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THE EFFECTIVENESS OF HIGH-INTENSITY LASER ON PAIN AND GRIP STRENGTH AMONG PATIENTS WITH CARPAL TUNNEL SYNDROME

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ABSTRACT

Introduction*: Carpal tunnel syndrome (CTS) is widely acknowledged as the most commonly occurring kind of peripheral nerve compression. There is a lack of agreement among medical professionals regarding the most effective therapeutic approaches for carpal tunnel syndrome (CTS), as well as the ideal order in which these interventions should be implemented. The primary aim of this study is to conduct a comparative analysis of the effects of high-intensity laser therapy (HILT) and ultrasound therapy on several outcome variables in persons who have been diagnosed with carpal tunnel syndrome.*

Methods*: The study involved 38 participants (20-60 years old) with mild or moderate carpal tunnel syndrome.Participants were divided into two groups through random allocation. Group 1 received 10 sessions of high-intensity laser therapy focused on the wrist, along with tendon gliding exercises. Group 2 underwent ten sessions of ultrasound therapy combined with tendon gliding exercises. Outcome measurements included pain levels, hand performance, finger pinch grip, hand grip strength, and carpal tunnel extent, assessed before and after therapy sessions for both groups.*

Results*: Significant alterations were seen when comparing the groups to the baseline data. Nevertheless, the assessment of individuals after the 10-week therapeutic duration did demonstrate these modifications. The mean scores of visual analog scale (VAS), pinch grip (KG), grip strength (GS) and BOSTON questionnaires reduced significantly in High-Intensity Laser Therapy with tendon gliding exercise group and however, these variables had no significant difference in the Ultrasound Therapy with tendon gliding exercise group.* ***Conclusions****: It can be concluded that High-Intensity Laser Therapy (HILT) demonstrates greater efficacy compared to Ultrasound Therapy (US) in the treatment of Carpal Tunnel Syndrome (CTS).*

Keywords: carpal tunnel syndrome, high-intensity laser, ultrasound therapy, pain scale, finger pinch grip, grip strength, BOSTON questionnaire, tendon gliding exercise

1. INTRODUCTION

Entrapment neuropathies are often seen as mononeuropathies in the field of clinical practice. These neuropathies lead to nerve injury as they pass via constricted and confined anatomical pathways. Entrapment neuropathies lead to partial nerve injury, specifically impacting a restricted section of the nerve. However, these circumstances can significantly affect multiple facets, including physical health, mental well-being, and economic consequences such as potential wage loss. Due to the absence of a definitive understanding of the precise aetiology of these neurological disorders and the prevailing notion that they result from various variables, entrapment syndromes are commonly classified as idiopathic in such instances (6).

Carpal tunnel syndrome is widely recognized as the most widespread and well-studied kind of nerve entrapment disorder. The tunnel of the carpal is characterized by the compression of the median nerve as it traverses a narrow osteofibrous channel located within the wrist (1). The carpal tunnel, alternatively referred to as the carpal canal, is composed of the wrist bones, the longitudinal carpal ligament, the median nerve, and the digital flexor tendons. Nerve compression may be aggravated by several situations, including oedema, tendon inflammation, hormone fluctuations, and manual labour. The sensation of pain may also arise as a result of the occurrence of oedema and inflammation within tendons. The occurrence of hand weakness can be attributed to a reduction in muscular strength in the muscles innervated by the median nerve, particularly in more severe circumstances (4).

The examination and management of carpal tunnel syndrome have been addressed through various viewpoints and utilizing a range of approaches. The syndrome demonstrates a remarkably high incidence, with even minor instances typically manifesting symptoms. The aforementioned phenomenon can be ascribed to the existence of responsive electrophysiological indicators, the progress of patient-centric indicators, the advent of innovative nerve imaging methodologies, and the accessibility of a diverse array of treatments, including both non-surgical and surgical modalities. The observed heterogeneity in the condition can be attributed to the combined influence of these factors. (7)

The existing body of literature (5) encompasses a diverse array of prevalence and incidence statistics pertaining to carpal tunnel syndrome (CTS). The prevalence of carpal tunnel syndrome (CTS) is approximately 4% to 5% globally, with those in their 40s and 60s exhibiting the most susceptibility to this condition. The selection of a specific case definition has a crucial role in determining the prevalence and incidence rates of carpal tunnel syndrome (CTS). The diagnostic triad's partial agreement leads to the existence of multiple choices, and it is possible to characterise electrophysiological anomalies using different plausible cut-points. The prevalence estimates exhibit significant variations due to a range of decisions made during the estimation process.

