Cadernos Brasileiros de Terapia Ocupacional
Brazilian Journal of Occupational Therapy

ISSN 2526-8910

Original Article

Evaluation of the effectiveness of night splints and occupational therapy in carpal tunnel syndrome

Evaluación de la eficacia de férulas nocturnas y terapia ocupacional en síndrome del túnel carpiano

Avaliação da eficácia das talas noturnas e da terapia ocupacional na síndrome do túnel do carpo

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How to cite: Castán Gasquet, R., Pardo Sanz, M. P., Casas Lázaro, J., Estallo Bernadós, V., & Roman Cosculluela, N. (2026). Evaluation of the effectiveness of night splints and occupational therapy in carpal tunnel syndrome. *Cadernos Brasileiros de Terapia Ocupacional*, *34*, e4081. https://doi.org/10.1590/2526-8910.cto415240812

Abstract

Introduction: Carpal Tunnel Syndrome (CTS) is a common condition that can significantly affect the quality of life of patients. It affects 3% of the global population and is a major cause of absenteeism from work. Treatment can be conservative or surgical. Night splints and occupational therapy are common interventions in conservative treatment. **Objective:** To evaluate the efficacy of a combined intervention of night splints and OT in improving symptoms in patients with mild to moderate CTS. **Method:** Quasi-experimental study with 20 participants diagnosed with CTS without surgical intervention evaluated, over six weeks, the efficacy of using night splints combined with a treatment program led by an occupational therapist. Assessment tools were BCTQ-S, VAS and tactile discrimination between two points. **Results:** The data showed a marked improvement in the majority of participants, highlighting the importance of ergonomic treatment to perform Activities of Daily Living. In 40% of patients, a Minimal Clinically Significant Improvement (MCDI) was observed on the BCTQ-S scale and in 65% on the EVA scale. **Conclusion:** The proposed treatment can reduce the symptoms of mild to moderate CTS. The importance of changes in gestural habits to improve the symptoms of patients was highlighted. The combination of night splints and ergonomic treatment may be an effective option in the management of mild and moderate CTS, but further studies are needed to confirm these findings.

Received on Mar. 27, 2025; Revised on Jun. 29, 2025; Accepted on Oct. 6, 2025.

Keywords: Carpal Tunnel Syndrome, Occupational Therapy, Splints, Ergonomics, Activities of Daily Living.

Resumen

Introducción: El Síndrome del Túnel Carpiano (STC) es una afección común que puede afectar significativamente la calidad de vida de los pacientes. Afecta al 3% de la población global y es una causa importante de absentismo laboral. El tratamiento puede ser conservador o quirúrgico. Las férulas nocturnas y la terapia ocupacional son intervenciones comunes en el tratamiento conservador. **Objetivo:** Evaluar la eficacia de una intervención combinada de férulas nocturnas y terapia ocupacional en la mejora de los síntomas en pacientes con STC leve a moderado. **Método:** Estudio cuasi-experimental con 20 participantes diagnosticados con STC sin intervención quirúrgica evaluó, durante seis semanas, la eficacia del uso de férulas nocturnas combinado con un programa de tratamiento dirigido por un terapeuta ocupacional. Las herramientas de evaluación fueron BCTQ-S, EVA y discriminación táctil entre dos puntos. **Resultados:** Los datos mostraron una mejora notable en la mayoría de los participantes, destacando la importancia del tratamiento ergonómico para realizar Actividades de la Vida Diaria. En el 40% se objetivó una Mejora Mínima Clínicamente Significativa (MCDI) en la escala de BCTQ-S y el 65% en la escala EVA. **Conclusión:** El tratamiento propuesto puede reducir los síntomas del STC leve a moderado. Se destacó la importancia de los cambios de hábitos gestuales para mejorar la sintomatología de los pacientes. La combinación de férulas nocturnas y tratamiento ergonómico puede ser una opción eficaz en el manejo del STC leve y moderado, pero se necesitan más estudios para confirmar estos hallazgos.

Palabras clave: Síndrome del Túnel Carpiano, Terapia Ocupacional, Férulas, Ergonomía, Actividades Cotidianas.

