RESEARCH PAPER

# EFFECT OF LOW-LEVEL LASER THERAPY VERSUS TRANSCUTANEOUS ELECTRICAL NERVE STIMULATION ON PAIN RELIEF AND β-ENDORPHIN HORMONE IN DE QUERVAIN'S SYNOVITIS

**Eman Abd El-Rahman Mohamed Al-Daydamony[1], Mona Ebrahim Morsy[2], Ola Ali Essawy Dabbous[3], Hala Ahmed Abdelgwad[4]**

1 Physical Therapist, Physical Therapy Department, First Settlement Medical Center, Cairo, Egypt.
2 Photobiology in Medical Application of Laser Department, National Institute of Laser Enhanced Sciences, Cairo University, Giza, Egypt.
3 Pediatrics in Medical Application of Laser Department, National Institute of Laser Enhanced Sciences, Cairo University, Giza, Egypt.
4 Physical Therapy Department, Faculty of Physical Therapy, Sphinx University, Assiut, Egypt.

Eman Abd El-Rahman Mohamed Al-Daydamony, Physical Therapy Department, First Settlement Medical Center, Cairo, Egypt,
First gathering, Abd El-Baset Abd El-Samed, Cairo, Egypt, e-mail: eman.aldaydamony@gmail.com

**Abstract**

**Purpose:** The present study was conducted to investigate the difference between effect of low-level laser therapy (LLLT) versus transcutaneous electrical nerve stimulation (TENS) on pain relief and endorphin hormone in De Quervains's tenosynovitis. **Subjects and Methods:** Forty women with De Quervains's tenosynovitis participated in this study; their age ranged from 25 – 35 years old. They were divided randomly in to two equal groups (A and B). Group (A) received LLLT and selected physical therapy program (strengthening and stretching exercises), while group (B) received TENS and the same selected physical therapy program as in group (A). The outcome measures of the current study were Visual analogue scale (VAS), Quick disabilities of the arm, shoulder, and hand (Q-DASH) score and β-endorphin hormone which were assessed in both groups before and after treatment. Both groups received treatment program 3 sessions a week for 6 weeks. **Results:** The obtained results revealed significant improvement of all measured variables in two groups after 6 successive weeks, also revealed statistically significant difference between the two groups after treatment in favor of the group (A). **Conclusion:** LLLT and TENS were effective treatment modalities in women with De Quervains's tenosynovitis and LLLT was more effective than TENS in treating De Quervains's tenosynovitis.
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## Introduction

Pain is the most frequent complaint in pregnancy, occurring mostly in the low back and less commonly in the hands and wrists. Carpal tunnel syndrome (CTS) and De Quervain's tenosynovitis (DQT) are the main cause of hand and wrist pain **[1].**

Low-level laser therapy (LLLT) has a large spread of usage in medicine. During the previous decades, LLLT has been used in the treatment of a variety of pathological conditions such as musculoskeletal complications, wounds, and pain controls **[2].**

Transcutaneous electrical nerve stimulation (TENS) is a device that emits low voltage currents and which has been used for pain relief. The way that TENS works is not well understood. The electrical pulses are thought to stimulate nerve pathways in the spinal cord which block the transmission of pain **[3].**

It refers to the delivery of electrical currents through the skin to activate peripheral nerves. The technique is widely used in developed countries to relieve a wide range of acute and chronic pain conditions, including pain resulting from cancer and its treatment **[3].**

De Quervain's tenosynovitis is a frequently encountered pain of the hand and wrist. It results from compression and irritation of the APL and EPB as they pass through the first dorsal compartment of the wrist. Patients complain of tenderness and swelling proximal to the radial styloid process, as well as pain in the wrist and on the radial side of the hand **[5].**

The LLLT is a well-established clinical tool used to treat pathological tissue conditions, inflammatory processes, and promote wound healing. LLLT refers to the use of lasers emitting a wavelength ranging from 600 to 1100 nm with an output power within 1 to 500 mW. A number of different laser light sources, including semiconductor diode lasers, and argon lasers, have been applied in different treatments **[6].**

The TENS is a non-pharmacological treatment for control of pain. When reading and analyzing the existing literature for which systematic reviews show that TENS is inconclusive or ineffective, it is clear that a number of variables related to TENS application have not been considered. TENS is an adjunct treatment for pain control that produces its effects through activation of the endogenous inhibition system using neurotransmitters with defined duration of action **[7].**

So, adding low-level laser therapy and transcutaneous electrical nerve stimulation could be of help to improve pain relief and β-endorphin hormone in De Quervain's tenosynovitis.

