EFFICACY OF LASER VERSUS IONTOPHORESIS IN THE MANAGEMENT OF SHOULDER IMPINGEMENT SYNDROME IN YOUTH HANDBALL PLAYERS

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Resumo

Background: Repetitive overhead throwing is the main cause of shoulder impingement syndrome (SIS), a common overuse condition among young handball players. It results in decreased performance, discomfort, and restricted range of motion. Although there is little comparison data in young athletes, non-invasive physiotherapeutic treatments like Iontophoresis and High-Intensity Laser Therapy (HILT) are being employed more and more to treat this disease.

Objective: The purpose of this study was to evaluate how well HILT and Iontophoresis worked for young handball players with SIS in terms of pain relief, shoulder function, and joint mobility.

Methods: The participants in this randomized controlled experiment were young handball players between the ages of 14 and 18. Two equal groups of [40] participants having a clinical diagnosis of subacromial impingement syndrome were chosen at random. For around 10 to 15 minutes each session, three times a week for four weeks, Group A got HILT utilizing a Class IV laser device applied across the subacromial region at a wavelength of 1064 nm, with an energy density ranging from 10 to 12 J/cm². Dexamethasone sodium phosphate (0.4%) was the active ingredient in Group B's iontophoresis, which was administered transdermally three times a week for four weeks using a low-intensity direct current for 20 minutes each session. A systematic physiotherapy program that included proprioceptive training, strengthening exercises, and range-of-motion exercises was administered to both groups. The Visual Analog Scale (VAS) for pain, the Shoulder Pain and Disability Index (SPADI) for functional limitations, a bubble inclinometer for shoulder joint range of motion, and a hand-held dynamometer for muscle strength evaluation were used to measure outcome measures both before and after treatment.

Results: Both groups showed significant improvements in pain, function, and shoulder mobility post-treatment. However, the HILT group demonstrated significantly superior outcomes across all measured variables. Pain reduction was faster and more sustained, shoulder range of motion improved more significantly, and muscle strength gains were more pronounced in the HILT group compared to the Iontophoresis group.

Conclusion: When treating SIS in young handball players, high-intensity laser therapy has more therapeutic advantages than iontophoresis, which makes it a useful supplement to sports rehabilitation regimens. Long-term impacts, the involvement of female athletes, and the results of return to sport should all be investigated in future research.

Keywords: laser, iontophoresis, shoulder impingement syndrome, youth handball players

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Introduction

Shoulder injuries are a major contributor to physical impairment in athletes, especially those involved in overhead sports like handball, tennis, volleyball, and swimming. Among these injuries, Shoulder Impingement Syndrome (SIS) is particularly widespread, resulting from repeated compression and inflammation of the rotator cuff tendons or the subacromial bursa during lifting of the arm. This condition is commonly noted in youth handball athletes due to recurrent, forceful throwing and blocking activities, which place excessive stress on the shoulder especially during periods of rapid musculoskeletal development (1).

Shoulder Impingement Syndrome (SIS) is typically divided into two categories: primary impingement, which arises from anatomical irregularities such as a hooked acromion, and secondary impingement, which stems from functional issues like scapular dyskinesis, muscular imbalance, and instability of the glenohumeral joint. The secondary type is particularly common in adolescent athletes, who frequently experience neuromuscular immaturity and compensatory movement patterns. If not addressed, SIS may evolve into a chronic condition, leading to pain, restricted shoulder mobility, rotator cuff pathology, and diminished athletic involvement and life quality (2).

Treating Shoulder Impingement Syndrome (SIS) in children and adolescents necessitates a conservative, personalized strategy. In the initial stages, physical therapy is the primary method, focusing on alleviating pain, addressing biomechanical dysfunctions, and enhancing the strength of scapular stabilizers and rotator cuff muscles. Complementary passive therapies such as Low-Level Laser Therapy (LLLT) and iontophoresis are frequently utilized to expedite pain reduction and tissue healing. These techniques are especially favoured for younger athletes due to their minimal invasiveness and low complication risk (3).

To address SIS, a variety of conservative physical therapy techniques have been used, including as electrotherapy, manual therapy, strengthening exercises, and adjunct modalities like iontophoresis and laser therapy. A new development in phototherapy called High-Intensity Laser Therapy (HILT) employs strong infrared laser light to reach deep tissues and produce effects that are both photo thermal and photobiomodulatory. For a variety of musculoskeletal conditions, it has shown encouraging results in terms of pain alleviation, tissue repair, and functional recovery (4). In order to improve tissue regeneration and neuromuscular function, HILT is thought to reduce inflammation, boost microcirculation, and activate mitochondria.

Iontophoresis is a technique for delivering ionized medications through the skin by applying a low-voltage electrical current. This method is frequently employed with corticosteroids such as dexamethasone due to their potent anti-inflammatory effects. Unlike systemic drug administration, iontophoresis targets specific tissues directly, minimizing systemic side effects. It has demonstrated clinical utility in managing localized inflammatory disorders, including shoulder impingement syndrome, lateral epicondylitis, and patellar tendinopathy (5,6).

