5-1-2023

Comparison Between Active Interventions and Passive Interventions for Patients With Carpal Tunnel Syndrome Using The Boston Carpal Tunnel Questionnaire: A Systematic Review and Meta-Analysis

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COMPARISON BETWEEN ACTIVE INTERVENTIONS AND PASSIVE INTERVENTIONS FOR PATIENTS WITH CARPAL TUNNEL SYNDROME USING THE BOSTON CARPAL TUNNEL QUESTIONNAIRE: A SYSTEMATIC REVIEW AND META-ANALYSIS

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Presented to the Faculty of the Doctor of Physical Therapy Program of

The University of Texas at El Paso

in partial fulfillment of the requirements for the degree of

DOCTOR OF PHYSICAL THERAPY

THE UNIVERSITY OF TEXAS AT EL PASO

MAY 2023

Abstract

Aims and Objectives
To assess the effectiveness of active interventions, such as manual therapy and gliding exercises compared to passive interventions, such as kinesiotaping, splints, and modalities utilizing the Boston Carpal Tunnel Questionnaire in patients with carpal tunnel syndrome.

Background
A large number of people worldwide suffer from carpal tunnel syndrome, which is a type of entrapment neuropathy. Treatment includes active interventions (manual therapy and gliding exercises) and passive interventions (splinting, kinesiotaping, and modalities). The Boston Carpal Tunnel Questionnaire is the most widely used self-administered outcome scale to measure the improvement of carpal tunnel syndrome. The effectiveness of the various physical therapy interventions for patients with carpal tunnel syndrome has been examined in several studies. The purpose of this systematic review is to provide the outcomes of the selected studies and give a better understanding of active and passive interventions.

Design
A systematic review and meta-analysis of 5 randomized controlled trials.

Methods
A review and meta-analysis of 5 randomized controlled trials were conducted. PubMed was used to select the qualified studies for this systematic review. PEDro scale was utilized to evaluate the quality of the studies. The main outcome included is Boston Carpal Tunnel Questionnaire score. Online tools were used to analyze data on the effectiveness of active interventions for treating carpal tunnel syndrome. The analysis focused on comparing active to passive interventions and included various comparisons of scores before and after treatment.

Results
The results of the study indicate that active interventions have a greater impact on the Symptom Severity Scale and Functional Status Scale of the Boston Carpal Tunnel Questionnaire compared to passive interventions. The effect sizes, as measured by Hedge's *g*, for active interventions are found to be statistically significant and fell in the large range. The Symptom Severity Scale showed an effect size of -1.49 (95% CI: [-1.80, -1.19]), while the Functional Status Scale showed an effect size of -1.03 (95% CI: [-1.31, -0.75]), both indicating a large impact on functional and symptom improvement. These findings suggest that active interventions may be more effective than passive interventions in improving scores on the Boston Carpal Tunnel Questionnaire. A comparison of scores between two groups revealed that the combination of active and passive interventions had a slight advantage over active interventions alone. The Symptom Severity Scale score had a Hedge's *g* effect size of -0.30 (95% CI [-0.67; 0.07]) with a *p*-value of 0.02, indicating a statistically significant difference between the groups. However, the Functional Status Scale score had an effect size of -0.13 (95% CI [-0.49; 0.24]) with a *p*-value of 0.15, indicating no statistically significant difference between the groups.

Introduction

Carpal tunnel syndrome (CTS) is an entrapment neuropathy that affects a large number of people worldwide. Within the carpal tunnel, there are 9 flexor tendons and the median nerve that are roofed by the flexor retinaculum. Most cases of CTS are idiopathic, but the suggested mechanisms include increased carpal tunnel pressure, median nerve microcirculation injury, and median nerve connective tissue alterations with a combination of compression and traction.[1] The symptoms associated with CTS tend to fluctuate, as is commonly observed in many other medical conditions. Patients are often prompted to seek medical attention during periods of exacerbated symptoms, which leads to observations of improvement at follow-up visits.[2] Additionally, the resolution of spontaneous inflammatory changes within the flexor tendon paratenon may also contribute to the improvement of symptoms in some cases. However, a significant proportion, ranging from 40-62%, of patients with untreated CTS exhibit persistence of clinical symptoms and subjective experiences over a period of 10 months to 2 years during follow-up evaluations.[2]

The first symptoms for CTS include intermittent nocturnal paresthesia and dysesthesias, followed by loss of sensation with weakness, and potentially progresses to thenar muscle atrophy. In more severe CTS, the symptoms can spread to the proximal forearm, upper arm, and shoulder.[3] There are a number of factors that may increase the risk of developing CTS, including diabetes, arthritis, obesity, and menopause.[3]

Although clinical assessment can diagnose CTS, the gold standard is electrophysiological nerve conduction study (NCS).[4] A recent study argues ultrasonography as a noninvasive and quick tool for assessing carpal tunnel, recommending use of ultrasonography to be used in conjunction with NCS. [4] Clinicians consider clinical assessment the most accurate way to diagnose CTS, with the use of Tinel's sign and Phalen's maneuver being considered the most useful and widespread clinical diagnostic tests. [3] The sensitivity and specificity of Tinel's sign ranges from 38% to 100% and 55% to 100% respectively, while sensitivity and specificity for Phalen's maneuver range from 42% to 85% and 54% to 98% respectively. [3]

CTS is known as the most common peripheral neuropathy in the U.S. with an annual incidence of around 1 to 3 cases per 1,000.[5] Even though conservative treatment is the first option, many patients require surgery, which accounts for approximately 600,000 annual cases. The annual economic burden to manage CTS is $2.7 to $4.8 billion. The average workday lost time is 47.5 days, representing 7.3% of total lost workdays in all occupations.[6]