Resumo

Introdução: A Síndrome do Túnel do Carpo (STC) é uma condição comum que pode afetar significativamente a qualidade de vida dos pacientes. Afeta 3% da população mundial e é uma das principais causas de absentismo laboral. O tratamento pode ser conservador ou cirúrgico. Talas noturnas e terapia ocupacional são intervenções comuns no tratamento conservador. **Objetivo:** Avaliar a eficácia de uma intervenção combinada de talas noturnas e terapia ocupacional na melhora dos sintomas em pacientes com STC leve a moderada. **Método:** Estudo quase experimental com 20 participantes com diagnóstico de STC sem intervenção cirúrgica avaliou, durante seis semanas, a eficácia do uso de talas noturnas combinadas com um programa de tratamento liderado por um terapeuta ocupacional. Os instrumentos de avaliação foram BCTQ-S, VAS e discriminação tátil entre dois pontos. **Resultados:** Os dados mostraram uma melhora notável da maioria dos participantes, destacando a importância do tratamento ergonômico para a realização das Atividades da Vida Diária. Melhora Mínima Clinicamente Significativa (MCDI) foi observada em 40% na escala BCTQ-S e 65% na escala VAS. **Conclusão:** O tratamento proposto pode reduzir os sintomas da STC leve a moderada. Foi destacada a importância das mudanças nos hábitos gestuais para a melhora dos sintomas dos pacientes. A combinação de talas noturnas e tratamento ergonômico pode ser uma opção eficaz no manejo da STC leve e moderada, mas são necessários mais estudos para confirmar esses achados.

Palavras-chave: Síndrome do Túnel do Carpo, Terapia Ocupacional, Talas Estáticas, Ergonomia, Atividades Cotidianas.

Introduction

Carpal tunnel syndrome (CTS) is a condition affecting the median nerve due to compression, impacting approximately 3% of the global population. It is more common in women, with a 3:1 ratio, typically between the ages of 40 and 60, while the incidence in men is 0.6% (Granados et al., 2020).

Symptoms include wrist and hand pain, which may radiate to the arm, as well as paresthesia (numbness or tingling) in the thumb, index, middle, and radial half of the ring finger (Karjalainen et al., 2023).

CTS is more frequent in professions that require repetitive or forceful gripping, sustained wrist flexion, or exposure to vibrations from hand tools (Karjalainen et al., 2023; Kraut et al., 2024). It is among the conditions that lead to the highest rates of work absenteeism, with a substantial economic impact (Crijns et al., 2020; Sears et al., 2019). It generates significant disability-related costs for workers, employers, and insurance systems, in addition to indirect costs for society and the healthcare system. CTS causes considerable functional impairment, leading to pain and reduced hand use, which negatively affects performance in activities of daily living (ADLs) and overall quality of life (Karjalainen et al., 2023).

Treatment of CTS can be conservative and/or surgical. Conservative treatment is more common in individuals with mild or moderate symptoms, whereas surgical treatment involves releasing the carpal tunnel (Sears et al., 2019). Evidence supporting conservative management primarily highlights the use of splinting combined with exercise (Roll & Hardison, 2017). Splints aim to limit wrist movement and thereby reduce pain and numbness (Chen et al., 2022; Gatheridge et al., 2020). Neutral position can increase carpal tunnel space, decrease median nerve compression (Gradim & Paiva, 2018), and consequently alleviate symptoms (Gatheridge et al., 2020; Karjalainen et al., 2023; Šošić et al., 2020).

Given the benefits of conservative treatment, evidence supports its use prior to surgical intervention (Karjalainen et al., 2023; Parish et al., 2020; Shi et al., 2020). The main goal of occupational therapy is to enable individuals to participate in activities of daily living (ADLs) and to reduce risk factors that affect their performance. Some of the intervention methods used in occupational therapy to treat carpal tunnel syndrome (CTS) include ergonomic postural education for activities of daily living (ADLs), therapeutic manipulative activities, the design and fabrication of night splints, the provision and training in the use of assistive devices, and environmental modifications (Karjalainen et al., 2023; Lewis et al., 2020; Nazarieh et al., 2020; Parish et al., 2020; Wise & Bettleyon, 2022).

