Efficacy of Neurodynamic and Wrist Glide Exercises on Management Carpal Tunnel Syndrome

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Abstract

Background: The most common peripheral nerve compression disorder worldwide is CTS which, commonly demand surgery which may be costly and risky. Therefore, some techniques such as neurodynamic exercise and wrist glide exercises have not been researched for a possible improvement of symptoms and hand function in patient with CTS.

Objective: A quasi- experimental study was used in this study to compare the neurodynamic wrist exercises and wrist glide exercises on severity of symptoms, range of motion and hand functions of adults with mild to moderate chronic carpal tunnel syndrome.

Methods: Four weeks of a comprehensive intervention starting on the day of diagnosis was completed by thirty-four adult patients who received a diagnosis of mild to moderate CTS affecting 34 affected hands that met the inclusion criteria. This study was taken before and after the intervention with the help of Visual Analog Scale (VAS), and Boston Carpal Tunnel Questionnaire (BCTQ), which includes the Symptom Severity Scale (SSS) and Functional Status Scale (FSS).

Results: The study showed significant improvements in pain, symptoms severity, functioning capability, as well as the range of wrist movements offered by Neurodynamic Wrist Exercises in Carpal Tunnel Syndrome. The degree of pain was determined by VAS; it started at an average of 7.81 before the intervention and reduced to 2.34; statistically significant value of 'p' < 0.05. The mean score of SSS reduced from 31.14 _ 1.06, to 19.56 _ 0.58, p < 0.001 and FSS reduced from 26.86 _ 0.69, to 17.23 _ 0.67, p < 0.001. The post intervention of wrist ROM also demonstrated significant changes, in which flexion increased from 73.14° to 77.04° and extension improved from 69.18° to 77.12° as well (F = 28.126, p < 0.001). Improve ulnar and radial deviations also support the effectiveness of this therapy method in decreasing and eliminating the signs and symptoms of persons with carpal tunnel syndrome, and enhancing the functional results in those individuals.

Conclusion: These findings should be of significant interest in supporting its use of neurodynamic wrist exercises and hand glide exercises as part of the management of CTS. This brings the current research within the physiotherapy CTS literature – particularly in relation to lateral wrist denervation – firm footing by providing evidence of the therapeutic potential of these interventions. It also stresses for further studies on more enhanced exercise schedules and assessment of the effectiveness of exercising routines.

Keywords: Carpal tunnel syndrome, Neurodynamic wrist exercises, Glide exercises, Hand function.

Introduction

Carpal Tunnel Syndrome is an ailment brought about by maximum median nerve entrapment underneath the carpal tunnel which is formed from ligaments and bones just beneath the palm of the hand [1]. Nerve injury is also common in gastric bypass surgery and symptoms like numbness and tingling, weakness, and muscle problems. This is what, according to the study conducted by Rüsch et al in 2021, is believed to be caused by compression of the median nerve within the carpal tunnel. The second postulates that the repeated movement movement, particularly during sleep positions, is probably at the root of non-occupational CTS. These genetic factors are assumed to have a causative impact on CTS [2].

CTS is usually linked with repeatedly keeping the wrists in the same positions or making repetitive wrist movements, medical conditions such as diabetes or rheumatoid arthritis. That can potentially worsen the compression of the median nerve and the manifestation of symptoms [1].

Idiopathic CTS as a valid medical ailment of compressed median nerve in the carpal tunnel with no apparent cause. Differences between the general and scientific understanding of the etiology of CTS have also been discussed. Possible risk factors of idiopathic are vitamin B6 deficiency, tenosynovitis, typing/computer use [3].

According to literature, the global prevalence rate of CTS is between 4% and 5% . The most common type of peripheral neuropathy is CTS which affects population around the world [4]. Some researchers followed the prevalence rate by Garcia et al. (2022) where the incidence of CTS constituted 3.1% in women and 2.6% in men. It is not unanimously distributed among the population, although its incidence ranges from 3.72 % to 7.8%. All incidence rates are expressed as new cases per 100,000 person/years varying between 2.3 and 227.2. Gender; marital status; and age, as well as occupational exposure – as mentioned by Dale et al. in 2013 – all affect these rates.

Symptoms of carpal tunnel syndrome usually develop in three progressive stages distinguished by clinical features. There is also transient tingling and oedema of the hand at the start and these are most aggravated in the morning as LH [5]. But there could also be discomfort that arises from the wrist and travels up to the shoulder. The second stage of CTS is characterized by increased symptoms that are ongoing and worst than the early stages. Repetitive motions involving the hand or wrist are the most common causes of this kind of injury. This further supports the fact that symptoms get worse with usage of the affected hand, an implication that the CTS is progressive in nature [6].

