

EFFECTIVE ULTRASOUND THERAPY AND NEURAL MOBILIZATION COMBINATIONS IN REDUCING HAND DISABILITIES IN CARPAL TUNNEL SYNDROME PATIENTS

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Abstract

Excessive activity in the hands and wrists over a prolonged period of time can cause repetitive strain injury, which leads to the occurrence of carpal tunnel syndrome. The purpose of this study is to determine the differences in the effectiveness of ultrasound therapy and neural mobilization interventions with ultrasound therapy and passive stretching in reducing hand disabilities in patients with carpal tunnel syndrome. It is an experimental study, using the pre- and post-test control group design. The sampling technique employed was simple random sampling, with a study sample comprising 30 people. The difference test with an independent t-test showed a significant difference between the control group and the treatment group ($p= 0.000$), with a decrease hand disability percentage of 7% in the control group and 15% in the treatment group. Based on the results, it can be concluded that the combination of ultrasound therapy and neural mobilization is more effective in reducing hand disability than a combination of ultrasound therapy and passive stretching in patients with carpal tunnel syndrome.

Keywords: carpal tunnel syndrome, hand disability, neural mobilization, passive stretching, ultrasound therapy

Abstrak

Kombinasi Ultrasound Therapy dan Neural Mobilization Efektif dalam Menurunkan Disabilitas Tangan pada Penderita Carpal Tunnel Syndrome. Aktivitas yang berulang pada pergelangan tangan apabila berlangsung lama dapat menimbulkan repetitive strain injury yang berujung terhadap terjadinya carpal tunnel syndrome. Tujuan dari penelitian ini adalah untuk mengetahui perbedaan efektivitas intervensi ultrasound therapy dan neural mobilization dengan ultrasound therapy dan passive stretching dalam menurunkan disabilitas tangan pada pasien carpal tunnel syndrome. Penelitian ini merupakan penelitian eksperimental dengan menggunakan rancangan penelitian pre-test and post-test control group design. Teknik pengambilan sampel dalam penelitian ini dengan cara simple random sampling. Sampel penelitian pada penelitian ini berjumlah 30 orang. Uji beda selisih dengan independent t-test menunjukkan adanya perbedaan yang bermakna antara kelompok kontrol dan kelompok perlakuan ($p= 0,000$) dengan persentase penurunan disabilitas tangan sebesar 7% pada kelompok kontrol dan 15% pada kelompok perlakuan. Berdasarkan hasil penelitian dapat disimpulkan bahwa kombinasi ultrasound therapy dan neural mobilization lebih efektif dalam menurunkan disabilitas tangan daripada kombinasi ultrasound therapy dan passive stretching pada pasien carpal tunnel syndrome.

Kata Kunci: carpal tunnel syndrome, disabilitas tangan, neural mobilization, passive stretching, ultrasound therapy

Introduction

In daily life, humans often carry out repetitive activities involving hands. Such excessive activity can trigger repetitive strain injury (RSI), and frequent injuries to the hands can lead to carpal tunnel syndrome (CTS). CTS is a median nerve neuropathy in the upper limbs caused by

an increase in pressure on the carpal tunnel, which triggers pressure on the median nerve (Rambe, 2004). Based on data from the United States national health survey in 2010, the prevalence of CTS was recorded at 8% and those related to employment were 2.1% (Lim, Chee, Girdler, & Lee, 2017). The incidence of CTS is estimated to be 0.6% in men and 5% in women;

in the United States, there are 1–3 cases per 1,000 population per year. In the UK the incidence rate is higher, at 70–160 cases per 1,000 people, while in the Netherlands there are 2.5 cases per 1,000 people per year (Dewi & Khotimah, 2017).

Patients who experience hand disorders in the form of CTS can be given pharmacological and non-pharmacological therapy in an effort to reduce pain, which is one of the symptoms that patients suffer (Daryono, Wibawa, & Tianing, 2014). Non-pharmacological therapy to reduce pain includes the use of physiotherapy modalities such as ultrasound therapy (US) and exercise therapy in the form of neural mobilization and passive stretching. US and passive stretching are physiotherapy treatments that are commonly used clinically, while neural mobilization interventions are new methods of physiotherapy interventions.

