RESEARCH PAPER

Effect of High Intensity Laser on Sonographic Supraspinatus Tendon Thickness in Adolescents with Impingement Syndrome: Randomized Control Trial

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Received: 26th July, 2026; Revised: 06th August, 2026; Accepted: 16th August, 2026; Available Online: 19th August, 2026

ABSTRACT
Background: Shoulder Impingement Syndrome (SIS) has been identified with incidence of around 40 percent of all shoulder pathologies. In SIS adding high intensity laser which is used widely in modern medicine to manual therapy technique and exercise therapy may improve the outcomes of the rehabilitation.
Objective: Assessing the effect of high intensity power laser therapy (HILT) on the supraspinatus tendon thickness in adolescent with SIS.
Methods: Randomized controlled trial, forty volunteers ranged in age 12 to 18 years with SIS, they were assigned randomly into two matched groups, study group was 20 adolescents treated for 15 sessions with HILT added to exercises therapy and manual therapy (MT), and control group was 20 adolescents received 15 sessions of MT and exercises therapy. All adolescents assessed pre and post intervention by blindfolded expert in sonographic clinician for supraspinatus tendon thickness.
Results: the laser group demonstrated a numerically greater tendon thickness reduction with a small-to-medium effect size (11.34%) compared to the control group's small effect size (5.96%), while neither intervention produced a statistically significant change in supraspinatus sonographic tendon thickness (P=0.133 and P=0.514 respectively).
Conclusion: adding HILT to MT and exercises had small reduction on supraspinatus tenson's sonographic thickness which may save against SIS.
Keywords: High Intensity Laser; supraspinatus thickness; manual therapy; exercise; ultrasonography; shoulder impingement; adolescents.
How to cite this article: Mansour A, Olama K.A, Elshafey M.A, El-Azizi H, Effect of High Intensity Laser on Sonographic Supraspinatus Tendon Thickness in Adolescents with Impingement Syndrome: Randomized Control Trial. 2026;16(78s): 369-379; DOI: 10.25258/ijddt.16.78s.45
Source of support: None
Conflict of interest: None

INTRODUCTION
Shoulder impingement was first defined by Charles Neer in 1972, described as the tightness of the soft tissues under the acromion that compromise its functionality, it represents mechanical compression of the rotator cuff tendons and sub-acromial bursa against the anteroinferior undersurface of the acromion and coracoacromial ligament especially during elevation of Several kinematic changes are present in people with symptoms of impingement which results in further decrease in the available supraspinatus muscle outlet or supra humeral space (Neer, 1972& Creech et al., 2026).
Shoulder impingement is a common musculoskeletal complaint for all aged patients with different activity levels. People who are frequently doing repetitive overhead motions related to their professions or athletic activities are also at risk of shoulder impingement syndrome (Moezy et al., 2014).
Shoulder pain was a common complain among adolescents, independent of the sport, with prevalence ranged from 43.5% to 54.2%. Athletes older than tweelve years presented with shoulder complaints of pain and higher levels of dysfunction, compared to younger athletes and was associated with increasing age (Tate et al., 2012 & Oliveira et al., 2017).
Conservative treatment commonly includes manual therapy techniques added to exercises therapy to get more interventional outcomes for shoulder impingent syndrome, also some treatment protocol has electrotherapy, supervised home exercises, ultrasound and shock waves, high power laser and low intensity laser. (Şenbursa et al., 2011, Steuri et al., 2017& Yoma et al., 2022)
Rehabilitative interventions to SIS include adding manual therapy techniques with exercise therapy to improve the outcomes of the rehabilitation also MT, high power laser or exercise and many research articles and systemic reviews

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stated that combination between MT and exercise are better than exercise alone (Steuri et al., 2017 & Sharma et al., 2021).

Manual therapy schools are used commonly by physical therapists for pain reduction and increasing function in patients with impingement disorders like mulligan and Maitland technique, all these techniques stated that have truly added effect on EMG activity of rotator cuff, shoulder range, pain, shoulder capsule flexibility and decrease dysfunction in SIS (Swanson et al., 2016 & Satpute et al., 2022).

Physical therapy interventions of glenohumeral mobilizations and MWM in combination with a supervised exercise program resulted in a higher percentage of change from pre- to post-treatment in decreasing pain and improving function compared to the supervised exercise only and control groups. (Kachingwe et al., 2008)

High-intensity laser technologies are used widely in modern medicine, and indications for their use are expanding. These technologies are safe and effective and Has a wide range of significantly pronounced therapeutic effects for treating many diseases (Ponomarenko ., (2023)).

Randomized control trial for short term effect of high-power laser, manual therapy and Kinesio-taping in cases with shoulder SIS founded that high intensity laser, manual therapy was more effectively in minimizing pain and disability in patients with subacromial impingement syndrome. (Pekyavas et al., 2016)

MSK ultrasound is highly sensitive and specific in diagnosing supraspinatus tears, equivalent to MRI imaging. MSK ultrasonography, with its advanced imaging, facilitates precise visualization of the supraspinatus tendon's internal structure. This advanced imaging technique allows clinician to examine the internal structures of the shoulder in real-time, producing detailed and accurate images of the supraspinatus tendon. (Manske et al., 2023)

There's no doubt that, there is a lack of research data available to inform us about effect of high intensity power laser on supraspinatus tendon thickness measured by ultrasonography in adolescents and it was a matter of investigation in this study that could be tool for rehabilitation optimization.