The study's participants were primarily Malays, comprising 74.2% of the sample. Chinese respondents accounted for 17.7%, while Indians constituted 4.8%. These findings align with the ethnic composition of Malaysia as reported in the 2010 Malaysia Population Census, which indicated that Malays accounted for 67.4% of the population, followed by Chinese at 24.6%, and Indians at 7.3% (Department of Statistics Malaysia,2010). The workplace issues of CTS remain a subject of ongoing discussion and analysis. With the exception of the elevated level of vibration exposure. There is a notable prevalence of carpal tunnel syndrome (CTS) within some occupational fields. The existence of other additional elements that played a role in the development and exacerbation of compression neuropathy was widely recognised, with occupational activities being just one among them.

Overall study reported that housewives had the highest prevalence of carpal tunnel syndrome (CTS), representing 33.9% of the sample population. Moreover, a substantial percentage of these people were categorized as perimenopausal women. The increased prevalence of carpal tunnel syndrome (CTS) among housewives may be linked to the physiological changes that occur around menopause, making the nerve more vulnerable to compression. Individuals who regularly performed manual jobs requiring the use of their hands and wrists were shown to have a higher likelihood of acquiring carpal tunnel syndrome (CTS).

Furthermore, the individuals most affected by Carpal Tunnel Syndrome (CTS) included clerks (21%), teachers (17.7%), healthcare professionals (8.1%), and manual labourers. Healthcare professionals may possess a more comprehensive understanding of health-related matters compared to individuals in other fields, thereby explaining the elevated prevalence of carpal tunnel syndrome (CTS) within this occupational group. Additionally, there were two individuals who were receiving medical treatment, one of them was employed in the culinary industry while the other worked at a grocery store. All individuals were engaged in occupations characterised by shared attributes, involving repetitive manual movements encompassing both flexion and extension, and prolonged durations of exposure (8).

2. OBJECTIVES

General Objectives: To find out the efficacy of High Intensity Laser Therapy on pain and grip strength among patients with Carpal Tunnel Syndrome.

Research Objectives: The primary aim of this study is to establish clear and specific research objectives that will guide the investigation and analysis of the research problem: To compare the effectiveness of HILT vs Ultrasound Therapy on pain among patients with Carpal Tunnel Syndrome

- To compare the effectiveness of HILT vs Ultrasound Therapy on hand function among patients with Carpal Tunnel Syndrome
- To compare the effectiveness of HILT vs Ultrasound Therapy on pinch strength among patients with Carpal Tunnel Syndrome
- To compare the effectiveness of HILT vs Ultrasound Therapy on hand grip strength among patients with Carpal Tunnel Syndrome
- To compare the effectiveness of HILT vs Ultrasound Therapy on cross-sectional area of median nerve among patients with Carpal Tunnel Syndrome.

3. METHODS

The current study uses a single-blinded, quasi-experimental trial with two different treatments. The participants in a single-blinded trial are not aware of the treatment they will receive, but the researchers or assessors are. The subjects are evaluated twice: once at the baseline, before any treatment is given, and once after the tenth week. It enables comparisons between treatment groups and evaluations of how the dependent variables have changed over time.

The selected participants were instructed to visit the Physio at Work facility located in Bukit Jelutong, where they proceeded to articulate their symptoms associated with carpal tunnel syndrome. The research was conducted in June to July 2023 at the Physio at Work Bukit Jelutong with ethical approval from the Research Ethics Committee of AIMST University. The study was designed as an assessor-blind non-randomised controlled trial (AUHEC/FAHP/13/07/2023/MPT-PT-B1-004).

The sample size and the effect size are the two important variables that have a substantial impact on a study's power. This non-randomized clinical trial is a quasi-experimental study. Carpal tunnel syndrome patients make up the study population. Using Epi Info Statistical Software (Dean, Andrew G,2000), the estimated sample size is determined based on the population size, the margin of error, and the power in the software. The level of significance (α) is kept at; power ($1-\beta$) = 0.8 and effect size 0.8. The computation indicates that 42 will be the approximate sample size.