**Subjects and methods**

Design of the current study

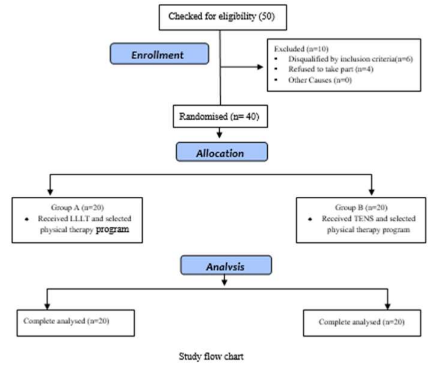
The study was randomized and single-blinded. All patients provide their informed consent to participate, and the study was conducted from July 2023 to January 2024.

Sample size calculation

The sample size was calculated using the G*Power software (version 3.1.9.2; Franz Faul, Universitat Kiel, Germany). F-test MANOVA within and between interaction effects was selected. Considering a power of 0.80, an α level of 0.05 (2 tailed) and effect size of 0.91; two groups and number of measurements two, a generated sample size of at least 40 subjects, 20 participants per group was required.

Randomization

The randomization was carried out using computer-generated block randomization program at http://www.randomization.com/. The participants were randomized in block sizes of 6 and 9 with a 1:1 allocation ratio. Concealed allocation was done using sealed, sequentially numbered opaque envelopes. The randomization was carried out by a blinded researcher who was not involved in recruiting, data collection or treatment.




Study flow chart

Participants

Forty women with De Quervain's tenosynovitis participated in this study, they randomly allocated into two equal groups (A and B); twenty patients in each group. Each woman of the two groups received as 3 sessions a week for 6 weeks. They were recruited from and carried out at the out-patient clinics of faculty of physical therapy, Cairo University and out-patient clinics of New Cairo hospital, Cairo, Egypt.

The criteria for inclusion were as follows: (a) women aged from 25 – 35 years, (b) women were able to participate in all sessions of the study, (c) women suffered from De Quervain's tenosynovitis and (d) women were clinically and medically stable. Women with (i) any significant tightness and/or fixed deformity of upper limb, or (ii) suffering from skin disease at the site of treatment, (iii) using medications as contraceptive pills or pain relief drugs were excluded.

The participating women were divided into two groups of equal size. Each participant in the two groups was administered an identical selected physical therapy program: Group A received LLLT and selected physical therapy program (strengthening and stretching exercises), while group (B) received TENS and the same selected physical therapy program as in group (A). The treatment program was applied 3 sessions/week for 6 weeks.

Measurements used

*Pain severity measured by VAS*

It is considered as reliable and valid method available for estimation of pain intensity pain level. It is a straight horizontal line of fixed length, usually 100 mm. The ends are defined as the extreme limits of the parameter to be measured (symptom, pain, health) orientated from the left (worst) to the right (best). In some studies, horizontal scales are orientated from right to left, and many investigators use vertical VAS **[8,9].**

*Functional disabilities measured by Q-DASH*

It is a self-administered region-specific outcome instrument developed as a measure of self-rated upper-extremity disability and symptoms. The DASH consists mainly of a 30-item disability/symptom scale, scored 0 (no disability) 100 (most severe disability) **[10].** The DASH-Arabic version demonstrated sound psychometric properties of reliability, validity and responsiveness. It is an effective patient status and outcome tool that will support evidence-based practice. This tool is recommended for evaluating upper extremity work-related injuries and tracking therapeutic outcomes **[11].**