METHODS:

Study design

Pretest-posttest single-blinded randomized controlled trial carried out from February 2024 to Nov 2025. Each volunteer's caregiver was signed a consent form authorizing the participation of their children in this study. The current investigation was conducted with the approval of the local ethical committee at The Faculty of Physical Therapy (P.T.REC/012/005091), Cairo University. Ethical principles of the Declarations of Helsinki were followed, and clinical trial registry were performed (NCT06732570).

Participants

Adolescents of both sexes who was 40 volunteers aged 12-18 years old were selected for this study; they were recruited from Egyptian national clubs and bab elsharie university hospital. The participants were enrolled by following criteria: The patient was aged of 12 up to 18 years with unilateral complain of anterolateral region of the shoulder. Additionally, the patient exhibited a painful arc, 2 or 3 impingement tests (Neer,Jobe , and Hawkin) were inducing pain, and they experienced pain upon palpation of the supraspinatus tendon insertion. An adolescent who had at least one of the following criteria were excluded from the investigation: Shoulder dislocation, history of shoulder trauma, no corticosteroid injections received within 3 months prior to the study, cervical or thoracic fractures or operations, cervical ache or arm radiation. (Maenhout et al., 2013 & Pekyavas et al., 2016)

Sampling

The sample size estimation was performed for the study relation between pinch grip strength and handwriting score in children using G*Power version 3.1.9 (Heinrich-Heine-University, Düsseldorf, Germany) for two tailed tests. The effect size for the sample size calculation was depending on the previous study (Beyrami et al., 2023). The sample size calculation utilized t tests - Means: Difference between two independent means (two groups), with assuming a medium effect size (d=0.5), Type I error (α) of 0.05, power (1-β error probability) of 0.80 and an effect size d= 0.99872651. This calculation aimed for a total sample size of 34 participants for comparing supraspinatus tendon thickness as the primary outcome across 2 independent groups. To account for an anticipated 10% dropout, the final adjusted sample size is 38 participants and 2 participants added to ensure adequate statistical power for detecting a large clinically meaningful difference (20 patients/ group as a minimum). (figure 1&2)

Randomization

The selected patient was randomized by simple randomization method into two groups (study and control). piece of paper chosen by independent person from sealed envelope which indicating whether the patient was randomized to which group. (Figure 3)

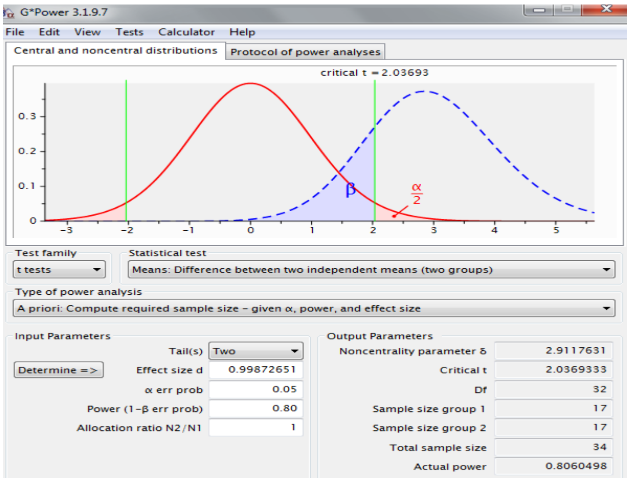

Fig1: sample size.

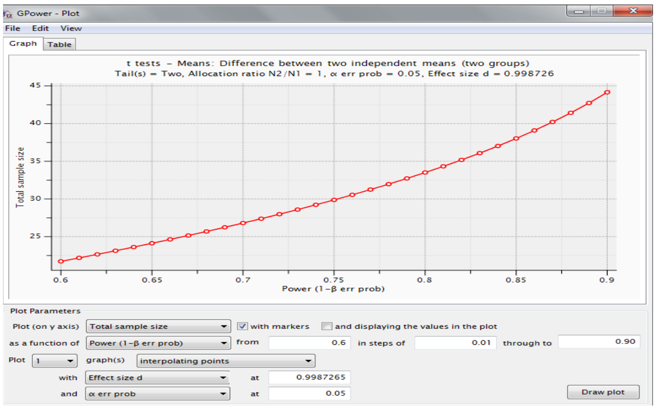

Fig 2: sample size

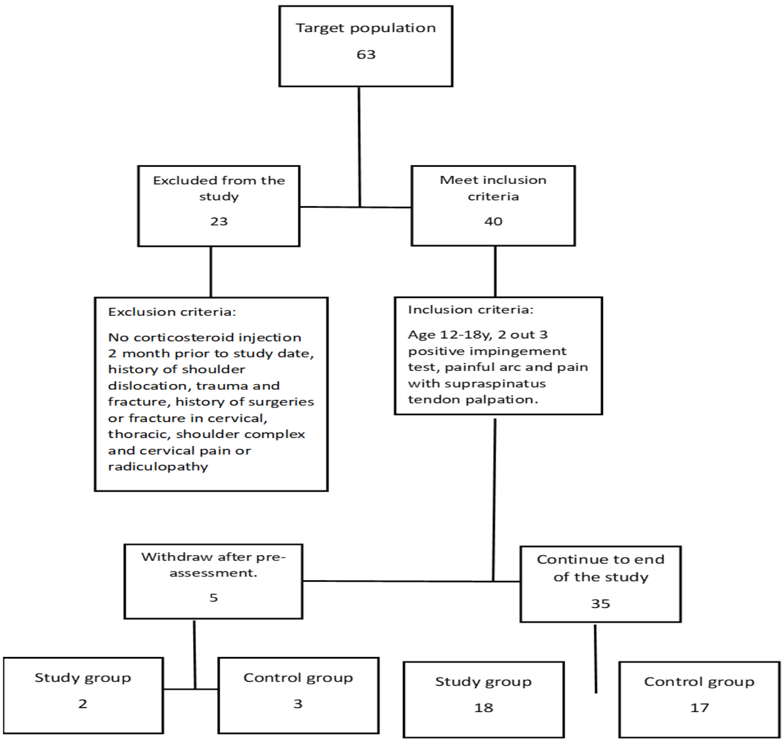

Fig 3: Flow chart for the study.

