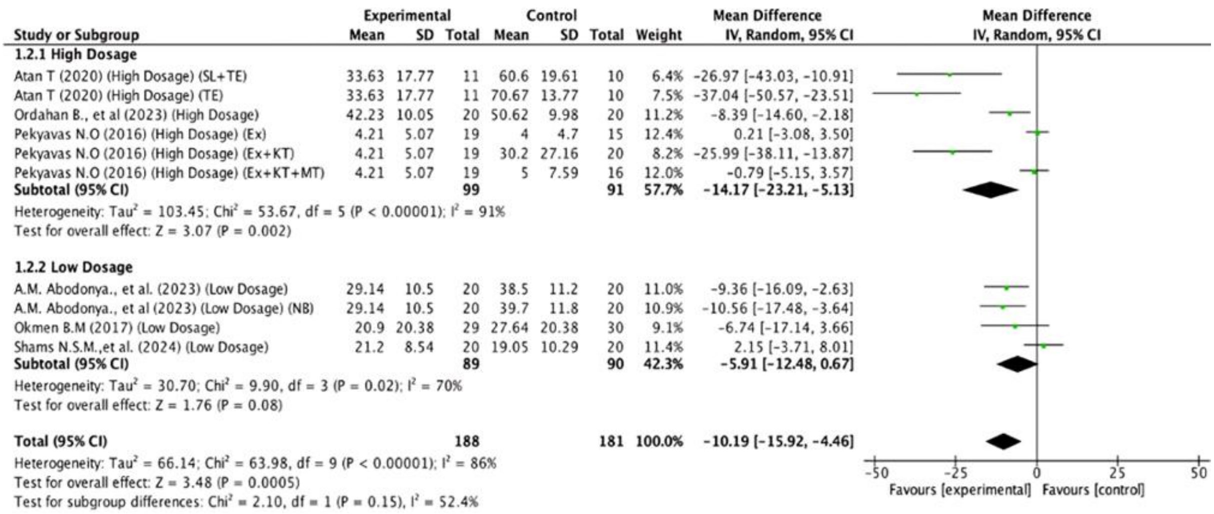

Figure 4. Forest and funnel plots displaying the comparison of SPADI-pain scores between HILT and LLLT with conventional physical therapy for patients with frozen shoulders in RCTs [5-10]

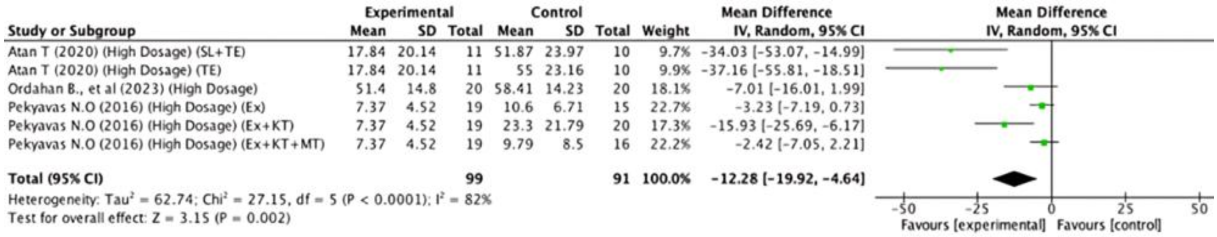

Figure 5. Forest and funnel plots displaying the comparison of SPADI-disability scores between HILT and conventional physical therapy in RCTs [6, 7, 10]

Figure 6. Forest and funnel plots displaying the comparison of SPADI-total scores between HILT and conventional physical therapy for patients with frozen shoulders in RCTs [6, 7, 10]

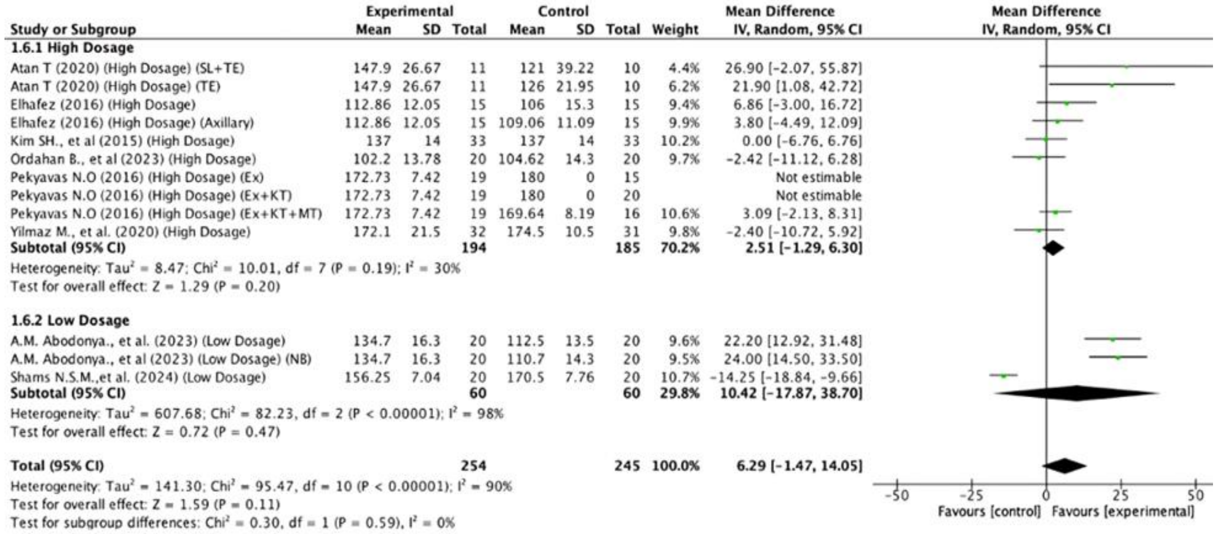

Figure 7. Forest and funnel plots displaying the comparison of ROM-shoulder flexion between HILT and LILT with conventional physical therapy for patients with frozen shoulders in RCTs [5-8, 10-13]

SPADI-disability score: Our comprehensive analysis of 3 studies (n = 190) showed that HILT remarkably decreased SPADI-disability scores (RR-12.28 [95% CI -19.92, -4.64], p = 0.002, I^2 = 82%) for patients with frozen shoulders as displayed in **Figure 5**.

SPADI-total score: Our pooled analysis of 3 studies (n = 190) revealed that HILT substantially lower SPADI total scores (RR -20.04 [95%CI -31.37, -8.71], p = 0.0005, I^2 = 84%) compared to conventional physical therapy for patients with frozen shoulders, as shown in **Figure 6**.

Shoulder Flexion

The pooled analysis of 8 studies (n = 493) indicated that patients with frozen shoulders improved their ROM-shoulder flexion (RR 6.22 [95% CI -1.46, 13.90], p = 0.11, I^2= 89%) by using conventional physical therapy than laser treatment. Subgroup analysis describing that both laser therapy has not proven an impact on increasing ROM-shoulder flexion.

There's a much lower RR and p-values in HILT (RR 2.51 [95% CI -1.29, 6.30], p = 0.20, I^2 = 30%) rather than LILT (RR 10.39 [95% CI -17.99, 38.78], p = 0.47, I^2 = 97%) for patients with frozen shoulders as it is shown in **Figure 7**.