In the last stage of CTS; patients exhibit considerable functional loss as depicted by such changes such as severe pain and thenar eminence atrophy. This stage is marked by the build-up of pressure within the carpal tunnel and the gradual degeneration of many of the structures found within the tunnel leading to clear deficits in motor function and sensations [7]. According to Joshi et al., 2022, CTS patients with complication to an advanced extent report lower capability to conduct simple tasks using the affected hand, indicating the pervasiveness of the illness's impact on activity.

The diagnosis of the CTS is mainly reached clinically by the assessment of the patient medical history and examination. Nerve conduction studies and EMG is utilised to objectively measure impaired function of the median nerve and confirm the diagnosis of CTS by clinical examination [8,9]. Neuromuscular ultrasound imaging enables the detection of disease conditions because of enlarged nerve calibre and other structural abnormalities that might lead to median nerve compression in the carpal tunnel [8].

The flick sign, Phalen maneuver, and the median nerve compression test are the most typical diagnostic tests used in patients with CTS [10]. Altogether, these tools provide an explicit, fully-fledged approach for the diagnosis of CTS. Physiotherapists do participate early in the process of diagnosing CTS through efficient physical tests and functional examination. Using an assortment of tests and measures, they assess the force in wrist as well as the range of motion and dexterity of the wrist that can help in deciding on the question of the extent of the involvement of the median nerve [10].

The main therapy for mild to moderate CTS is physiotherapy. Jiménez-del-Barrio et al. (2022) also found that physiotherapy should be used in the management of CTS related symptoms [11]. As noted by Tulipan and Ilyas (2020), physiotherapy strategies entail soft tissues mobilizations, splinting, carpal

bone manipulations, therapeutic ultrasound, tendon and nerve sliding exercises, neurodynamic techniques [12]. Surgical management should be considered in patients with chronic conditions when conservative measures have failed, though Alhusain et al. (2019) consider it the last resort since it brings about risk and outcome. But few investigation has been done towards neurodynamic exercises, therefore, more research should be conducted to establish the feasibility, effectiveness and role of neurodynamic exercising in medical management of CTS [13].

The objective of this study was to establish whether neurodynamic wrist exercises offer themselves as effective physiotherapy interventions for CTS symptoms. The research describes the impact of these activities in patients' quality of life, post-stroke motor performance and pain relief in CTS patients. While evaluating the efficiency of neurodynamic wrist exercises, the present study was intended to provide useful measures for considering one form of physiotherapy treatment plan for CTS as well as contribute to the handling of this frequently observed as well as important medical condition.

Materials and Methods

A quasi-experimental study design was employed to examine the efficacy of neurodynamic wrist exercises and wrist glide exercises on symptoms and hand functionality in individuals diagnosed with carpal tunnel syndrome. The investigation was carried out at two accredited physiotherapy and rehabilitation centers in Bethlehem, Palestine. Two centers were utilized for the patient's convenience from September 2024 to November 2024.

The study included adult males and females who had been diagnosed with mild to moderate CTS and had either unilateral. The following sections provide a comprehensive explanation of the sampling techniques and considerations for determining the appropriate sample size.This study has adopted purposive sampling technique, whereby the participants must have characteristics as required by the research. People with mild and moderate carpal tunnel syndrome were included and recruited from hospitals and outpatient facilities. For carpal tunnel syndrome, the symptoms had to reach clinical diagnosis level, to allow utilizing nerve conduction studies or electromyography for confirmation.Specialists from the different fields of medicine in Hebron Governorate were involved in the recruitment process, including orthopedic doctors, neurologists and those from the rehabilitation

centers, physiotherapist and occupational therapist. These practitioners were informed of the inclusion and exclusion criteria for the study and referred eligible patients to the principal investigator until the sample size for November 2024 was achieved.This approach have the potential of increasing the internal validity of the study findings given the fact that only participants with given characteristics were allowed to take part in the study. These issues are also solved by the collaboration with multiple medical specialists across different types of healthcare settings Since the study samples are different for each setting, this diversification of the samples allows increasing external validity of the results.

For this study, 34 patient of either gender, more than 18 years old and diagnosed with mild or moderate CTS were chosen to participate. These patients had symptoms that involved the upper radical of the affected side either left hand right hand or both. With the projected CTS rates in the selected population in mind, the sample size of this study was believed to be size sufficient to achieve the objectives of the research and ensure that the power of the statistical tests would be sufficient to point out significant differences in the treatment effects.