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MATERIAL AND METHODS:

A-Materials for evaluation:

TOSHIBA Aplio 500, japan. Linear probe 12-15 MHZ sonography machine was used. It is composed of a hand-held probe: a linear probe emitting ultrasonic waves and receiving ultrasonic waves and a screen: forming a digital image. (Abbass et al., 2022)

B-Materials for intervention:

High intensity laser therapy device:

BI-POWER SN/477, an Italian machine from PAGANI company has scanner transducer with a 16 j/cm2 density and a high-intensity laser (Figure 4)

Fig (4): High power laser PAGANI

Procedure

Procedure for evaluation

Procedure for subject selection

Adolescents were asked to provide a history of their shoulder, cervical, and thoracic injuries and impingement diagnostic tests were done only pre the study begins.

Before the starting of the study, diagnostic tests for SIS (Neer test, Hawkins–Kennedy test, and Jobe test) were applied. (Phillips, 2014)

II- Procedure for subject evaluation

sonographic measurement for supraspinatus tendon was done pre and post fifteen sessions with frequency of 3 sessions per week of interventions.

Ultrasonography:

Musculoskeletal sonography was used to assess supraspinatus tendon thickness. The ultrasound clinician was blinded to treatment methods and groups randomization, who is a radiology professor and one of the Egyptian eminent‘s sonographer.

A water-based substance was applied to the epidermis by the examiner to improve the conduction of the sonography probe. Participants were required to sit upright in the chair without slouching their back and place their feet on the floor with their knees and hips in a 90-degree flexion position. From 0-degree shoulder abduction with longitudinal view over the acromion laterally, the examiner assessed the tendon thickness by identifying the acromion and the greater tuberosity of the humerus. The supraspinatus tendon can be seen running between these two landmarks with a longitudinal view of the supraspinatus tendon, scanning from its origin at the supraspinatus fossa to its insertion at the greater tuberosity of the humerus and measure the tendon thickness (Özçakar et al., 2015 & Navarro-Ledesma et al., 2021**&** Ishigaki et al., 2022) (Figure5 & 6).

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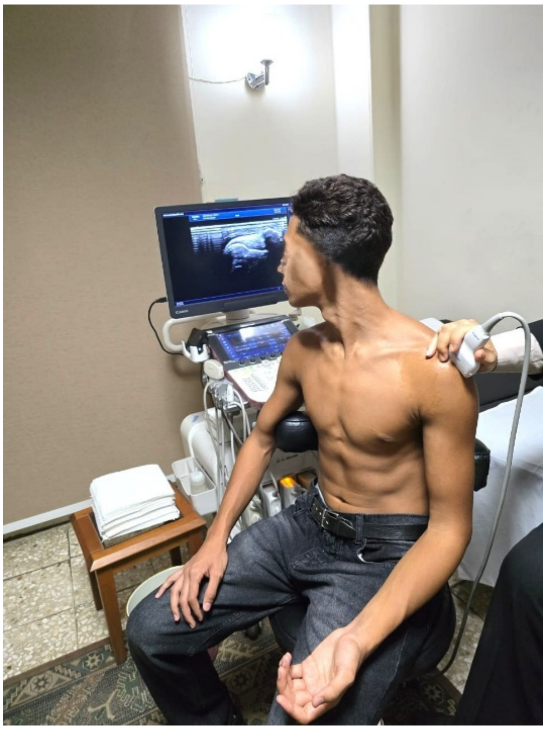

From 0-degree

Fig (5): ultrasongraphy position.

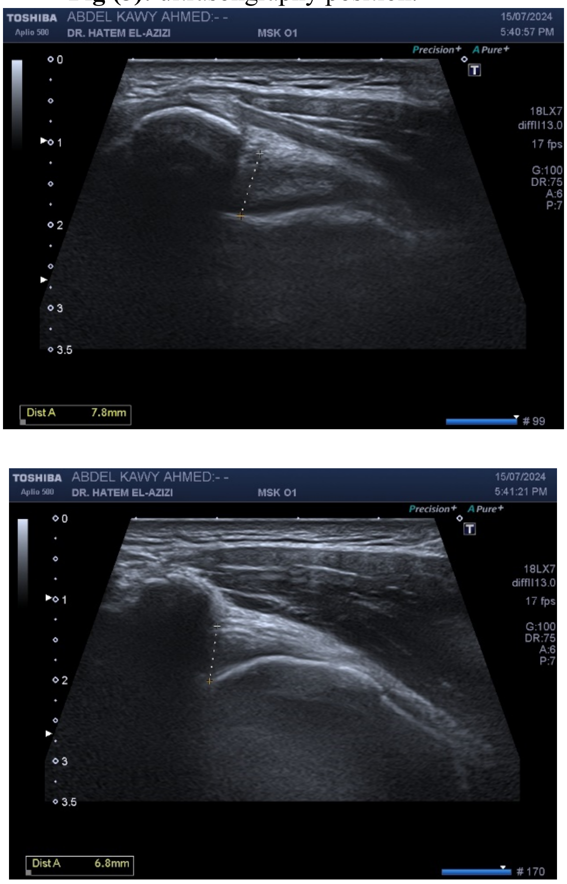

Fig (6): ultrasonography image of supraspinatus tendon thickness.