*Potential biomarker of chronic pain measured by β-endorphin hormone*

It is released from hypothalamus and pituitary gland in response to pain or stress. It also relieves pain and creates a general feeling of well-being. Venous blood samples (5 mL) will be collected from all subjects between 7.30 and 10 am after 12 h of fasting to determine levels of β-endorphin. 5 ml will be withdrawn before treatment and 5 ml will be withdrawn after treatment and the serum will be separated and kept at -4 ° C until the β-endorphin hormone is evaluated **[12].**

Intervention

*Selected physical therapy program*

As shown in Table 1, strengthening and stretching exercises was applied in every treatment session **[13].**

Table 1. Selected physical therapy program.

| **Strengthening exercises** | **Stretching exercises** |
|---|---|
| <u>1) Thumb lifting exercise:</u> Therapist asked the patient to put her hand on a flat surface, with the palm up. Then, lift the thumb away from the palm to make a "C" shape. Finally, holding for about 6 seconds. Repeat 8 to 12 times. | <u>1) Isolated thumb MP-joint extensor stretching exercise:</u> Therapist asked the patient to hold her hand in front of her, and turning hand so the little finger faces down and the thumb faces up (the patient's hand should be in the position used for shaking someone's hand); she may also rest hand on a flat surface. Then, Use the fingers on the other hand to bend thumb down at the point where the thumb connects to the palm. Finally, holding for at least 15 to 30 seconds. Repeat 2 to 4 times. |
| <u>2) Thumb opponens exercise:</u> Active exercises of wrist, thumb and tendon gliding exercises for adductor pollicis longus and extensor pollicis brevis muscles were the exercise received by subject treatments for 2 weeks continues for 2 to 3 times repeated in per/day. | <u>2) Finkelstein stretching exercise:</u> Therapist asked the patient to hold her arms out in front of her (the patient's hand should be in the position used for shaking someone's hand). Then, Bending the thumb toward the palm. Use the other hand to gently stretch the thumb and wrist downward until feeling a stretch on the thumb side of the wrist. Finally, holding for at least 15 to 30 seconds. Repeat 2 to 4 times. |

*Low-level laser therapy (LLLT)*

Each patient in this group asked to sit on arm chair and rest her dominant hand on the treatment table and the tender points detected and remarkabled then the low level laser device was adjusted on the following parameters: (Wave length: 830 nm, Energy density: 20 J/cm$^2$, Power: 30-40, Contanous output of 100%, Irradiation rate: 1min for each tender point, Beam diameter: 4mm). Protective goggles worn by patients and therapist to protect their eyes from the laser beam. After that the laser probe held perpendicular to the area to be treated (the distance between the probe and the skin will be 2.5 cm$^2$), Then the laser device switched on to deliver the low level laser beam on each tender point for 1min. This performed to the all tender points (the total duration of treatment session is 10 minutes). After finishing the session the LLLT device switched off then the patient started performing strengthening and stretching exercises for the EPB and APL for 30 minutes, then she asked to wear the thumb spica splint. This session repeated 3 times per week for 6 weeks **[14].**

*Transcutaneous electrical nerve stimulation (TENS)*

Protocol of Low-Frequency High-Amplitude TENS: one electrode is fixed about 1 $cm^2$ below the level of the wrist joint and the other is fixed about 1 $cm^2$ on the distal part at the base of thumb (the radiostyloid process). The current characteristics were as follows: monophasic, rectangular with a frequency of 1 Hz; duration – 200 µs; and the stimulation amplitude was raised until a comfortable painless motor response was achieved. Stimulation was administered for 30 minutes **[15].**

Statistical analysis

Data were collected for each participant calculated at base line and after 6 weeks of intervention for the two groups. The following statistical steps were done:

- The normality of data was checked using Shapiro-Wilk test. Levene's test for homogeneity of variances was conducted to test the homogeneity between both groups. Data were normally distributed and there was homogeneity of variance as p-value >0.05. Unpaired T-test was conducted for comparison between both groups regarding demographic characteristics.
- The level of significance for all statistical tests was set at p-value ≤ 0.05. Statistical analysis was performed through the statistical package for social studies (SPSS) version 25 for windows.