Shoulder Abduction

Our pooled analyses from 7 studies (n = 427) demonstrated that laser therapy is significantly more effective in increasing ROM-shoulder abduction (RR 8.74 [95% CI 1.37, 16.11], p = 0.02, I^2 = 83%) than conventional physical therapy within patients diagnosed with frozen shoulder.

Subgroup analysis considering the intensity showed that HILT proved to have significant increase on ROM-shoulder abduction (RR 7.45 [95% CI 2.08,12.81], p = 0.007, I^2 = 56%), while LILT did not prove to have a significant reduction (RR 8.91 [95% CI -16.58, 34.40], p = 0.49, I^2 = 95%) as displayed in **Figure 8**.

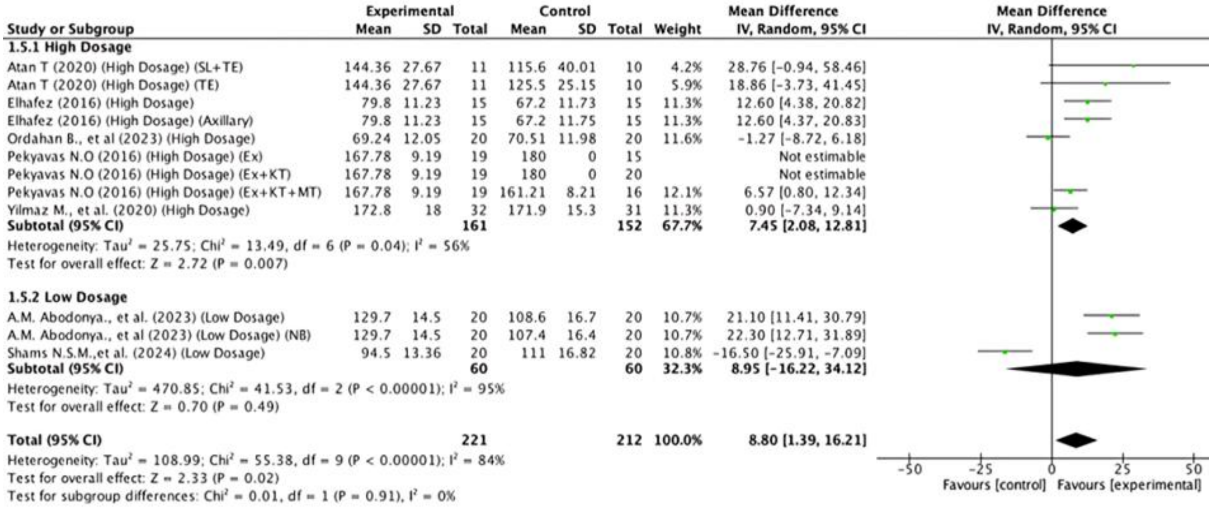

Figure 8. Forest and funnel plots displaying the comparison of ROM-shoulder abduction between HILT and LILT with conventional physical therapy for patients with frozen shoulders in RCTs [5-8, 10-12]

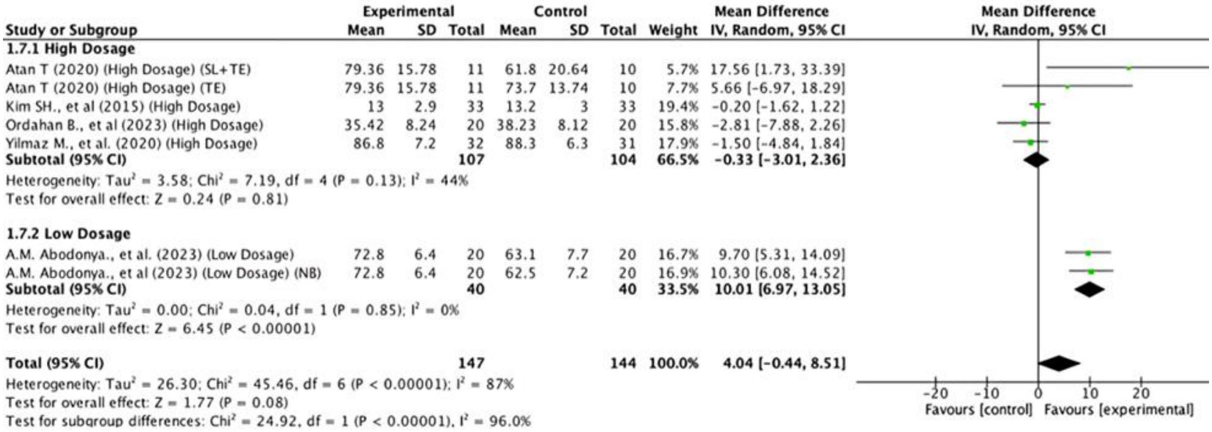

Figure 9. Forest and funnel plots displaying the comparison of ROM-shoulder internal rotation between HILT and LILT with conventional physical therapy for patients with frozen shoulders in RCTs [5-7, 11, 13]

Shoulder Internal Rotation

The pooled analysis of 6 studies (n = 285) indicated that laser therapy is proven to be more effective in increasing ROM-shoulder internal rotation (RR 3.98 [95% CI -0.43, 8.40], p = 0.08, I^2 = 86%) than conventional physical therapy with frozen shoulder's patients. Subgroup analysis on the intensity showed that HILT hasn't prove to have significant outcome (RR -0.33 [95% CI -3.01, 2.36], p = 0.81, I^2 = 91%).

For as, LILT has proven to have an improvement in ROM-shoulder internal rotation (RR 10.00 [95% CI 6.83, 13.17], p < 0.00001, I^2 = 0%) for frozen shoulder's patients as it is shown in **Figure 9**.

Shoulder External Rotation

According to the pooled analysis of 8 studies (n = 493), laser therapy is not effective (RR 4.47 [95% CI -2.05, 11.00], p = 0.18, I^2 = 93%) compared to conventional physical therapy in increasing ROM-shoulder external rotation for patient with frozen shoulder. Similarly, the subgroup analysis by intensity showed that neither HILT (RR 5.52 [95% CI -1.56, 12.60], p = 0.13, I^2 = 88%) nor LILT (RR 1.57 [95% CI -14.95, 18.08], p = 0.65, I^2 = 98%) achieved statistical significance in treatment efficacy.

However, HILT demonstrated a lower RR and provided stronger evidence, suggesting it might have a more favorable effect despite not reaching statistical significance, as shown in **Figure 10.**

SF-36 Emotional Well-Being

Result from the pooled analysis of 3 studies (n = 179) demonstrating that laser therapy is significantly effective in increasing SF-36 emotional well-being score (RR 11.47 [95% CI 3.95, 18.99], p = 0.003, I^2 = 70%) compared to conventional therapy in treating patients with frozen shoulders. Subgroup analysis based on the intensity showed that HILT (RR 14.96 [95% CI -3.21, 33.13], p = 0.11, I^2 = 80%) didn't show a significant outcome, but the LILT (RR 11.35 [95% CI 6.19, 16.52], p < 0.0001, I^2 = 0%) was effective for increasing the score. This result is shown in **Figure 11**.