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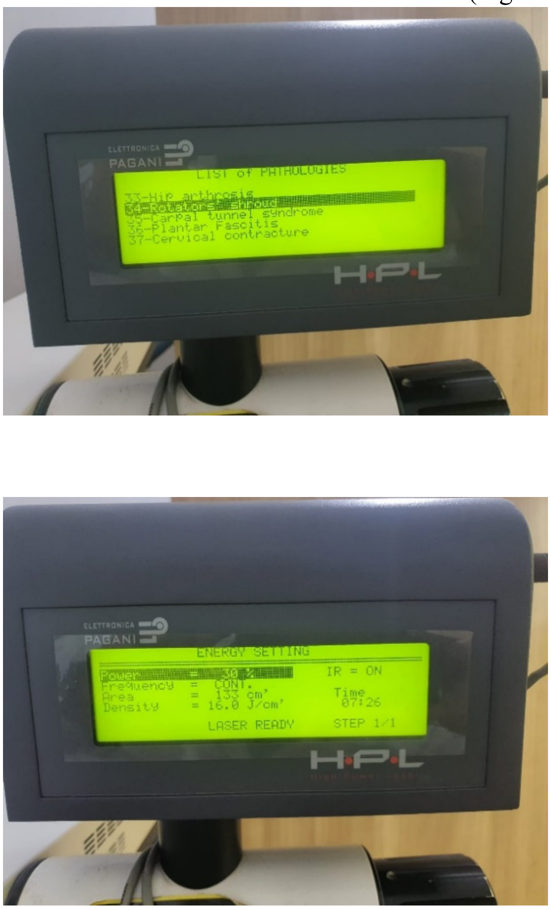
B-Procedure for intervention

Control group: was received the therapeutic exercises and MT three session weekly over 5 weeks.

The exercises were applied inform of rotator cuff strengthening exercise, cool's scapular exercise, serratus punch supine, modified sleeper posterior capsule stretching and focused and gross pectoralis minor stretching exercise. (Blackburn et al. (1990), Cools et al. (2007), Ganderton et al., 2013, Williams et al,.2013, Castelein et al., 2016 and D et al., 2023)

The treatment with MT included scapular mobilization, glenohumeral joint mobilization by Maitland (caudal and posterior humeral glide), Mulligan Mobilization with Movement (MWM) abduction, and deep transverse friction technique on the supraspinatus muscle. (Cools et al., 2007, Pinto, J. (2014) and Pekyavas and Baltaci (2016))

Study group: will receive 15 consecutive sessions of high intensity laser therapy three sessions weekly over 5 weeks (Pekyavas and Baltaci (2016)), in addition to therapeutic exercises and MT as the control group. The patient, who was wearing a laser protective eyeglass to protect their eyes from laser radiation, was in a supine position with their shoulder exposed from their garments (figure 6), From the device pathologies list programs number thirty-four, the dosage will be determined (figure 18- A). In order to accommodate the scanning area's width (medially from the coracoid process to the middle fiber of the deltoid laterally and superiorly from the acromioclavicular joint to the end of the biceps tendon), the device's duration will be automatically adjusted. It has a 30% power output, a continuous frequency, and a density of 16 j/cm2. The infrared will be on (Figure 7A&B)



(A) (B)

Fig (7): Laser screen A- List of pathologies. B- Energy settings.

Statistical analysis

Data were screened, for normality assumption test and homogeneity of variance. Normality test of data using Shapiro-Wilk, that reflect the data was normally distributed (P>0.05) after removal outliers that detected by box and whiskers plots. Additionally, Levene's test for testing the homogeneity of variance revealed that there was no significant difference (P>0.05). All these findings allowed to conducted parametric and non-parametric analysis. The data is normally distributed and parametric analysis is done. The statistical analysis was conducted by using statistical SPSS Package program version 25 for Windows (SPSS, Inc., Chicago, IL). Quantitative data are reported as mean and standard deviation for clinical adolescents' demographic data and supraspinatus variables. Qualitative data are expressed as frequency (percentage) for adolescents' gender and dominant variables and compared statistically between both groups by Chi-square test.

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Independent t-test used to compare between laser and control therapy groups for demographic data and supraspinatus variables. Paired t-test used to compare between pre- and post-treatment of supraspinatus within each group. All statistical analyses were significant at level of probability (P≤0.05).

RESULTS

A total of 40 adolescents from both genders (27 boys and 13 girls) were participated in this study and divided randomly into 2 groups equal in the numbers (20 adolescents / group). Table (1) presents the baseline demographic characteristics of the study adolescents in both the laser and control groups. For quantitative variables, independent samples t-tests revealed no statistically significant differences between groups for age (Laser: 15.05 ± 1.84 years; control: 15.20 ± 1.85 years; P=0.799), weight (Laser: 61.95 ± 6.38 cm; control: 63.70 ± 6.61 cm; p = 0.400), or height (Laser: 157.30 ± 6.60 kg; control: 161.20 ± 5.86 kg; P=0.056). These findings confirm adequate randomization and baseline equivalence for all continuous demographic variables.

For qualitative variables, Chi-square tests demonstrated no significant between-group differences for gender distribution (Laser: 40% boys, 60% girls; control: 50% male, 50% female; P=0.525) or handedness (95% right-handed in both groups; P=1.000). The high proportion of right-handed participants in both groups is notable and reflects the general population distribution. Generally, these findings indicate that randomization successfully balanced the groups regarding all measured demographic parameters, minimizing the risk of confounding and supporting the validity of subsequent between-group comparisons.

