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Ocena czynników wpływających na skuteczność terapii integracji sensorycznej u dzieci w wieku przedszkolnym i wczesnoszkolnym

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Effect of low level laser therapy versus pulsed ultrasound on postpartum carpal tunnel syndrome

Wpływ terapii laserem niskiej mocy w porównaniu z ultradźwiękami pulsacyjnymi na zespół cieśni nadgarstka po porodzie

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Abstract
Background. Carpal tunnel syndrome (CTS) is a major health issue that can impede postpartum women's activities and skills in both their personal and professional lives. Purpose. To compare the effectiveness of low-level laser therapy (LLLT) and pulsed ultrasound (US) in relieving postpartum CTS. Methods. Forty-eight women with mild to moderate CTS were divided into three groups. In addition to wrist exercises, Group (A) (n = 16) received LLLT, Group (B) (n = 16) received pulsed US, and Group (C) (n = 16) performed wrist exercises alone. For all groups, the treatment sessions were applied to the affected hand, 3 sessions weekly for four weeks. All postpartum women were evaluated pre- and post-treatment via a visual analogue scale (VAS) for pain intensity, the Boston Questionnaire of CTS (BCTS) for diagnosing CTS symptoms, electromyography for measuring motor conduction velocity (MCV), sensory conduction velocity (SCV), motor distal latency (MDL), and sensory peak latency (SPL), and a hand grip dynamometer for assessing hand grip strength. Results. All measured variables were significantly improved in the three groups post-treatment compared to pre-treatment. Between-groups comparison showed a highly significant decrease in the VAS, BCTS, and SPL and a significant increase of SCV and hand grip strength between groups A and C in favor of group A and between groups B and C in favor of group B, while the significant change in MDL and MCV was found between groups A and C only in favor of group A ($p < 0.05$), with no significant change in all outcome measures between groups A and B ($P > 0.05$). Conclusion. Either LLLT or pulsed US are useful modalities that can be used as an effective conservative therapy for alleviating postpartum CTS.

Keywords
low-level laser therapy, pulsed ultrasound, carpal tunnel syndrome, postpartum period

Streszczenie
Tło. Zespół cieśni nadgarstka (CTS) jest znaczącym problemem zdrowotnym, który może ograniczać aktywność i zdolności kobiet w okresie połogu zarówno w życiu osobistym, jak i zawodowym. Cel. Porównanie skuteczności terapii laserem niskiej mocy (LLLT) i ultradźwięków pulsacyjnych (US) w łagodzeniu objawów CTS po porodzie. Metody. Czterdzieści osiem kobiet z łagodnym do umiarkowanego CTS zostało podzielonych na trzy grupy. Oprócz ćwiczeń nadgarstka, grupa (A) (n = 16) otrzymała terapię laserem niskiej mocy, grupa (B) (n = 16) otrzymała ultradźwięki pulsacyjne, a grupa (C) (n = 16) wykonywała tylko ćwiczenia nadgarstka. Dla wszystkich grup, zabiegi były aplikowane na dotkniętą rękę, trzy sesje tygodniowo przez cztery tygodnie. Wszystkie kobiety po porodzie były oceniane przed i po terapii za pomocą wizualnej skali analogowej (VAS) dla intensywności bólu, Kwestionariusza Bostońskiego na CTS (BCTS) dla diagnozy objawów CTS, elektromiografii dla pomiaru prędkości przewodzenia motorycznego (MCV) i czuciowego (SCV), motorycznego opóźnienia dystalnego (MDL) oraz szczytowego opóźnienia czuciowego (SPL), oraz dynamometru chwytu ręki dla oceny siły chwytu ręki. Wyniki. Wszystkie zmierzone parametry wykazały znaczącą poprawę we wszystkich trzech grupach po terapii w porównaniu do stanu przed terapią. Porównanie międzygrupowe wykazało wysoce znaczący spadek wartości VAS, BCTS i SPL oraz znaczący wzrost SCV i siły chwytu ręki między grupami A i C na korzyść grupy A oraz między grupami B i C na korzyść grupy B, podczas gdy znaczące zmiany w MDL i MCV zaobserwowano tylko między grupami A i C na korzyść grupy A ($p < 0{,}05$), bez znaczących różnic we wszystkich mierzonych parametrach między grupami A i B ($P > 0{,}05$). Wnioski. Zarówno terapia laserem niskiej mocy, jak i ultradźwięki pulsacyjne są skutecznymi metodami, które mogą być stosowane jako efektywna terapia zachowawcza w łagodzeniu objawów CTS po porodzie.