SF-36 General Health

The pooled analysis of 2 studies (n = 106) demonstrates that conventional physical therapy is significantly showing an impact in SF-36 general health score treating frozen shoulder patients compared to HILT (RR 13.70 [95% CI -3.95, 31.35], p = 0.13, I^2 = 87%). This result is shown in **Figure 12**.

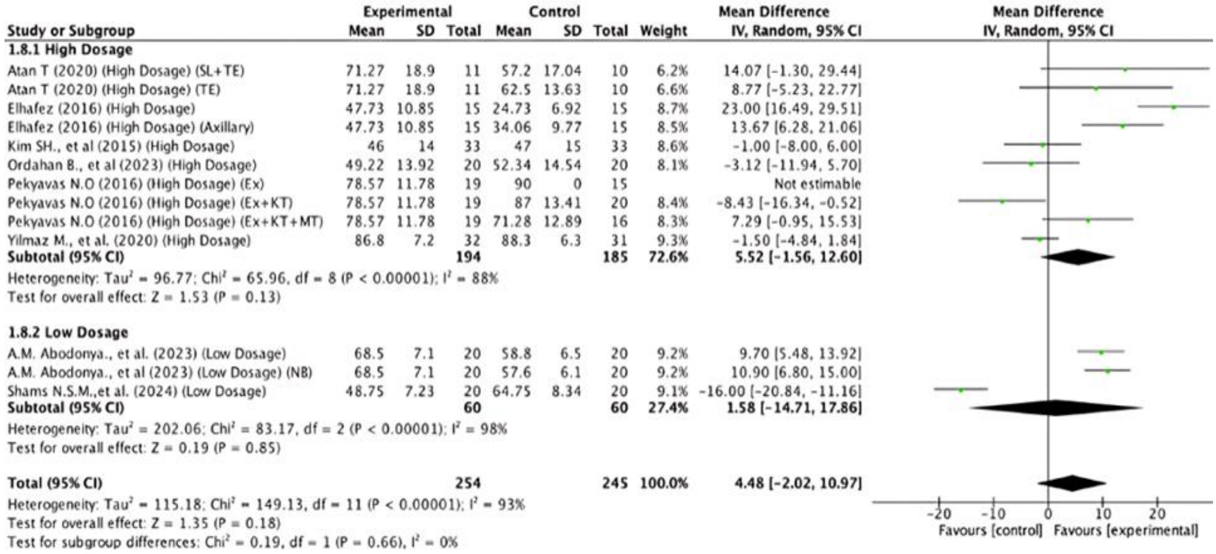

Figure 10. Forest and funnel plots displaying the comparison of ROM-shoulder external rotation between HILT and LILT with conventional physical therapy for patients with frozen shoulders in RCTs [5-8, 10-13]

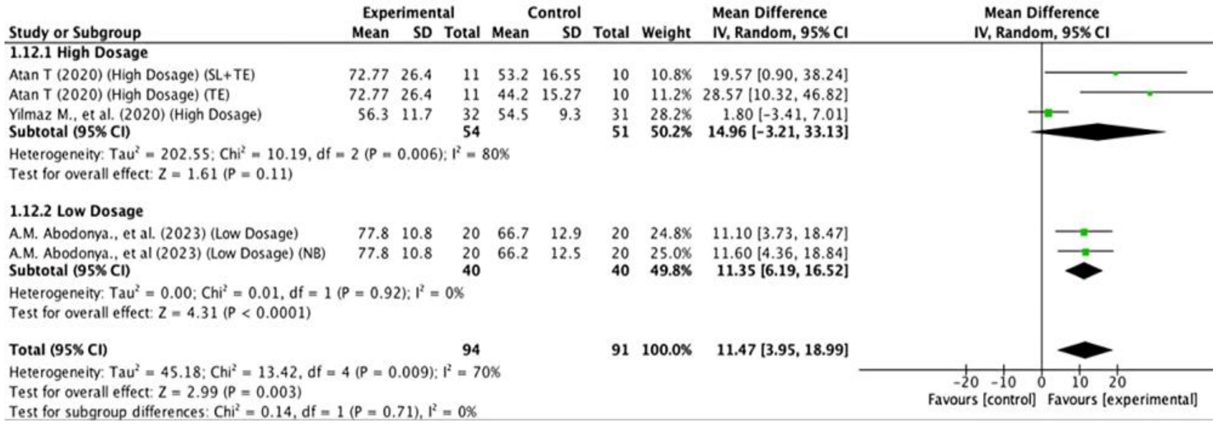

Figure 11. Forest and funnel plots displaying the comparison of SF-36 emotional well-being between HILT and LILT with conventional physical therapy for patients with frozen shoulders in RCTs [5, 6, 11]

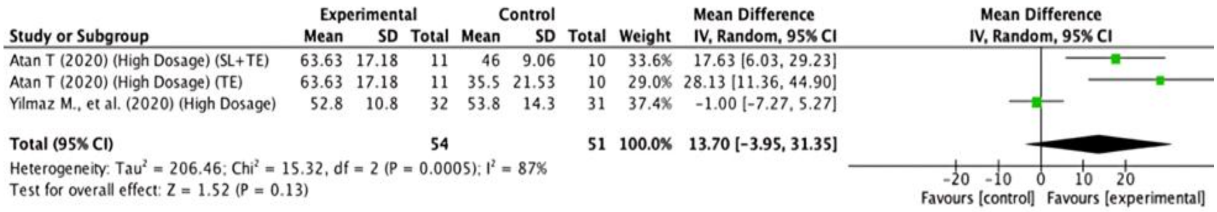

Figure 12. Forest and funnel plots displaying the comparison of SF-36 general health between HILT and conventional physical therapy for patients with frozen shoulders in RCTs [6, 11]

SF-36 Physical Functioning

The pooled analysis of 3 studies (n = 179) found that laser therapy is significantly effective compared to conventional physical therapy (RR 12.32 [95% CI 5.44, 19.20], p = 0.0005, I^2 = 43%) in increasing SF-36 physical functioning score. The intensity-based subgroup analysis revealed that LILT is effective (RR 11.11 [95% CI 4.97, 17.25], p = 0.0004, I^2 = 0%). In contrast, HILT did not demonstrate effectiveness (RR 16.21 [95% CI -0.22, 32.64], p = 0.05, I^2 = 72%). For as, LILTshows a better outcome on the evidence. This result is shown in **Figure 13**.

SF-36 Role Limitation Due to Emotional Problem

The pooled analysis of 2 studies (n = 105) shows that conventional physical therapy significantly improves SF-36 role limitation due to emotional problem score in frozen shoulder patients more than HILT (RR 6.61 [95% CI -6.16, 19.38], p = 0.31, I^2 = 0%). This result is shown in **Figure 14**.