40 people were initially enrolled in the trial. 38 patients made up the main group, which was randomly split into two groups and given either HILT and tendon gliding exercise and ultrasound therapy along with nerve gliding exercises. At the following stage, two patients (one from each group) were omitted for specified reasons. On the basis of a doctor's recommendation letter, forty patients of both sexes between the ages of 25 and 70 who had Carpal Tunnel Syndrome were originally enrolled via signs posted throughout the centre and hospital. The inclusion criteria are: (3).

- People with a mild or moderate case of CTS
- between the ages of 20 and 65
- positive results on the Tinel and Phalen clinical provocative tests for CTS and
- a history of paraesthesia, numbness, or pain in the median nerve distribution, night waking, or nocturnal pain.

- natural state of mind
- No previous fractures
- No history of a chronic illness and no conditions that would interfere with the study
- No previous intra-articular injections during the previous six months

The Criteria for Exclusion Were: (3).

- Cervical disc prolapses,
- Cervical spondylosis,
- Thoracic outlet syndrome,
- Diabetes,
- Heart conditions, or hypertension.
- Patients who had surgery to relieve their carpal tunnel

Tools and Materials:

Pain Scale:

The outcome measures comprised of carpal tunnel pain severity assessed using the Numeric Rating Scale (NRS). The pain assessment utilised a numeric Visual Analogue Scale (VAS), which spanned from 0 (indicating the absence of pain) to 10 (representing the most intense pain conceivable).

Symptom Severity Scale and Functional Status scale:

The Boston Carpal Tunnel Syndrome Questionnaire (BCTQ) comprises two distinct components: The Symptom Severity Scale (SSS) and the Functional Status Scale (FSS). A higher score is indicative of the severity of symptoms and insufficient functional status. The Boston Symptom Severity Scale (BQ-SS) is comprised of eleven items that assess the severity and frequency of symptoms, including nocturnal and diurnal muscle weakness, tingling, and numbness. The Boston Questionnaire Functional Scale (BQ-FS) comprises a series of eight inquiries designed to evaluate an individual's proficiency in executing various activities. Participants were asked to rate each item using a 5-point Likert scale, where a score of 1 indicated the absence of symptoms and a score of 5 indicated the presence of the most severe symptoms. The scale comprises five distinct possibilities, with each possibility being assigned a numerical value ranging from 1 to 5. In order to evaluate the intensity of symptoms and functional status, the mean scores were computed for each section.

Hand Grip Strength:

The handgrip strength of the participants was evaluated utilising a hand dynamometer (Baseline Dynomometer, New York, USA), while the pinch grip strength was examined utilising a pinch metre (Baseline Pinchmeter, New York, USA).

Cross–Sectional Area of Median Nerve:

Cross-sectional area (CSA) examinations were conducted on the affected wrist of patients with carpal tunnel syndrome (CTS), whereas a random selection of healthy individuals had either a unilateral or bilateral wrist examination. The assessment of all patients was carried out by a single operator, who utilised the established methodology to measure the diameter of the right major bronchus (RMB) at the level of the vertical tract. Additionally, the following parameters were collected: The cross-sectional area of the MN at the level of the proximal carpal row. Ultimately, the concept of major MN compression was established to encompass instances where compression of the median nerve occurs either at the proximal or distal region of the carpal tunnel.

Data Collection:
The data collection technique commenced with initial interactions and informal discussions between the researcher and participants, aimed at establishing a sense of ease and rapport between the two parties. The participants were initially recruited for the study in accordance with the predetermined criteria for inclusion and exclusion. Following the completion of the screening process, a signed informed consent was obtained from each participant. All participants were blinded to the group allocation. The participants were allocated into two groups using a random allocation method. Group 1, referred to as the Experimental group, was administered High Intensity Laser Therapy in combination with tendon gliding exercise and conventional therapy. On the other hand, Group 2, known as the Control group, received Ultrasound Therapy along with tendon gliding exercise. The participants were allocated to undergo therapy in a series of 1 session, with each session occurring at weekly intervals over a span of 10 weeks. The outcome measurements were carried out at two points: baseline, or the first week before the intervention, and the conclusion of the follow-up, or the 10th week. These measures included the utilisation of the Numerical Rating Scale (NRS), the BOSTON Questionnaire (BCQT), pinch and grip strength and ultrasonography.