Ultrasound therapy interventions whereby thermal effects provide local heat to joint capsules, tendons, ligaments or muscles can result in increased cell activity and vasodilation of blood vessels that provide added nutrients and oxygen, and also facilitate the transport of metabolic waste back to the heart, resulting in decreased tip irritation nociceptive nerve endings and consequently reduced pain. The effect of heat will increase tissue temperature, causing an increase in elasticity and reducing the viscosity of collagen fibers, thereby increasing the scope of joint motion. US will not affect the process of tissue repair, but will accelerate the process of fibrotic tissue repair by accelerating the induction of controlled inflammatory substances. This, in turn, will accelerate the process of proliferation and consequently the formation of new tissue, which will be followed by an increase in the pain excitatory threshold and a decrease in tissue adhesion. This will have an impact on pain reduction and increase flexibility as well as the range of motion of the joints of the arm, leading to increased functional activity ability and decreased disability (Prentice, 2009).

When the muscles are stretched and elongated, the strength of the strain is transmitted to the muscle fibers through the connective tissue (endomysium and perimysium) around the muscle fibers. Molecular interactions link these non-contractile elements to the contractile unit of the muscle, the sarcomere. During passive stretching, longitudinal and lateral force transduction occurs. When stretching is applied to muscle-tendon units, either quickly or over long periods, the primary and secondary afferents of intrafusal muscle fibers detect changes in length and activate extrafusal muscle fibers through alpha motor neurons in the spinal cord, thereby activating stretch reflexes and increasing (facilitating) tension in the muscles being stretched. Increased tension causes resistance to elongation and in turn is considered to promote the effectiveness of stretching procedures. When the stretch reflex is activated in the extended muscle, decreased activity (inhibition) of the muscle on the opposite side of the joints, referred to as autogenic inhibition, can also occur (Kisner & Colby, 2012).

Neurodynamic techniques can improve mechanical functions in nerve structures, such as tension and sliding functions. When the nerve structure experiences clamping and disrupts mobility, pain will occur along the nerve. Neurodynamic sliding techniques play a major role in improving blood circulation and axonal transport, as well as increasing nerve integrity and reducing the pressure caused by intraneural and extraneural fibrosis (Shacklock, 2005). Neural mobilization aims to mobilize peripheral nerve tissue and surrounding structures, thus affecting the mechanical properties of the peripheral nerves. Physiotherapy uses this technique for the management of different nerve tissue compression disorders and other disorders that may include neuropathic pain in order to restore the disrupted nerve tissue mechanical function. Many theories explain about the benefits of neural mobilization, including increased circulation within the nerve; axoplasmic flow; improved the viscoelasticity of nerve connective tissue; dispersion

of intraneural edema; reduction in sensitization from the dorsal horn; supraspinal sensitization; and improved nerve travel (ELDesoky & Abutaleb, 2016).

Methods

The Health Research Ethics Commission, Research and Development Unit, Faculty of Medicine Udayana University - Sanglah Hospital has provided ethical approval for this study with Number 2054/UN14.2.2.VII.14/LP/2018. It is an experimental study, with a randomized pre-test and post-test control group design. The study sample was divided into two groups and chosen randomly. The research locations were several physiotherapy practice clinics in City X. The treatment was performed three times a week from October to November 2018.

The target population were all patients who had carpal tunnel syndrome while the accessible population involved in this study are all patients who have carpal tunnel syndrome in City X. The study population needed to meet the following inclusion criteria: (1) they were patients with carpal tunnel syndrome, male or female, and 30–50 years old; and (2) they volunteered to take part in the research by signing an informed consent form. The exclusion criteria included: (1) the presence of musculoskeletal injuries such as fractures, sprains and other injuries in the arm area; (2) experiencing of postural abnormalities and spinal structures; and (3) the presence of anatomical deformities or abnormalities in the hand. Finally, the drop-out criteria established were: (1) if the patient fell ill or was injured while the data collection was taking place; and (2) if the patient did not take part in the exercises more at least three times.

The sample selection was chosen by the consecutive sampling technique from patients indicated to have carpal tunnel syndrome, who were visiting the physiotherapy clinic in City X at the time of the study, and met the inclusion and exclusion criteria. The sample size was 30 people, who were divided into two groups by random

allocation. The treatment group was given ultrasound intervention and neural mobilization, while the control group was given ultrasound therapy intervention and passive stretching.