The medical options for CTS managements are non-steroidal anti-inflammatory drugs (NSAIDs), gabapentin, oral steroid, and corticosteroid injection. A systemic review by Huisstede, et al concludes that oral steroids and corticosteroid injections are more beneficial than the other medications listed above. [7] Despite the greater benefit of steroid medications, especially with a higher dose, their effectiveness is only for the short term. A possible reason is that physicians may not want to use steroid medications for long term management of CTS due to the adverse effects of the medications that are harmful to body systems, such as weakening of soft tissues and bones, increasing blood glucose level, and increasing blood pressure. According to a systematic review conducted by Huisstede et al, there were significant differences in efficacy between corticosteroid injections and oral steroids at both the 8-week and 12-week follow-up periods, as demonstrated by the calculated weighted mean differences of -7.16 (95% confidence interval: -11.46 to -2.86) and -7.10 (95% confidence interval: -11.68 to -2.52), respectively. In other words, the use of corticosteroid injections was found to be more effective in reducing global symptoms.[7]

Passive treatments for CTS include splinting, C-TRAC and alternative therapies. Splinting is a relatively inexpensive treatment. Splinting reduces wrist movement and, as a result, tends to improve numbness and pain at the wrist. It may also be helpful to use a splint to limit excessive wrist flexion or extension during sleep to prevent the occurrence of nocturnal paresthesia. C-TRAC is a dynamic and pneumatic hand traction device designed for enlarging the carpal tunnel through progressive stretching. As the air bladder is inflated, the device produces a three-point action force, which stretches the transverse carpal ligament along the hand. In addition to medical and rehabilitative measures, approximately 38% of US adults use alternative therapies to control pain. There is limited evidence as to whether alternative therapies (acupuncture, low-level laser therapy, yoga, and static magnetic field therapy) can be used to treat CTS symptoms safely and effectively.[8]

In patients with CTS, axonal transport and nerve conduction are believed to be improved through mobilization exercises (e.g., tendon gliding, and nerve gliding). A gliding exercise that integrates flexor tendons and nerves may maximize median nerve movement within the carpal tunnel as well as flexor tendon movement. A cadaveric study by Boudier-Reveret et al found the positive effect of neurodynamic mobilization in decreasing intraneural edema after performing the mobilization, such as tensioning and sliding techniques for 5 minutes by significantly dispersing the intraneural fluid in the carpal tunnel region.[9]

In patients with severe nerve entrapment, motor weakness, or thenar atrophy, carpal tunnel release surgery is normally considered when conservative measures fail to relieve symptoms or function remains limited.

A systematic review by Klokkari and Mamais compared the outcomes of surgical intervention and conservative treatment for patients with severe CTS.[10] The results indicated that, after a follow-up period of six months, surgical intervention was associated with a significantly greater improvement in CTS symptoms as compared to conservative treatment (Mean difference: 0.52, 95% Confidence Interval 0.27 to 0.78). The conservative treatment approach consisted of corticosteroid injections, splints, physiotherapy, diuretics, and/or vitamin B6 supplementation.[10] However, the authors of this study emphasized the importance of careful consideration of the decision to undergo surgical intervention for the treatment of CTS. This is due to the fact that surgical treatment is associated with the potential risk of complications and the possibility of spontaneous resolution of CTS symptoms.

A separate recent systematic review compared physical therapy specifically to surgical intervention assessed outcomes at 1, 3, 6, and 12 months. In the short term (one month) follow-up range, hand function during daily activities and grip strength were both found to have superior performance in the physical therapy group compared to the surgical group. For the next follow-up sessions at 3, 6, and 12 months, both groups demonstrated similar improvements in daily activity function and grip strength. After 1 year, patients in the physical therapy group, which focused on manual therapy of the neck, median nerve glides, and stretching exercises, demonstrated similar significant improvements to patients in the surgical group. In their review, strong evidence is provided to support the choice of patients desiring to try physical therapy initially as a conservative treatment option.[11]

The purpose of this systematic review is to compare the effectiveness of passive and active interventions in reducing symptoms of CTS as measured by the BCTQ. Neurodynamic mobilization can be performed either by manual techniques conducted by therapists or by patients themselves, such as nerve gliding exercises. Therefore, nerve gliding exercise was defined as the active intervention for this systematic review. The hypothesis of this systematic review is that active interventions will be more effective in treating CTS compared to passive interventions, as measured by BCTQ scores. This hypothesis is based on the following. Neurodynamic techniques have been used in the management of various nerve related conditions, such as CTS, cervical radiculopathy, and cubital tunnel syndromes over several decades since its introduction.[12] Also, other manual techniques have been utilized to treat and manage the symptoms of CTS, such as soft tissue mobilization, functional massage, and facial manipulation techniques. One study showed that there were no significant differences between manual therapy and surgery in the management of CTS in terms of BCTQ scores and pinch-tip grip force.[13] On the other hand, passive interventions, such as KT, splints, and modalities tend to be considered as adjunctive measures.

This review included randomized controlled trials that have used the BCTQ to assess the impact of passive and active interventions on CTS symptoms. The review aims to determine which type of intervention appears to be more effective in reducing symptoms and improving function in individuals with CTS.

The PICO research question for this systematic review is:

In patients with carpal tunnel syndrome, do active (manual therapy or gliding exercises) interventions demonstrate greater improvement than passive (modalities or augmented devices) interventions on the Boston Carpal Tunnel Questionnaire?