Słowa kluczowe
terapia laserem niskiej mocy, ultradźwięki pulsacyjne, zespół cieśni nadgarstka, okres połogu

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Introduction

The median nerve experiences compression at the transverse carpal ligament's level as it moves across the carpal tunnel, resulting in an entrapment neuropathy called carpal tunnel syndrome (CTS) [1, 2]. CTS is a more prevalent issue that occurs in pregnancy. Median nerve function is reduced in the majority of pregnant women, particularly during the third trimester of gestation. Up to 62% of pregnant women experience CTS, and the majority of them may continue to experience some symptoms up to one to three years after delivery [3]. A previous study found that because hormones like relaxin cause the transverse carpal ligament to become lax, which exacerbates CTS, 40% of affected women continued to experience symptoms of the condition one month after giving birth, 24% for three months, 11% for six months, and 4% for a year [4].

Postpartum CTS can make it more difficult for a mother to breastfeed her child successfully. This is because nursing provides more physical strain on the mom's hands and a frequent necessity for bending during lactation and lifting the baby [5]. Tingling sensation, numbness, palmar aspect pain in the radial 3.5 fingers, a loss of hand strength, trouble gripping objects, and frequent falling are all signs of CTS. Afferent distribution, median nerve hypoesthesia, positive provocation tests, and atrophy or weakening of the thenar muscles may be seen in the physical examinations [6].

It has been demonstrated that the gold standard for diagnosing CTS is the nerve conduction study (NCS). The NCS evaluates the action potential of the motor and sensory nerves to determine the severity of median nerve entrapment. Electrophysiological testing, also known as nerve conduction investigations, is very sensitive for evaluating the median nerve. It can determine the extent of demyelination and axonal loss [7]. It depends on changes in the thenar muscles' denervation and the delay of distal latencies (DL) of both motor and sensory nerve action potentials [8]. Longer DL and slower nerve conduction velocities of the median sensory and motor fibers indicate their demyelination [8].

For CTS, there are numerous non-surgical options available. Patient education aimed at reducing repetitive, stressful wrist movements should be part of first-line management [9]. The degree of the condition determines whether CTS should be treated conservatively. In mild and moderate cases, standard treatment is recommended for the patients, including splinting, corticosteroids, anti-inflammatory medications, physiotherapy, therapeutic ultrasound (US), low-level laser therapy (LLLT), and yoga. Such types of therapy stimulate symptom improvement between two and six weeks, with the best effect felt at three months, while surgical intervention is recommended for severe cases [10].

One of the novel approaches to managing CTS symptoms is exercise treatment. Wrist and finger exercises stretch the carpal tunnel connections, widen the longitudinal region connecting the median nerve and transverse carpal ligament, decrease tenosynovial edema, enhance the lymph nodes' venous return, and lower the compression within the carpal tunnel [11].

LLLT is the usage of red and near-infrared light, usually with wavelengths between 600 and 1000 nm, to biological tissues to produce therapeutic effects [12]. By increasing cellular oxygen consumption and ATP production in mitochondria, LLLT can effectively alleviate the symptoms of CTS. It also improves skin blood flow, reduces inflammation by inhibiting prostaglandin synthesis, and decreases the permeability of nerve cell membranes to sodium and potassium ions. That causes hyperpolarization of neurons, increases lymphatic drainage, and reduces edema. In addition, it causes a rise in the synthesis of myelin, which promotes neuron regeneration [13].

Additionally, because the therapeutic US focuses on stimulating nerve transmission and regeneration, it is beneficial in lowering the symptoms of CTS [9]. Its actions are anti-inflammatory, anti-irritating, and fibrinolytic [2]. Furthermore, it reduces inflammation and promotes nerve recovery through increased circulation and membrane permeability. These thermal and non-thermal effects support the idea that therapeutic US may aid in the recovery of nerve compression [2].

A previous study showed the positive effects of LLLT on mild to moderately severe CTS because it enhances nerve conduction velocity, reduces motor and sensory delay, and significantly reduces pain [14]. Additionally, previous research revealed that the US helps treat mild to moderate cases of CTS; after treatment, there was a noticeable change in the median nerve's electrophysiological properties and a considerable decrease in pain [15]. To the author's knowledge, there was no earlier research comparing the impacts of LLLT and pulsed US on postpartum CTS. So, this study was conducted to distinguish between their effects on relieving median nerve compression symptoms and improving hand grip strength in postpartum women with CTS.