In the study, ultrasound therapy was used at a frequency of 1 MHz, with continuous current, at an intensity of 0.5W/cm² for 1 minute. Passive stretching in relation to the carpal tunnel syndrome condition is a stretching technique performed by the therapist on the patient's hand; in this case, the stretching of the flexor wrist muscles. This position is held for 30 seconds and repeated four times, and the procedure is repeated three times per week. Neural mobilization exercises involve stretching or stretching actions on the nervous system and aim to help develop nerve tissue movements through joint movements, such as those of the shoulders, elbows, hands and wrists. The exercise consists of two movements: (1) glenohumeral abduction, wrist extension, and supination, and (2) elbow extension, wrist extension, and cervical counter lateral movement. The application is repeated three times per week, with each movement carried out for three sets with ten repetitions and held for three seconds at the end of the movement.

To measure the level of disability of the CTS patients, the Wrist and Hand Disability Index (WHDI) was employed, which is able to evaluate related problems. The questionnaire consists of ten assessment points, namely pain intensity, numbness and tingling, strength, sleep, writing or typing tolerance, self-care, work, homework, driving, and recreation/sports. Each point is valued on the scale of 0–5; a value of 0 means no interference, and a value of 5 is experienced by the high interference.

Results

Sample Characteristic Data. The sample characteristics based on age and sex can be seen in Tables 1 and 2. Table 1 shows that the treatment group had an average age of 37.80, with that of the control group 37.67. Table 2 shows that the subjects of the control and treatment groups were

Table 1. Distribution of Sample Data by Age

Characteristic	Average Value and Standard Intersection			
	Treatment group		Control group	
	Average	Standard Intersection	Average	Standard Intersection
Age	37.80	5.074	37.67	6.079

Table 2. Distribution of Sample Data Based on Gender

Characteristic	Treatment group		Control group	
	N	%	N	%
Male	1	6.7	3	20
Female	14	93.3	12	80

Table 3. Normality and Homogeneity Test Results for the Disability Values of Hands Before and After Intervention

Data Group	Test for Normality with the Shapiro-Wilk Test				Homogeneity results with Levene's test
	Treatment group		Control group		
	Average ± SD	p	Average ± SD	p	
WHDI Before	13.07±11.78	0.647	13.33±11.09	0.315	0.882
WHDI After	5.27±17.78	0.169	10.07±9.78	0.122	0.441
WHDI Difference	7.80±9.31	0.666	3.27±2.92	0.144	0.088

Table 4. Paired Sample T-Test Results

Data Group	Before Intervention Mean±SD	After Intervention Mean±SD	p
Control group	13.33±3.33	10.07±3.12	0.000
Treatment group	13.07±3.43	5.27±4.27	0.000

Table 5. Test Results for the Difference in Decreased Hand Disability after Intervention

	Group	Average±SD	n	p
Difference in Decrease in Hand Disability	Treatment	7.80±3.05	15	0.000
	Control	3.27±1.71	15	

dominated by females, with 12 (80%) in the control group and 14 (93.3%) in the treatment group.

Normality and Homogeneity Tests. Normality was tested using the Shapiro-Wilk test, while homogeneity was tested using Levene's test. Based on Table 3, the probability values for the two groups are normally distributed ($p > 0.05$) both before and after, and in terms of difference. The homogeneity results with Levene's test

also showed homogeneous data on the value of the disability of the hands before, after, and in terms of difference ($p > 0.05$). Based on the results of the two tests, the study hypothesis was tested using the parametric statistical test.

Mean Difference Test for Reduced Disability of Hands Before and After Intervention. The mean decreases in the value of hand disability before and after the administration of intervention

Table 6. Percentage of Decreased Hand Disability

Analysis Results	Treatment group	Control group
Hand Disability Before Intervention	13.07	13.33
Hand Disability After Intervention	5.27	10.07
Difference	7.80	3.27
Percentage (%)	15%	7%

or exercise in both study groups was tested by a paired sample t-test. Based on Table 4, the average difference in the value of hand disability decreased in the control and treatment groups, with a value of $p=0.000$ ($p<0.05$), which means that there are significant differences in the value of hand disability before and after intervention.

Test for the Difference in the Reduction in Hand Disability after Intervention in the Control Group and Treatment Group. A comparison of the mean difference in the decrease in hand disability was measured by the wrist and hand disability index (WHDI) in both groups; the treatment group was given ultrasound therapy and neural mobilization intervention, while in the control group the ultrasound therapy and passive stretching intervention was tested using the independent sample t-test.