The inclusion criteria are adults 18 years and older, gender: males and females, mentally able to comprehend and follow simple verbal commands or instructions, patients without any previous surgical intervention for cts, patients who have not undergone any recent treatment specifically targeting cts and patients who are willing to give informed consent to participate in the study.

The exclusion criteria are Patients with severe CTS symptoms, patients with other underlying neurological conditions that may influence hand function or contribute to similar symptoms, patients who are pregnant, patients with a history of wrist or hand trauma or injury that could impact the effectiveness of the exercises, patients with severe cognitive impairments or communication difficulties that would hinder their ability to follow the exercise protocol, patients currently undergoing other treatments specifically targeting CTS (e.g., steroid injections), patients with any contraindications or medical conditions that make the exercises unsafe or unsuitable for them and patients unwilling to commit to the study's required evaluations and assessments.

Tools

Visual analog scale (VAS) is used to assess the level of pain that a patient is currently experiencing. The pain scale, is commonly referred to as a bi-directional scale on either a vertical or horizontal axis with 0 representing no pain and 10 representing the most intense pain (Appendix III). Research has shown that the use of the VAS on paper is a reliable, precise, consistent, and replicable approach for assessing the degree of pain [14].

Boston Carpal Tunnel Questionnaire (BCTQ): The Boston Carpal Tunnel Questionnaire was created in 1993 as an internationally recognized tool for evaluating symptoms and functional limitations related to CTS (Appendix IV). The method includes two validated scales: the Symptom Severity Scale (SSS) and the Functional Status Scale (FSS) (Multanen et al., 2020).

The SSS assesses the severity and duration of common symptoms of CTS, such as pain, tingling, numbness, and weakness in the hand and wrist that are afflicted. Clinicians are provided with a measurable indicator of symptom intensity by rating responses on a five-point scale, which ranges from 1 (mildest) to 5 (most severe) [15,16].

Simultaneously, the FSS assesses the influence of CTS on normal daily duties and physical capabilities, such as writing, grasping items, and carrying out everyday tasks. Responses are evaluated using a five-point scale, ranging from 1 (indicating no difficulty) to 5 (indicating extreme difficulty or inability to perform) [15,16].

Both scales are extensively employed in clinical practice and research to facilitate treatment decisions and track the progression of CTS over time. The reliability and validity of the BCTQ have been thoroughly verified using traditional test theory and longitudinal validation methods. This makes it a reliable tool for evaluating the effectiveness of therapies and quantifying the impact of symptoms on patients' quality of life [15,16].

Range of Motion : Having a sufficient ROM in the wrist is essential for preserving functional capabilities in everyday activities and work-related duties. Sufficient ROM accurate and precise movements that are crucial for activities like typing, writing, and gripping items. Additionally, it has a crucial function in minimizing rigidity, enhancing blood flow, and decreasing the

possibility of musculoskeletal problems. Whether in therapeutic or occupational settings, maximizing wrist and hand ROM improves overall ability and productivity, emphasizing its essential role in preserving quality of life and independence in daily activities [17].

The entire ROM for the wrist and hand joints was evaluated before and after the treatment. Three repetitions of each ROM were measured, and the mean value was recorded (Appendix V). The typical parameters for wrist mobility are as follows: The recommended range of motion for wrist flexion is between 80° and 90°, whereas for wrist extension it is between 70° and 90° . The radial deviation usually has an angle of 15°, and ulnar deviation can vary between 30° and 45° [18].

Data Collection

In accordance with specified inclusion and exclusion criteria, which were confirmed by symptomatology and diagnostic techniques such as nerve conductivity testing and electromyography, participants were selected. Then, using a variety of tools, including the Visual Analog Scale (VAS), Phalen's Test, Reverse Phalen's Test, Tinel's Test, Boston Carpal Tunnel Questionnaire (BCTQ) and wrist range of motion (ROM), they were evaluated, diagnosed, and assessed.

After being fully informed about the benefits and possible risks of the research, both orally and in writing, all participants gave written informed consent. The process of gathering data was carefully documented and then statistically examined. Three physiotherapy sessions each week were part of the four-week treatment program. The trial took place from September 2024 to November 2024, a span of more than 2 months in total.

Results

In this study, thirty people who had been identified with carpal tunnel syndrome were carefully examined to see how well neurodynamic wrist exercises worked as an intervention. The first study showed that the participants 58% being men and 42% being women. Upon closer examination of the sample composition, it was found that most of the participants (65% of the total) were now working, while the remaining 35%

were not working. The people who took part in the study were, on average, 35 years old, 171 cm tall, and 73 kg weighty. In addition, the subjects' Body Mass Index (BMI) was found to be 27.17 (Table 4.1).