Participants & methods

Study design and ethical considerations

This study was designed as a single-blind, randomized and controlled trial. The research received ethical approval [012/003870] from the Cairo University Faculty of Physical Therapy's institutional review board. Additionally, it was prospectively registered under the identification number [NCT05904561] at clinicaltrials.gov. The study was carried out from April to October of 2023. Following detailed clarification of the research objectives, procedures, and withdrawal rules before the study started, every participant signed a written consent form.

Participants

Forty-eight postpartum women with CTS reported moderate to severe pain in the carpal tunnel region (visual analog scale ≥ 4), and their nerve conduction study, Tinel sign, and Phalen test results were all positive. Their body mass index (BMI) varied from 25 to 30 kg/m^2, and they were between the ages of 25 and 35 years. Electrophysiological evidence indicated that they had a mild or moderate median nerve injury at the wrist (mild: sensory nerve latency is more than 3.5 ms at the 3rd digit; moderate: sensory nerve latency is more than 3.5 ms at the 3rd digit and median motor latency is more than 4.2 ms) [16]. Postpartum women were not permitted to participate in the study if they had a history of brachial plexopathy, radial/ ulnar neuropathy, polyneuropathy, trauma, fracture, deformity, inflammation, or previous operation in the wrist, abnormal co-

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agulation, pregnancy, infections, cutaneous disorders/ cancers, spots, or tattoos over their treated areas, pacemakers, or implementable medical instruments [17].
They had been allocated from the outpatient clinic at Cairo University's Faculty of Physical Therapy in Cairo, Egypt. Before and after the 4-week treatment duration, all postpartum women in all groups underwent evaluations using the visual analogue scale (VAS) to measure pain intensity, the Boston Carpal Tunnel Questionnaire (BCTS) to assess symptoms of CTS, an electromyography-based median NCS to measure motor conduction velocity (MCV), sensory conduction velocity (SCV), motor distal latency (MDL), and sensory peak latency (SPL), and a hand grip dynamometer to measure hand grip strength.

Randomization and blinding
Using sealed envelope technique, all postpartum women were randomly split into three equal groups (A, B, and C). One researcher, blind to the study process, was asked to select one card from a sealed envelope containing written cards on LLLT, pulsed US, or wrist exercises. Women were assigned to groups based on which card was selected. Group (A) included 16 patients with CTS who had LLLT on the affected hand, in addition to wrist exercises; Group (B) included 16 women with CTS who received pulsed US on the affected hand, in addition to wrist exercises; and Group (C) included 16 women with CTS who only had wrist exercises on the affected hand (Figure 1). No participant withdrawals following randomization.

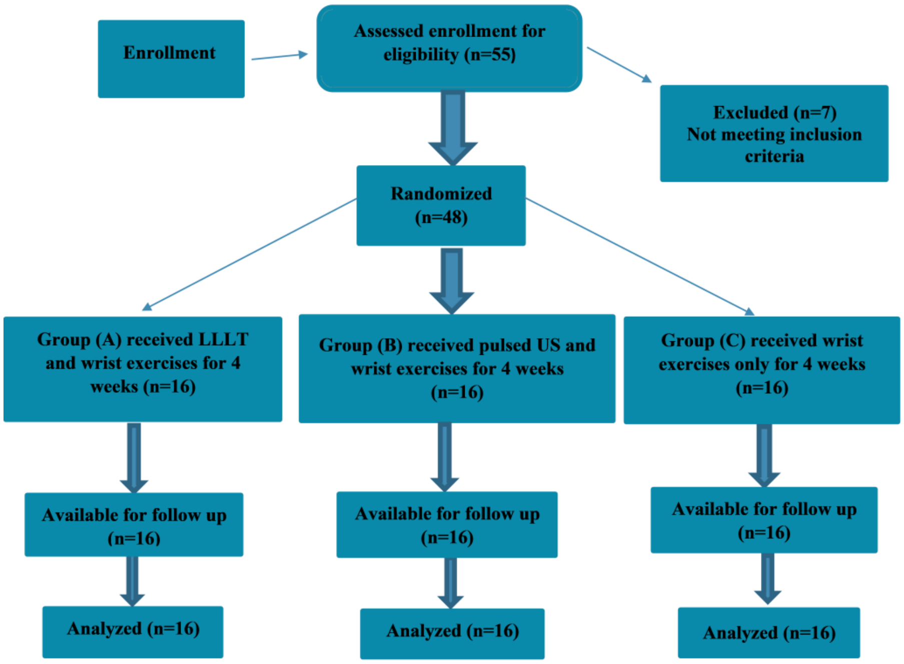

Figure 1. Flow chart of the study

Procedures
Firstly, before starting the study, each participant in the three groups was thoroughly briefed about the objectives, procedures, and advantages of each treatment method to guarantee their active participation and collaboration throughout the treatment.