SF-36 Role Limitation Due to Physical Health

The combined analysis of two studies (n = 105) indicates that HILT significantly affects the SF-36 role limitation due to physical health compared to conventional physical therapy (RR

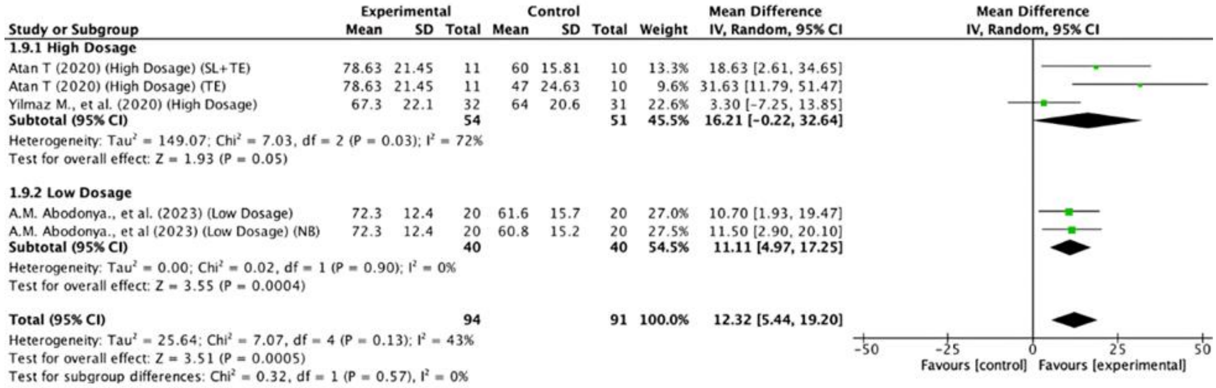

Figure 13. Forest and funnel plots displaying the comparison of SF-36 physical functioning between HILT and conventional physical therapy for patients with frozen shoulders in RCTs [5, 6, 11]

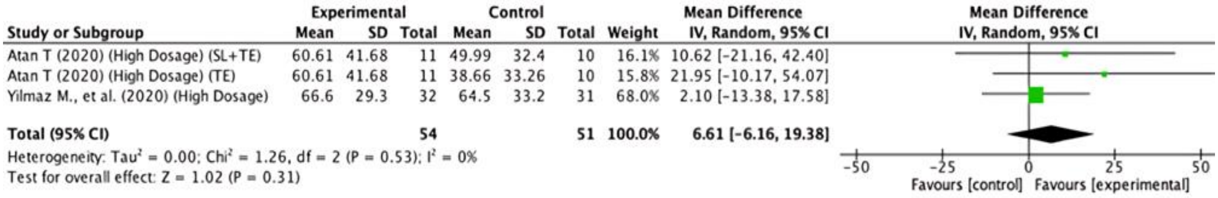

Figure 14. Forest and funnel plots displaying the comparison of SF-36 role limitation due to emotional problem between HILT and conventional physical therapy for patients with frozen shoulders in RCTs [6, 11]

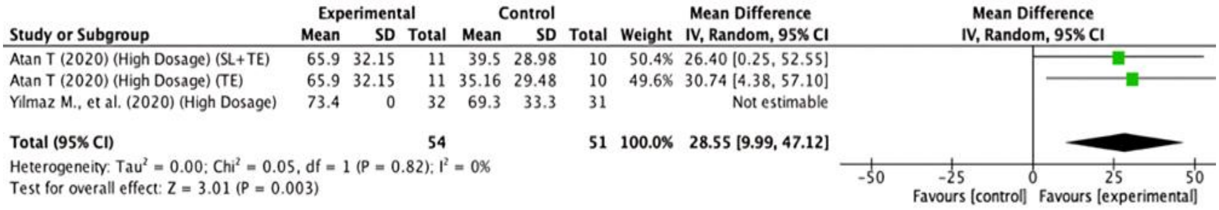

Figure 15. Forest and funnel plots displaying the comparison of SF-36 role limitation due to physical health between HILT and conventional physical therapy for patients with frozen shoulders in RCTs [6, 11]

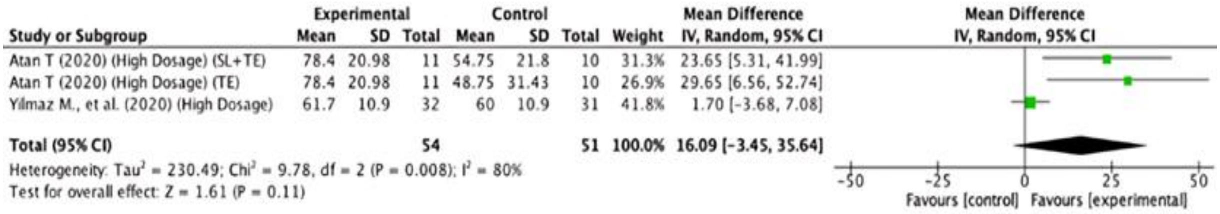

Figure 16. Forest and funnel plots displaying the comparison of SF-36 social functioning between HILT and conventional physical therapy for patients with frozen shoulders in RCTs [6, 11]

28.55 [95% CI 9.99, 47.12], p = 0.003, I^2= 0%). This result is shown in **Figure 15**.

SF-36 Social Functioning

The combined analysis of 2 studies (n = 105) indicates that laser therapy isn't significantly impactful in advancing SF-36 social functioning score as opposed to conventional physical therapy (RR 16.09 [95% CI -3.45, 35.64], p = 0.11, I^2 = 80%). This result is shown in **Figure 16**.

Meta-Regression

We utilized meta-regression to identify risk factors influencing the correlation between HILT and LILT with physical conventional therapy on 14 outcomes: VAS scores, SPADI-pain, SPADI-disability, SPADI-total, ROM-shoulder flexion, ROM-shoulder abduction, ROM-shoulder internal rotation, ROM-shoulder external rotation, SF-36 emotional well-being, SF-36 general health, SF-36 physical functioning, SF-36 role limitation due to emotional problems, SF-36 role limitation due to physical health, and SF-36 social functioning. **Table 3** shows meta-regression of included studies.

VAS Score

The coefficient for age is positive indicates that an increase in age might be associated with an increase in VAS scores, suggesting a higher pain level. However, the p-value of 0.924 shows that this correlation is not statistically significant and the wide range of CIs indicates that age is not a reliable predictor.