The Phalen test showed that only 14% of the patients still had clear signs that they had symptoms of carpal tunnel syndrome. The other 86% had negative results. On the other hand, none of the patients showed any signs on the Reverse Phalen test after the intervention. Additionally, Tinel's test results showed that only 7.5% of patients continued to show positive signs, while 92.5% of them showed negative results.

From the sample, it was found that 21 out of the subjects (62%) had symptoms in their right hand and 13 out of them (38%), in their left hand.

Table 4.1: participants' demographic characteristics

Variable	Mean ± SD
Age (years)	35.12 ± 7.88
Height (Cm)	171.18± 9.67
Weight (Kg)	73.10 ± 11.51
BMI (kg/Cm32	27.17 ± 2.54

According to Table 4.2 and Chart 1, the results strongly support the idea that neurodynamic wrist movements can help a lot with relieving the symptoms of carpal tunnel syndrome. After the intervention, the average Visual Analog Scale (VAS) scores went from 7.81 before the intervention to 2.34 after it, which shows that the amount of pain went down a lot. With a p-value of less than 0.05, the study showed that the decrease was statistically important.

Table 4.2: Comparison between pre- and post VA Sscores (n=34)

	Pre- treatment	**Post-treatment**	**P- value**
	Mean ± SD	**Mean ± SD**	

VAS	7.81 ± 1.66	2.34±1.77	<0.001

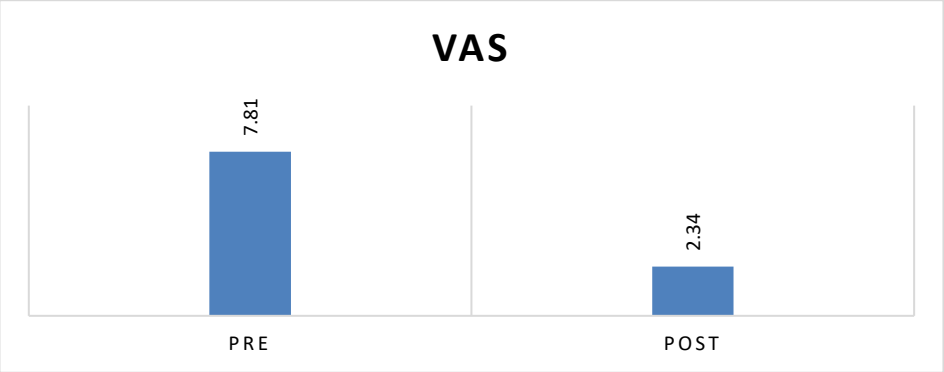

Chart 1: Comparison of average VAS Scores before and after intervention

The results of Symptom Severity Scale (SSS) and the Functional Status Scale (FSS) can be found in Table 4.3 and Chart 2. Both of these scales are used to measure how bad a person's symptoms are. With p-values less than 0.001, both the SSS and the FSS showed a significant difference between the ratings done before and after the intervention. The patients' mean SSS score before treatment started was 31.14, which shows how bad their symptoms were. A post-treatment average score of 19.56 shows that the severity of the symptoms got a lot better after the therapy. Additionally, the FSS scores also got a lot better, going from an average of 26.86 before treatment to an average of 17.23 after intervention. According to the study's results, the therapeutic intervention had a big impact on easing the severity of symptoms and making people more useful.