Low level laser therapy
Each woman in the group (A) underwent a program of LLLT using SUNDOM-300IB (Sandum Co., Beijing, China), gallium aluminum arsenide with an 810 nm wavelength, 500 MW power, and a laser beam diameter of 10 mm, 3 sessions weekly for four weeks (12 sessions as a total).

The woman was first instructed to sit in a comfortable position, place their hand in supination, relax on their thigh, and keep their wrist in a neutral position. Each of the two points that LLLT covered was located using a tape measure. The first point was placed near the middle of the distal wrist crease, over the carpal tunnel. The second one was located on the same line as the first point along the median nerve, 5 cm adjacent to the distal wrist crease. This is where the median nerve becomes superficial to the flexor digitorum superficialis muscle bellies. With the laser probe applied perpendicularly, each point was treated for five minutes, for an overall treatment time of ten minutes (Figure 2) [18].

Figure 2. Application of LLLT for group (A)

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Pulsed ultrasound

The women in group (B) were administered a pulsed US program (Digisonic Chung Woo Medical 302, manufactured in Korea) with three weekly sessions, a total of 12 sessions (10 min/session), at a frequency of 1.0 MHZ and a pulsed intensity of 0.1-3 W/CM2. The woman was instructed to sit in a comfortable position, with her wrist rested on the thigh in a neutral position and her forearm in a supination position. On the carpal tunnel distal to the distal wrist crease, an aquasonic coupling gel with the US head was applied perpendicularly and slowly in a circular motion (Figure 3) [18].

Figure 3. Application of pulsed US for group (B)

Wrist exercises

All women in all groups were advised to do the following wrist exercises:

Nerve-gliding exercises

Women were instructed to sit in a comfortable position, and the median nerve was self-mobilized by placing the wrist and hand in 6 various positions: A: neutral wrist position, fingers, and thumb flexed; B: neutral wrist position, fingers and thumb extended; C: wrist and fingers extended, neutral thumb position; D: extension of wrist, thumb, and fingers. E: As in D, but with a supinated forearm; F: Similar to E, but with the thumb gently stretched with the opposing hand. Throughout the exercises, the elbow was in supination and 90 degrees of flexion, while the shoulder and neck were in neutral positions (Figure 4) [19].

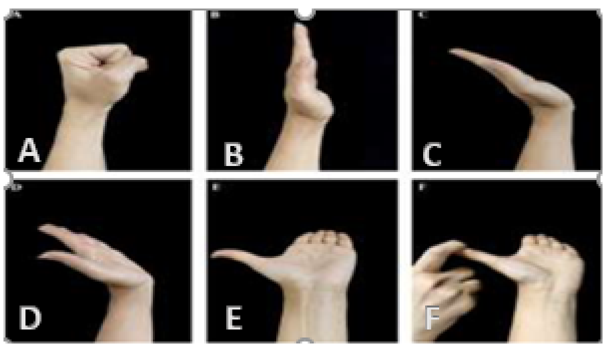

Figure 4. Median nerve gliding exercises (Adapted from Subadi et al. [20]).

Tendon gliding exercises

The mobilization technique was self-applied while the women were in comfortable positions. It included moving the fingers through the following five distinct positions to slide the hand's flexor tendons: A: straight; B: straight fist; C: table top; D: fist; and E: hook (Figure 5) [19].

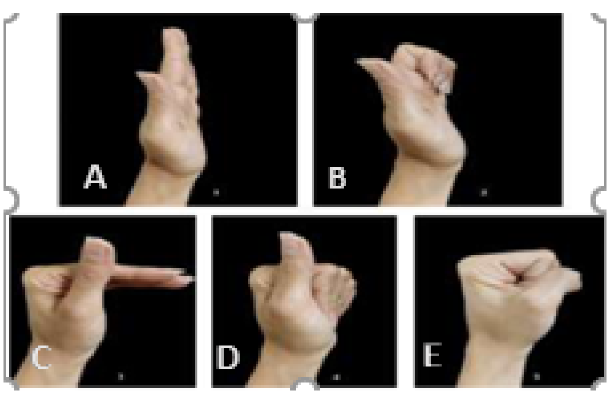

Fig. 5. Tendon gliding exercises (Adapted from Subadi et al. [20])

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Neurodynamic technique
The women were positioned in a range of motion (ROM) that is known to put a great deal of stress on the median nerve. The women were put in a comfortable position and told to do lateral cervical bending to the opposite side, depress and abduct the ipsilateral shoulder to 90°, rotate the shoulder externally to 90° with a 45° extended elbow and supinated forearm, and repeat bending and straightening of the wrist and fingers through their full ROM [21].