High Intensity Laser Protocol:
The HILT group underwent HILT using the Republic of Korea's HILTERA 4.0 pulsed ND-laser YAG HT. Nd: YAG laser with a wavelength of 1064 nm was used for the laser treatment. Each subject received a radiating dosage of a 1064 nm, power laser given in pulsed mode to the skin overlaying the median nerve's path at the wrist. In one session, the patients received laser with a density of 6 J/cm2, a frequency of 20 Hz, a peak power of 8 W, a duty cycle of 70&, and a total energy of 2400 J. Therefore, each session in each hand involved the delivery of laser at specific locations along the median nerve's journey. This was done using a fibre optic probe with a 0.2 cm2 spot size. For 10 cm, the probe was moved in the direction of the nerve. In 10 weeks, this group underwent 10 sessions of laser therapy. This group received the allocation of 18 patients.

Ultrasound Therapy Protocol:
The experimental setup involved the utilisation of an Enraf Sonopuls 434 machine, which was coupled with aqua sonic gel as the couplant. Ultrasound therapy was administered to the carpal tunnel region for a duration of 5 minutes per session. The ultrasound waves were emitted at a frequency of 1 MHz, an intensity of 1.0 W/cm2, a pulsed mode duty cycle of 1:4, and a transducer area of 5 cm2. The equipment employed initially adhered to normal specifications, and an easy underwater radiation balance was utilised to regularly adjust the output. During a duration of ten weeks, a cumulative number of ten ultrasound treatments were administered.

Exercise Therapy Protocol:
An exercise program was created that was readily completed at home without the need to visit a designated location. During the first session, participants received instruction on how to do the exercises correctly. All groups underwent the identical, standardised Carpal Tunnel Exercise, or tendon gliding exercise, regimen. The workouts were performed three times a day in three sets of ten repetitions each. It was strongly encouraged to perform the exercises three times each day for 10 weeks to all patients who received an exercise booklet with the images, numbers, and sets of the exercises. It was requested that a family member attest that the patient completed the exercises at home. All patients were instructed to stop taking their prescriptions one week prior to the start of the study in order to standardise the medications used by participants.

4. RESULTS
Visual (histograms and probability graphs) and analytical (Shapiro-Wilk Test) techniques were used to assess the variables' adherence to the normal distribution. The format for descriptive statistics is meanSD. Because the variables had a normal distribution, parametric tests were applied while analysing the data. The paired t-test was used for comparisons within groups, while the unpaired T-test was used for comparisons between groups. The categorical variables were analysed using the 2 tests. For the variables confirmed to have a normal distribution, the Independent Groups T-Test was employed to determine the statistical significance between two independent

groups. The ANOVA was used to compare baseline demographic data's means values. The results were statistically assessed at the $p<0.05$ level and analysed at the 95% confidence level.

Normality Test:

Using the data, I collected, I conducted a normality test to assess the distribution of each variable before and after the intervention. The post-intervention grip strength and CSA exhibited a normal distribution in the pre-intervention and post-intervention groups of both the Ultrasound Group and HILT Group, as indicated by a p-value greater than 0.05. The post-intervention changes in the Numeric Rating Scale (NRS), Pinch Grip (PG), SSS (Symptom Severity Scale), and FSS (Functional Status Scale) in both groups are not normally distributed, as shown by a p-value of less than 0.05.

The changes of NRS score, BCQT score, pinch grip, grip strength and cross-sectional area in both the clinical and electrophysiological parameters groups were normally distributed in Ultrasound Therapy. Therefore, a paired sample *t*-test was run on the data. The change of grip strength score in Group 1 was not normally distributed. Therefore, a Wilcoxon Signed-Ranks test was run on the data. Firstly, the table reveals NRS score were significantly reduced in Group US from before (M=4.83, SD=1.58) to after the intervention (M=3.39, SD=1.79), t (17) =9.96, p-value less than 0.001 and in Group HILT from before (M=3.90, SD=1.37) to after the intervention (M=0.5, SD=0.61), t (19) =10.64, p-value less than 0.001. Secondly, Pinch Grip were significantly increased in Group US from before (M=6.19, SD=1.23) to after the intervention (M=10.0, SD=1.82), t (17) =-11.7, p-value less than 0.001 and in Group HILT from before (M=5.65, SD=1.09) to after the intervention (M=10.70, SD=2.27), t (19) =12.03, p-value less than 0.001.