**Results**

Demographic data

When comparing the age-related mean values of Groups A and B, we found no statistically significant differences ($p > 0.05$) (Table 2).

Table 2. Age comparison between groups (A and B)

| | Group A (mean ± SD) | Group B (mean ± SD) | t-value | p-value |
|---|---|---|---|---|
| Age (years) | 30.15 ± 2.85 | 28.85 ± 2.74 | 1.47 | $0.15^{NS}$ |

SD: Standard Deviation. t-value: Paired and Un-paired. t- test value. p-value: Probability value. S: Significant.

Variables of measurement

(1) Pre-treatment comparison between groups A and B. The comparison between the pre-treatment mean± SD values in all measurable variables was revealed among the 2 groups ($p> 0.05$) (Table 4).

(2) Comparison of pre- and post-treatment groups A and B. Between the pre- and post-treatment comparison mean ± SD values of all measurable variables were revealed among the 2 groups ($p< 0.05$) (Table 3).

(3) Comparison of post-treatment within and between groups A and B. The comparison among the post-treatment mean ± SD values of all measurable variables was revealed within the 2 groups ($p< 0.05$) (Table 3).

Table 3. Comparison of arm girth measurements, VAS, Q-DASH and β-endorphin hormone for the two groups (A and B).

| Items | | Group A (mean ± SD) | Group B (mean ± SD) | t-value | p-value |
|---|---|---|---|---|---|
| VAS | pre-treatment | 6.95 ± 1.15 | 6.7 ± 1.03 | 0.73 | $0.473^{NS}$ |
| | post-treatment | 2.65 ± 0.93 | 3.55 ± 0.89 | 3.13 | $0.003^{S}$ |
| | p-value | $0.0001^{S}$ | $0.0001^{S}$ | | |
| Q-DASH | pre-treatment | 69.2 ± 7.53 | 71.1 ± 8.55 | 0.75 | $0.46^{NS}$ |
| | post-treatment | 36.6 ± 6.1 | 41.95 ± 7.21 | 2.53 | $0.016^{S}$ |
| | p-value | $0.0001^{S}$ | $0.0001^{S}$ | | |
| β-endorphin | pre-treatment | 41.17 ± 5.14 | 43.4 ± 4.23 | 1.5 | $0.143^{NS}$ |
| | post-treatment | 26.66 ± 4.24 | 30.88 ± 4.02 | 3.23 | $0.003^{S}$ |
| | p-value | $0.0001^{S}$ | $0.0001^{S}$ | | |

Pre: Before treatment. Post: After 6 weeks of treatment. SD: Standard Deviation.
t-value: Paired and Un-paired t- test value. p-value: Probability value. S: Significant NS: Non Significant.

**Discussion**

The efficacy of LLLT and TENS with the conventional physical therapy for women with De Quervain's tenosynovitis was examined in the current study. No previous studies reporting solely to determine their effects and comparison between them with the conventional physical therapy for women with De Quervain's tenosynovitis. Therefore, to the best of our knowledge, this is the first study solely focus on the consensus of data concerning effects and comparison between them with the conventional physical therapy for women with De Quervain's tenosynovitis.

When comparing between the pre and post-treatment results of VAS of group (A) revealed significant differences that are accepted with **Stausholm et al. [16]** who said that pain reduction from the recommended LLLT doses was significantly superior to placebo even at follow-ups 12 weeks after the end of therapy, and the difference was greater than 20 mm VAS from the final 4–8 weeks of therapy through follow-ups 6–8 weeks after the end of therapy. Interestingly, the pain reduction from the recommended LLLT doses peaked at follow-ups 2–4 weeks after the end of therapy (31.87 mm VAS highly significantly beyond placebo).

The results of our study in group (A) are accepted with **Suresh and Kecha [13]** who found that there was a significant reduction in pain post the management of Ultrasound, massage and Exercises. The VAS score which had a pretest score of 6 was reduced to a post test score of 2. This can be explained by the physiology of ultrasound therapy which increases the blood flow in the treated area which speeds the healing process. It reduces swelling and edema which are the main sources of pain.