Methods

Outcome Measures

In CTS, the Boston Carpal Tunnel Questionnaire (BCTQ) is the most used self-administered outcome scale for patients suffering from carpal tunnel syndrome.[14]

BCTQ is a meaningful outcome measure in research and clinical practice, especially with the recent addition of an individualized MCID. In patients with carpel tunnel, the MCID of BCTQ has been demonstrated to be variable. MCID is best used when based on the patient's Symptom Severity Scale and Functional Status Scale scores at baseline to post-intervention.[14]

The BCTQ has been used since 1993 for patients with carpel tunnel syndrome and is the first disease-specific questionnaire for this patient population. The BCTQ has been through extensive testing and demonstrates adequate levels of validity, reliability, and responsiveness.[15]

There are two subscales in the BCTQ, a Symptom Severity Scale (SSS) and a Functional Status Scale (FSS). There are 11 items on the SSS that measure pain, paresthesia, numbness, weakness, nocturnal symptoms, and difficulty grasping. A total of eight activities are affected by CTS on the FSS, including writing, buttoning clothes, holding books while reading, gripping the telephone handle, opening jars, carrying grocery bags, bathing, and dressing.[15]

In comparison with regional measures such as Disability of Arm, Shoulder, and Hand and generic health status measures like Short-Form 36, the BCTQ shows better reliability and responsiveness for patients with carpal tunnel syndrome. For the SSS, clinicians can use 0.72 as the minimum detectable change at

90% confidence interval (MDC_{90}), while for the FSS, they can use 0.79 as the MDC_{90}. Likewise, clinicians should consider 1.05 as the minimal clinically important difference in SSS and 1.13 as the minimal clinically important difference in FSS when using BCTQ three months after carpal tunnel release.[16]

Data Sources and Searches

Following PRISMA guidelines, eligible studies were identified from MEDLINE. The searches used the PICO (P: patient or problems; I: intervention being considered; C: comparison intervention; O: outcome measurements) framework[17] and were performed on December 1, 2021. Figure 1 demonstrates the search strategy. The keywords used are ((carpal tunnel syndrome) AND (BCTQ) AND (Boston Carpal Tunnel Questionnaire) AND ((manual therapy) AND (exercise) OR (night splinting) OR (orthosis) OR (night splint) OR (kinesiotaping) OR (modalities) OR (cryotherapy) OR (heat) OR (ultrasound) OR (massage) OR (C-TRAC) OR (ice))). The three researchers independently extracted data on participant and intervention characteristics. The quality of evidence was rated on predetermined criteria of the studies being random controlled trials. BTCQ was included as a main outcome.

Study Selection

This systematic review includes RCTs. The inclusion criteria include participants having been diagnosed with CTS based on nerve conduction study and having mild to moderate symptoms. Interventions include any of the following: kinesiotaping (KT), night splinting, exercises, modalities, or manual therapy. The studies should have been published between January 1, 2011 and December 31, 2021, with BCTQ as an outcome measure. Studies that solely compare passive interventions in isolation to other passive interventions, or those that lack a comparison between passive and active interventions are excluded from the analysis.

Two studies (Study D and Study E) are included in the systematic review despite the fact that all groups in both studies receive an active intervention. The inclusion of these studies aims to investigate the potential benefit of adding a passive intervention to an active intervention in terms of BCTQ scores.

The objective is to determine if the combination of active and passive interventions will yield better outcomes compared to active intervention alone.

Data Extraction and Quality Assessment

The researchers screened all titles from the searches to exclude studies that are irrelevant. Then, the title and abstracts were reviewed using an eligibility checklist. The full texts of the potentially eligible studies were retrieved for full review and final selection. Any discrepancies in the extracted data were discussed by all 3 researchers with 100% consensus. Data were extracted based on the following: (a) general information (author and title); (b) study characteristics (study design, number of participants, demographic details); (c) intervention and setting (setting where intervention is delivered and description of it); (d) outcome data (baseline and follow-up measure), (e) data analysis (statistical tests and measures), and (f) findings (overall results). A summary of this information can be seen in Table 2. The quality of the studies was assessed using the PEDro scale to assess methodological quality of each study and the determination of study validity. Studies were then scored on a scale between 0 and 11. PEDro scores of 0-3 are considered 'poor', 4-5 'fair', 6-8 'good', and 9-10 'excellent'. The

RTCs used in this systematic review demonstrated PEDro scores ranging from 7-9.

Data Synthesis and Analysis

The data for this systematic review were analyzed using an online meta-analysis generator and a Hedge’s *g* calculator. The meta-analysis generator was used to create forest plots and calculate the pooled effect size for the studies included in the review. A fixed model is used for the forest plots.

Despite the potential limitations associated with its use, we decided to employ a forest plot as a visual tool to summarize the results of the studies included in our analysis. A forest plot is a commonly used graphical representation of data in meta-analyses, which allows for the visualization of the effect estimates and their confidence intervals for each individual study, as well as the overall pooled estimate. However, it is important to note that the validity and usefulness of a forest plot may be compromised when there is insufficient homogeneity between studies, as it may not provide meaningful insights into the variation in effect sizes. Nonetheless, we decided that a forest plot can still serve as a useful tool to aid in the interpretation of the results, and as a means to assess the overall consistency of the findings across studies.

The primary outcome measure for this study is the BCTQ, a discrete measure of CTS symptom (and function) severity. Patient demographics, parameters of the interventions, duration, and outcome measures of each study are documented in Table 1. The statistical analysis of the meta-analysis was performed by three researchers. Any disagreements or discrepancies in the analysis were resolved through discussion.

For the meta-analysis, a fixed model was used, and the pooled effect sizes were calculated using Hedge’s *g* statistic. In some cases, researchers may selectively report Cohen's *d* over Hedge's *g* if the former yields a larger effect size estimate. By reporting Hedge’s *g* measures, we can avoid potential reporting bias and provide a more complete picture of the effect size. The effect sizes were calculated by comparing the scores of the experimental group (active interventions) to the scores of the control group (passive interventions), since the hypothesis is that active interventions will be more effective in treating CTS than passive interventions on the BCTQ.

An additional analysis was performed to compare the effectiveness of active intervention and active with passive intervention. The Hedge's *g* statistic was used to demonstrate the potential benefits of combining the two interventions. The results of this analysis provide insights into the potential efficacy of combining active and passive interventions for improving outcomes.