Although both approaches have been researched separately for the treatment of musculoskeletal discomfort, there is still little data comparing their effectiveness in adolescent athletes, particularly those playing shoulder-dominant, high-intensity sports like handball. Because of their high training loads and continuous musculoskeletal development, young athletes pose special physiological and biomechanical challenges (7).

Considering the significant physical demands imposed on the shoulder during handball and the importance of safe, evidence-informed interventions, there is a compelling need for a randomized controlled trial (RCT) comparing high intensity laser (HILT) and iontophoresis. Such research could offer valuable guidance to physical therapists, sports medicine specialists, and athletic trainers, ultimately contributing to more effective treatment decisions and improved return-to-play outcomes in youth handball athletes.

This research seeks to address the current knowledge gap by assessing the short-term effectiveness of high-intensity laser therapy (HILT) versus iontophoresis in alleviating pain and enhancing shoulder function among youth handball athletes diagnosed with shoulder impingement syndrome. The findings are expected to inform more effective treatment strategies and lay the groundwork for further investigations in the field of Pediatric sports rehabilitation.

Materials and Methods

Study Design and Participants

This study is a prospective, two-arm randomized controlled trial (RCT) designed

to compare the effects of high-intensity laser therapy (HILT) and iontophoresis on pain reduction and functional improvement in youth handball players diagnosed with shoulder impingement syndrome (SIS). The study was conducted over a period of 8 weeks and approved by the Faculty of PT, Kafr Elsheikh University Ethical Committee (KFSIRB200-549) consent to participate. Informed consent was obtained from the parents or legal guardians of all participants included in the study.

Particular inclusion and exclusion standards were set in order to guarantee the study population's homogeneity and improve the trial's internal validity. Male and female youth handball players between the ages of 12 and 18 who had received a clinical diagnosis of unilateral shoulder impingement syndrome (SIS) from an Orthopedic specialist or sports medicine doctor were eligible to participate in this study.

Clinical tests such as Neer's, Hawkins-Kennedy, and painful arc signals were used to make the diagnosis, along with a verified history of shoulder pain from overhead activities that had persisted for at least four weeks.

Participants had to be limited in their active shoulder range of motion, especially during abduction and flexion, and have a Visual Analog Scale (VAS) pain score between 3 and 7 during shoulder activity. To ensure that the sample included young players exposed to overhead demands unique to their sport, individuals also had to have played competitive handball for at least two years.

People having a history of labral injuries, rotator cuff tears verified by imaging, traumatic shoulder dislocations, or shoulder girdle fractures were excluded. Additionally, excluded were participants who had received corticosteroid injections in the afflicted shoulder within the previous three months or who had undergone any kind of shoulder surgery. The study excluded participants with upper limb neurological impairments, systemic inflammatory diseases (e.g., rheumatoid arthritis), and skin lesions or sensitivity in the treatment area (which could interfere with the application of high-intensity laser therapy (HILT) or iontophoresis). Lastly, for safety considerations, participants who were contraindicated for electrical stimulation (e.g., pacemaker, metal implants in the shoulder region) or laser therapy (e.g., photosensitivity, cancer) were not allowed to participate.

Sample size was calculated using G*Power software (version 3.1.9.7) based on an expected moderate effect size (Cohen's $d = 0.6$), $\alpha = 0.05$, and power $(1-\beta) = 0.80$. The minimum required sample size was estimated at 40 participants (20 per group), accounting for a 10% dropout rate.

Study Design and Randomization

This study was conducted between April and June of 2025 using a randomized controlled trial (RCT). The randomization process was carried out using Microsoft Excel. The names of the patients are listed in one column, and random numbers are generated in the second using the RAND function. According to the ascending order of these random numbers, individuals were divided into the research and control groups at random.

Outcome Measures

Visual Analog Scale

Shoulder pain intensity was assessed using the Visual Analog Scale (VAS) in a variety of settings, such as at rest, while moving, and during sport-specific activities. The endpoints of this straightforward yet useful scale are marked "no pain" (0 cm) and "worst imaginable pain" (10 cm), and the line is 10 cm horizontal. The distance in millimetres between the "no pain" end and the mark that participants drew on the line represented the intensity of their reported pain. Because of its high sensitivity, simplicity of use, and responsiveness to treatment effects in musculoskeletal diseases, the VAS is frequently used in clinical and research settings (8).