When comparing between the pre and post-treatment results of Q-DASH score of group (A) revealed significant differences that come in agreement with **Sharma et al. [17]** and **Sharma et al. [18]** who found that using a low intensity laser therapy (LILT). LILT and sham LILT were applied to 28 patients, and a significant reduction was found in grip strength and combined thickness of the abductor pollicis longus and extensor pollicis brevis tendon sheaths. In the second study comparing LILT and Ultrasonic in DQT, significant difference was observed between the two groups, whereas US was found to be more effective in the mean values for grip strength and Q-DASH.

The results of our study in decreasing pain in group (A) are agreed with **Awotidebe et al. [19]; Moshkovska and Mayberry [20]** who said that demonstrated that LLLT facilitates the stimulation of fibroblasts and collagen synthesis in connective tissue repair. In addition, there is an effect that LLLT modulates pain and reduces inflammation through the prevention of cyclooxygenase-2 and reduction of prostaglandin E2 receptor concentration.

When comparing between the pre and post-treatment results of β-endorphin hormone of group (A) revealed significant difference that are accepted with **Laakso et al. [21]** who indicated that the analgesic response to phototherapy may be mediated through hormonal/opioid mechanisms, and that responses to LLLT are dose and wavelength dependent. A mechanism by which peripheral stimulation using LLLT may elicit activity in the central pathways is proposed.

In addition, the results of our study of group (A) are agreed with **Mannaa et al. [22]** who stated that LLLT had an effect during neuroinflammation, analgesic and anti-inflammatory pathways can be activated in an attempt to modulate the response. In addition, the authors of this previous study demonstrated reduced pain sensitivity with gabapentin-treatment or non-pharmacological approaches based on LLLT, to which IL-10/β-endorphin may be related.

Furthermore, **Hagiwara et al. [23]** who found that LLLT has been reported to relieve pain, free of side effects. However, the mechanisms underlying LLLT are not well understood. Recent studies have also demonstrated that opioid-containing immune cells migrate to inflamed sites and release β-endorphins to inhibit pain as a mode of peripheral endogenous opioid analgesia.

When comparing between the pre and post-treatment results of VAS of group (B) revealed significant differences that are accepted with a study applied by **Zhu et al. [24]** who said that TENS supplementation intervention was associated with a significantly reduced VAS scores and total postoperative morphine dose at 24 h in patients after total knee arthroplasty.

The results of our study in group (B) are supported by the results of **Gladwell et al. [25]** and **Gozani et al. [26]** who confirmed that neuromodulation techniques such as TENS are indicated as adjuncts to core treatment and used to alleviate sensations of pain, muscle tension and spasm, and the impact of an ‘overprotective brain’. Patients report that TENS provides indirect benefits including enhanced function, improved psychological well-being, better sleep and medication reduction; therefore, TENS is widely accepted by patients because it is inexpensive, can be self-administered and has no toxicity.

The results of our study are agreed by the results of **Simpson et al. [27]** who proved that the effectiveness of TENS of the reduction in pain severity observed in this meta-analysis (38 mm VAS) appears to compare favorably to that produced by pharmacological analgesia. In the prehospital setting, morphine, fentanyl and methoxyflurane have been reported to produce mean reductions in pain measured by a numeric rating scale of 4.5, 4.5 and 3.2, respectively, whereas a recent prehospital clinical trial of nitrous oxide reported a reduction of 4 (numeric rating scale).

When comparing between the pre and post-treatment results of Q-DASH score of group (B) revealed significant differences that are accepted with **Watson [28]** who confirmed that TENS reduces pain without the presence of adverse effects. It does not involve any risk for the burn patient because electrodes are placed on the periphery of the injured skin. It also represents a low-cost option. In addition to the benefit of reducing pain, electrical stimulation can accelerate wound healing by promoting greater cell migration to the site of injury **[29].**

Another mechanism of pain relief can be explained by a study done by **Ma and Sluka [30]** who found that TENS did not exacerbate pain in these cases despite activating low threshold mechanoreceptive peripheral afferents. Furthermore, **Johnson et al. [31]** stated that TENS may be beneficial for pain irrespective of pain characteristics or medical diagnosis, supporting the view that TENS should primarily be indicated according to symptoms, that is, the presence of pain rather than medical diagnosis.