Table 3. Meta-regression of included studies

Outcome variable	Predictor	Coefficient	Standard error	95% CI	p-value
VAS score	Age	0.0306	0.3090	[-0.725, 0.786]	0.924
	Sample size	0.2000	0.2150	[-0.327, 0.727]	0.389
	Time to follow up	-0.0570	0.1000	[-0.302, 0.188]	0.590
SPADI-pain	Age	0.7860	0.9410	[-1.830, 3.400]	0.451
	Sample size	-0.7320	0.3530	[-1.710, 0.250]	0.107
	Time to follow up	0.1670	0.2160	[-0.432, 0.767]	0.482
SPADI-disability	Age	3.9800	8.2500	[-101, 109]	0.714
	Sample size	-0.6200	1.1500	[-15.200, 14.000]	0.685
	Time to follow up	-0.1210	0.5380	[-6.960, 6.720]	0.859
SPADI-total	Age	4.0400	7.1500	[-86.800, 94.900]	0.672
	Sample size	-0.6210	0.9920	[-13.200, 12.000]	0.644
	Time to follow up	-0.0775	0.4890	[-6.290, 6.130]	0.900
Shoulder flexion	Age	-1.5300	1.6100	[-5.470, 2.420]	0.380
	Sample size	0.8810	0.7350	[-0.916, 2.680]	0.276
	Time to follow up	0.0550	0.3970	[-0.917, 1.030]	0.894
Shoulder abduction	Age	0.9870	3.1100	[-7.000, 8.980]	0.764
	Sample size	2.1800	1.1400	[-0.742, 5.110]	0.113
	Time to follow up	0.0436	0.6850	[-1.720, 1.800]	0.952
Shoulder internal rotation	Age	-4.9200	4.0400	[-17.800, 7.940]	0.310
	Sample size	-0.7190	1.4100	[-5.190, 3.760]	0.645
	Time to follow up	0.5350	0.5070	[-1.080, 2.150]	0.368
Shoulder external rotation	Age	0.1410	1.0900	[-2.510, 2.800]	0.901
	Sample size	0.4940	0.4730	[-0.663, 1.650]	0.336
	Time to follow up	0.0391	0.2490	[-0.571, 0.649]	0.881
SF-36 emotional well-being	Age	2.3900	0.6040	[-5.280, 10.100]	0.158
	Sample size	-0.4520	0.6740	[-9.010, 8.110]	0.624
	Time to follow up	0.2410	0.2200	[-2.550, 3.040]	0.472
SF-36 physical functioning	Age	1.0500	0.6710	[-7.480, 9.570]	0.362
	Sample size	-0.4040	0.0666	[-1.250, 0.442]	0.104
	Time to follow up	0.1640	0.0125	[0.00525, 0.323]	0.048

Similarly, a positive coefficient for sample size indicates that an increase of sample size results in an increase in VAS score. Because of the wide range CI and the p-value of 0.389 showing that sample size is not statistically significant as the predictor of VAS score.

The negative coefficient for time to follow up shows that the longer it takes, the VAS score tends to decrease. Despite the correlation, the result is not statistically significant, as evidenced by the p-value of 0.590 and the high variability in the CIs.

SPADI-Pain

The analysis shows a positive coefficient for age suggesting that SPADI-pain tends to increase in older patients. However, the statistical significance is not met, as indicated by a p-value of 0.451 and the CIs that include zero.

Sample size appears to have a negative coefficient, suggesting that an increase in sample size could be associated with lower SPADI-pain score. Although there was a correlation, it wasn't statistically significant showing that the p-value is 0.107 and the CIs include zero.

Similarly to age, time to follow up also has a positive coefficient suggesting that SPADI-pain tends to increase in a longer period to follow up. However, it's not statistically significant as the p-value is 0.482 and has wide CIs.

SPADI-Disability

The data shows a positive coefficient for age, indicating that older individuals might experience higher pain levels as measured by VAS scores. However, the p-value of 0.714 indicates this is not statistically significant, and the wide CI points to high variability, suggesting that age is not a reliable predictor.

Sample size has the opposite coefficient, showing that SPADI-disability tends to decrease as the sample size increases. However, the p-value of 0.685 and the CIs including zero showing these results is not significant.

Similarly, the time to follow up has the same coefficient as sample size, indicating a longer period to follow up indicates a better outcome of SPADI-disability. However the p-value of 0.859 and the CIs including zero shows this result is not significant.

SPADI Total

Age has a positive coefficient, suggesting that as age increases, VAS scores also increase indicating a higher pain level. However, with a p-value of 0.672 and a wide CI suggest that it's not statistically significant.

The analysis shows sample size has a negative coefficient, indicating that larger sample size is associated with a lower SPADI-total score. However, this result is not statistically significant showing a p-value of 0.644 and the wide CIs suggest a high variability.

Time to follow up appears to have a negative coefficient showing that a longer time to follow up tends to lower SPADI-total scores. Regardless of the correlation, the p-value of 0.900 and the CIs including zero indicates it's not significant.

Shoulder Flexion

Age has a negative coefficient, which indicates that older individuals have a lower score in ROM in shoulder flexion.

However, a p-value of 0.380 and the CI that includes zero indicate that it's not significant and not a reliable predictor.

Sample size appears to have a positive coefficient showing that an increase of sample size tends to increase ROM in shoulder flexion scores but, the p-value of 0.276 show this result is not statistically significant. The CI including zero indicates that there is a high variability. Therefore, it is not a reliable predictor.

Time to follow up has a positive coefficient that indicates that a longer time to follow up have an increased ROM in shoulder flexion. However, the p-value of 0.894 and the wide CI indicates that this association is not significant and not as a reliable predictor.

Shoulder Abduction

The analysis shows a positive coefficient for age, indicating that as age increases, the ROM in shoulder abduction might increase. However, the p-value of 0.764 means this association is not significant and the wide CI suggest high variability, making age an unreliable predictor for ROM in shoulder abduction.

The data shows a positive coefficient between the ROM in shoulder abduction and sample size, where a larger sample size might be associated with a higher ROM in shoulder abduction. However, with a p-value of 0.113, this association is not statistically significant and the wide CI indicates a lot of variability, making age a weak predictor of ROM in shoulder abduction.

The positive coefficient for the time to follow-up suggests that a longer duration to follow-up is associated with improved outcomes in shoulder abduction ROM. However, the p-value of 0.952 and the wide intervals shows that it's not statistically significant and not likely to be a reliable predictor.

Shoulder Internal Rotation

The negative coefficient for age indicates ROM for shoulder internal rotation tends to decrease as the number of age increases. Although there is a correlation, the p-value of 0.310 and the CIs include zero indicates that this is insignificant and not a reliable predictor.

The data shows that sample size also has a negative coefficient. As the sum of sample size increases, the ROM for shoulder internal rotation decreases. However, the p-value of 0.645 and the wide CI indicates that it does not meet the requirement as a reliable predictor.

Time to follow up appears to have a positive coefficient, suggesting that a longer duration to follow up results in a higher ROM for shoulder internal rotation. Regardless of the association, The p-value of 0.368 and the wide CI shows that it's not significant.

Shoulder External Rotation

The positive coefficient in ROM for shoulder external rotation suggest that older individuals tend to experience an increase in ROM for shoulder external rotation. However, it's not statistically significant and can't be use a predictor as it is shown by the p-value of 0.901 and the wide CI.

The coefficient for sample size is also positive, implying that larger sample size could be associated with a higher ROM for shoulder external rotation. However, the p-value of 0.336 shows that this association is not statistically significant, and the wide CI indicates a high variability. Thus, it's not consider as a meaningful predictor for ROM in shoulder external rotation

Similarly, the time to follow-up shows the same coefficient results, indicating an improvement in the ROM with a longer follow-up period. However, the p-value of 0.881 suggests a lack of statistical significance, as the CI crosses zero.

SF-36 Emotional Well-Being

Age and SF-36 emotional well-being scores are positively coefficient, meaning that as patients age, their quality of life is reflected in higher ratings. However, age and SF-36 emotional well-being scores don't show a significant correlation, as indicated by a wide CI and a p-value of 0.158, according to statistical analysis.