Following these recommendations, the Occupational Therapy Department at San Jorge University Hospital in Huesca, Aragon, Spain (HUSJ) has been fabricating splints for patients with non-surgical CTS since 2007. Since then, we have observed notable improvements with the use of night splints combined with occupational therapy. This was the primary motivation for conducting the study, because although evidence is limited regarding the extent to which splints benefit individuals with CTS (Karjalainen et al., 2023), our clinical experience suggests associated symptomatic improvement. Previous studies also show moderate to strong evidence supporting the use of night splints (Lewis et al., 2020).

The hypothesis of our study was to determine whether patients with carpal tunnel syndrome (CTS) treated in our Occupational Therapy Department experience improvement after combined treatment with a nighttime postural splint and group occupational therapy.

The overall objective was to describe the results of using a nighttime postural splint, fabricated in the Occupational Therapy Department, for individuals with non-interventional CTS, combined with group occupational therapy.

The specific objectives were twofold. First, to examine whether the use of a nighttime splint combined with occupational therapy significantly reduces CTS symptoms. Second, to conduct an initial clinical evaluation before splint use and treatment, followed by a second evaluation six weeks later.

Methods

A study was conducted on patients with non-interventional CTS, following the standard practice of the Occupational Therapy Department at HUSJH. Given the favorable treatment outcomes, it was considered unethical to exclude any portion of the population from receiving this intervention. For this reason, no control group was included, and a quasi-experimental design was deemed the most appropriate.

The Scientific Research Ethics Committee of Aragon (CEICA) approved the study on December 10, 2022. All participants signed an informed consent form ensuring that their data would be processed anonymously and that only information relevant to the study would be used.

Patients between 25 and 65 years of age, referred from the Rehabilitation Medicine Clinic of the HUSJ (University Hospital San Jorge), with mild to moderate carpal tunnel syndrome (CTS) without prior intervention, and with at least 3 months of confirmed diagnosis, verified by electroneurogram and a positive Tinel's sign, were included. Exclusion criteria were: severe CTS, diabetes, prior diagnosis of arthritis, use of a night splint before the study, and non-adherence to treatment (defined as not using the night splint and not attending occupational therapy sessions).

Two interrelated interventions were carried out: the use of a night splint and occupational therapy education and training.

Six weeks was considered the optimal time to assess the effects of the intervention. Although splint use varies between 1 and 12 weeks, evidence to guide the ideal duration of splinting is limited (Gatheridge et al., 2020).

The intervention was performed by two occupational therapists. The splint was fabricated the week before the start of treatment, based on each patient's measurements to ensure correct use. The model used was a Cock-up orthosis in a neutral wrist position, made of 2.4 mm thermoplastic material (Agnelli Martinez et al., 2023).

The six-week treatment period then began in groups of four, with two one-hour sessions per week.

The treatment content included:

- Education on the biomechanical and ergonomic implications of CTS.
- Self-awareness of gestures and personal movement patterns during various Activities of Daily Living (ADLs) and work tasks.
- Instruction on protective wrist postures to prevent CTS symptoms.
- Habit changes at work and during ADLs.
- Instruction in self-care techniques (self-stretching, neurodynamics).
- Low-resistance activities to promote tendon gliding.
- Strengthening of intrinsic hand muscles while avoiding excessive use of forearm musculature during different occupations.

The evaluation tools were the Visual Analog Scale (VAS) for pain, the two-point discrimination test (measured with a Baseline esthesiometer), and the Boston Carpal Tunnel Syndrome Symptom Severity Scale (BCTSQ-S) (Andani Cervera et al., 2017; Mertz et al., 2022).

The independent variable was the combined intervention of night splints and occupational therapy (nominal qualitative variable).

The dependent variables were:

1. Carpal tunnel syndrome (CTS) symptoms, assessed using the symptom severity subscale of the Boston Carpal Tunnel Questionnaire (BCTQ-S). This instrument comprises two subscales: one measuring symptom severity (BCTQ-S) and another assessing function (BCTQ-F). In this study, only the BCTQ-S subscale was used. It consists of 11 items rated from 1 to 5, where 1 indicates mild or no symptoms and 5 represents the most severe symptoms.

