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APLICACION DE AGENTES ELECTROFISICOS EN LA PATOLOGIA DE LA MANO EN EL AMBITO LABORAL

ELECTROPHYSICAL AGENTS APPLICATION IN WORK-RELATED HAND PATHOLOGY

UNIVERSIDAD DE GRANADA

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A mi familia y amigos

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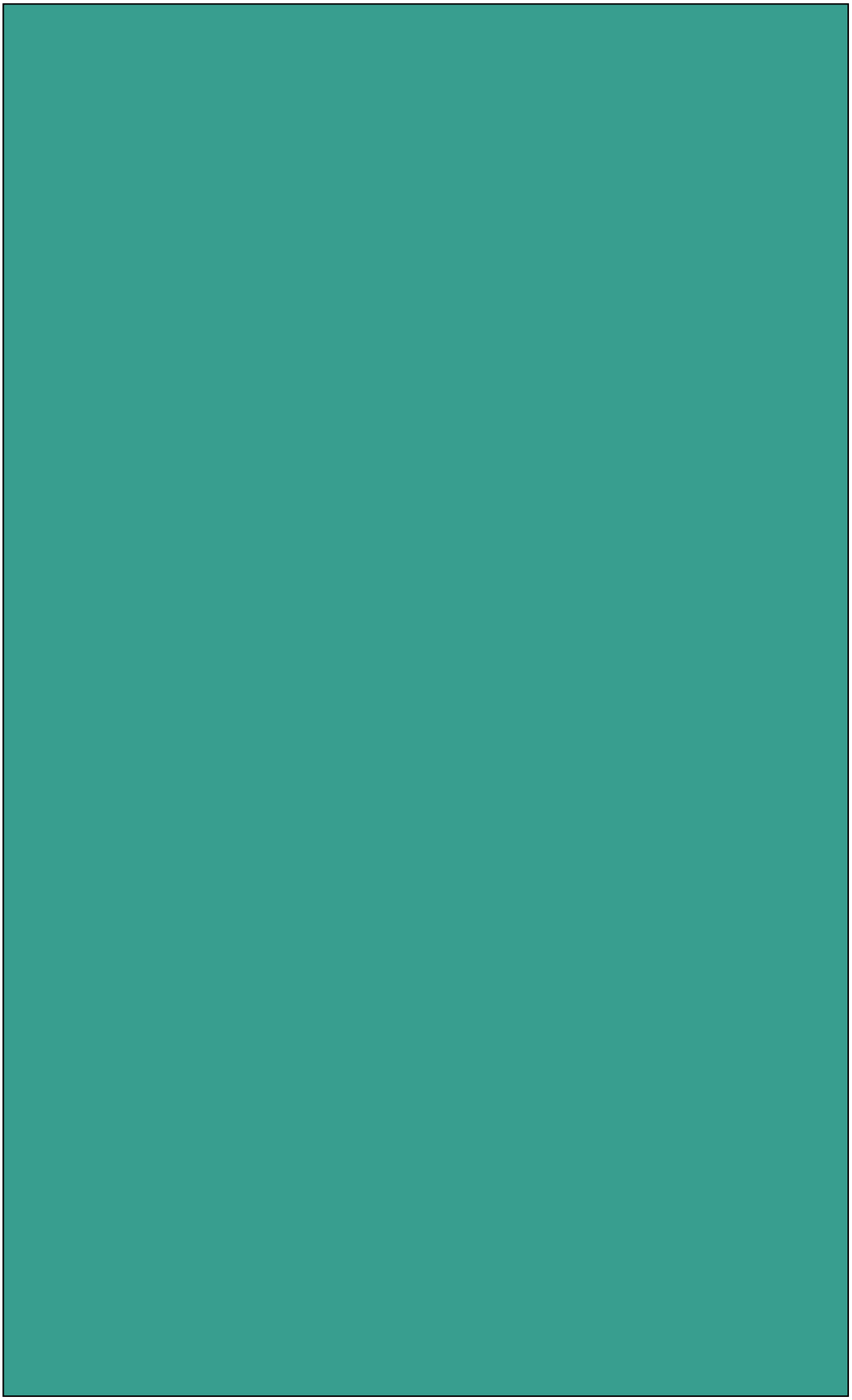