Table 5 shows the results of the calculation of the difference in the decrease in disability in hands, with a p-value of 0.000 ($p<0.05$) in the difference before and after intervention. This shows that there was a significant difference in the decrease in hand disability between the ultrasound and neural mobilization interventions and the ultrasound therapy and passive stretching interventions. Table 6 shows that the percentage reduction in the average hand disability as measured by WHDI in the treatment group was greater than in the control group.

Discussion

The Effectiveness of the Combination of Ultrasound Therapy and Passive Stretching in Reducing Hand Disability in CTS. Based on the statistical test results of the decrease in hand disability before and after being given a combi-

nation of ultrasound therapy and passive stretching, p-value 0.000 ($p<0.05$) means that there are significant differences in that group. This is in line with research by Awan, Babur, Ansari, and Liaqat (2014), who found that stretching the flexor retinaculum can reduce pain, improve paresthesia assessment scale scores, and increase muscle strength in CTS patients. Besides, Hafez, Alenazi, Kachanathu, Alroumi, and Mohamed (2014) established that stretching can increase the range of flexion and extension of the wrist joints and increase grip strength.

When the muscles are stretched and elongated, the strength of the strain is transmitted to the muscle fibers through connective tissue (endomysium and perimysium) around the muscle fibers. Molecular interactions link these non-contractile elements with the contractile unit of the muscle, the sarcomere. During passive stretching, longitudinal and lateral force transduction occurs. When stretching is applied to muscle-tendon units, either quickly or over long periods, the primary and secondary afferents of intrafusal muscle fibers detect changes in length and activate extrafusal muscle fibers through alpha motor neurons in the spinal cord, thereby activating stretch reflexes and increasing (facilitating) tension in the muscles being stretched. Increased tension causes resistance to elongation and in turn is considered to promote the effectiveness of stretching procedures. When the stretch reflex is activated in the extended muscle, decreased activity (inhibition) of the muscle on the opposite side of the joints, referred to as autogenic inhibition, can also occur (Kisner & Colby, 2012).

The Combination of Ultrasound Therapy and Neural Mobilization is Effective in Reducing Hand Disability in CTS. Based on the statistical

test results on the decrease in disability of hands before and after the combination of ultrasound therapy and neural mobilization, p-value 0.000 ($p < 0.05$), which means that there are also significant differences in the group. This is in line with research by Asal, Elgendy, Ali, and Labib (2018), who examined the effectiveness of neural mobilization in CTS patients, and the intervention was applied three times per week for two weeks. Significant improvements were seen in pain levels, together with improvement in upper limb function, as measured using the upper extremity functional scale (UEFS). Neurodynamic plays an important role in pain management and increases the mobility of nerve roots. When the nerve root is under pressure and microcirculation is disrupted, the pressure on the nerve root can cause edema and demyelination. Neurodynamic techniques involving short oscillations have been shown to reduce edema and thus reduce hypoxia and its symptoms (Cleland, Childs, Palmer, & Eberhart, 2006; Bertolini, Silva, Trindade, Ciena, & Carvalho, 2009).

Neurodynamic techniques can help reduce nerve compression, frictional force, and tension forces, thereby reducing mechanical sensitivity to the nervous system. Such techniques can also improve mechanical functions in nerve structures, such as tension and sliding functions. When the nerve structure experiences clamping and is impaired in terms of mobility, pain will occur along the nerve. Neurodynamic sliding techniques play a major role in improving blood circulation and axonal transport, as well as improving nerve integrity and being able to reduce the pressure caused by intraneural and extraneural fibrosis. During normal movement, nerve blood moves constantly along with distortion that occurs in blood vessels and nerves. When the nervous structure becomes irritated, there will be an increase in tension (neural tension) due to tissue fibrosis. It is known that some of the effects of nervous tension include reduced intraneural blood flow (by 8–15%), ischemia of nerve tissue, and decreased nerve conductivity. Neurodynamic techniques can improve the mechanical function of nerves in terms of flexibility

through tension techniques, thus increasing the ability of nerve structures to withstand tension loads without producing tissue hypoxia (Shacklock, 2005).