Table 1. adolescents' demographic data in both groups

Items	Groups		*P*-value
	Laser group (n=20)	control group (n=20)	
Age (year)	15.05 ±1.84	15.20 ±1.85	0.799
Weight (kg)	61.95 ±6.38	63.70 ±6.61	0.400
Height (cm)	157.30 ±6.60	161.20 ±5.86	0.056
Gender (boys : girls)	8 (40.00%) : 12 (60.00%)	10 (50.00%) : 10 (50.00%)	0.525
Dominant (right : left)	19 (95.00%) : 1 (5.00%)	19 (95.00%) : 1 (5.00%)	1.000

Quantitative data (age, weight, height) are expressed as mean ±standard deviation and compared by t-independent test.
Qualitative data (gender and dominant) are expressed a frequency (percentage) and compared by Chi-square test
P-value: probability value P-value > 0.05: non-significant

Table (2) and Figure (8) present the between-group comparisons for supraspinatus at pre-treatment and post-treatment between the laser and control therapy groups. For pre-treatment comparison, there was no statistically significant difference between the laser and control groups (MD = 0.16; 95% CI: -0.56 to 0.88; P= 0.659). The effect size was small (Cohen's d = 0.14), confirming adequate randomization and baseline comparability between the groups. At post-treatment comparison, the between-group difference remained non-significant (MD = 0.21; 95% CI: -1.88 to 1.45; P=0.795), with a negligible effect size (Cohen's d = 0.08). The wide confidence intervals crossing zero indicate substantial uncertainty in the estimate of the between-group difference. Collectively, these findings confirm that there was no differential effect between the laser and control therapy interventions on supraspinatus at either time point. The small effect sizes at both pre-treatment (Cohen's d =0.14) and post-treatment (Cohen's d =0.08) suggest that the interventions produced essentially equivalent outcomes.

Table 2: Intra-groups comparison for supraspinatus

Items	Treatments	
	Pre-treatment	Post-treatment
Laser group (n=20)	6.70 ±1.17	5.94 ±2.29
control group (n=20)	6.54 ±1.09	6.15 ±2.87
Change (MD)	0.16	0.21
95% CI	-0.56 – 0.88	-1.88 – 1.45
Effect size	0.14	0.08
P-value	0.659	0.795

Data are reported as mean ± standard deviation (SD) MD: Mean difference CI: confidence interval P-value: probability value * Significant (P<0.05)
Effect size (Cohen's d): 0.2 = small, 0.5 = medium, 0.8 = large.

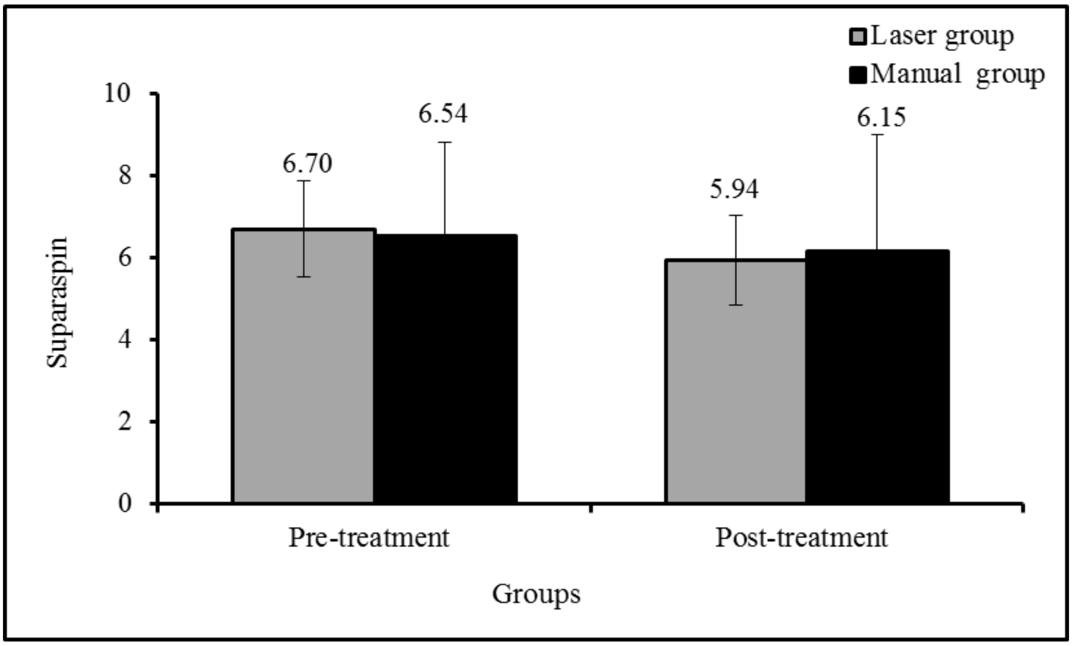

Fig8: Mean values supraspinatus between both groups at pre- and post-treatment.

Table (2) and Figure (9) present the within-group comparisons for supraspinatus before and after the respective interventions in both the laser and control therapy groups. The laser group demonstrated a mean reduction of 0.76 units (95% CI: -0.25 to 1.77), corresponding to an 11.34% improvement with a small-to-medium effect size (Cohen's d = 0.42). However, this change did not reach statistical significance (P=0.133), as indicated by the confidence interval crossing zero. The control group showed a mean reduction of 0.39 units (95% CI: -0.82 to 1.59), representing a 5.96% improvement with a small effect size (Cohen's d = 0.27). Similar to the laser group, this change was not statistically significant (P=0.514), with the confidence interval spanning zero. Collectively, these findings indicate that while the laser group demonstrated a numerically greater improvement with a small-to-medium effect size compared to the control group's small effect size, neither intervention produced a statistically significant change in supraspinatus. The wide confidence intervals crossing zero in both groups suggest substantial uncertainty in the estimates of treatment effect.