Table 4.3:Means of pre and post symptom severity and functional status scores

	Pre- treatment	**Post-treatment**	**P- value**
	Mean ± SD	**Mean ± SD**	

BCTQ-SSS	31.14± 5.20	19.56±4.12	<0.001
BCTQ-FSS	26.86± 2.10	17.23± 2.83	<0.001

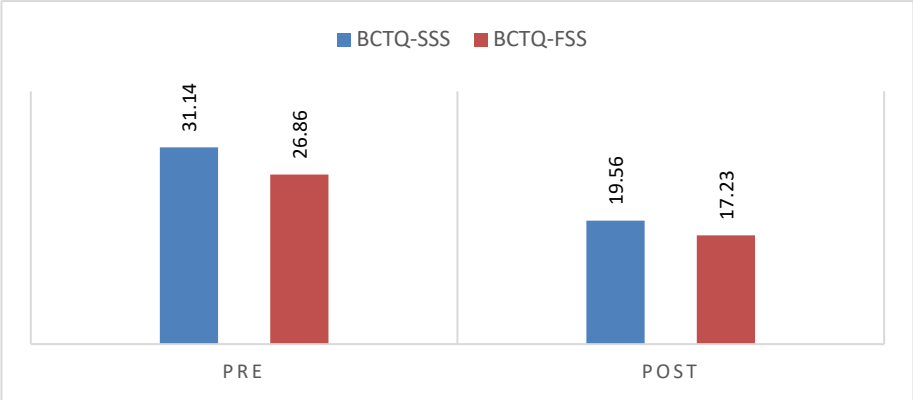

Chart 2: Average SSS and FSS scores before and after intervention

Table 4.4 and Chart 3 present a detailed comparison of the wrist's range of motion (ROM) for different movements, both pre- and post-intervention. The outcomes of the paired sample test indicate substantial improvements in flexion, extension, ulnar deviation, and radial deviation following the treatment.

Prior to the intervention, the mean flexion range of motion was 73.14 degrees. Subsequent to the treatment, a notable improvement to 77.04 degrees was observed. The observed increase in flexion was statistically significant, with a p-value of less than 0.001.
The average degree of mobility for extension increased from 69.18 degrees prior to the intervention to 77.12 degrees following the intervention. The enhancement exhibited a statistically significant impact, evidenced by a significance level of 0.001.

Prior to therapy, the mean ulnar deviation was 19.01 degrees, which rose to 24.14 degrees post-treatment, with a significant p-value of less than 0.05.

The average radial deviation prior to therapy was 16.12 degrees, which increased to 20.21 degrees post-intervention. The observed change exerted a significant impact, evidenced by a p-value of 0.001.

This study's results indicate a substantial improvement in wrist range of motion for various activities following the intervention. This illustrates the effectiveness of this therapeutic approach in enhancing functional outcomes for individuals diagnosed with carpal tunnel syndrome.

Table 4.4: Comparison between pre- and post-range of motion (flexion, extension, Ulnar deviation, Radial deviation) of the wrist

	Pre- treatment	**Post-treatment**	**P -value ***
	Mean ± SD	**Mean ± SD**	
Flexion	73.14 ± 4.94	77.04±2.51	<0.001
Extension	69.18 ± 9.16	77.12±2.70	0.001
Ulnar deviation	19.01± 3.12	24.14±1.51	<0.001
Radial deviation	16.12± 2.14	20.21±2.34	<0.001

* Paired sample t- test

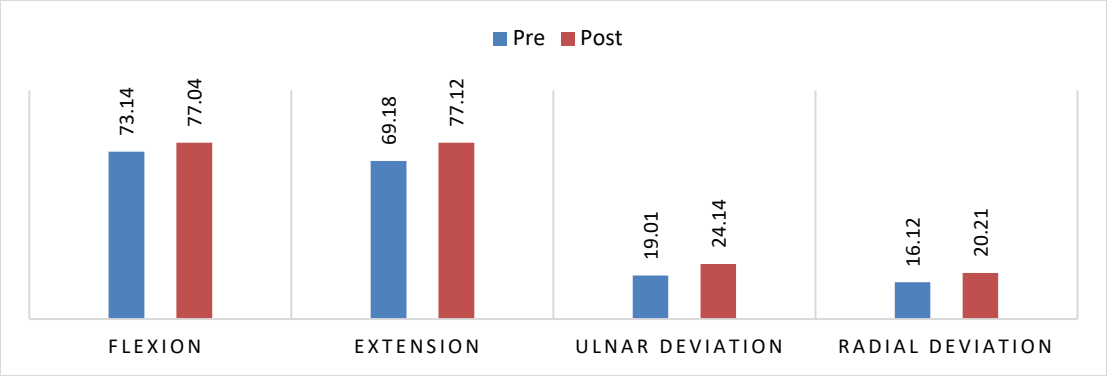

Chart 3: Changes in average ROM of the wrist Pre- and Post-intervention

Discussion

Carpal tunnel syndrome is a clinical condition resulting from the compactness of the median nerve in the wrist. This compression may be as a result of movements or overuse, physical trauma or any cause, which triggers an inflammation of the tissue surrounding the nerve. The characteristic symptoms of carpal tunnel syndrome are tingling, pain, and numbness in the thumb, first, second, third, and half of the fourth fingers. CTS is not causally related to psychological disorders, but does significantly impact the patient's ability to perform activities of daily living, which may cause frustration, anxiety and sleep disturbances. Therefore it becomes clear that in order to treat CTS and to prevent further progression of the disorder's consequences, it is crucial to unite medical and psychological approaches. Early diagnosis of CTS and use of measures like rest, splinting, physiotherapy, and medications treat the symptoms of CTS best.