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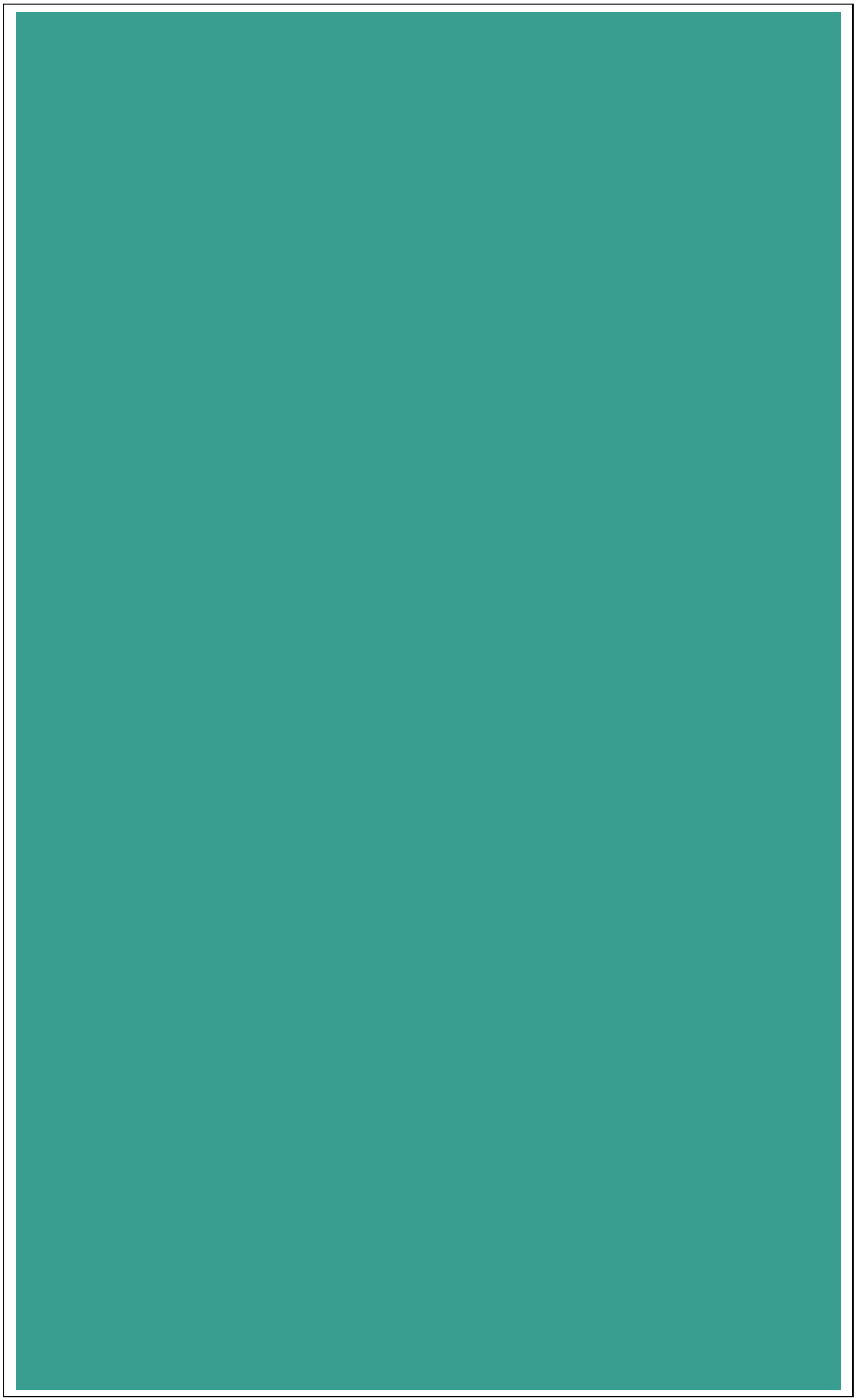


RESUMEN

En el ámbito clínico asistencial es preciso disponer de información de calidad que pueda ser trasladada y aplicada de forma sencilla y eficaz a la práctica clínica habitual. La patología de la mano en el ámbito laboral es muy relevante. Su importancia no sólo radica en su frecuencia, que se estima que es en torno a un tercio de las lesiones laborales totales, además suponen un elevado coste humano y económico.

En el mundo de la fisioterapia cada vez es más importante que las decisiones relativas a los tratamientos de los pacientes se fundamenten en estudios con una alta evidencia científica. Por esta razón, el objeto de esta tesis es ahondar en el conocimiento de los agentes electrofísicos utilizados en la patología de la mano. Para ello, se seleccionaron dos patologías de las más frecuentes en la asistencia de fisioterapia en el ámbito laboral.

Con este fin se condujeron tres revisiones sistemáticas y meta-análisis; el primero relativo a la mejora del dolor, la fuerza y la función mediante el uso de los agentes electrofísicos en la rizartrosis. El segundo relativo a la respuesta en cuanto al dolor, severidad de los síntomas, función, fuerza y parámetros neurofisiológicos tras la aplicación del ultrasonido terapéutico en los pacientes diagnosticados de síndrome del túnel carpiano. Y un tercero investigando las modificaciones en cuanto al dolor, severidad de los síntomas, función, fuerza y modificación de los parámetros neurofisiológicos tras la aplicación del ultrasonido terapéutico con respecto a la fonoforesis, así como la diferencia en cuanto a los cambios producidos en los parámetros neurofisiológicos y la función en la aplicación de fonoforesis con AINES, o la aplicación de fonoforesis con corticoesteroides.