The study shows that a larger sample size has a negative coefficient and is associated with a lower SF-36 emotional well-being. The conclusion is not statistically significant, as indicated by the p-value of 0.624, despite the huge CIs suggesting a high variability.

Longer follow-up times are frequently linked to greater SF-36 emotional well-being, as seen by the positive follow-up time coefficient. Regardless of the value, the p-value of 0.472 and the CIs that contain zero imply that the connection is not significant.

SF-36 Physical Functioning

Age has a positive coefficient, indicating that patients' quality of life is indicated by higher SF-36 physical functioning ratings as they age. A large CI and a p-value of 0.362, however, indicate that it is not statistically significant.

According to the analysis, sample size has a negative coefficient, meaning that a lower SF-36 physical functioning is linked to a bigger sample size. The large CIs imply a great degree of variability, but the p-value of 0.104 indicates that the findings are not statistically significant.

A longer follow-up period is often associated with higher SF-36 physical functioning, as indicated by the positive coefficient for time to follow-up. The p-value of 0.048 and the narrow CIs show that the correlation is statistically significant

DISCUSSION

Interpretation of Findings

The analysis of eight studies involving 444 participants suggests that laser therapy is significantly more effective in reducing VAS scores compared to conventional physical therapy for patients with frozen shoulders. The pooled RR of -1.36, with a 95% CI ranging from -1.95 to -0.76 and a p-value of less than 0.00001, indicates a substantial reduction in pain levels. The heterogeneity index (I^2) of 89% highlights the variability across studies, necessitating careful interpretation. Subgroup analysis by laser intensity reveals that both HILT and LILT significantly reduce VAS scores, with HILT showing a more pronounced effect (RR -1.74, 95% CI -2.69 to -0.79, p = 0.0003) compared to low-intensity therapy (RR -0.90, 95% CI -1.72 to -0.07, p = 0.03).

The pooled data from six studies (n = 363) underscore the efficacy of laser therapy in reducing the SPADI-pain score, with an RR of -10.20 (95% CI -15.95 to -4.44, p = 0.0005, I^2 = 86%). Notably, HILT demonstrates a significant reduction in SPADI-pain (RR -14.17, 95% CI -23.21 to -5.13, p = 0.002), while LILT does not achieve statistical significance (RR -5.85, 95% CI -12.46 to 0.76, p = 0.08), suggesting a potential threshold effect where higher laser intensities are required for significant pain alleviation.

For SPADI-disability, a smaller subset of three studies (n = 190) shows that HILT significantly decreases disability scores (RR -12.28, 95% CI -19.92 to -4.64, p = 0.002, I^2 = 82%). Similarly, in the SPADI-total score analysis, HILT is associated with a substantial reduction in overall shoulder disability (RR -20.04, 95% CI -31.37 to -8.71, p = 0.0005, I^2 = 84%). These findings reinforce the notion that HILT may offer superior benefits in managing both pain and functional impairment in patients with frozen shoulders.

The impact of laser therapy on shoulder ROM yields mixed results. While shoulder flexion shows no significant improvement with laser therapy compared to conventional therapy (RR 6.22, 95% CI -1.46 to 13.90, p = 0.11, I^2 = 89%), shoulder abduction benefits from laser therapy, particularly high-intensity treatments (RR 7.45, 95% CI 2.08 to 12.81, p = 0.007, I^2 = 56%). However, shoulder internal rotation is significantly improved with LILT (RR 10.00, 95% CI 6.83 to 13.17, p < 0.00001, I^2 = 0%), while HILT does not demonstrate significant effects (RR -0.33, 95% CI -3.01 to 2.36, p = 0.81). Shoulder external rotation, however, does not significantly benefit from laser therapy, with neither intensity achieving statistical significance.

Laser therapy shows a notable advantage in improving SF-36 emotional well-being scores, particularly with LILT (RR 11.35, 95% CI 6.19 to 16.52, p < 0.0001, I^2 = 0%). However, high-intensity therapy does not reach significance in this domain (RR 14.96, 95% CI -3.21 to 33.13, p = 0.11). In contrast, conventional physical therapy outperforms HILT in improving SF-36 general health scores, highlighting the differential impact of these therapies across various health dimensions. Similarly, laser therapy significantly enhances SF-36 physical functioning, especially with low-intensity therapy (RR 11.11, 95% CI 4.97 to 17.25, p = 0.0004, I^2 = 0%), whereas high-intensity therapy shows borderline significance (p = 0.05). For role limitations due to physical health, HILT proves superior (RR 28.55, 95% CI 9.99 to 47.12, p = 0.003).

Meta-regression analysis reveals that age, sample size, and time to follow-up do not significantly predict outcomes across most measures, including VAS and SPADI scores, shoulder ROM, and SF-36 domains. The findings suggest that these variables do not substantially influence the effectiveness of laser therapy relative to conventional physical therapy in treating frozen shoulders. The exception is seen in the time to follow-up for SF-36 physical functioning, where a longer follow-up period appears to be associated with improved outcomes (p = 0.048). longer follow-up periods allow for the assessment of sustained effects, which are crucial for understanding the long-term impact of the treatment on a patient's quality of life. Early follow-ups might not capture potential relapses or the durability of the treatment benefits. Conversely, a short follow-up period might show improvements in acute symptoms but fail to account for whether these improvements are maintained or lead to lasting functional and emotional benefits. Therefore, the timing of follow-up assessments can influence the observed outcomes on the SF-36, with longer follow-up periods potentially providing a more comprehensive view of the treatment's efficacy.

Clinical Outcomes

VAS score

The VAS is a measure used to quantify the intensity of pain experienced by patients, where they rate their pain on a scale typically from 0 (no pain) to 10 (worst possible pain). When compared to traditional physical treatment, laser therapy significantly reduces VAS scores for individuals with frozen shoulders (RR -1.36 [95% CI-1.95,-0.76], p < 0.00001, I^2 = 89%], according to an analysis of eight studies including 444 participants.

Both high intensity (RR-1.74 [95% -2.69, -0.79], p = 0.0003, I^2 = 90%) and LILT (RR -0.90 [95% CI -1.72,-0.07], p = 0.03, I^2 = 90%) demonstrated a significant reduction in VAS scores, with lower RR seen in LILT, according to subgroup analysis based on laser therapy intensity. Analyses for the correlation between VAS score and confounding such as age, sample size, time to follow up doesn't show a significant value. This suggests a strong effect of laser therapy, especially HILT in pain reduction for patients with frozen shoulders.

SPADI-pain score

The SPADI-pain score is a component of the SPADI that assesses the severity of shoulder pain based on patient-reported levels of discomfort during various activities. An analyses of six studies with 363 participants found that laser therapy significantly reduces SPADI-pain score for those with frozen shoulders when compared to regular physical treatment (RR -10.20 [95% CI -15.95, -4.44], p = 0.0005, I^2 = 86%).

LILT (RR -5.85 [95% CI -12.46, 0.76], p = 0.08, I^2 = 69%) did not show a substantial reduction in SPADI-pain, whereas HILT (RR-14.17 [95% CI -23.21, -5.13], p = 0.002, I^2 = 91%) showed a significant result. Age, sample size, and follow-up period are not correlated with SPADI-pain in a statistically meaningful way. This implies that HILT has a significant impact on lowering frozen shoulder patients' pain levels.