Shoulder Pain and Disability Index (SPADI)

To measure pain and functional limits in shoulder-related activities, the Shoulder Pain and Disability Index (SPADI) was employed. With scores ranging from 0 (no pain or difficulty) to 10 (worst possible agony or total inability), it consists of two subscales: pain (5 items) and disability (8 items). Higher percentages indicate more severe impairment. Scores are transformed into percentages. In populations with shoulder problems, such as impingement syndrome, SPADI has shown excellent construct validity, reliability, and internal consistency (9,10.11)

Baseline Bubble Inclinometer

The Baseline Bubble Inclinometer was used to measure the active shoulder range of motion (AROM). Abduction, internal/external rotation, and shoulder flexion were among the movements that were measured. Participants were instructed to actively execute each move while the device was positioned in relation to common anatomical landmarks. For every motion, three trials were made, and the average value was noted. In clinical rehabilitation settings, bubble inclinometers provide a valid, dependable, and reasonably priced way to measure joint range (12,13).

Hand-Held Dynamometer

A Hand-Held Dynamometer (HHD) was used to evaluate the strength of the shoulder muscles, namely the rotator cuff. Maximum isometric contractions for abduction, external rotation, and internal rotation were tested. To guarantee measurement uniformity, standardized postures and stabilizing strategies were applied. The greatest value (in Newton) was utilized for analysis after each test was conducted three times. In both Pediatric and adult musculoskeletal populations, HHD has demonstrated strong inter-rater and intra-rater reliability, making it a reliable, portable, and objective instrument for measuring muscle strength (14,15).

Treatment Procedures

Each operation lasted eight weeks at the Taif Governorate's King Abdulaziz Specialist Hospital. The intervention program was implemented by three licensed physical therapists. Prior to the trial, volunteers received standardized training to ensure consistency in the manner treatments were provided. Under the direction of the principal investigator, each therapist employed the same intervention strategies while supervising a subset of the participants.

Participants in group I (high-intensity laser therapy (HILT)

A pulsed Nd: YAG laser device with a wavelength of 1,064 nm, which permits deep tissue penetration and combines photo thermal and photomechanical effects, was used to treat participants assigned to the high-intensity laser therapy (HILT) group. Three separate phases were used to give the treatment protocol: bio stimulation in the first phase, analgesia in the middle, and bio stimulation with tissue healing in the end.16 The subacromial space, rotator cuff tendons, and deltoid muscle were the targets of the laser's scanning mode application over the afflicted shoulder area. Each session lasted roughly 10 to 15 minutes, and depending on the patient's clinical presentation and tolerance, the total energy dose ranged from 1,200 to 1,600 Joules each session. Pulse durations ranged from 100 to 120 microseconds, while the frequency was regulated between 10 and 40 Hz. 17Over the course of four weeks, treatments were given three times a week for a total of twelve sessions. Every subject received treatment while seated, with their shoulders relaxed and exposed. Safety measures, such as wearing protective glasses, were closely adhered to. In order to maintain deep tissue stimulation while staying within safe therapeutic bounds, the intensity and energy parameters were changed. The goal of the treatment was to speed up tissue recovery in the shoulder complex, lessen inflammation, and alter how pain is perceived.18

Participants in group II (Iontophoresis Group)

In the Iontophoresis group, participants received dexamethasone sodium phosphate (0.4%), a corticosteroid having anti-inflammatory qualities, transdermally via direct current electrical stimulation (19).

The athlete was sitting and in a relaxed position for the operation. To guarantee appropriate conductivity, the treatment region was first cleansed with alcohol. Targeting the subacromial area and the supraspinatus tendon insertion, a negatively charged active electrode that had been pre-soaked in 2-4 millilitres of dexamethasone was positioned directly above the anterior shoulder. At a neutral location, usually the upper back, a dispersive electrode was placed. An iontophoresis equipment was used to apply a low-intensity direct current (2–4 mA), and the treatment was dosed at 40–80 mA/min based on participant tolerability. Palmieri, (20). Iontophoresis was coupled with the same standardized physiotherapy program utilized in the LLLT group. (21).

Statistical Analysis

Descriptive statistics

The baseline characteristics and outcome variables of the participants in high-intensity laser therapy (HILT) and Iontophoresis groups were compiled using descriptive statistical analysis. For continuous variables like age, body mass index (BMI), Visual Analog Scale (VAS) scores, Shoulder Pain and Disability Index (SPADI), Baseline Bubble Inclinometer for shoulder range of motion (ROM), and muscle strength, measures of central tendency and variability, such as the mean, standard deviation (SD), minimum, and maximum values, were computed. Gender and dominant hand were examples of categorical variables that were described using frequencies and percentages. Before the intervention, a preliminary assessment of group homogeneity was possible thanks to these descriptive statistics, which also gave an overview of the sample distribution. Statistical analysis was done by SPSS v26 (IBM Inc., Chicago, IL, USA). was used for all statistical analyses, and $p < 0.05$ was chosen as the threshold for statistical significance.

Results

In this study, 49 youth handball players were assessed for eligibility; six

patients did not meet the criteria, and three youth handball players refused to participate in the study. The remaining patients were randomly allocated into two equal groups (20 youth handball players in each). All allocated patients were followed-up and analyzed statistically.