Hedge's *g* was calculated to compare baseline scores and post-treatment scores. The purpose of this analysis was to determine the effectiveness of interventions by comparing baseline scores to post-intervention scores. The previous analysis (forest plot) only compared post-intervention scores, which can be misleading, because not all groups started at the same baseline score. This difference in baseline score could potentially impact the analysis results. By comparing baseline scores to post-intervention scores, we were able to get a more accurate representation of the impact of each study’s interventions. This allowed us to determine if the interventions were effective in and of themselves, rather than being influenced by baseline score disparities between groups. By taking into account the baseline scores, we attempted to minimize the potential for exaggeration or underestimation in our analysis.

The results of the BCTQ were also analyzed using mean difference scores, with 95% confidence intervals. The mean difference scores were calculated by comparing the scores of the experimental group to the scores of the control group on the BCTQ.

Results

Selection of Studies

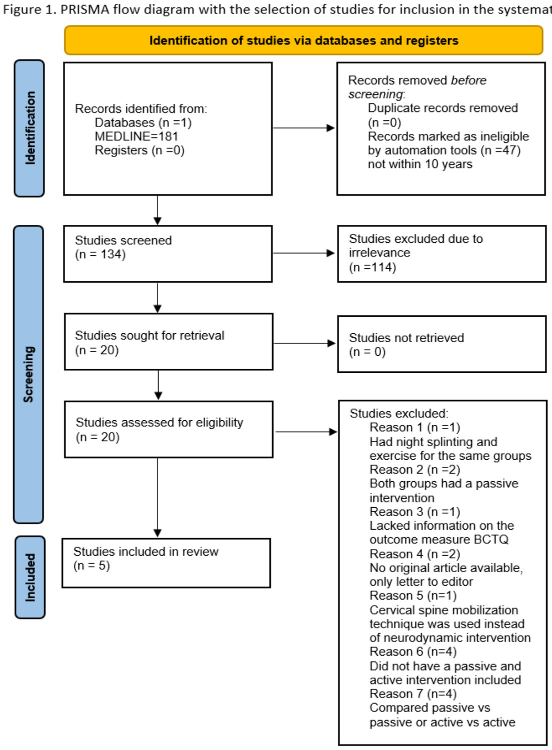
In the study selection process for this systematic review, a total of 134 studies were identified through a search of an electronic database. These studies were screened for relevance based on their titles and abstracts, and 20 were deemed potentially eligible for inclusion in the review. Full-text versions of these 20 studies were then obtained and assessed in more detail to determine their eligibility for inclusion. After this detailed assessment by each researcher independently, five studies were found to meet the inclusion criteria and were included in the review.

The interventions evaluated in these studies vary slightly in terms of the number and duration of sessions, but they all focus on active and passive interventions. All of the studies are randomized controlled trials and the duration of the interventions ranges from 1 to 10 weeks. A summary of these studies is provided in Table 1.

In terms of the quality of the methodology, the included studies were scored using the PEDro scale. Four of the included studies are considered "good" according to this scale, while one is considered "excellent." The scores for each study are shown in Table 2. All five studies used individual-based interventions and were in a clinical setting.

The majority of the included studies have good quality in their methodology and provide adequate information on their objectives, methods, and findings. Items 5 and 6 of the PEDro scale (blinding of all subjects and therapists, respectively) were consistently missed. This may be due to the nature of physical therapy interventions making blinding difficult to achieve, as patients may be able to identify the type of treatment received, and therapists may be aware of the intervention they are administering. The search processes for this systematic review are depicted in Figure 1 as a PRISMA diagram, which shows the flow of studies through the various stages of the review process.

Figure 1. PRISMA flow diagram with the selection of studies for inclusion in the systematic review.



From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

Table 1. Summary of the elegible studies comparing the effectiveness of passive and active interventions in reducing symptoms of carpal tunnel syndrome as measured by the BCTQ.

Title	Author	Primary Outcome Measure	Secondary Outcome Measure	Intervention(s)	Length of Intervention	Stage of Disease	How was CTS diagnosed
(A) Efficacy of Manual Therapy Including Neurodynamic Techniques for the Treatment of Carpal Tunnel Syndrome: A Randomized Controlled Trial. 2017	Tomasz Wolny, Edward Saulicz, Pawel Linek	Nerve conduction study, NPRS (0 to 10 scale), BCTQ	None	Manual therapy (MT) group included the use of neurodynamic techniques, functional massage, and carpal bone mobilizations techniques. Electrophysical modalities (EM) group included laser and ultrasound therapy.	Twice weekly. 20 therapy session. 10 weeks.	Mild to moderate CTS	NCS (nerve conduction study)
(B) Conservative treatment of carpal tunnel syndrome: comparison between laser therapy and Fascial Manipulation(®). 2015	Pratelli E, Pintucci M, Cultrera P, Baldini E, Stecco A, Petrocelli A, Pasquetti P.	Visual Analogic Scale (VAS) and Boston Carpal Tunnel Questionnaire (BCTQ)	None	Deep friction over specific points and laser infrared diode (M300 level laser) with a wavelength of 780-830 nm and a power between 1000 and 3000 mW	Three sessions of FM for 45 min once a week for a total of 3 weeks. LLT on median nerve five daily sessions lasting 10 min each.	Not described	Clinical (Phalen and Tinel test positive) and electromyographic (positive EMG showing a decrease in nerve conduction within the last six months)
(C) Effect of Splinting and Exercise on Intraneural Edema of the Median Nerve in Carpal Tunnel Syndrome—An MRI Study to Reveal Therapeutic Mechanisms. 2012	Annina B. Schmid, James M. Elliott, Mark W. Strudwick, Mary Little, Michel W. Coppieters	Signal intensity of the median nerve	BCTQ	Either night spliting or a home program of nerve and tendon gliding exercises	1 week	Mild to moderate	Electrodiagnostic testing
(D) Kinesiotaping as an alternative treatment method for carpal tunnel syndrome. 2016	Duygu GELER KÜLCÜ, Canan BURSALI, İlknur AKTAŞ, et al.	Visual analogue scale (VAS) and Douleur Neuropathique 4 (DN4) scores, dynamometric grip strength measures, and the BCTQ	None	Experimental KT group, a placebo KT group , and an orthotic device group. All groups got home exercise programs during the 4 weeks, consisting of tendon-gliding exercises.	To stay on for 5 days, with a 2-day rest, for a total of four times. ODs night and day, whenever possible, for 4 weeks.	Mild and moderate CTS patients, symptoms for less than 1 year	Electromyography
(E) Ultrasonographic and clinical evaluation of additional contribution of kinesiotaping to tendon and nerve gliding exercises in the treatment of carpal tunnel syndrome. 2018	Pınar YILDIRIM, Banu DİLEK, Ebru ŞAHİN, Selmin GÜLBAHAR, Ramazan KIZIL	BCTQ, Moberg pick-up test, hand grip and pinch strength, cross-section area (CSA) of the median nerve measured by ultrasonography.	None	Tendon and nerve gliding exercises both groups. In intervention group additional kinesiotaping was performed.	3 weeks, kinesiotaping was performed three times with 5-day intervals	Mild or moderate CTS, who had the symptoms for at least 3 months	Clinically and electrophysiologically diagnosed