   This is a continuous quantitative variable, as the result is obtained from the arithmetic mean of the item scores.

   The items assessed include:

   1. Severity of pain or discomfort in the hand during the night.
   2. Frequency with which pain awakens the patient during the night.
   3. Presence of wrist or hand pain during the day.
   4. Frequency of daytime pain.
   5. Average duration of daytime pain.
   6. Presence of numbness or loss of sensation in the hand during the day.
   7. Sensation of weakness in the hand or wrist.
   8. Presence of tingling in the hand.
   9. Severity of nighttime numbness or tingling.
   10. Frequency with which numbness or tingling awakens the patient during the night.
   11. Difficulty manipulating small objects.
2. Pain level, measured using the Visual Analogue Scale (VAS), a subjective tool that allows the patient to indicate their pain intensity on a scale from 0 to 10, where 0 represents no pain and 10 represents the worst pain imaginable. This is a continuous quantitative variable, as it can take any value within the range, including decimal fractions.
3. Tactile discrimination between two static points, assessed on the first three fingers (thumb, index, and middle) using a calibrated discrimination disc. The minimum distance at which the patient could perceive two simultaneous stimuli as separate was measured in millimeters. This is a continuous quantitative variable. The normative reference values established by Pandian et al. (2024) were used, reporting average ranges of 2.78 to 3.5 mm on the fingertips of healthy adults.

The assessments were performed by rehabilitation specialists before and after treatment, with a minimum interval of six weeks and a maximum of eight. This variation depended on physician availability, always respecting the minimum six-week period stipulated by the protocol, which included both splint use and the occupational therapy intervention.

The sample was analyzed based on the results of the BCTQ-S, which is validated and used in 60% of carpal tunnel syndrome (CTS) studies; the Visual Analogue Scale (VAS) for pain, used in 50% of the studies; and the two-point discrimination test (measured with an esthesiometer), used in 9% of the studies (Mertz et al., 2022).

Data were compiled in an Excel spreadsheet for subsequent statistical processing. The data collection period was from December 2022 to January 2024.

For data analysis, qualitative variables were presented using their frequency distribution, and quantitative variables were presented using measures of central tendency (mean, median), dispersion (standard deviation), and non-central tendency (first and third quartiles).

To compare the BCTQ-S, VAS, and tactile discrimination scores measured before and after follow-up, non-parametric tests for paired samples (Wilcoxon signed-rank test) were used, as these variables did not follow a normal distribution (verified using the Shapiro–Wilk test).

A difference was considered statistically significant at p-values < 0.05, using two-tailed tests.

A difference was considered clinically important with VAS scores ≥ 2.2 (Randall et al., 2022) and BCTQ-S scores ≥ 1 (Karjalainen et al., 2023), and the proportion of patients meeting or exceeding these thresholds was estimated along with its confidence interval (5% significance level).

Analyses were performed using R software (Foundation for Statistical Computing, 2022).

Results

The initial sample consisted of 31 patients, 11 of whom did not meet the inclusion criteria. Treatment was discontinued in six cases for various reasons: one due to cervical symptoms that prevented participation in group therapy, four who dropped out of the program, and one who discontinued treatment after receiving an injection in the carpal tunnel area. Of the remaining patients, two cases were not confirmed by electroneurography, and one was diagnosed with severe CTS. The final sample consisted of 20 patients aged between 30 and 63 years, 17 women and 4 men. The unit of analysis for the intervention was the hand, with bilateral involvement observed in 50% of the sample (10 patients), resulting in a total of 30 cases included in the study. The sociodemographic and clinical characteristics are summarized in Table 1.

Table 1. Participant characteristics.

Characteristic[1]	**N = 20**
Sex	
Man	4 (20)
Woman	16 (80)
Age	52 (9) ; 53 (47, 57)
Dominanthand	16 (80)
Affectedhand	
Both	10 (50)
Right	6 (30)
Left	4 (20)
Arthrosis	5 (25)
Medication	8 (40)
Anti-inflammatories	2 (10)
Analgesics	6 (30)
Neurotrophics	2 (10)
Heavy duty profession	9 (45)
Occupational repetitive movements	17 (85)

[1]n (%); Mean (SD); Median (IQR).