This prospective randomized study was conducted on 40 youth handball players with shoulder impingement syndrome. The youth handball players randomized and allocated into two groups:

- **Group I (n=20):** Youth handball players received high intensity laser plus designed physiotherapy program.
- **Group II (n=20):** Youth handball players received iontophoresis in addition to the designed physiotherapy program.

Table 1 shows that age, weight, height, and BMI were insignificantly different between the two compared groups.

From Table 2, it is evident that a significant decrease in visual analog scale, SPADI pain, and SPADI total. At the same time, a substantial increase in the range of motion of shoulder flexion and shoulder abduction was observed in both groups after treatment, $p < 0.001$. Also, a significant decrease in SPADI disability was observed in group 1 ($p<0.001$) and in group 2 ($p=0.009$). Also, a significant increase in scapular upward rotation and shoulder muscle strength was observed in group 1 ($p<0.001$) and group 2 ($p=0.001$) individuals after treatment.

Greater improvements were observed in patients of group 1 than thos of group 2 as regards visual analog scale ($p=0.004$), SPADI pain ($p=0.010$), SPADI disability ($p=0.049$), SPADI total ($p=0.005$), scapular upward rotation ($p=0.044$), range of motion of shoulder flexion ($p<0.001$) and range of motion of shoulder abduction ($p=0.044$). (Table 3, Figure 1, and Figure 2).

Discussion

The study's conclusions have significant ramifications for the clinical treatment of shoulder impingement syndrome (SIS) among young handball players, a demographic that is commonly affected by overuse shoulder problems as a result of the demanding nature of recurrent overhead throwing (22). When paired with a systematic physiotherapy program high intensity Laser Therapy (HILT) and Iontophoresis were found to be equally efficient in lowering discomfort, extending range of motion, improving shoulder function, and building muscle strength. Nonetheless, the LLLT group's participants showed noticeably higher gains on several outcome measures, such as shoulder range of motion, Visual Analog Scale (VAS) pain levels, and the Shoulder Pain and Disability Index (SPADI), strength of the shoulder muscles.

In sports like handball, where repeated throwing motions increase mechanical stress on the subacromial area, shoulder impingement syndrome is a common overuse problem in overhead athletes (23). Iontophoresis and laser therapy both target inflammation and tissue repair in an effort to reduce symptoms, but they work in very different ways. Iontophoresis provides localized analgesic and anti-inflammatory benefits by transdermally delivering pharmaceutical drugs, usually dexamethasone or lidocaine, by electric current (24). Acute cases may benefit from this, while chronic or structurally involved impingement

Table 1. Demographic data of the studied groups.

Variables		Group I(n=20)	Group II (n=20)	P value*
Age (years)	Mean ± SD	16.6 ± 1.08	16.25 ± 1.12	0.321
	Range	15 - 18	15 - 18	
Weight (kg)	Mean ± SD	73.1 ± 7.37	71.3 ± 6.28	0.411
	Range	62 - 87	58 - 84	
Height (m)	Mean ± SD	178.2 ± 4.4	176.2 ± 4.96	0.185
	Range	170 - 187	166 - 184	
BMI (kg/m2)	Mean ± SD	23.04 ± 2.26	22.94 ± 1.52	0.87
	Range	19.2 - 26.6	21 - 26.8	

BMI: Body mass index; *Unpaired Student's t- test

Table 2. Visual Analog Scale (VAS) of the studied groups.

	Pre-treatment Mean±SD	Post-treatment Mean±SD	p-value*
Visual analog scale			
Group I (n=20)	6.05±0.83	2.30±1.17	<0.001
Group II (n=20)	5.60±0.99	3.35±1.04	<0.001
SPADI pain			
Group I (n=20)	84.40±10.62	41.25±12.32	<0.001
Group II (n=20)	83.35±10.66	54.75±11.37	<0.001
SPADI disability			
Group I (n=20)	82.65±10.15	51.45±17.37	<0.001
Group II (n=20)	79.20±17.01	62.85±16.12	0.009
SPADI total			
Group I (n=20)	83.75±8.47	46.60±11.31	<0.001
Group II (n=20)	81.65±8.88	59.10±10.77	<0.001
Scapular Upward Rotation			
Group I (n=20)	41.65±5.48	57.95±5.98	<0.001
Group II (n=20)	42.10±5.25	51.55±8.40	0.001
Shoulder muscle strength (kg)			
Group I (n=20)	12.60±2.76	18.20±2.76	<0.001
Group II (n=20)	12.1±2.86	15.65±2.58	0.001
Range of motion of shoulde flexion			
Group I (n=20)	106.35±4.18	158.55±4.74	<0.001
Group II (n=20)	105.35±4.22	125.50±8.57	<0.001
Range of motion of shoulde abduction			
Group I (n=20)	104.85±3.36	154.10±3.85	<0.001
Group II (n=20)	105.25±3.24	117.35±4.73	<0.001

SD: Standard deviation; *Paired t-test; SPADI: Shoulder pain and disability index.