Table 2. Quality of the 6 studies assessed by the PEDro Scale.

Study	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Item 11	Total score
Wolny	Y	Y	Y	Y	N	Y	Y	Y	N	Y	Y	9
Pratelli	Y	Y	N	N	N	N	Y	Y	Y	Y	Y	7
Schmid	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	8
Kulcu	Y	Y	Y	Y	N	N	Y	Y	N	Y	Y	8
Yildirim	Y	Y	N	Y	N	N	Y	Y	Y	Y	Y	8

Active versus Passive Interventions

The first forest plot (Figure 2) illustrates the effects of active and passive interventions on the SSS part of the BCTQ. The total standardized mean difference, calculated using the scores of the SSS, is -1.49 with a confidence interval (CI) of (-1.8; -1.19). This result is statistically significant, with a *p* value of less than 0.01. The forest plot shows that the active interventions have a larger effect on the scores of the SSS part of the BCTQ compared to the passive intervention.

The second forest plot (Figure 3) compares the effects of active and passive interventions on the FSS part of the BCTQ. The total standardized mean difference is -1.03 with a confidence interval of (-1.31, -0.75) and a *p* value of less than 0.01. These 2 forest plots show that the active interventions have a larger effect on the scores of the FSS part of the BCTQ compared to the passive intervention.

According to Hedge's *g* guidelines, an effect size of 0.2 is considered small, 0.5 is considered medium, and 0.8 is considered large.[18] In this comparison, the effect sizes for the active interventions fall in the large range, with values equal to or above 0.8.

The results of the study by Schmid et al showed that the calculated confidence interval of their findings cross 0, indicating that there is a lack of statistical significance in their results.

Figure 2. Forest plot for the effect of the scores of the active to the scores of the passive interventions on the SSS of the BCTQ.

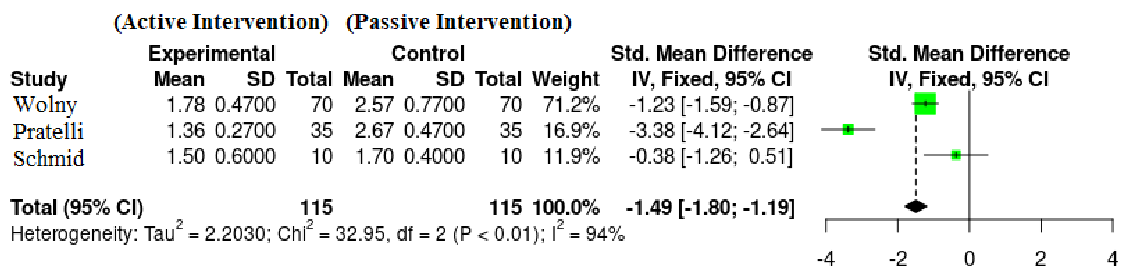
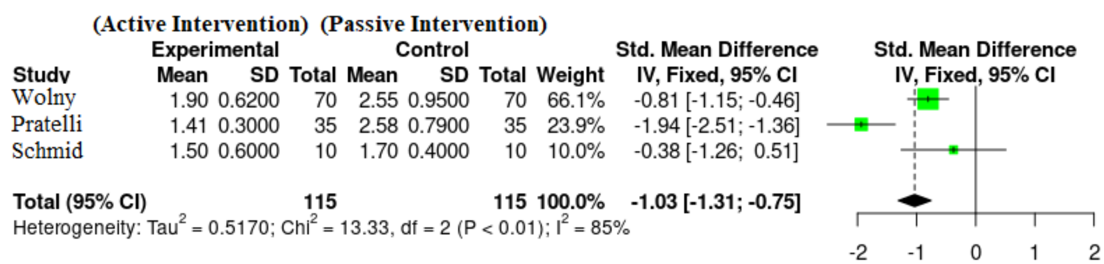


Figure 3. Forest plot for the effect of the scores of the active to the scores of the passive interventions on the FSS of the BCTQ.



Active versus Active with Passive Interventions

To compare the specific effects of different interventions, we divided study D into two subgroups: D1 and D2. In D1, we compared the effects of KT (group 1) with placebo KT (group 2). In D2, we compared the effects of placebo KT (group 2) with an orthotic device (OD) (group 3). All groups in study D received therapeutic exercise as a constant factor, which is an active intervention.