The 34 patients with mild to moderate CTS were included in this study for a detailed assessment of neurodynamic wrist exercises and wrist glide exercises in relieving symptoms and increasing the function of the affected hand. Among 34 patients, these patients were identified, to make easily unrelated patients omitted including those patients who could not be diagnosed clearly, and those who physically could not complete the entire treatment. In this study, the researchers wanted to know whether effect of exercises in relieving CTS symptoms to enhance the quality of life of those who are suffering from this disease. CTS is a strong neurological complaint arising from the median nerve inflammation or compression at the wrist area, where patients complain of numbness, tingly feelings, and weakness of the fingers and hand. To avoid the aggression of the CTS in question and the

subsequent appear to of severe complications this form of the condition must be diagnosed and treated in the early stages.

As a means of evaluating the efficiency of the neurodynamic wrist exercises and wrist glide exercises, the study researchers assessed a number of indices such as symptom intensity, the degree of hand dysfunction and patients' subjective impression. The researchers requested that this survey be completed by the patients before the intervention and then three weeks after the intervention in order to evaluate the efficacy of exercises for enhancing hand function and reducing the symptoms of CTS. The results of the present study may provide some insight into clinical practice to inform treatment decisions regarding CTS, which could lead to improved knowledge and the creation of practice guidelines. Additionally, insight into which exercises promote relief of CTS symptoms might be useful for anybody suffering this affliction; contemplating knowledge, patients could avoid choices in handling this condition. The results outlined in this study show that neurodynamic wrist exercises produce substantial therapeutic benefits in diagnosed CTS patients. Such benefits include a significantly reduced average VAS score, and increases in the range of motion of the wrist as regards to various tasks, including abduction. The study is emphasizing its robustness in providing the useful inference about the benefits of the intervention. It is considered that the effectiveness of the treatment program can be considered high because the numerical values of the VAS scores and the differences in the SSS and FSS, both before and after the exercise program, were statistically significantly lower all of them had p-values <0.001. Therefore, the neurodynamic wrist exercises reduce the subject's symptoms and enable them to achieve better functional use of their hand; these findings offer a potential non-operative intervention for treating CTS. The subsequent research could focus on the efficacy of this intervention yet after the treatment as well as on the generalization of results for patients of different age, gender and pathology, as well as in different occupations.

Concisely it was concluded that neurodynamic exercise, carpal bone mobilization technique (CBMT) proved efficient in managing CTS patient according to Sheereen and her colleagues' (2022) research. Comparable results were observed for both the interventions comprising TGE; both revealed marked enhancements, for the pain, grip strength, function, as well as the motor nerve conduction velocity following a three-week treatment plan. On average, the neurodynamic exercises group displayed greater improvements in nerve conduction velocity and functional status than the CBMT group; thus

the results suggest that neurodynamic exercises are probably more effective than CBMT when combined with therapeutic exercise in terms of improving these particular parameters. However, both interventions were established to be almost similar in decreasing pain and increasing grip strength. The results of this investigation provide a basis for using manual therapy and therapeutic exercises in chronic CTS treatment. It is important that further studies analyse the possible long-term consequences of these interventions, while other studies can focus on identifying potential mediating factors that may enable to explain the efficiency of these interventions. Also, more works to compare neurodynamic exercises on several patients and the effectiveness of CBMT for patients with CTS, as well as, different periods of treatment can be useful for further clinics and for health care specialists [19] . This is in agreement with our study what indicated that implementing neurodynamic mobilization has an ability of minimizing pain and improving hand dexterity.

Sekaringtyas et al. (2021) conducted a study to establish the difference in the outcome for patients with mild to moderate Carpal Tunnel Syndrome by using neurodynamics exercises and nerve and tendon gliding exercises. There were significant reductions in symptoms in both treatment groups but no marked differences in functional ability, nerve conduction measurements, or grip strength between the two methods. This implies that exercises involving the nerve and the tendon may be as effective as neurodynamics to treat CTS. However, more study can be conducted to get a clear result on these findings [20]. This is inline with our study whereby we showed that by introducing neurodynamic mobilization it is possible to reduce the severity of the condition being researched.