Strengthening and stretching exercises
All women were asked to perform the following exercises, and each exercise was repeated 10 times, 3 sessions per week, for four weeks [22].
1. Wrist extension and flexion: The woman was asked to sit in a comfortable position with her elbow resting on the plinth and the wrist pronated at the edge, then asked to extend the wrist upward toward the ceiling, starting with manual resistance, then weights were added according to muscle strength, then was asked to flex the wrist upward toward her face, starting with manual resistance, then weights were added according to muscle strength (0.5–1 kg) (Figure 6; A &B).
2. Grip strengthening: The woman was sited in a comfortable position, rested the elbow on the plinth, and supinated the wrist, then asked to grip the therapist's fingers, hold for 10 seconds, then release, starting with hand resistance, then hand weights were added according to muscle strength (0.5–1 kg) (Figure 6; C).
3. Wrist stretching exercise with weights: This exercise stretches the flexor muscles in the forearm. The woman was sited in a comfortable position with elbow rested on the plinth and the wrist supinated at the edge, then asked to extend the wrist downward toward the ground, using the weight as a factor to stretch the carpal tunnel in addition to gravity (Figure 6; D).

Figure 6. Wrist strengthening exercises A: Extension exercise; B: Flexion exercise; C: Grip strengthening exercise; D: wrist stretching exercise

Outcome measures
Pain intensity
Each woman in the three groups had her pain level measured using the VAS both before and after the treatment program ended. It is a commonly used pain intensity assessment tool in rehabilitation that is based on self-reported pain and has been demonstrated to be valid and reliable. It is composed of a line, usually 10 cm long, that might be horizontal or vertical. The worst pain and no pain are the labels for the line's extremes. The participating women were instructed to identify their pain level by marking a point between the two extremes, reflecting their pain level [23].

Boston Carpal Tunnel Questionnaire (BCTS)
The BCTS was utilized to evaluate the severity of CTS. Each woman will be asked to mark the score in front of each item both before and after the treatment to record the improvement since it is valid, reliable, and sensitive to any clinical change brought about by the treatment. This questionnaire comprises of 18 items split into two sections: the functional status scale (FSS) and the symptom severity scale (SSS). The SSS consists of eleven questions that are graded from one (normal) to five (extremely serious, very difficult, more than five times, and continued) based on painful wrist episodes, numbness, weakness, and difficulties grasping. Additionally, the FSS includes

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a subscale consisting of eight items that assess daily hand functions. The FSS has a score range of one (without difficulty) to five (unable do the task at all). The overall score is determined as the average of all items for every subscale. Higher scores are a sign of worse symptoms or functions [24].

Median nerve conduction study

For every woman in all groups, electromyography was done using a portable device (Deymed Diagnostic Device, TruTrace 4 EMG System, Czech Republic) both before and after the study program ended. Electrodiagnostic (EDx) studies are a valid and reliable procedure of ensuring the diagnosis [25]. The functional condition of axons is reflected by the amplitudes and conduction velocities of the sensory and motor nerve action potentials, which are valuable parameters that support clinical grading in determining the severity of CTS [26]. About 30 to 31°C were kept at room temperature. For the first set of recordings for the motor NCS, two surface electrodes were used: G1 was put on top of the abductor pollicis brevis muscle, and G2 was put on top of the first metacarpal phalangeal joint. The median nerve was then stimulated between the flexor carpi radialis and palmaris longus tendons at a distance of 7 cm from the recording electrode (Figure 7a). Second, two ring electrodes were put on the index finger to record G1 (over the metacarpal-phalangeal joint) and G2 (over the distal interphalangeal joint, 3–4 cm away). The median nerve was then activated at a distance of 13 cm antidromically between the flexor carpi radialis and palmaris longus tendons (Figure 7b) [27].