SPADI-disability score

The SPADI-disability score is another component of the SPADI that evaluates the degree of functional disability caused by shoulder issues, based on difficulties in performing daily activities. The SPADI-disability score for patients with frozen shoulders was found to be considerably reduced by HILT (RR-12.28 [95% CI -19.92, -4.649, p = 0.002, I^2 = 82%), according to an analysis of three trials including 190 individuals.

Confounding and SPADI-disability do not correlate in a way that is statistically significant. This suggests that the degree of functional impairment in day-to-day activities can be significantly reduced with HILT.

SPADI-total score

The SPADI-total score is a composite score derived from both the pain and disability components of the SPADI, providing an overall assessment of shoulder-related impairment. Based on an analysis of three trials including 190 patients, HILT was found to significantly reduce the SPADI-total score for patients with frozen shoulders (RR -20.04 [95%CI -31.37, -8.71], p = 0.0005, I^2 = 84%).

There is no statistically significant correlation between confounding and SPADI-total. This shows that HILT can greatly lower the degree of functional impairment in daily activities.

Shoulder Flexion

Shoulder flexion refers to a measure of the ROM that evaluates the degree to which the shoulder can be moved forward and upward, typically assessed in degrees. When compared to standard physical treatment, laser therapy did not substantially enhance ROM or shoulder flexion for patients with frozen shoulders (RR 6.22 [95% CI -1.46, 13.90], p = 0.11, I^2 = 89%), according to an analysis of eight research including 493 individuals.

Shoulder flexion did not significantly improve with LILT (RR 10.39 [95% CI -17.99, 38.78], p = 0.47, I^2 = 97%) or HILT (RR 2.51 [95% CI -1.29, 6.30], p = 0.20, I^2 = 30%). Age, sample size, and length of follow-up do not statistically significantly correlate with ROM-shoulder flexion. This suggests that for patients with frozen shoulders, laser treatment has no effect on increasing shoulder flexion.

Shoulder Abduction

Shoulder abduction is a measure of the ROM assessing the extent to which the arm can be moved away from the body's midline, again usually recorded in degrees. An analysis of seven studies including 427 participants found that laser therapy is more successful than regular physical treatment for increasing patients' ROM of shoulder flexion for those with frozen shoulders (RR 8.74 [95% CI 1.37, 16.11], p = 0.02, I^2 = 83%).

While HILT (RR 7.45 [95% CI 2.08,12.81], p = 0.007, I^2 = 56%) shows a significant outcome, LILT (RR 8.91 [95% CI -16.58, 34.40], p = 0.49, I^2 = 95%) did not demonstrate a significant improvement in shoulder abduction. There is no statistically significant correlation seen between shoulder abduction and age, sample size, or follow-up duration. This suggests that for patients with frozen shoulders, HILT significantly improves the ROM for shoulder abduction.

Shoulder Internal Rotation

Shoulder internal rotation describes a ROM measures evaluating how far the arm can be rotated inward toward the body while keeping the elbow at a 90-degree angle. Laser therapy is more effective than standard physical therapy for increasing ROM-shoulder internal rotation (RR 3.98 [95% CI -0.43, 8.40], p = 0.08, I^2 = 86%) in patients with frozen shoulders, according to an analysis of six research including 285 participants.

LILT (RR 10.00 [95% CI 6.83, 13.17], p < 0.00001, I^2 = 0%) has demonstrated a significant improvement in shoulder internal rotation, but HILT (RR-0.33 [95% CI -3.01, 2.36], p = 0.81, I^2 = 91%) does not exhibit a meaningful effect. The relationship between confounding factors and shoulder internal rotation is not statistically significant. This implies that LILT increases shoulder internal rotation ROM significantly for patients with frozen shoulders.

Shoulder External Rotation

Shoulder external rotation is a ROM measures that assesses the ability to rotate the arm outward, away from the body, with the elbow flexed at a 90-degree angle. An analysis of eight studies including 493 participants found that laser therapy is less effective than regular physical therapy for enhancing ROM-shoulder external rotation (RR 4.47 [95% CI -2.05, 11.00], p = 0.18, I^2 = 93%) in patients with frozen shoulders.

There is no discernible difference in the effectiveness of LILT (RR 1.57 [95% CI -14.95, 18.08], p = 0.65, I^2 = 98%) and HILT (RR 5.52 [95% CI -1.56, 12.60], p = 0.13, I^2 = 88%). There is no statistically significant correlation discovered between confounding variables and shoulder external rotation. Though it did not approach statistical significance, HILT showed a lower RR and stronger evidence, suggesting it would have a more favorable effect.

SF-36 Emotional Well-Being

The SF-36 emotional well-being is a subscale of the SF-36 that evaluates the emotional state of an individual, including levels of happiness, calmness, and peacefulness, often used to assess mental health. In patients with frozen shoulders, laser therapy significantly improves the SF-36 emotional well-being score (RR 11.47 [95% CI 3.95, 18.99], p = 0.003, I^2 = 70%), according to an analysis of three trials including 179 individuals.

LILT (RR 11.35 [95% CI 6.19, 16.529, p < 0.0001, I^2 = 0%) gives a substantially outcome, but HILT (RR 14.96 [95% CI -3.21, 33.13], p = 0.11, I^2 = 80%) do not significantly differ from one another in terms of efficacy. LILT offered very great evidence, suggesting a better benefit.

SF-36 General Health

The SF-36 general health is a subscale of the SF-36 that assesses an individual's overall perception of their health, including their current health status and future health expectations. Laser therapy did not substantially improve the SF-36 general health score in patients with frozen shoulders when compared to HILT (RR 13.70 [95% CI -3.95, 31.35], p = 0.13, I^2 = 87%), according to an analysis of two trials with 106 patients.

Age, sample size, and follow-up period do not differ statistically significantly in the SF-36 general health. This demonstrates that laser therapy has no effect on a person's general health perception.

SF-36 Physical Functioning

The SF-36 physical functioning is a subscale of the SF-36 that measures the degree of physical limitations in performing daily activities, ranging from basic movements to more vigorous activities. An analysis of three studies involving 179 patients found that laser therapy significantly enhanced the SF-36 physical functioning in patients with frozen shoulders (RR 12.32 [95% CI 5.44, 19.20], p = 0.0005, I^2 = 43%).

The LILT (RR 11.11 [95% CI 4.97, 17.25], p = 0.0004, I^2 = 0%) have a statistically significant difference in the efficacy, but not in HILT (RR 16.21 [95% CI -0.22, 32.64], p = 0.05, I^2 = 72%). One of the confounding factors, time to follow up, have a significant correlation with SF-36 physical functioning with the p value of 0.048. This demonstrates that long-term monitoring through follow-up allows for the identification of recovery patterns, which is crucial for adjusting further treatment and monitoring the patient's quality of life. Suggest that LLLT demonstrated a lower RR and stronger evidence, indicating that it would have a positive effect with statistical significance [15, 16].