Thirdly, Grip Strength were significantly reduced in Group HILT from before (M=20.64, SD=6.76) to after the intervention (M=24.95, SD=5.86), t (19) = 9.32, p-value less than 0.001 but not significantly reduced in Group US from before (M=20.81, SD=10.07) to after the intervention (M=21.42, SD=8.95), t (16) =0.17, p-value is 0.87. Next, the score value of SSS were significantly increased in Group US from before (M=14.11, SD=2.08) to after the intervention (M=12.06, SD=1.26), t (17) =6.27, p-value less than 0.001 and in Group HILT from before (M=12.95, SD=1.76) to after the intervention (M=11.0, SD=0.00), t (19) =4.95, p-value less than 0.001. Next, the score value of FSS were significantly increased in Group US from before (M=14.11, SD=7.58) to after the intervention (M=12.17, SD=6.25), t (17) =2.41, p-value less than 0.001 and in Group HILT from before (M=10.35, SD=2.64) to after the intervention (M=8.0, SD=0.00), t (19) =3.98, p-value less than 0.001. Lastly, the CSA were significantly increased in Group US from before (M=12.79, SD=1.12) to after the intervention (M=14.79, SD=1.27), t (17) =11.93, p-value less than 0.001 and in Group HILT from before (M=11.28, SD=0.99) to after the intervention (M=14.73, SD=1.01), t (19) =18.38, p-value less than 0.001.

Post intervention NRS score, BCQT score, pinch grip, grip strength and cross-sectional area in both the clinical and electrophysiological parameters group was normally distributed for both groups. Therefore, an independent t-test was run on the data as well as 95% confidence intervals (CI) for the mean difference. Therefore, a Mann Whitney test was run on the data. Firstly, the table shows that post intervention NRS scores were significantly different between Group US (M=3.39, SD=1.79) and Group HILT (M=0.5, SD=0.61) with p-value of 0.006. Next, post intervention Pinch Grip scores were also significantly different between Group US (M=10.0, SD=1.82) and Group HILT (M=10.70, SD=2.27) with the p-value of 0.31. Moreover, post intervention CSA were not significantly different between Group 1 (M=14.79, SD=1.27) and Group HILT (M=14.73, SD=1.27) with p-value of 0.86. Furthermore, post intervention Grip Strength scores were also not significantly different between Group US (M=21.42, SD=8.95) and Group HILT (M=24.95, SD=5.86), with p-value of 0.970. Next, post intervention SSS scores were also significantly different between Group US (M=12.06, SD=1.26) and Group HILT (M=11.0, SD=0.00) with the p-value of 0.01. Last, post intervention FSS scores were also significantly different between Group US (M=12.17 SD=6.25) and Group HILT (M=8.0, SD=0.0) with the p-value of 0.05.

5. DISCUSSION

The goal of the current study was to compare the effects of HILT and ultrasound therapy on the pain and function of carpal tunnel syndrome patients. Our results showed that HILT outperformed standard treatment in terms of lowering pain, enhancing function, and improving BOSTON scores. Additionally, after a 10-week follow-up, we saw significant differences between the groups on the VAS, BOSTON (total), pinch grip, grip strength, and CSA, all of which supported the HILT's efficacy.

In summary, it can be concluded that High-Intensity Laser Therapy (HILT) demonstrates greater efficacy compared to Ultrasound Therapy (US) in the treatment of Carpal Tunnel Syndrome (CTS), but with a limited improvement in the pinch grip strength value. One of the limitations of this study was to the limited sample size, as well as the inclusion of individuals with prior neurophysiological evaluations, uncontrolled repetitive hand and wrist movements, and diverse occupational backgrounds. In order to achieve best outcomes, Future research endeavours should prioritize well-designed randomized controlled trials (RCTs) with adequate sample sizes, standardized outcome measures, and long-term follow-up to address the existing research gap. These studies could contribute significantly to the optimization of therapeutic interventions for individuals suffering from Carpal Tunnel Syndrome, facilitating more informed clinical decision-making and improving overall patient outcomes.

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