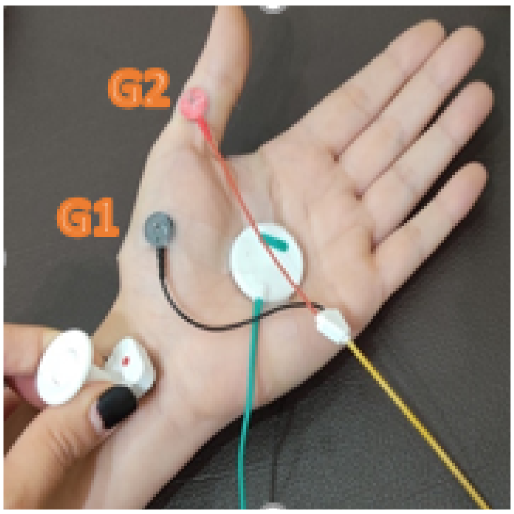

Figure (7a): Median motor nerve conduction Fig. (7b): Median sensory conduction study

Hand grip strength

The hand grip strength of every woman in each of the three groups (A, B, and C) was measured using a hand dynamometer (Gripx Digital Hand Dynamometer, China) both before and after therapy. It provides gripping power up to 198 lbs/90 kg (division: 0.2 lbs/100 grams, unit: lb/kg). Using dynamometry to measure grip strength is the most common, valid, and reliable way to report motor outcomes for CTS and some other clinical disorders. It gives numerical values for the muscles being studied [28, 29]. The participating women were instructed to sit comfortably, adduct the shoulder, bend the elbow to 90°, and then squeeze the handle firmly (flex fingers) three times while applying the greatest amount of force. For statistical analysis, the three measurements' mean value was recorded [28].

Sample size calculation

By comparing the median compound motor action potential (CMAP), latency and nerve conduction velocity (NCV) of CTS patients receiving LLLT, shame LLLT, and the control group, the sample size was determined as stated in Rayegani et al. [16]. The within- and between-interaction effect F-test MANOVA was chosen. A generated sample size of at least 44 people was needed, plus an additional 4 (10% dropout), for a total sample size of 46. 16 participants per group were required, taking into account a power of 0.80, an α level of 0.05 (2-tailed), and an effect size of 0.556; three groups; and the number of measures of two. G*Power (version 3.0.10) was utilized to compute the sample size.

Statistical data analysis

Data were represented as mean ± SD. Utilizing ANOVA and chi-square, the subject characteristics of the three groups were compared. Kolmogrov-Smirnov and Shapiro-Wilk tests were employed to prove the normality of the data distribution. To examine the impact of the measured variables within and across groups, MANOVA was used. Data analysis was performed utilizing the statistical package for the social sciences computer program (version 20 for Windows; SPSS Inc., Chicago, Illinois, USA). A significance level of P less than or equal to 0.05 was applied.

Results

Subjects characteristics

Table 1 indicates that there was no significant change in the mean values of age, weight, height, or BMI between the three groups. Chi-square analysis also didn't reveal any significant change in the affected side among the three groups ($p > 0.05$).

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Table 1. General characteristics of subjects of all groups

Characteristics	Group A	Group B	Group C	f- value	p-value
Age [years]	30.4 ± 3.4	29.4 ± 3.1	31.2 ± 2.8	1.33	0.274
Weight [kg]	75.1 ± 7.6	77.3 ± 5.6	74.5 ± 6.5	0.753	0.477
Height [cm]	165.6 ± 5.8	167.6 ± 4.6	164.9 ± 4.8	1.22	0.304
BMI [kg/m^2]	27.1 ± 1.6	27.8 ± 1.3	27.7 ± 1.2	1.15	0.325
Affected side					
Right	10 (62.5%)	6 (37.5%)	11 (69%)	$\chi 2 = 3.55$	0.169
Left	6 (37.5%)	10 (62.5%)	5 (31%)		

Table 2 illustrates that there was a significant decrease in the mean value of VAS and BCTQ (SSS and FSS) and a significant increase in the mean value of grip strength in the three groups post-treatment ($p < 0.05$). The between-group comparison revealed a significant difference in VAS, BCTQ, and grip strength post-treatment between the three groups ($p = 0.001$). A post hoc test showed that there was a statistically significant difference in VAS, BCTQ, and grip strength between groups A and C ($P = 0.001$) in favor of group A and between groups B and C ($P = 0.001$) in favor of group B (Table 3).