When comparing between the pre and post-treatment results of β-endorphin hormone of group (B) revealed significant differences that come in agreement with a study applied by **Sabino et al. [32]** who found that TENS can reduce pain through central and peripheral mechanisms. The central mechanism includes activation of the opioid, muscarinic, and serotonin receptors in the spinal cord and brainstem. Peripherally, at site of TENS application, the reduction of pain may be through activation of the opioid and α-2 adrenergic receptors involved in analgesia.

The results of the current study are consistent with findings of **Dailey et al. [33]** who said that TENS may improve adherence to an exercise task, while not directly improving function. Also, **Sluka and Walsh [35]; Vance et al. [36]** added that TENS activates endogenous inhibitory pathways in the central nervous system, releasing the inhibitory neurotransmitters serotonin, opioids, and GABA to reduce sensitization of central neuron, and the greatest effects occur during stimulation, when endogenous inhibitory neurotransmitters are released. Moreover, the research applied by **Trupkovic et al. [37]** added that the mechanism of TENS action is similar to the pharmacological treatment used for analgesia and sedation in intensive care units, but without the known side effects of these drugs.

Also, the significant improvement results in favor of group (B) when compared with group (A) that are accepted with the results of **Karagul et al. [38]** who proved that both LLLT and TENS were found to be effective in treating pain of the sciatic nerve associated with lumbar disk herniation with radiculopathy. LLLT was found to be more effective than TENS in reducing leg and neuropathic pains. Follow-up assessments revealed that the only lasting effect of the treatments, which continued into the third month, was the improvement in leg pain.

The superiority of the results in group (A) is in agreement with findings of controlled study by **Naesar et al. [38]** who found that an active treatment of LLLT to be more effective than placebo in relation to pain and electrophysiological parameters. Moreover, **Coderre et al. [39]** said that different experimental studies suggest that LLLT has anti-inflammatory and analgesic effects. It has been reported that LLLT therapy has both anti-inflammatory and anti-oedematous effects due to its reductive effect in prostaglandin synthesis.

The results of the current study in favor of group (A) are confirmed with the findings of the research applied by **Battecha and Atya [40]** who concluded that LLLT has to be more efficient than TENS in increasing cutaneous microcirculation and decreasing pain in patients with diabetic neuropathy.

The results of our study of group (A) are disagreed with **Li et al. [41]** who considered the results of published studies, the use of LLLT cannot yet be considered a standard treatment for orthodontic pain, because the various commercial laser systems differ both in technical specifications and in methods of application, as well as in the study designs, which are limited and have risk of bias.

Also, the results of current study are rejected with the controlled trial study applied by **Irvine et al. [42]** who showed LLLT not to be any more effective than placebo in improving CTS symptoms, pain, hand function and electrophysiological parameters.

Furthermore, the results of current research are inconsistent with the research applied clinically by **Thorsen et al. [43]** found that there was no significant effect of LLLT (GaAlAs, 830 nm) for chronic myofascial pain in the neck and shoulder girdle.

**Limitations**

This study has some limitations related to changes in the patients' lifestyle habits and educational levels, differences in motivation between all patients – some patients did not complete the treatment protocol for various reasons and were excluded from the study – possible conflicts with knowledge gained from course work, and a lack of knowledge of whether the skills will transfer to a clinical environment.

## Conclusions

LLLT with selected physical therapy program was more effective than TENS with selected physical therapy program on pain relief and endorphin hormone in De Quervains's tenosynovitis.

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**Ethical approval**
The research related to human use complied with all the relevant national regulations and institutional policies, followed the tenets of the Declaration of Helsinki, and were approved by the Research Ethical Committee at National Institute of Laser Enhanced Sciences, Cairo University, located in Cairo, Egypt. The researchers performed a concise interview to assess the women' demographic information and verify their eligibility for the research study.

**Informed consent**
Informed consent was obtained from all individuals included in this study.

**Disclosure statement**
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**Conflict of interest**
The authors state no conflict of interest.

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