In the BCTQ-S, the VAS scale, and the two-point tactile discrimination test, the median values decreased from 2.59 to 1.68, from 6 to 3, and from 2.50 to 2, respectively. In all three cases, the differences were statistically significant (p-value < 0.05). The effect size indicator used was the Wilcoxon signed-rank test (V-T). For the BCTQ-S, the VAS scale, and the two-point tactile discrimination test, values of 1, 0.98, and 0.91 were obtained, respectively. These results indicate an ideal relationship in the first case (Figure 1) and a near-perfect relationship in the second and third cases between the different tests and the two moments analyzed. The detailed results of the pre- and post-intervention evaluation are presented in Table 2.

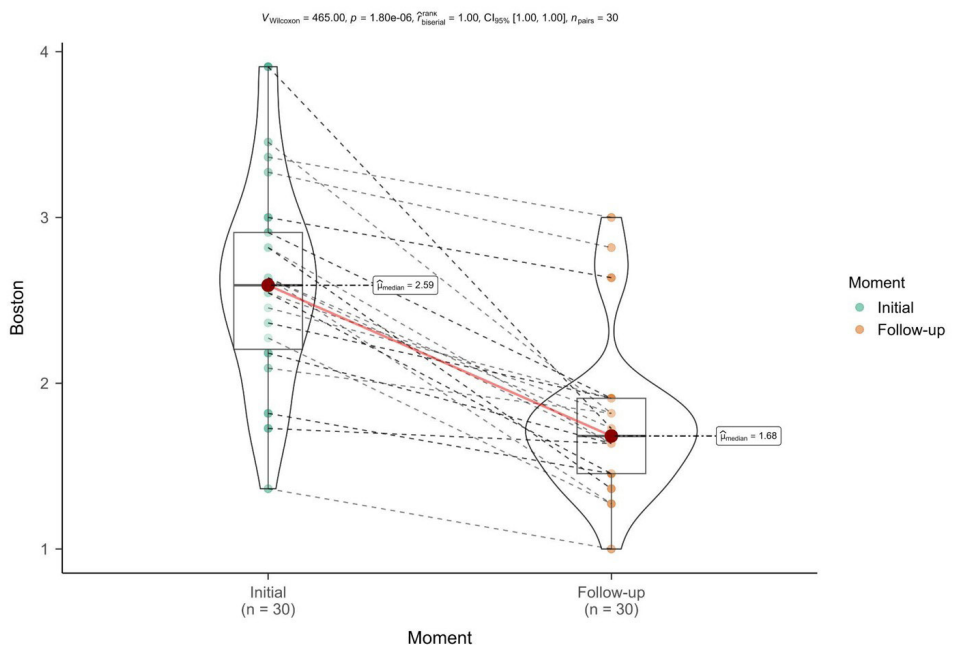

Figure 1. BTCQ-S Scale.

Table 2. Evaluation of different parameters.

Parameters[1]	Moment		U-statistic p-value[2]
	Initial (n = 30)	Follow-up (n = 30)	
BCTQ-S	2.60 (0.62); 2.59 (2.20, 2.91)	1.77 (0.46); 1.68 (1.45, 1.91)	769.5 < 0.001
BCTQ-S_item_1	2.77 (1.14); 3.00 (2.00, 3.75)	1.50 (0.63); 1.00 (1.00, 2.00)	729 <0.001
BCTQ-S _item_2	2.10 (1.03); 2.00 (1.00, 3.00)	1.40 (0.62); 1.00 (1.00, 2.00)	619 0.01
BCTQ-S _item_3	2.40 (0.72); 2.00 (2.00, 3.00)	2.07 (0.69); 2.00 (2.00, 2.75)	550 0.10
BCTQ-S _item_4	3.20 (1.32); 3.00 (2.00, 4.75)	2.43 (1.25); 2.00 (2.00, 3.00)	597.5 0.02
BCTQ-S _item_5	3.10 (1.35); 3.00 (2.00, 4.75)	2.27 (1.20); 2.00 (2.00, 2.00)	622 0.01

[1]Mean (SD); Median (IQR); [2]Wilcoxonrank sum test.