SF-36 Role Limitation Due to Emotional Problems

The SF-36 role limitation due to emotional problems is a subscale of the SF-36 that assesses the extent to which emotional issues interfere with an individual's ability to work or carry out daily activities. Based on an analysis of two trials with 105 patients, laser therapy did not significantly improve the SF-36 role limitation due to emotional problems score in patients with frozen shoulders (RR 6.61 [95% CI -6.16, 19.38], p = 0.31, I^2 = 0%).

The SF-36 role limitation due to emotional problems does not show statistically significant differences based on age, sample size, or follow-up period. This proves that laser therapy has no effect on emotional problems that make it difficult for a person to work or go about their daily business.

SF-36 Role Limitation Due to Physical Health

The SF-36 role limitation due to physical health is a subscale of the SF-36 that measures how physical health problems limit an individual's ability to perform their roles at work or in daily life. HILT, as opposed to traditional physical therapy, significantly affects the SF-36 role limitation due to physical health (RR 28.55 [95% CI 9.99, 47.129, p = 0.003, I^2 = 0%), according to an analysis of two trials with 105 patients.

Age, sample size, and follow-up duration do not exhibit statistically significant changes in the SF-36 role limitation due to physical health. This implies that the patient's capacity to carry out their responsibilities in daily life or at work is impacted by HILT.

SF-36 Social Functioning

The SF-36 social functioning is a subscale of the SF-36 that evaluates how health conditions impact an individual's ability to engage in social activities and maintain personal relationships. A study of two studies with 105 patients found that laser therapy had no significant effect on the SF-36 social functioning (RR 16.09 [95% CI -3.45, 35.64], p = 0.11, I^2 = 80%).

The SF-36 social functioning shows no statistically significant changes with age, sample size, or length of follow-up. This suggests that a person's capacity to interact socially and uphold interpersonal connections was unaffected by laser therapy.

Mechanisms of Action

HILT uses high-energy lasers, such as Nd:YAG lasers, with power outputs ranging from 1 to 20 watts and wavelength between 800 to 1,064 nm . This allows for deeper tissue penetration in reaching depths of over 10cm. The thermal effect generated by HILT can elevate tissue temperatures up to 43 °C, therefore enhancing blood flow and enhancing healing. HILT is typically applied in two phases: the first phase involves an analgesic approach using intermittent pulse (8 W, 10 J/cm²), then followed by a bio-stimulation phase with continuous light (12 W, 120 J/cm²). The thermal effects of HILT stimulate cellular metabolism, Schwann cell proliferation, fibroblast activity, and collagen production, while also promoting angiogenesis and inhibiting inflammatory cytokines. Due to this benefits, HILT is an effective technique for managing pain and treating deep tissues and structures over a short time [17, 18].

LLLT uses lower energy lasers, typically gallium-aluminum-arsenide diode lasers operating at a shorter range of 600 to 950 nm wavelength and less than 500 mW power. Unlike high-intensity lasers, LLLT relies on photochemical rather than thermal effects; the light is absorbed by cellular chromophores, which then stimulate mitochondria to increase ATP production and modulate reactive oxygen species. This changes improves cellular activities such as proliferation and migration, particularly in fibroblast, thus facilitating tissue repair and regeneration. LLLT is administered with a dose of 3 J/cm² per point. With its lower power levels, LLLT achieves more superficial tissue penetration, from 0.2 to 0.5 cm, making it appropriate for treating superficial tissue damage [19, 20].

Clinical Implications

This study underscores the potential significance of both HILT and LLLT in the rehabilitation of patients with frozen shoulders. The observed improvements in pain reduction, as measured by VAS scores, along with enhancements in functional outcomes such as SPADI-pain, shoulder ROM, and overall quality of life assessed by SF-36, suggest that laser therapy could be a valuable component in treatment plans for frozen shoulder.

Tailoring laser therapy–whether HILT or LLLT–to individual patient needs and responses may lead to improved rehabilitation outcomes. This personalized approach aligns with findings from [21], which reported that incorporating thoracic spine manipulation into physical therapy yielded superior clinical benefits for patients with adhesive capsulitis.

Furthermore, integrating laser therapy into existing rehabilitation strategies might enhance recovery and improve long-term quality of life. This perspective is supported by [22, 23] that demonstrated that combining laser acupuncture with diet and Pilates exercise significantly improved lipid profiles in obese women with systemic lupus erythematosus.

Additionally, incorporating complementary therapies has shown promise in enhancing treatment outcomes. For instance, it was found that adding pranayama yoga exercises and muscle training to laser acupuncture significantly improved inflammatory markers in elderly patients with allergic rhinitis [22, 23]. Such findings suggest that a multimodal approach, integrating laser therapy with other therapeutic modalities, could be beneficial in managing frozen shoulder [24, 25].

However, further research, particularly RCTs, is necessary to establish the most effective laser therapy protocols. By acknowledging the potential of laser therapy and incorporating it into clinical practice, healthcare professionals can contribute to better outcomes in the management of frozen shoulder.

Strength and Limitation

The key aspect of this study lies in its broad comparison of HILT and LILT with conventional physical therapy. Our findings encompass multiple clinical outcomes, offering a comprehensive assessment of patients with frozen shoulders. Notably, we observed significant improvements in VAS and SPADI scorers with HILT, underscoring its potential effectiveness in managing this condition. This study emphasizes the importance of treatment intensity, revealing its crucial role in determining clinical efficacy. Our meta-regression analysis aimed to identify predictors of treatment outcomes, which could guide individualized treatment strategies.

This study faces several limitations, primarily due to the high heterogeneity which is shown by the significant variability (I^2 = 89%) across studies limiting the generalizability. Inconsistent effectiveness across different ranges of motion outcomes is attributed to a complicated interpretation. The study also failed to identify significant impact on health-related quality of life measures and significant predictors. Moreover, this suggests that unmeasured factors may play a role in the outcomes. Lastly, the current evidence may need further validation through larger and longer term studies to strengthen the conclusion.

CONCLUSION

This systematic review, meta-analysis, and meta-regression provide robust evidence supporting the use of laser therapy–particularly HILT–as an effective adjunct to conventional physical therapy in managing frozen shoulder. Across multiple domains, including pain reduction (VAS, SPADI-pain), functional disability (SPADI-disability and SPADI-total), ROM (especially shoulder abduction and internal rotation), and quality of life (SF-36 emotional well-being and physical functioning), laser therapy demonstrated statistically significant benefits over conventional therapy alone. HILT showed superior outcomes in alleviating pain and disability, while LLLT was particularly effective in improving emotional well-being and physical functioning. Although some outcomes, such as shoulder flexion, external rotation, and SF-36 social functioning, did not reach statistical significance, the overall findings suggest that laser therapy can meaningfully enhance the rehabilitation of frozen shoulder patients. Meta-regression analysis revealed that variables such as age, sample size, and follow-up duration generally did not significantly influence treatment outcomes, with the exception of follow-up time for physical functioning, emphasizing the importance of long-term evaluation in assessing treatment efficacy. Taken together, these results support the integration of laser therapy–especially tailored by intensity–into evidence-based clinical protocols for frozen shoulder rehabilitation. Future large-scale RCTs are warranted to further refine treatment parameters and confirm long-term benefits.

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