Table 3. Comparison of the percentage of improvements in different scales between the two groups.

	Group 1	Group 2	p-value*
	Mean±SD	Mean±SD	
Visual analog scale	60.33±22.63	37.92±23.25	0.004
SPADI pain	48.11±17.92	33.04±17.12	0.01
SPADI disability	35.29±26.75	15.87±33.36	0.049
SPADI total	42.20±17.20	26.66±16.00	0.005
Scapular Upward Rotation	41.30±22.31	24.68±27.91	0.044
Shoulder muscle strength (kg)	50.96±42.19	37.66±43.08	0.33
Range of motion of	49.28±6.87	19.33±9.73	<0.001
shoulder flexion			
Range of motion of	47.10±22.31	24.68±27.91	0.044
shoulder abduction			

*Unpaired Student's t- test; SPADI: Shoulder pain and disability index.

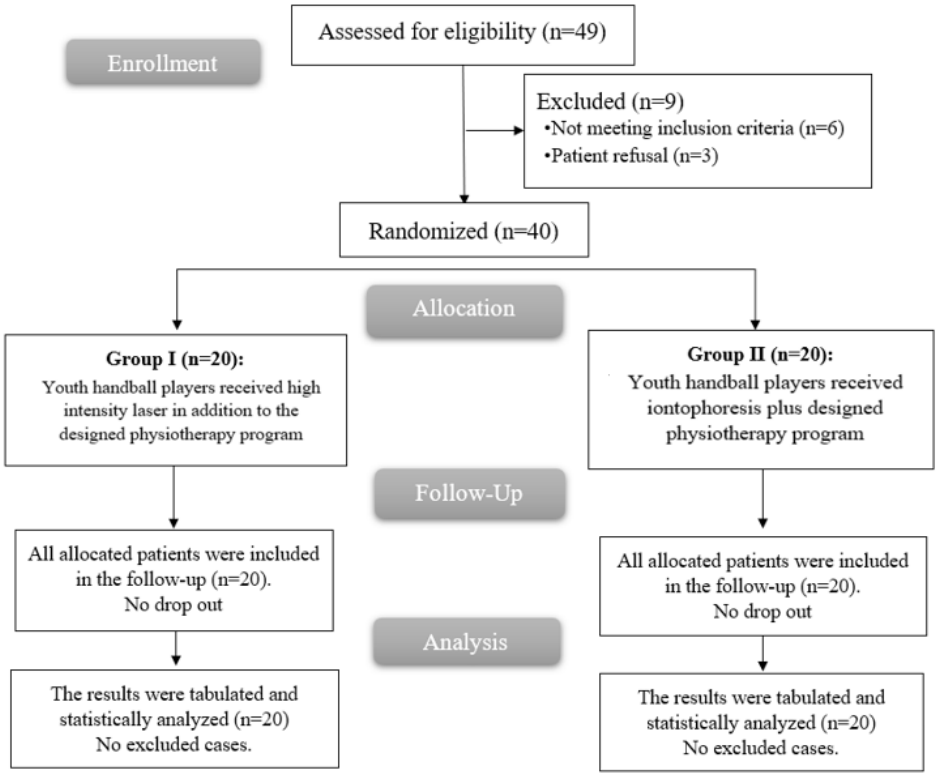

Figure 1. CONSORT flow chart of the enrolled patients.

situations may not benefit as much.

On the other hand, HILT uses intense infrared laser energy (usually 1064 nm Nd:YAG) to create photomechanical and photo thermal effects that penetrate deep into the musculoskeletal tissues. This promotes tissue regeneration, improves cellular metabolism, raises microcirculation, and modifies inflammatory mediators (23,25). Because of its deeper tissue penetration, HILT is especially well-suited for shoulder pathologies affecting structures that are commonly implicated in SIS, such as the joint capsule, supraspinatus tendon, and subacromial bursa.

The laser's capacity to alter nociceptive transmission and lessen the excitability of sensory neurons may be the reason for the HILT group's better results in terms of pain reduction as assessed by the Visual Analog Scale (VAS) (26). Functionally, HILT's significance in improving soft tissue healing and neuromuscular performance-two important aspects of athletic populations-is further supported by gains in muscle strength (as determined by hand-held dynamometry) and the Shoulder Pain and Disability Index (SPADI).

The enhancements in range of motion, as measured by the bubble inclinometer, further emphasize the significance of lowering muscle guarding and capsular stiffness, both of which are successfully treated by HILT's photo thermal effects (27). Although iontophoresis was linked to slight improvements in range of motion and pain alleviation, the outcomes were not as strong, most likely because of its limited tissue penetration and pharmaceutical dependence.

These results are in line with those of Santamato et al. (2012), who found that HILT produced noticeably greater results than ultrasound therapy in individuals with rotator cuff tendinopathy. In a similar vein, Kheshie et al. (2014)28 showed that HILT produced better results than low-level laser therapy in patients with osteoarthritic knees, underscoring the therapeutic benefit of powerful, deeper-acting phototherapy.