Table 2. Comparison between pre`- and post-study mean values of the measured variables between and within groups

Measured variables	Group A	Group B	Group C	f-value	P value (between groups)
Pain intensity (cm)					
Pre-study	5.2 ± 0.5	5.1 ± 1.2	4.4 ± 1	2.75	0.074
Post-study	0.8 ± 0.5	0.7 ± 0.4	2.5 ± 0.7	30	0.001*
(P-value)	0.001*	0.001*	0.001*		
BCTQ (SSS)					
Pre-study	29.2 ± 5.3	26.8 ± 6	27.9 ± 5.1	0.750	0.478
Post-study	13.8 ± 1.4	13.8 ± 2.5	22.7 ± 4.8	40.11	0.001*
(P-value)	0.001*	0.001*	0.001*		
BCTQ (FSS)					
Pre-study	18.6 ± 3	17.8 ± 3.6	20.6 ± 3.4	2.9	0.064
Post-study	9.5 ± 1.1	9.5 ± 1.2	16.2 ± 3.2	55	0.001*
(P-value)	0.001*	0.001*	0.001*		
Hand grip strength (Lbs/kg)					
Pre-study	24.6 ± 10.8	23.3 ± 8.7	25.3 ± 5.2	0.238	0.789
Post-study	51.4 ± 5.6	52.1 ± 7.3	31.9 ± 4.8	57.6	0.001*
(P-value)	0.001*	0.001*	0.002*		
Sensory peak latency (SPL) (ms)					
Pre-study	3.9 ± 0.3	4 ± 0.6	4.2 ± 0.8	1.544	0.225
Post-study	3 ± 0.5	3 ± 0.4	3.9 ± 0.6	19.16	0.001*
(P-value)	0.001*	0.001*	0.019*		
Sensory conduction velocity (SCV) (m/s)					
Pre-study	40.5 ± 6.5	40.7 ± 6.7	39.2 ± 7.7	0.230	0.795
Post-study	51 ± 3.1	51.7 ± 3.9	42.5 ± 6.7	18	0.001*
(P-value)	0.001*	0.001*	0.018*		

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Measured variables	Group A	Group B	Group C	f-value	P value (between groups)
Distal motor latency (DML) (ms)					
Pre-study	3.5 ± 0.6	3.7 ± 0.8	3.9 ± 0.9	1.21	0.307
Post-study	3.2 ± 0.4	3.3 ± 0.5	3.8 ± 0.7	3.96	0.026*
(P-value)	0.004*	0.001*	0.049*		
Motor conduction velocity (MCV) (m/sec)					
Pre-study	55.7 ± 6.5	52.5 ± 7.3	52.5 ± 6.3	1.17	0.319
Post-study	58.6 ± 5.9	58.2 ± 5.7	51 ± 12	3.94	0.026*
(P-value)	0.041*	0.009*	0.445		

*Data is represented as mean ± SD p-value: probability value *: significant*

Table 3. Post hoc test between groups of measured variables post-study

Post hoc test between groups		VAS	BCTQ		Grip strength	Sensory		Motor	
			SSS	FSS		SPL	SCV	DML	MCV
Group A Vs. B	Mean difference	0.063	0	0.063	−0.68	0.006	−0.7	−0.038	0.43
	P-value	1	1	1	1	1	1	1	1
Group A Vs. C	Mean difference	−1.7	−8.9	−6.7	19.5	−1	8.5	−0.52	7.6
	P-value	0.001*	0.001*	0.001*	0.001*	0.001*	0.001*	0.046*	0.048*
Group B Vs. C	Mean difference	−1.8	−8.9	−6.7	20.2	−1	9.2	−0.48	7.1
	P-value	0.001*	0.001*	0.001*	0.001*	0.001*	0.001*	0.071	0.068

*Vs: versus, *: significant*

Discussion

CTS is a terrible, debilitating illness that can significantly impair a person's capability to do different daily living activities, such as working, sleeping, handling objects, and lactation in nursing mothers [5]. Although there are numerous therapeutic alternatives for CTS, no single modality has been proven to be better than any other [30]. This study was conducted to compare the effectiveness of LLLT and pulsed US on symptoms and electrophysiological findings of the median nerve in postpartum women with CTS.

The study's findings showed that, after therapy, all three groups' assessed variables had significantly improved over their pre-treatment levels. A comparison of the groups showed that there was a highly significant decrease of VAS, BCTS, and SPL and a significant increase of SCV and hand grip strength between groups A and C in favor of group A and between groups B and C in favor of group B, while the significant variation in DML and MCV was found between groups A and C only in favor of group A ($p < 0.05$), with no significant change in all outcome measures between groups A and B ($P > 0.05$).