Table 2. Continued...

Parameters[1]	Moment		U-statistic p-value[2]
	Initial (n = 30)	Follow-up (n = 30)	
BCTQ-S _item_6	2.57 (0.82); 3.00 (2.00, 3.00)	1.87 (0.68); 2.00 (1.00, 2.00)	664.5 <0.001
BCTQ-S _item_7	2.50 (0.94); 3.00 (2.00, 3.00)	1.93 (0.78); 2.00 (1.00, 2.00)	612 0.01
BCTQ-S _item_8	2.67 (0.76); 3.00 (2.00, 3.00)	1.63 (0.72); 1.50 (1.00, 2.00)	737.5 <0.001
BCTQ-S _item_9	2.90 (1.12); 3.00 (2.00, 4.00)	1.43 (0.57); 1.00 (1.00, 2.00)	766.5 <0.001
BCTQ-S _item_10	2.23 (1.28); 2.00 (1.00, 3.00)	1.33 (0.66); 1.00 (1.00, 1.00)	645.5 0.001
BCTQ-S _item_11	2.20 (1.16); 2.00 (1.00, 3.00)	1.63 (1.00); 1.00 (1.00, 2.00)	583.5 0.03
EVA	5.37 (1.96); 6.00 (4.00, 6.75)	2.80 (2.35); 3.00 (0.00, 4.75)	719 < 0.001
Average 2 points discrimination	3.49 (2.43); 2.50 (2.00, 4.00)	2.16 (0.98); 2.00 (1.67, 2.33)	609 0.02

[1]Mean (SD); Median (IQR); [2]Wilcoxonrank sum test.

According to the MCID, 40% of the sample showed improvement on the BCTQ-S and 65% on the VAS scale. Items 1, 8, and 9 of the BCTQ-S exceeded the MCID in all cases, with a 100% improvement rate.

One of the most relevant findings was the difference in the percentage of improvement between patients with and without arthrosis (50% vs. 36%) (Figure 2).

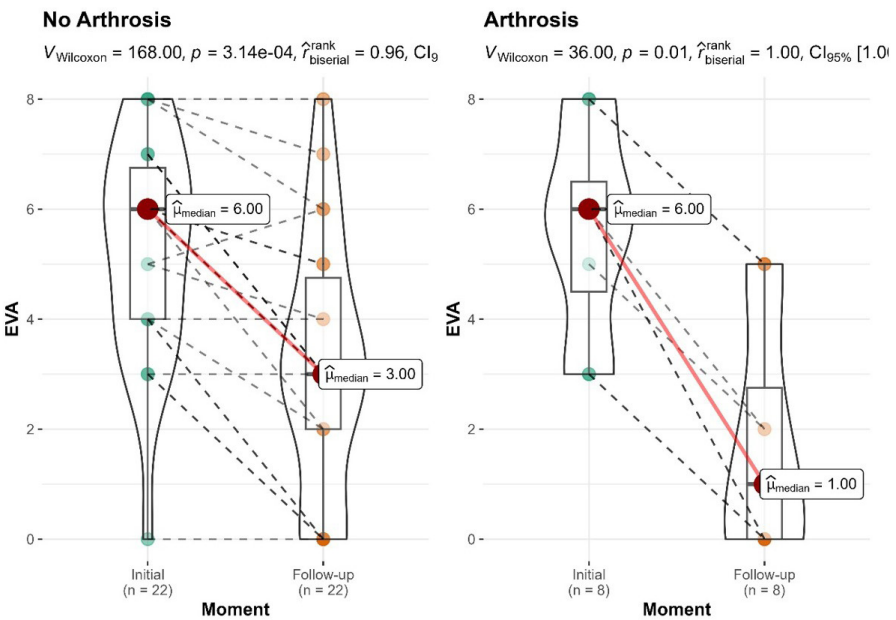

Figure 2. Patients with and without arthrosis.

No significant differences were observed between patients taking medication and those not taking it (mostly analgesics and anti-inflammatories).