Table 2: Inter-groups comparison for supraspinatus

Items	Groups	
	Laser group (n=20)	control group (n=20)
Pre-treatment	6.70 ±1.17	6.54 ±1.09
Post-treatment	5.94 ±2.29	6.15 ±2.87
Change (MD)	0.76	0.39
95% CI	-0.25 – 1.77	-0.82 – 1.59
Improvement %	11.34%	5.96%
Effect size	0.42	0.27
P-value	0.133	0.514

Data are reported as mean ± standard deviation (SD) MD: Mean difference CI: confidence interval P-value: probability value * Significant (P<0.05)
Effect size (Cohen's d): 0.2 = small, 0.5 = medium, 0.8 = large.

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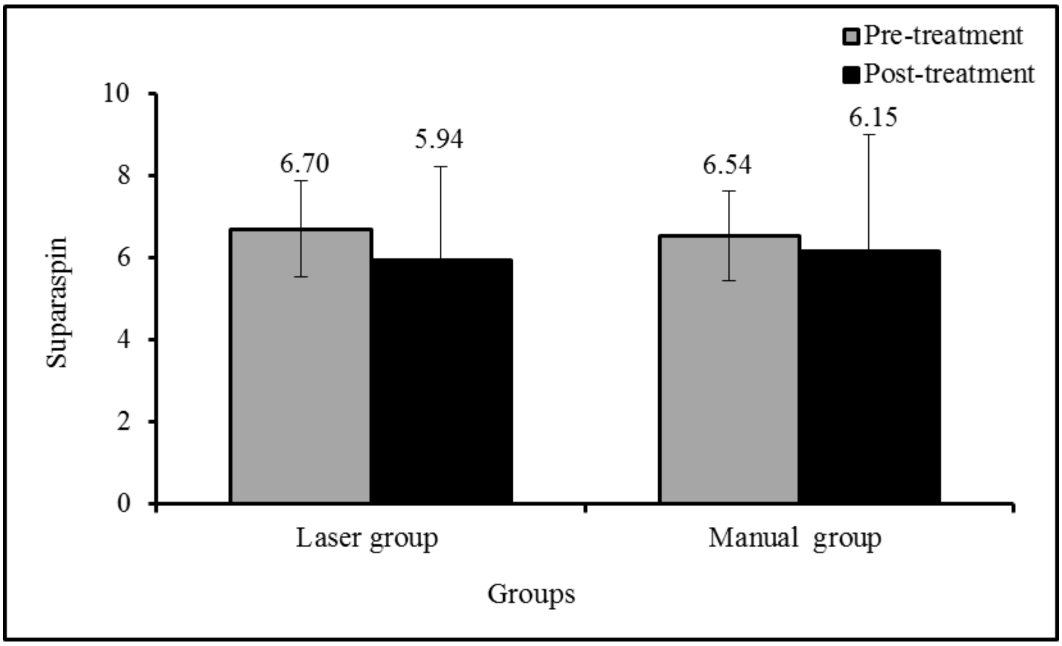

Fig 9: Mean values pre- and post-treatment of supraspinatus within each group.

DISCUSSION

The current randomized control trial investigates the effect of high intensity power laser on supraspinatus tendon thickness measured by MSK ultrasonography in adolescents' athletes with shoulder SIS containing two groups; laser group and control group. The main finding was there was no differential effect between the laser and manual therapy interventions on supraspinatus tendon thickness at either time point unless there was small effect sizes post treatment for both groups with favor to laser group was 11.34% improvement with a small-to-medium effect size (Cohen's d = 0.42). However, this change did not reach statistical significance.

Supraspinatus tendon is one of the content of subacromial space that when inflamed has more fluid collection causing more occupation for this space leads to shoulder impingement, several studies measured rotator cuff tendon thickness using ultrasound (US) and reported that patients with subacromial impingement (SAI) syndrome and rotator cuff tendinopathy showed thickened rotator cuff tendons.Decreasing tendon thickness may alleviate subacromial space pressure causing less impingement symptoms. (Michener et al., 2015 & Ishigaki et al., 2022)

There was no difference in the thickness of the supraspinatus muscle's tendon before and after the intervention between two groups, unless HILT cause clinically accepted reduction of sub-acromial fluid and supraspinatus tendon thickness (11.34%) that save against impingement and reduce patient pai, these findings might be associated with decrease inflammation level by lowering the levels of PGE2 and some other factors in cell culture. (Beyrami et al.,2023)

It was stated by Kamal et al., (2020) that post-program of HILT in addition to exercises revealed a statistically significant reduction in Ultrasonography Dimension of supraspinatus tendon which has partially agreement with the current study result that there is small effect size reduction in tendon thickness unless it was non-significant. HILT applied together with physical therapy protocol had no effect on tendon structural changes and elasticity in the short term said by Akbaş et al., 2025 which in agreement with the current study results that tendon thickness has no significant difference between both groups.

HILT has been proposed to improve tissue healing through photobiomodulation mechanisms, including increased mitochondrial ATP production, enhanced microcirculation, modulation of inflammatory mediators, and stimulation of fibroblast activity (Bjordal et al., 2006& Hamblin et al., 2017). And all these effects may illustrate the small effect size post treatment for the current study that indicate the HILT affect structure of the tendon causing tendon thickness reduction unless it was non-significant difference between groups which may be due to short time treatment or the control group contained recommended protocol by multiple research (ex's with manual therapy) as better outcomes with combination for SIS. (Steuri et al., 2017 & Sharma et al., 2021).