At the end of treatment, both groups demonstrated statistically significant change on all measure of outcome. While the electrophysical modalities group showed improved results in number of sensory nerve action potentials, mean value of 113,5, the manual therapy group improved more significantly in the aspect of sensation conduction velocity with mean value of 11,5 m/sec increase. Further, in the second phase of the test for grip strength, the DASH test and the Grip Strength Test the patients under the manual therapy had better results than the sham and control groups. The change in pain intensity according to the VAS was also considerably greater in the manual therapy group rather than the electrophysical modalities group. In conclusion, it can be stated that according to the study of Wolny and Linek the manual therapy methods may be more beneficial for the patients with mild-moderate CTS than any kind of electrophysical treatment modalities. This conclusion is rather an indication to

make certain observations which can be underpinned with empirical evidence and clinician's practical experience, and therefore should be taken along with patient's requirement as well as patient's decision to embrace the treatment plans. Additional studies are needed to determine if the two approaches are effective in the long term and whether there are any side effects from using each one [21].The study revealed that the median nerve sensory conduction velocity of the manual therapy group increased greatly more than that of the electrophysical modalities group ($p < 0.01$). The manual therapy group exhibited a more significant reduction in pain and an increase in grasping strength than the electrophysical modalities group ($p < 0.05$). According to Wolny and Linek (2019), neurodynamic based manual therapy is a promising treatment for patients with mild to moderate CTS. The results suggested that these kinds of treatments substantially improved functional status, decreased pain intensity, and decreased symptom severity.

Talebi et al., (2020) conducted the before mentioned research focusing on the influence of employing manual therapy with neurodynamic approach on patients with mild to moderate CTS. The study was conducted with 30 participants; both groups consisted of 15 people. These groups were hence offered mechanical interface therapy and nerve mobilization respectively. All the respective groups participated in three sessions of the intervention in a week for four consecutive weeks. The results pointed out that two examined manual therapy methods were beneficial in terms of pain relief and increasing the grip strength and functional status. Comparative analysis shows that there were no significant differences in the results of the two groups and thus both methods of conservative treatment of CTS are effective. Therefore, the study substantiated the findings of the utilisation of neurodynamic therapies that incorporate mechanical interface manipulation and specific nerve mobilisation techniques to the conservative treatment procedure of mild to moderate CTS [22]. These result may help health care professionals as a resource when dealing with patient diagnosed with CTS

Thus, the Vaidya and Nariya (2020) study had an objective of identifying the differences in NM and NTGE for CTS patients. They randomly assigned sixty patients diagnosed with CTS into two groups: the NM group in which n=30 and the NTGE group in which n=30. The NM group received 10 sessions of neural mobilization consisting of neurodynamic slides, neuroscience, and adjuncts from ultrasound therapy and night splinting. The NTGE group was also given 10 sessions of programmatic nerve and tendon gliding exercise, low-intensity ultrasound therapy and wearing of night splint. The

main measure evaluated in the research was the alteration in median nerve sensory conduction velocity. Secondary parameters were pain intensity changes, grip force, and functional capabilities. The findings of this work can be useful for further the comprehension of the efficiency of NM and NTGE in patients with CTS by healthcare workers . A comparison of the two treatment techniques might give information on which method would be more efficient in enhancing patient's reported symptoms, grip strength and functional status. This information may be useful to clinicians in treating CTS patients and to improve the quality of life for these patients [23].

Finally, the study conducted by Vaidya & Nariya (2020) found that the NM participants were able to increase the median nerve sensory conduction velocity, decrease the extent of pain and increase the grip strength more than the NTGE group. The analysed data evidences no differences in terms of functional outcomes; however, it may be postulated that the use of NM as one of the adjuncts to conventional conservative approach, commonly consisting of wearing a night splint and ultrasound therapy, may offer clinicians a useful therapeutic resource aimed at moderate and mild CTS patients. The study provides evidence that, when NM treatments are used together with conventional treatment, patient outcomes may be better in the treatment of CTS [23]. This is in parallel with our study, which revealed that it is possible to reduce pain of the particular condition under inquest through applying neurodynamic mobilization. The result of this work supports the possibility of using neurodynamic mobilization as a useful treatment approach towards the condition aching symptoms.