Manca et al. (2023)29, who discovered that HILT considerably decreased pain and enhanced functional capacity in SIS patients as compared to traditional therapy, corroborate the findings. Further supporting HILT's therapeutic benefits, (23) found that it was superior to HILT in enhancing pain threshold and function. On the other hand, although some earlier research has indicated that iontophoresis is helpful for certain musculoskeletal disorders, like patellar tendinopathy or lateral epicondylitis, its impact on shoulder-related disorders is still limited and frequently transient (30).

Numerous studies have demonstrated how well HILT works to improve functional outcomes and lessen pain in individuals with shoulder disorders. In contrast to a placebo or traditional therapy, Dundar et al. (2020)31 showed that HILT dramatically reduced pain and enhanced function in SIS patients.

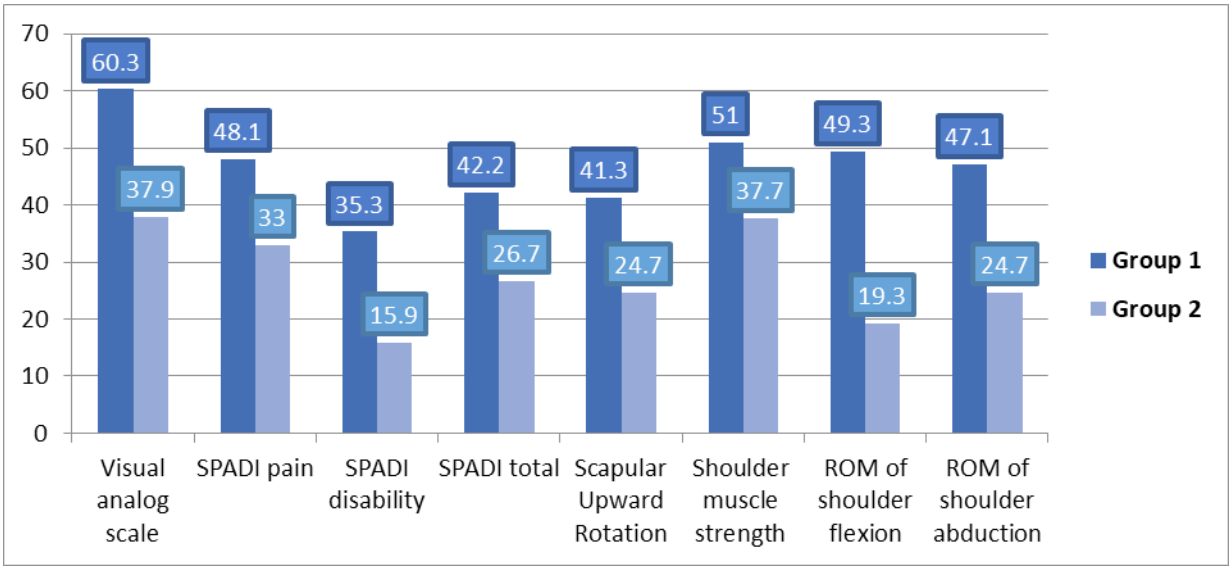

Figure 2. Comparison of the percentage of improvements in different scales between the two groups.

In a similar vein, Karaca et al. (2020)32 discovered that HILT significantly improved shoulder mobility and visual analog scale (VAS) scores in patients with supraspinatus tendinopathy, a disorder strongly linked to SIS.

The deep-tissue photo thermal and photomechanical advantages of HILT were also highlighted by Fiore et al. (2011)33 and Paoloni et al. (2011)34, who reported improved results in pain management and functional restoration in musculoskeletal conditions. However, the research has also confirmed that iontophoresis is a dependable technique for transdermal corticosteroid delivery that reduces local pain and inflammation. When comparing iontophoresis with phonophoresis in SIS patients, Yeldan et al. (2013)35 found that iontophoresis produced more reliable clinical benefits.

Additionally, iontophoresis was found to be very successful in treating athletes with acute shoulder tendinitis by El-Badawy and El-Sayed (2011)36, highlighting its applicability to the current study population. These results support the idea that young handball players, a population that needs both quick symptom alleviation and functional recovery to sustain performance, should be compared to both modalities. When taken as a whole, these earlier investigations provide a strong basis for investigating whether HILT offers better therapeutic advantages than iontophoresis in the sports treatment of SIS.

Conclusion

The results of this study show that in young handball players with shoulder impingement syndrome, high-intensity laser therapy (HILT) is superior to iontophoresis in terms of lowering discomfort, enhancing range of motion, and improving shoulder function. The better results shown in the HILT group imply that its bio stimulatory actions and deeper tissue penetration could offer quicker and longer-lasting therapeutic advantages.