Figures 4 and 5 present the results of the Hedge's *g* effect size comparison between the scores of the group with only an active intervention and the group with an active intervention combined with a passive intervention. The results indicate that the active intervention in combination with a passive intervention had a small effect, with an effect size of -0.30 (95% CI [-0.67; 0.07]) for the SSS and -0.13 (95% CI [-0.49; 0.24]) for the FSS. It is important to note that the confidence interval for both effect sizes cross zero, suggesting that there is some uncertainty as to whether the active intervention alone had a positive or negative effect. The *p*-value for the SSS is 0.02, indicating that the difference between the groups is statistically significant at the 5% level. On the other hand, the *p*-value for the FSS is 0.15, suggesting that there is no statistically significant difference between the groups for the FSS.

The result of D1 in Figure 4 shows that participants in the group of KT combined with gliding exercise have greater improvements in SSS part of BCTQ scores compared to the placebo KT group (only gliding exercise), but no significant difference in FSS part of BCTQ scores as shown in Figure 5. The result of Yildirim study shows that the experimental group (KT with gliding exercise) produced better outcomes in both SSS and FSS scores compared to the control group (only gliding exercise) as shown in Figure 4 and 5. However, the result of D2 shows that participants in the group of only gliding exercise produced better outcomes in both SSS and FSSS scores compared to the group of OD combined with gliding exercise as shown in Figure 4 and 5.

Figure 4. Forest plot for the effect of the scores of the active to the scores of the active with passive interventions on the SSS of the BCTQ.

(Active With Passive Intervention) (Active Intervention)

	Experimental			Control				Std. Mean Difference
Study	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% CI
Kulcu (D1)	20.00	7.5000	20	24.40	8.0000	20	34.2%	-0.56 [-1.19; 0.08]
Kulcu (D2)	28.70	11.8000	20	24.40	8.0000	20	34.8%	0.42 [-0.21; 1.05]
Yildirim	19.84	4.6500	19	25.66	8.7900	19	31.0%	-0.81 [-1.47; -0.15]
Total (95% CI)			**59**			**59**	**100.0%**	**-0.30 [-0.67; 0.07]**

Heterogeneity: $Tau^2 = 0.3154$; $Chi^2 = 7.93$, df = 2 (P = 0.02); $I^2 = 75\%$

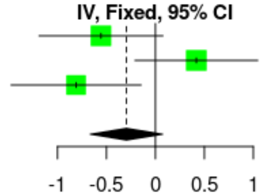
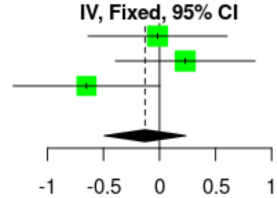


Figure 5. Forest plot for the effect of the scores of the active to the scores of the active with passive interventions on the FSS of the BCTQ.

(Active With Passive Intervention) (Active Intervention)

	Experimental			Control				Std. Mean Difference
Study	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% CI
Kulcu (D1)	16.20	5.4000	20	16.30	5.8000	20	34.6%	-0.02 [-0.64; 0.60]
Kulcu (D2)	19.70	19.7000	20	16.30	5.8000	20	34.4%	0.23 [-0.39; 0.85]
Yildirim	10.89	4.4000	19	13.73	4.1300	19	31.0%	-0.65 [-1.31; 0.00]
Total (95% CI)			**59**			**59**	**100.0%**	**-0.13 [-0.49; 0.24]**

Heterogeneity: $Tau^2 = 0.0959$; $Chi^2 = 3.85$, df = 2 (P = 0.15); $I^2 = 48\%$



Effect of Active and Passive Interventions on Symptom and Functional Improvement

Figure 6 and Figure 7 show the standardized effect sizes for the active and passive interventions, as measured by Hedge's *g*, at baseline and post-intervention for both the SSS and FSS portion of the BCTQ.

The results of the Wolny and Pratelli study show that active interventions demonstrate a significantly larger effect size compared to passive interventions in the SSS. In the SSS, active interventions have a Hedge's *g* effect size of 2.14 and 2.89, while passive interventions have a Hedge's *g* effect size of 0.49 and 0.92. However, the Schmid study has an outlier result with a smaller effect size for active interventions (0.54) compared to passive interventions (0.75) in the SSS. The results are similar in the FSS, with the Wolny and Pratelli study finding active interventions to have a Hedge's *g* effect size of 1.13 and 2.33 and passive interventions to have a Hedge's *g* of 0.23 and 0.38. Again, the Schmid study shows the opposite result with a larger effect size for passive interventions (0.75) compared to active interventions (0.54) in the FSS.

Figure 6. Comparison of Baseline and Post-Intervention SSS Scores

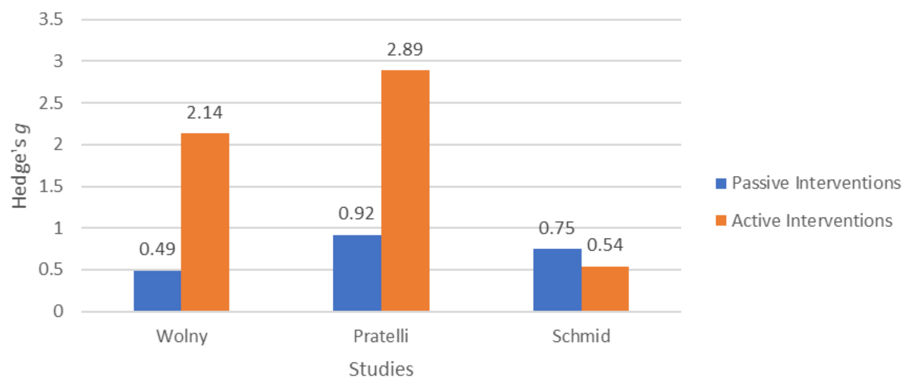
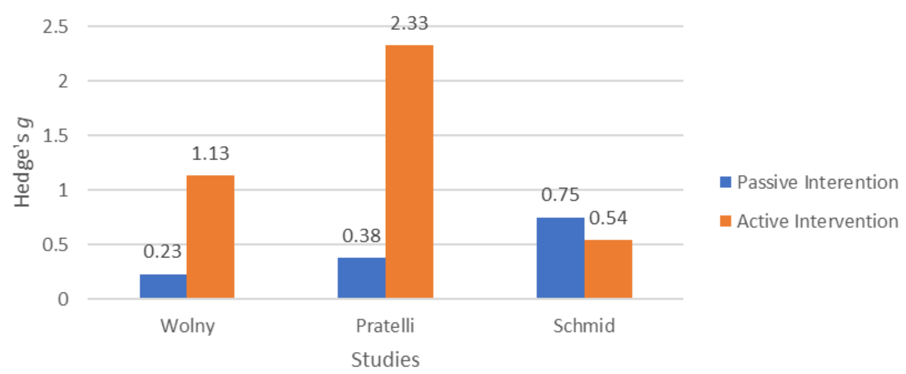