Abdolrazaghi and colleagues conducted the study to evaluate how effective TNGEs are in treating moderate idiopathic CTS. An RCT was conducted in 80 participants diagnosed with mild idiopathic CTS. The patients were randomly divided into two groups: TNGEs group consisting of 42 patient and control group of 38 patients. The TNGEs group performed sets of motions meant to rhythmically slide and glide the nerves and tendons of the upper extremity. The control group also only used wrist splints at night and did not initially begin any other types of therapy. The main assessment in the study was made on median nerve sensory conduction velocity. Secondary outcomes targeted the alterations in pain, sensation impaired grasp strength, and function. The obtained data revealed that after the treatment the TNGEs group achieved a significantly a greater augmented median nerve sensory conduction velocity in comparison with the control group ($p < 0.01$). Moreover, the TNGEs group showed mean difference reductions of pain and paresthesia compared to the control group (mean

difference = -1.58–2.49, 95% CI, $p < 0.05$). Both intervention groups did not differ in functional enhancement between the two groups. The results of study indicated that TNGEs can provide relief of mild Idiopathic CTS as evidenced by increased nerve conduction velocity and decreased symptoms. Also, regarding the intervention effects, the study showed that gliding exercises improve the functional status, pain intensity and severity of symptoms in patients with the mild idiopathic CTS (Abdolrazaghi et al., 2023). Therefore, it was found that tendon and nerve gliding exercises can be an effective treatment modality of mild idiopathic CTS since they improve the nerve's function and alleviate the symptoms such as pain and tingling sensation. The ischemic exercise can enhance functional status while the grip strength exercises may benefit patient with mild CTS. They may also use wrist splints as a supportive care at night to reduce symptoms and help increase their main treatment plan [24]. Physically, this statement can be parallel to neurodynamic and gliding exercises as much as physical therapy or rehabilitation is concerned. Neurodynamic exercises imply stretching / mobilization of nerves and nerve roots with the purpose to reduce pain, increase the range of movement and optimize the use of affected limb. Swinging lessons relate to sliding movement of the body segments and internal structures and are used in the improvements of joint flexibility, reduction of joint rigidity, and general facility of movement.

The neurodynamic and gliding exercises employed in this current study caused some changes on the participants' severity of symptoms and functional status scores. That means that these kinds of exercises are a potential treatment strategy for individuals with neurologic and musculoskeletal disorders to enhance quality of life and functional capacity.

Consequently our study focuses on neuro dynamic wrist exercise with as well as wrist glide exercises as effective strategies for the treatment of CTS. Through the application of these techniques, the clients are able to have decrease in pain and enhancing of functional status. These exercises serve a dual purpose, they help relieve mechanical nerve compression and participate in the process of restoring hand function necessary for proper management of the symptoms. In accordance with modern principles of rehabilitation, it is necessary to start the intervention as early as possible to exclude further adverse effects on a patient's health. However, such exercises can be integrated with total treatment not only for the condition of the said patients with CTS, but to improve the quality of their life as well.

The addition of neurodynamic and wrist glide mobilizations to managing CTS is a clear evidence progressive variety of conservative management approaches. The quasi-experimental and statistical methods used in the present research confirm the usefulness of this kind of treatment. In regards to approach, the study focuses on the range of motion of patients, amount of pain that they feel, and the intensity of the symptoms that are present in patients, and what this reveals is that there are so many advantages that these exercises have when included in therapy.

The implications of these findings are that individualized rehabilitation measures can be developed, resulting in an improved clinical effectiveness of the intervention and patient satisfaction. Additional studies of the chronic effects and the best practices to execute these exercises will help improve the treatment plans and extend the list of effective approaches available for clinicians working with CTS and other similar afflictions.

Conclusion

The present study showed that neurodynamic wrist exercises and wrist gliding exercises have significant beneficial effects on patients diagnosed with mild to moderate CTS. Following a four weeks intervention, participants observed significant decreases in pain, significant enhancements of wrist ROM for various activities. Comparisons of the SSS and FSS assessments conducted before and after the intervention revealed notable inequalities, providing evidence for the therapeutic efficacy of these exercises in the management of CTS.

The present studies have pointed out that the neurodynamic wrist exercises and the wrist glide exercises are two effective non-surgical interventions for CTS. These exercises relieve symptoms of CTS but also help to increase hand dexterity and enhance the patient’s quality of life. However, we hope that exercise protocol has potential of modifying these blood lipid profiles and the following findings despite the limitation of this study, including a small sample size and no follow-up information. These limitations beg for more studies with significantly sample sizes and heterogeneous samples, as well as longer follow up periods. While the results of this study demonstrate the values of the above-stated therapeutic exercises, more research is needed in the future including control groups in order to provide clear evaluation of the effectiveness of these

exercises. Moreover, studying the outcomes of these types of exercises along with other co-therapies may help estimate the most appropriate combinations of interventions for the CTS treatment. This approach can finally be used to optimize the CTS treatment, in other words, improve the quality of life of patients based on more individualized and more complex approaches.

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Authors' contributions

All authors equally contributed to preparing this article.

Conflict of interest

The authors declared no conflict of interest.

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