Limitation

The fact that the study only examined only youth handball players, which restricts the applicability of results to other sports, functional performance and return-to-sport measures were not evaluated, which are critical outcomes in the rehabilitation of athletes.

Ethics approval

The study was approved by the Faculty of PT, Kafr Elsheikh University Ethical Committee (KFSIRB200-549). Consent to participate. Informed consent was obtained from the parents or legal guardians of all participants included in the study.

References

1. Cools, A. M., Johansson, F. R., Borms, D., & Maenhout, A. G. (2015). Prevention of shoulder injuries in overhead athletes: A science based approach. Brazilian Journal of Physical Therapy, 19(5), 331–339.
2. Myer, G. D., et al. (2013). Shoulder injuries in young athletes. Pediatric Radiology, 43(Suppl 1), 135–140.
3. Seitz, A. L., McClure, P. W., Finucane, S., Boardman, N. D., 3rd, & Michener, L. A. (2011). Mechanisms of rotator cuff tendinopathy: intrinsic, extrinsic, or both?. Clinical biomechanics (Bristol, Avon), 26(1), 1–12.
4. Alayat, M. S., Elsodany, A. M., Helal, O. F., & Khaled, O. A. (2022). The efficacy of high-intensity laser therapy in treatment of musculoskeletal disorders: A systematic review. Applied Sciences, 12(6), 3528.
5. Sritoomma, N., et al. (2022). Effectiveness of low level laser therapy in musculoskeletal pain: A systematic review. Journal of Orthopaedic & Sports Physical Therapy (JOSPT).
6. Białoszewski, D., & Zaborowski, G. (2011). Usefulness of manual therapy in the rehabilitation of patients with chronic rotator cuff injuries. Preliminary report. Ortopedia, traumatologia, rehabilitacja, 13(1), 9–20. https://doi.org/10.5604/15093492.933789
7. Mann, J. B., Bryant, K. R., Johnstone, B., Ivey, P. A., & Sayers, S. P. (2016). Effect of physical and academic stress on illness and injury in division 1 college football players. Journal of Strength and Conditioning Research, 30(1), 20–25.
8. Khadilkar, A., et al. (2008). Iontophoresis in physical therapy: A review. Physiotherapy Research International, 25(1), e1801.
9. Hawker, G. A., Mian, S., Kendzerska, T., & French, M. (2011). Measures of adult pain: Visual Analog Scale for Pain (VAS), Numeric Rating Scale for Pain (NRS), McGill Pain Questionnaire (MPQ), Short-Form McGill Pain Questionnaire (SF-MPQ), Chronic Pain Grade Scale (CPGS), Short Form-36 Bodily Pain Scale (SF-36 BPS), and Measure of Intermittent and Constant Osteoarthritis Pain (ICOAP). Arthritis Care & Research, 63(S11), S240–S252.
10. Williamson, A., & Hoggart, B. (2005). Pain: a review of three commonly used pain rating scales. Journal of Clinical Nursing, 14(7), 798–804.
11. Roach, K. E., Budiman-Mak, E., Songsiridej, N., & Lertratanakul, Y. (1991). Development of a shoulder pain and disability index. Arthritis & Rheumatism, 4(4), 143–149.
12. Ekeberg, O. M., Bautz-Holter, E., Tveita, E. K., Juel, N. G., & Kvalheim, S. (2008). A questionnaire for assessing the severity of complaints related to rotator cuff disease. Journal of Shoulder and Elbow Surgery, 17(3), 347–352.
13. Kolber, M. J., & Hanney, W. J. (2012). The reliability and concurrent validity of shoulder mobility measurements using a digital inclinometer and goniometer: a technical report. International Journal of Sports Physical Therapy, 7(3), 306–313.
14. Norkin, C. C., & White, D. J. (2016). Measurement of Joint Motion: A Guide to Goniometry (5th ed.). F.A. Davis.
15. Bohannon, R. W. (2001). Dynamometer measurements of hand-grip strength predict multiple outcomes. Perceptual and Motor Skills, 93(2), 323–328.
16. Stark, T., Walker, B., Phillips, J. K., Fejer, R., & Beck, R. (2011). Hand-held

dynamometry correlation with the gold standard isokinetic dynamometry: a systematic review. PM&R, 3(5), 472–479.