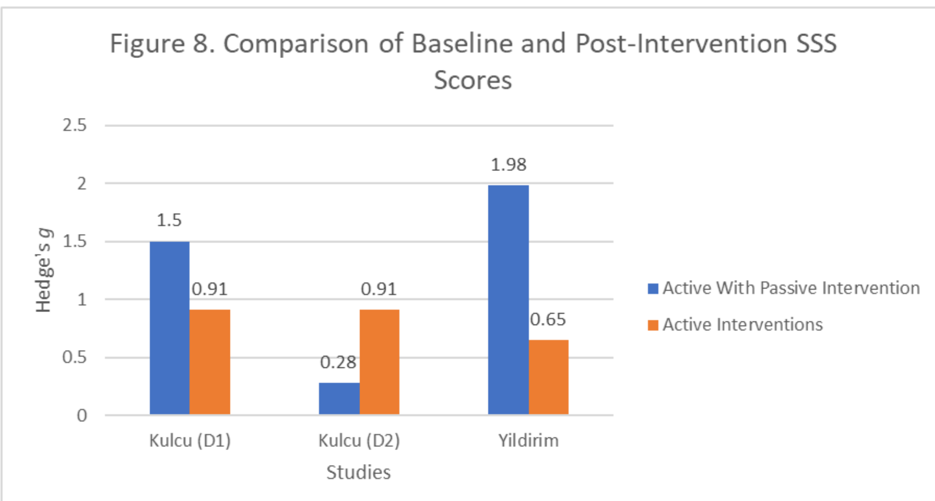
Figure 7. Comparison of Baseline and Post-Intervention FSS Scores

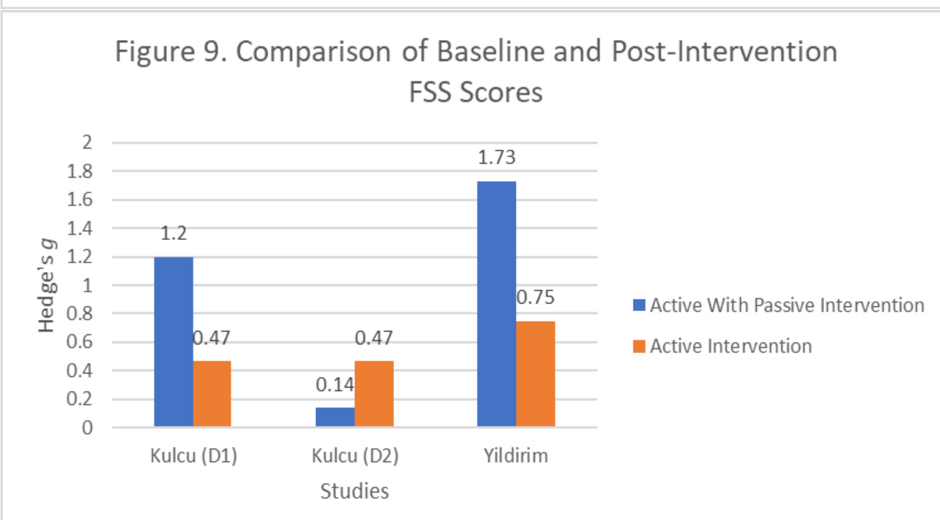


Effect of Active and Active with Passive Interventions on Symptom and Functional Improvement

Figure 8 and Figure 9 show the standardized effect sizes for the active and active with passive interventions, as measured by Hedge's *g*, at baseline and post-intervention for both the SSS and FSS portion of the BCTQ.

The results of the Kulcu (D1) and Yildirim studies show that combining active and passive interventions results in a higher effect size compared to active interventions alone. The effect sizes for SSS in the Kulcu (D1) study are 1.5 for active with passive intervention and 0.91 for active intervention alone. In the Yildirim study, the effect sizes for SSS are 1.98 for active with passive and 0.65 for active alone. The results for FSS also show that combining active and passive interventions is more effective, with effect sizes of 1.2 for active with passive in the Kulcu (D1) study and 1.73 for active with passive in the Yildirim study, compared to 0.47 and 0.75 for active intervention alone in the respective studies. However, the Kulcu (D2) study shows the opposite result, with a higher effect size for active intervention alone (0.91) than for active with passive intervention (0.28) for SSS and a higher effect size for active intervention alone (0.47) than for active with passive intervention (0.14) for FSS.





Discussion

Three of the studies we analyzed (Wolny, Pratelli, and Schmid) used mean values from each question in the BCTQ to calculate the scores. The other two studies (Kulcu and Yildirim) used accumulated scores, which were calculated by adding up the scores for each question. Only one of the studies (Kulcu) provided information on how the BCTQ was scored. One of the studies (Schmid) did not separate the BCTQ into the SSS and FSS.