The Combination of Ultrasound Therapy and Neural Mobilization is more Effective than the Combination of Ultrasound Therapy and Passive Stretching in Reducing Hand Disability in CTS. Based on the results of the statistical tests conducted, it can be seen that the results of the calculation of the difference in the decrease in hand disability obtained a p-value of 0.000 ($p > 0.05$) in the difference between pre and post-intervention. This means that there is a significant difference in the decrease in hand disability between ultrasound therapy and neural mobilization interventions and ultrasound therapy and passive stretching ones. The average percentage reduction in hand disability as measured by the wrist and hand disability index (WHDI) over one week shows that the reduction in the treatment group was greater than in the control group. Therefore, ultrasound and neural mobilization interventions are effective in reducing hand disability in carpal tunnel syndrome sufferers by 15%, whereas ultrasound interventions and passive stretching result in a 7% decrease. The results of this study are consistent with research conducted by Setiyaningrum (2015), who found that ultrasound and neural mobilization interventions were better than laser and neural mobilization in reducing disability in CTS cases.

The application dose of ultrasound therapy is based on the application of the frequency, mode and intensity application. At greater frequencies, more oscillation occurs and increased effort is needed for the sound waves to pass through molecular friction. This means that more energy is absorbed in superficial tissue and less is available for transmission to deeper tissue. Generally, the 3 MHz frequency is chosen, with a tissue target reaching 1–2 cm from the body surface, while the 1 MHz frequency is used for deeper tissue which is more than 2 cm from the skin surface. Ultrasound therapy is used to in-

crease tissue extensibility. Tendon tissue is a network that receives ultrasound therapy wave penetration faster because it has greater collagen content than muscle. Chan, in Michlovits, Bellew, and Nolan (2012), describes the effect of heating with an ultrasound therapy frequency of 3 MHz at an intensity of 1.0W/cm² for 4 minutes on an uninjured patellar tendon. When the area is treated twice the effective radiating area (ERA) the average increase in temperature in the tendon is 8°C (14.4°F) shortly after being given therapy, which does not return to baseline for 20 minutes post-treatment, while the therapeutic area (4xERA) temperature rises by 5°C (9°F) and returns to the baseline after 15 minutes. When tissue temperature rises by 4°C (7.2°F), this condition is very important in improving the extension of connective tissue. It is suggested to do the stretching in this session or to be called the "window of opportunity." In this study, the application (2xERA) made the temperature rise by more than 4°C (7.2°F) after 4 minutes of therapy time, so it is best to stretch afterward.

As a result of various human movements, various types of mechanical stress are absorbed into the nervous structure. When nerves experience compressive, tensile or shear forces that exceed their capacity, circulation within the nerve and axoplasmic flow are blocked, which causes ischemia and impaired function. Compression of the peripheral nerves can cause motor and sensory dysfunction. Moreover, compression of nerve structures causes some changes in the microvascular circulation of the nerve and facilitates the release of several inflammatory mediators that cause pain. Consequently, adhesion is formed between the nerve roots and the structure of the injured tissue as a result of inflammation, which causes traps in the nerve structure. Besides, intraneural edema, nerve conduction blocks, and mechanical sensitization are associated with compression of nerve structures (ELDesoky & Abutaleb, 2016).

Various physiotherapy interventions such as exercise, manual therapy and electrotherapy ha-

ve been used for the treatment of nerve compression. Neural mobilization aims to mobilize peripheral nerve tissue and surrounding structures so that it affects the mechanical properties of the peripheral nerves. Physiotherapy uses this technique for the management of different nerve tissue compression disorders, and other disorders that may include neuropathic pain, to restore the disrupted nerve tissue mechanical function. Many theories explain the benefits of neural mobilization, including increasing circulation within the nerve, axoplasmic flow, the viscoelasticity of nerve connective tissue, dispersion of intraneural edema, reduction of sensitization from the dorsal horn, supraspinal and supraspinal sensitization, and improving nerve travel (ELDesoky & Abutaleb, 2016). Other studies report that nerve mobilization has a hypoalgesic effect on c-fiber that sends pain signals after the application of several nerve mobilization techniques to the median nerve. Researchers believe that this hypoalgesic effect might be caused by inhibition of pain signals in the dorsal horn (Beneciuk, Bishop, & George, 2009).

Conclusions

Based on the results, it can be concluded that the combination of ultrasound therapy and neural mobilization is more effective in reducing hand disability than a combination of ultrasound therapy and passive stretching in patients with carpal tunnel syndrome.

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