Discussion

The study revealed notable improvements in carpal tunnel syndrome (CTS) symptoms in all participants. Importantly, these improvements were observed regardless of CTS severity or whether the dominant hand was affected, suggesting that the interventions applied may be effective in a variety of cases (Karjalainen et al., 2023).

The improvement observed in patients with arthrosis emphasizes the importance of ergonomic treatment and changes in daily habits (Algar et al., 2023; Tanashi et al., 2022). The implementation of ergonomic strategies, along with the teaching of joint protection techniques and the use of splints, may have contributed significantly to this improvement (Nazarieh et al., 2020; Parish et al., 2020).

The use of the splint was particularly effective in relieving nighttime symptoms, such as pain and tingling, which are common among patients with carpal tunnel syndrome (CTS), as reflected in the results of items 1, 3, and 9 of the BCTQ-S. This observation supports the use of a night splint in CTS, since many patients experience a worsening of symptoms at night (Benavides et al., 2023; Karjalainen et al., 2023; Šošić et al., 2020).

No significant differences were observed between patients who took medication and those who did not; this finding attributes the observed improvement to the treatment received rather than to medication, supporting the effectiveness of the conservative interventions applied in the study, such as patient education, the use of a night splint, and ergonomic modifications (Naughton & Algar, 2022; Šošić et al., 2020).

Hypoesthesia, a common subjective sensation among patients diagnosed with carpal tunnel syndrome, is frequently associated with treatment effectiveness and full recovery. This relationship suggests a marked improvement in most study participants, particularly in the reduction of nocturnal tingling symptoms (Šošić et al., 2020; Velázquez-Rueda et al., 2018).

Significant differences were observed in the tactile discrimination results. Other studies have also identified significant findings in two-point discrimination, reporting improvement in median nerve distribution after surgery, averaging 3.3 ± 2.7 mm (mean difference 7.7 vs. 4.4 mm, $p < 0.001$) (Colaokghm et al., 2021).

The main limitations of the study were the absence of a control group and the sample size. The lack of a control group reduces the ability to establish direct causality between the intervention and the observed results. The small sample size may affect the statistical power and generalizability of the findings; however, the results were strong enough to support the study's conclusions. Another limitation relates to the assessment tools, as comparability with other studies using different measures could be affected (Mertz et al., 2022). In the context of treatment options for carpal tunnel syndrome (CTS), this study highlights the role of conservative treatment as a viable alternative before considering surgery. The interventions used in this study could be easily administered by occupational therapists, suggesting that they may be effectively integrated into routine clinical practice (Chu et al., 2021).

Conclusion

The main conclusion of this study was the confirmation of the use of night splints combined with a program led by an occupational therapist as a method to reduce the symptoms of mild and moderate carpal tunnel syndrome (CTS). Teaching and training in ergonomic positions were relevant, generating a significant change in how patients performed their Activities of Daily Living (ADLs).

Few studies address this non-surgical intervention comprehensively; this reality underscores the need for further research that allows for a broader and longer evaluation, as well as long-term follow-up, to better understand the functional impact of the ergonomic intervention on the working group.

Furthermore, extending the study period would allow for the evaluation of the splint's effectiveness at different times, with more realistic monitoring of the results. A minimum follow-up of three months is suggested, similar to that carried out in other studies on conservative treatments for CTS. The possibility of conducting detailed studies, including the use of splints and the evaluation of treatment effectiveness in patients with more severe cases, is raised. Including functional questionnaires, such as the Boston Functional Questionnaire-F (BCTQ-F), in future research could provide a more comprehensive understanding of treatment effectiveness.

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Author's Contributions
The creation of the article was carried out equally by all authors, and all authors approved its final version.

Data Availability

The data supporting the results of this study are available from the corresponding author upon reasonable request.

Funding Source
This work was carried out with the financial support of the Aragón Health Research Institute and with the support of the Statistics and Methodology Service of the Aragonese Institute of Health Sciences, Spain. Additionally, it received support from the Library and Documentation Service of San Jorge University Hospital in Huesca, Spain. It includes the style editing by Dr. Ignacio Alins Rami from San Jorge University Hospital in Huesca, Spain.

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