In the Wolny et al study[19], the manual therapy (MT) group (active) was superior to the control group, which received electrophysical modalities (EM) treatment (passive). However, it is important to note that the MT group included a variety of interventions, such as functional massage, wrist mobilization, and neurodynamic techniques, which disallowed determining the definite effectiveness of each individual intervention. Both SSS and FSS score improvements (1.19 and 0.9 respectively) in MT group were greater than MDC. However, those in EM group were only 0.37 and 0.21 respectively.

The Pratelli et al study [20] examined the effectiveness of fascial manipulation compared to laser therapy for the treatment of CTS. Outcome measurements were at three time points: pre-treatment (T0), 10 days after the end of the intervention (T1), and 3 months after the end of the intervention (T2). The data at T1 were used in the analysis in order to match the follow-up time frame of the other RCTs in the study and avoid the wide range of follow-up times that would have resulted if T2 data had been used. Nonetheless, the data at T2 still shows a significant difference between the two groups, indicating that fascial manipulation is more effective than laser therapy. The improvement of BCTQ scores in the fascial manipulation group reached greater than MDC (SSS: 1.67 and FSS 1.69) whereas those in the laser therapy group only increased by 0.38 in SSS and 0.32 in FSS.

The Schmid et al study [21] also compared two treatment options, one involving the use of splints and the other involving tendon and nerve gliding exercises. The treatment period in this study was just one week, but the authors suggested that this may still produce real clinical improvements rather than simply being due to the natural healing process. Both groups showed significant improvements, but there were no significant differences between the groups. The effect size was larger for the splint group, but it was not possible to determine the effect size for each of the SSS and FSS measure as the study used a mean value from both SSS and FSS rather than distinguishing between the two. One significant limitation of the study is that the participants' exercise adherence was not recorded, so it is unclear how consistently the exercises were being performed. Both groups' BCTQ scores improved by only 0.3 points.

The Yildirim et al study [22] investigated the use of KT as an adjunctive treatment for CTS. Two groups were included in the study, with both receiving tendon and nerve gliding exercises. The experimental group included additional KT application. At the 3-week follow-up, significant differences were found between the two groups, with the KT group showing better outcomes. However, no significant difference was found between the groups at the 6-week follow-up. This suggests that while KT may provide some benefit in the management of CTS when used in conjunction with gliding exercises, the benefit appears limited.

The Kulcu et al study [23] also looked at the use of KT in the management of CTS but includes three groups in the study. All groups received tendon gliding exercises, with the first group receiving proper KT application, the second group receiving placebo KT, and the third group receiving wrist ODs. All three groups showed improvement in SSS and FSS following the 4-week treatment period. A significant difference in SSS and FSS scores was found between the KT and OD groups, with the difference in favor of the KT group. The OD group also showed some improvements in BCTQ scores, but the effect size was smaller compared to the placebo KT group. This may be due to the unknown adherence rate of participants in the OD group, as they were only recommended to use the ODs when convenient. While the study showed that KT application was effective after 4 weeks of treatment, no data was available on the long-term effects beyond the 6-week mark as found in the Yildirim et al study.

The research articles did not use the process of individually calculating the MCID for BCTQ based on the baseline SSS and FSS scores of each patient as suggested by the study from Kleermaeker et al.[14] Upon examination of the available information, it appears that the studies were not adequately robust to allow for the use of sliding scales to subgroup patients in the severe to moderate categories of the condition. One of the significant factors contributing to this limitation is likely the small sample sizes used in these studies.

On balance, this systematic review suggests that active interventions have a larger impact on the scores of both the SSS and FSS parts of the BCTQ compared to passive interventions. The effect sizes for active interventions are considered large and range from 0.8 and above, indicating that active interventions, including nerve gliding exercise, neurodynamic techniques, functional massage, carpal bone mobilization techniques, and fascial manipulation, may have a potentially substantial and clinically meaningful impact on symptom reduction and functional improvement.

Furthermore, an important finding from this systematic review is that a combination of KT and gliding exercises produced significantly better outcomes when calculated in Hedge’s *g* effect size using baseline data and post-intervention data in both SSS and FSS scores than only gliding exercises performed in the treatment of CTS as noted in Kulcu’s and Yildirim’s studies respectively. (Fig 8 and 9)

Limitations

The present study is subject to several limitations that must be taken into consideration when interpreting its results. Drawing firm conclusions about the true long-term efficacy of the interventions is challenging because of the outcome measurements conducted across varying durations. Another limitation arises from the inherent nature of CTS, which is characterized by fluctuations in symptoms over the course of the disease process. This raises the possibility that any observed improvement in symptoms may be due to the disease's natural course, rather than the result of the interventions under investigation. The lack of a true control group, in which participants receive no intervention, further complicates our understanding of the impact of active interventions. Finally, the significant heterogeneity among the studies analyzed in this systematic review represents a hindrance, as it restricts the ability to draw generalizable conclusions. Nevertheless, this systematic review still provides a useful comparative evaluation between active and passive interventions in the management of CTS.

Conclusion

In conclusion, the results of our systematic review suggest that active interventions, including manual therapy and gliding exercises, tend to exhibit superior effectiveness in the management of CTS when compared to passive interventions, such as KT, OD, and modalities. However, it's important to note that both active and passive interventions can still improve outcomes for individuals with CTS.

Furthermore, the utilization of KT in conjunction with active interventions, such as gliding exercises, may produce improved outcomes over the short-term when compared to the sole application of gliding exercises, but the benefit is limited. Consequently, it is important for clinical practitioners to exercise clinical reasoning and discretion in integrating both active and passive interventions into their treatment plans to optimize the outcomes for patients with CTS.

Acknowledgments

Thank you to our professors for guiding us during the process of doing the systematic review.

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