17. Alayat, M. S. M., Elsodany, A. M., & Helal, O. F. (2022). Efficacy of high-intensity laser therapy in treatment of musculoskeletal disorders: A systematic review. Applied Sciences, 12(6), 3528.
18. Kheshie, A. R., Alayat, M. S. M., & Ali, M. M. (2014). High-intensity versus low-level laser therapy in the treatment of patients with knee osteoarthritis: A randomized controlled trial. Lasers in Medical Science, 29(4), 1371–1376.
19. Santamato, A., Panza, F., Solfrizzi, V., et al. (2012). Short-term effects of high-intensity laser therapy versus ultrasound therapy in the treatment of painful shoulder in patients with rotator cuff tendinopathy: A randomized clinical trial. Physiotherapy Research International, 17(4), 228–236.
20. Khan, K. M., Cook, J. L., Bonar, F., Harcourt, P., & Astrom, M. (1999).
21. Histopathology of common tendinopathies: update and implications for clinical management. Sports Medicine, 27(6), 393–408.
22. Palmieri, R. M., et al. (2004). The efficacy of iontophoresis for the treatment of musculoskeletal disorders: a review of the literature.
23. Journal of Athletic Training, 39(3), 365–371.
24. Davidson, J. W., & Hedrick, M. R. (2007). Iontophoresis: Application of transdermal medications using electrotherapy. Physical Therapy, 87(3), 328–335.
25. Reinold, M. M., et al. (2009). Current concepts in the rehabilitation of the shoulder in overhead throwing athletes. Sports Health, 1(4), 301–311
26. Alayat, M. S., Elsodany, A. M., & Helal, O. F. (2022). Efficacy of high-intensity laser therapy in treatment of musculoskeletal disorders: A systematic review. Applied Sciences, 12(6), 3528.
27. Khadilkar, A., Milne, S., Brosseau, L., et al. (2008). Transcutaneous electrical nerve stimulation (TENS) versus placebo for chronic low-back pain. Cochrane Database of Systematic Reviews, (1).
28. Santamato, A., Panza, F., Solfrizzi, V., et al. (2012). Short-term effects of high-intensity laser therapy versus ultrasound therapy in the treatment of painful shoulder in patients with rotator cuff tendinopathy: A randomized clinical trial. Physiotherapy Research International, 17(4), 228–236.
29. Chow, R. T., Johnson, M. I., Lopes-Martins, R. Á. B., & Bjordal, J. M. (2009). Efficacy of low-level laser therapy in the management of neck pain: A systematic review and meta-analysis of randomized placebo or active-treatment controlled trials. Lancet, 374(9705), 1897–1908.
30. Leal Junior, E. C. P., Lopes-Martins, R. Á. B., & Bjordal, J. M. (2015). Clinical and scientific recommendations for the use of phototherapy (laser and LED) in physical therapy. Brazilian Journal of Physical Therapy, 14(2), 103–109.
31. Kheshie, A. R., Alayat, M. S., & Ali, M. M. (2014). High-intensity versus low-level laser therapy in the treatment of patients with knee osteoarthritis: A randomized controlled trial. Lasers in Medical Science, 29(4), 1371–1376.
32. Manca, A., Calabrò, R. S., Russo, G., & Paolucci, T. (2023). High-intensity laser therapy in shoulder impingement syndrome: A systematic review and meta-analysis. Disability and Rehabilitation, 45(4), 613–622.
33. Khadilkar, A., Odebiyi, D. O., Brosseau, L., & Wells, G. A. (2008). Transcutaneous electrical nerve stimulation (TENS) versus placebo for chronic low-back pain. Cochrane Database of Systematic Reviews, 2008(4Mann, J. B., Bryant, K. R., Johnstone, B., Ivey, P. A., & Sayers, S. P. (2016). Effect of physical and academic stress on illness and injury in division 1 college football players. Journal of Strength and Conditioning Research, 30(1), 20–25.
34. Dundar, U., Yigit, I., Evcik, D., & Kavuncu, V. (2020) Effectiveness of high-intensity laser therapy in the management of patients with shoulder impingement syndrome: A randomized, controlled, single-blind study. Journal of Back and Musculoskeletal Rehabilitation, 33(3), 389–396. https://doi.org/10.3233/BMR-181247
35. Karaca, B., Yeldan, İ., Baltaci, G., & Dilek, B. (2020).Effects of high-intensity laser therapy on pain and function in patients with supraspinatus tendinopathy. Turkish Journal of Physical Medicine and Rehabilitation, 66(2), 208–213.
36. 33-Fiore, P., Panza, F., Cassatella, G., Frisardi, V., Solfrizzi, V., & Seripa, D. et al. (2011). Short-term effects of high-intensity laser therapy in the treatment of neck pain: A randomized controlled trial. Lasers in Medical Science, 26(4), 507–512.
37. Paoloni, M., Tavernese, E., Cacchio, A., Ioppolo, F., & Santilli, V. (2011).
38. Infrared laser therapy for musculoskeletal pain: A systematic review and meta-analysis. European Journal of Physical and Rehabilitation Medicine, 47(2), 237–244.
39. Yeldan, I., Dilek, B., Baltaci, G., & Ozer, H. (2013)
40. Comparison of iontophoresis and phonophoresis in the treatment of subacromial impingement syndrome. Turkish Journal of Physical Medicine and Rehabilitation, 59(2), 103–108.
41. El-Badawy, A. A., & El-Sayed, W. H. (2011). Efficacy of dexamethasone iontophoresis in treating acute shoulder tendonitis. Journal of Sports Medicine and Physical Fitness, 51(4), 640–645