Current study agrees with sonographic study demonstrated that tendon thickness alone may not be sensitive sufficiently to detect early treatment related structural changes. R.C tendinopathy involves complex pathological alterations including collagen disorganization, neovascularization, extracellular matrix remodeling, and changes in tendon mechanical properties, many of which cannot be fully captured by a single measurement of tendon thickness which may be biological tendon changes unless it was stable in measurement. (Lewis, 2010)

The adolescents athletes' tendons biology compared to adults have more healing power, more vascularity which may indicate the nearly tendon structure thickness to normal at base line's measurements which may limit the tendon changes post HILT treatment, and this may illustrate

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the non-significant difference of tendon thickness changes post treatment in both groups. (McCarthy et al., 2014 ,Thorpe et al., 2016 & Kwan et al., 2023)

CONCLUSION

In contrast, clinicians may be more inclined to implement HILT if the efficacy of the therapy is investigated and positive significant results are obtained in future studies that evaluate outcomes for tendon thickness of the supraspinatus unless it may be used to reduce inflamed tendon thickness as it approved by the current research that small to medium reduction in supraspinatus tendon thickness that may save against impingement.

SOURCE OF FUNDING

researchers did not receive any public or commercial's fund.

CONFLICT OF INTERESTS

The authors declare that no conflict of interest that would prejudice the impartiality of this scientific work.

REFERENCES

1. Abbass, H., Fahim, Y., & Ibrahim, M. (2022). Comparative study of Ultrasound and MRI in diagnosis and assessment of shoulder impingement syndrome. Al-Azhar International Medical Journal, 2022(3), 159-164. doi: 10.21608/aimj.2022.105037.1652
2. Aceituno-Gómez, J., Avendaño-Coy, J., Gómez-Soriano, J., García-Madero, V. M., Ávila-Martín, G., Serrano-Muñoz, D., González-González, J., & Criado-Álvarez, J. J. (2019). Efficacy of high-intensity laser therapy in subacromial impingement syndrome: a three-month follow-up controlled clinical trial. Clinical rehabilitation, 33(5), 894–903. https://doi.org/10.1177/0269215518824691.
3. Akbaş, A., Özdemir, M., Akbaş, E., Usgu, S., & Bulut, H. T. (2025). Effect of high-intensity laser therapy on supraspinatus tendon elasticity in subacromial impingement syndrome: A double-blind randomized controlled study. Lasers in medical science, 40(1), 337. https://doi.org/10.1007/s10103-025-04582-w
4. Beyrami M, Soltani A, Eftekharsadat B, Sarbakhsh P, Habibi M, E. Oskouei A. Effects of High Power Laser Therapy on Clinical and Sonographic Findings in People with Chronic Rotator Cuff Tendinitis. J Adv Med Biomed Res 2023; 31 (149) :541-548
5. URL: http://journal.zums.ac.ir/article-1-7065-fa.html
6. Bjordal, J. M., Johnson, M. I., Iversen, V., Aimbire, F., & Lopes-Martins, R. A. (2006). Low-level laser therapy in acute pain: a systematic review of possible mechanisms of action and clinical effects in randomized placebo-controlled trials. Photomedicine and laser surgery, 24(2), 158–168. https://doi.org/10.1089/pho.2006.24.158
7. Creech JA, Busse A, Li D, et al. Shoulder Impingement Syndrome. [Updated 2026 Jan 10]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2026 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK554518/
8. Douglas UC, Efanga SA, Ikpeme AA, et al. Sonographic Assessment of Supraspinatus Tendon Thickness in Type 2 Diabetes Mellitus. Journal of Diagnostic Medical Sonography. 2026;42(2):121-129. doi:10.1177/87564793251380861
9. Hamblin M. R. (2017). Mechanisms and applications of the anti-inflammatory effects of photobiomodulation. AIMS biophysics, 4(3), 337–361. https://doi.org/10.3934/biophy.2017.3.337
10. Ishigaki, T., Yoshino, K., Hirokawa, M., Sugawara, M., & Yamanaka, M. (2022). Supraspinatus tendon thickness and subacromial impingement characteristics in younger and older adults. BMC musculoskeletal disorders, 23(1), 234. https://doi.org/10.1186/s12891-022-05179-y
11. Kachingwe, A. F., Phillips, B., Sletten, E., & Plunkett, S. W. (2008). Comparison of manual therapy techniques with therapeutic exercise in the treatment of shoulder impingement: a randomized controlled pilot clinical trial. The Journal of manual & manipulative therapy, 16(4), 238–247. https://doi.org/10.1179/106698108790818314
12. Kwan, K. Y. C., Ng, K. W. K., Rao, Y., Zhu, C., Qi, S., Tuan, R. S., Ker, D. F. E., & Wang, D. M. (2023). Effect of Aging on Tendon Biology, Biomechanics and Implications for Treatment Approaches. International journal of molecular sciences, 24(20), 15183. https://doi.org/10.3390/ijms242015183
13. Kolber, M. J., Fuller, C., Marshall, J., Wright, A., & Hanney, W. J. (2012). The reliability and concurrent validity of scapular plane shoulder elevation measurements using a digital inclinometer and goniometer. Physiotherapy theory and practice, 28(2), 161–168.
14. Lewis J. S. (2009). Rotator cuff tendinopathy. British journal of sports medicine, 43(4), 236–241. https://doi.org/10.1136/bjsm.2008.052175
15. Maenhout, A., Van Eessel, V., Van Dyck, L., Vanraes, A., & Cools, A. (2012). Quantifying acromio-humeral distance in overhead athletes with glenohumeral internal rotation loss and the influence of a stretching program. The American journal of sports medicine, 40(9), 2105–2112.
16. Manske, R. C., Voight, M., Page, P., & Wolfe, C. (2023). The Application of Musculoskeletal Ultrasound in the Diagnosis of Supraspinatus Injuries. International journal of sports physical therapy, 18(5), 88377. https://doi.org/10.26603/001c.88377
17. McCarthy, M. M., & Hannafin, J. A. (2014). The mature athlete: aging tendon and ligament. Sports health, 6(1), 41–48. https://doi.org/10.1177/1941738113485691
18. Michener, L. A., Subasi Yesilyaprak, S. S., Seitz, A. L., Timmons, M. K., & Walsworth, M. K. (2015). Supraspinatus tendon and subacromial space parameters