Wrist exercises, which are useful in reducing CTS symptoms, were given to all groups. Using tendon and nerve-gliding exercises along with other therapies may lead to better short- to medium-term results. These exercises lower swelling, increase nerve mobility by alleviating adhesions of the adjacent connective tissue, and lower pain by lowering levels of substances that cause inflammation and lowering the sensitivity of the peripheral and central nervous systems. They also promote soft-tissue repair and enhance median nerve vascularization within the carpal tunnel [11]. Even when hands remain motionless, flickering fingers cause the flexing tendon and median nerve to move properly along the wrist, preventing adhesion. Bending and extending wrist and finger exercises stretch the carpal tunnel connections, reduce swelling in the tenosynovial area, enhance circulation and venous return from the lymph nodes, and reduce compression over the median nerve, alleviating CTS symptoms [11].

The significant improvement observed in group A can be attributed to the advantageous impact of the LLLT on the compression of the median nerve. This is because the laser makes more myelin cells, improves energy transport, and spreads calcium around the cytoplasm. This increases the functional potential of cells, speeds up injury repair, makes scar tissue more resistant, encourages pro-inflammatory activity, and improves blood flow and tissue regeneration. The accelerated rate of cell growth and division, the stimulation of cytokine and protein synthesis, and the relaxation of blood vessel walls brought on by photolytic complexes are further factors [31].

It was proven that in mild to moderate cases of CTS, LLLT provided an improvement in nerve conduction parameters (a reduction in motor and sensory latencies and an increase in conduction velocity), a notable decrease in pain, and an im-

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provement in grip strength [18, 32]. Also, Fusakul et al. [33] discovered that LLLT is a successful therapy option for patients with mild to moderate CTS, supplementing a conservative approach. It can enhance the electrophysiological parameters and hand grip strength of the affected hands, with a lasting effect that extends for up to three months following therapy for grip strength.

According to Elgendy et al. [34] research, LLLT improves pinch grip strength in CTS sufferers. By lowering the amounts of pain chemicals like prostaglandins, beta-endorphins, interleukin-1 beta, and tumour necrotic factor-alpha, laser therapy may reduce inflammation-related pain. Additionally, it enhances local microcirculation, which promotes faster healing. Furthermore, Lazovic et al. [35] reported that the experimental LLLT group showed that after three weeks of treatment, there was a significant decrease in pain, a drop in the number of patients with a positive Tinel's sign, and a reduction in the median sensory and motor latencies in the NCS exams.

Baysal et al. [36] found improvement in the subjective symptoms and palmar pinch strength of CTS patients, hence supporting the effectiveness of pulsed US therapy. Also, Schuhfried et al. [37] found a small significant effect of pulsed US just for one major outcome parameter: the SSI (symptom severity index). When compared to the application of a placebo, the other electrophysiological parameters remained unchanged.

In double-blind, randomized research, ultrasound and a placebo treatment (for 20 sessions) were evaluated for the treatment of CTS. The findings demonstrated that after the second and seventh weeks, as well as after six months, the patient's symptoms had significantly improved [38]. Some studies showed that there was minimal evidence of US treatment in the long-term relief of CTS, despite the frequent results of the transitory benefits of ultrasound therapy [39, 40]. A previous study only suggested that cases with mild to moderate idiopathic CTS would benefit from short- to medium-term ultrasound therapy [38].

A comparison of the groups showed that there were no obvious changes between groups A and B in any of the outcome measures. These findings were in line with those of Ahmed et al. [18], who conducted a comparison between LLLT and US on CTS and showed that both were equally successful in treating mild to moderate CTS in diabetic patients.

In contrast, a prior study found that splinting alone was not as successful in treating CTS as a combination of US or LLL therapy with splinting. However, LLLT with splint usage was superior to US therapy with splint usage in terms of benefits, particularly when it came to symptom severity reduction, pain relief, and improved patient satisfaction [41]. Also, Bakhtiary and Rashidy-Pour's [42] study disagreed with the present one; it found that ultrasound treatment was superior to laser treatment for individuals with CTS.

In addition, Moya et al. [43] examined various conservative treatment modalities. They found that the US had only better after-therapy improvement in MDL than the other modalities, with no beneficial effects on pain, symptom severity, strength, function, SCV, or sensory DL.

Strength and limitations

This study was the first to compare the effectiveness of LLLT and pulsed US on postpartum CTS. The participants' randomization, sample size calculation, and objective methods of assessment, such as the median nerve electro-diagnostic study and hand grip dynamometer, are additional strengths. However, this study examined the short-term impact of either LLLT or pulsed US on postpartum CTS with no patient follow-up. Therefore, future research is required to examine their long-term impacts on postpartum CTS.

Conclusion

From the previous findings, it can be concluded that both LLLT and US are effective modalities for decreasing pain and symptoms severity, improving hand function and electrophysiological parameters of median nerve in postpartum women with CTS.

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