measured on ultrasonographic imaging in subacromial impingement syndrome. Knee surgery, sports traumatology, arthroscopy : official journal of the ESSKA, 23(2), 363–369. https://doi.org/10.1007/s00167-013-2542-8

19. Moezy, A., Sepehrifar, S., & Solaymani Dodaran, M. (2014). The effects of scapular stabilization based exercise therapy on pain, posture, flexibility and shoulder mobility in patients with shoulder impingement syndrome: a controlled randomized clinical trial. Medical journal of the Islamic Republic of Iran, 28, 87.
20. Navarro-Ledesma, S., Fernandez-Sanchez, M., & Luque-Suarez, A. (2021). Differences in supraspinatus occupation ratio between the symptomatic, the contralateral asymptomatic shoulder and control subjects: A cross-sectional study. Medicine, 100(6), e24734. https://doi.org/10.1097/MD.0000000000024734
21. Oliveira, V. M. A., Pitangui, A. C. R., Gomes, M. R. A., Silva, H. A. D., Passos, M. H. P. D., & Araújo, R. C. (2017). Shoulder pain in adolescent athletes: prevalence, associated factors and its influence on upper limb function. Brazilian journal of physical therapy, 21(2), 107–113. https://doi.org/10.1016/j.bjpt.2017.03.005
22. Özçakar, L., Kara, M., Chang, K. V., Tekin, L., Hung, C. Y., Ulaülı, A. M., Wu, C. H., Tok, F., Hsiao, M. Y., Akkaya, N., Wang, T. G., Çarli, A. B., Chen, W. S., & De Muynck, M. (2015). EURO-MUSCULUS/USPRM Basic Scanning Protocols for shoulder. European journal of physical and rehabilitation medicine, 51(4), 491–496.
23. Pekyavas, N. O., & Baltaci, G. (2016). Short-term effects of high-intensity laser therapy, manual therapy, and Kinesio taping in patients with subacromial impingement syndrome. Lasers in medical science, 31(6), 1133–1141. https://doi.org/10.1007/s10103-016-1963-2.
24. Phillips, N. (2014). Tests for diagnosig subacromial pain syndrome and rotator cuff disease. J. Shoulder & Elbow. 6(3) 215–221.
25. DOI: 10.1177/1758573214535368.
26. Ponomarenko G. N. (2023). Vysokointensivnaya lazeroterapiya v klinicheskoi meditsine: naukometricheskii analiz dokazatel'stv effektivnosti [High-intensity laser therapy in clinical medicine: scientometric analysis of evidence of effectiveness]. Voprosy kurortologii, fizioterapii, i lechebnoi fizicheskoi kultury, 100(1), 18–26. https://doi.org/10.17116/kurort202310001118.
27. Satpute, K., Reid, S., Mitchell, T., Mackay, G., & Hall, T. (2022). Efficacy of mobilization with movement (MWM) for shoulder conditions: a systematic review and meta-analysis. The Journal of manual & manipulative therapy, 30(1), 13–32. https://doi.org/10.1080/10669817.2021.1955181
28. Şenbursa, G., Baltaci, G., & Atay, Ö. A. (2011). The effectiveness of manual therapy in supraspinatus tendinopathy. Acta orthopaedica et traumatologica turcica, 45(3), 162–167. https://doi.org/10.3944/AOTT.2011.2385.
29. Sharma, S., Ejaz Hussain, M., & Sharma, S. (2021). Effects of exercise therapy plus manual therapy on muscle activity, latency timing and SPADI score in shoulder impingement syndrome. Complementary therapies in clinical practice, 44, 101390. https://doi.org/10.1016/j.ctcp.2021.101390
30. Steuri, R., Sattelmayer, M., Elsig, S., Kolly, C., Tal, A., Taeymans, J., & Hilfiker, R. (2017). Effectiveness of conservative interventions including exercise, manual therapy and medical management in adults with shoulder impingement: a systematic review and meta-analysis of RCTs. British journal of sports medicine, 51(18), 1340–1347. https://doi.org/10.1136/bjsports-2016-096515.
31. Swanson, B. T., Holst, B., Infante, J., Poenitzsch, J., & Ortiz, A. (2016). EMG activity of selected rotator cuff musculature during grade III distraction and posterior glide glenohumeral mobilization: results of a pilot trial comparing painful and non-painful shoulders. The Journal of manual & manipulative therapy, 24(1), 7–13. https://doi.org/10.1080/10669817.2015.1106819
32. Tate, A., Turner, G. N., Knab, S. E., Jorgensen, C., Strittmatter, A., & Michener, L. A. (2012). Risk factors associated with shoulder pain and disability across the lifespan of competitive swimmers. Journal of athletic training, 47(2), 149–158. https://doi.org/10.4085/1062-6050-47.2.149
33. Thorpe, C. T., & Screen, H. R. (2016). Tendon Structure and Composition. Advances in experimental medicine and biology, 920, 3–10. https://doi.org/10.1007/978-3-319-33943-6_1.