Como conclusión, los agentes electrofísicos han mostrado ser efectivos en cuanto a la mejora del dolor, la función y la fuerza en los pacientes diagnosticados de rizartrosis. El ultrasonido terapéutico mostró cambios significativos en la mejora de la latencia motora distal de los pacientes diagnosticados de síndrome del túnel carpiano. La fonoforesis se mostró más efectiva que la aplicación de ultrasonido en cuanto a la mejora de los parámetros neurofisiológicos de los individuos con síndrome del túnel carpiano. No se encontraron diferencias significativas entre los pacientes atendidos mediante fonoforesis con AINES y fonoforesis con corticoesteroides.

Tras la realización de estos tres metaanálisis hay que destacar la necesidad de realizar más estudios que puedan ampliar y dar un mayor respaldo científico en el uso de los agentes electrofísicos en la patología de la mano, así como evaluar la relación coste beneficio de estos tratamientos.

ABSTRACT

In the clinical care field, it is necessary to have quality information that can be transferred and applied in a simple and effective way to routine clinical practice. Work related hand pathology is very relevant. Its importance, it´s not only in its frequency, which is estimated to be around a third of total occupational injuries, but also in that it entails a high economic and human cost.

In physiotherapy, it is increasingly important that decisions regarding patient treatments are based on studies with high scientific evidence, which is why the purpose of this thesis is to delve into the knowledge of electrophysical agents that used in the pathology of the hand, selecting two of the most frequent pathologies in physiotherapy care in the workplace.

To this end, three systematic reviews and meta-analyses were conducted; the first related to the improvement of pain, strength and function through the use of electrophysical agents in rhizarthrosis. The second related to the response in terms of pain, severity of symptoms, function, strength and neurophysiological parameters after the application of therapeutic ultrasound in patients diagnosed with carpal tunnel syndrome. And third research, that studied the changes in terms of pain, severity of symptoms, function, strength and change in neurophysiological parameters after the application of therapeutic ultrasound versus phonophoresis, as well as the difference in the changes produced in the neurophysiological parameters and function in the application of phonophoresis with NSAIDs, or the application of phonophoresis with corticosteroids.

In conclusion, it was obtained that electrophysical agents are effective in terms of improving pain, function and strength in patients diagnosed with

rhizarthrosis. Therapeutic ultrasound showed significant changes in the improvement of motor distal latency on patients diagnosed with carpal tunnel syndrome. Phonophoresis was shown to be more effective than ultrasound therapy in terms of improving neurophysiological parameters on patients with carpal tunnel syndrome. No significant differences were found between patients treated with phonophoresis with NSAIDs and phonophoresis with corticosteroids.

After carrying out these three meta-analyses, it is necessary to highlight the need to carry out more studies that can expand and provide greater scientific support for the use of electrophysical agents in hand pathology, as well as to evaluate the cost-benefit ratio of these treatments.

ABREVIATURAS/ ABREVIATIONS

AINEs	Anti-Inflamatorios No Esteroideos
AUSCAN	AUStralian CANadian Osteoarthritis Hand Index
CTS	Carpal Tunnel Syndrome
EPAs	Electrophysical Agents/ Agentes Electrofísicos
FSS	Functional Status Subscale
GRADE	Grading of Recommendations, Assessment, Development and Evaluation
IVS	Internal Validity Score
LGSS	Ley General de la Seguridad Social
MATEPSS	Mutuas de Accidentes de Trabajo y Enfermedades Profesionales de la Seguridad Social
MD	Mean Differences
MDL	Motor Distal Latency
NSAIDs	Non-Steroidal Anti-Inflammatory Drugs
OA	Osteoarthritis/ Osteoartritis
PEDro	Physiotherapy Evidence Database
PIB	Producto Interior Bruto
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta Analyses
RCTs	Randomized Controlled Trials

RD	Real Decreto
ROM	Range of Movement
SDL	Sensory Distal Latency
SMD	Standardized Mean Differences
SSS	Symptom Severity Subscale
STC	Síndrome del Túnel Carpiano
TESEO	Tecnología, Servicios y Organización
US	Ultrasound/ Ultrasonido
VAS	Visual Analogue Scale

INTRODUCCION/ INTRODUCTION

1. INTRODUCCION/ INTRODUCTION

La patología de la mano en el ámbito laboral es una entidad diagnóstica con una alta prevalencia[1], asociada frecuentemente a grandes costes humanos y económicos[2]. La mano es anatómica y funcionalmente muy valiosa y su lesión produce distintos grados de limitaciones e incapacidades que pueden afectar al adecuado desempeño laboral y social[3].

Las estrategias terapéuticas aplicadas en el ámbito clínico deben basarse en la evidencia y deben tener procedimientos de calidad[2]. De esta forma, dichas estrategias podrán conseguir la mejor evolución clínica y funcional posible para los pacientes con patología de la mano. De esto deriva la necesidad de disponer de forma rápida y eficaz de los mejores conocimientos basados en la evidencia para poder resolver de forma favorable dichos procesos[4]. Los hallazgos en esta línea facilitarán la transferencia de conocimiento para que el fisioterapeuta clínico asistencial pueda disponer de forma veraz, rápida y apropiada de conocimiento de alta evidencia científica[4]. Esta evidencia será clave para la toma de decisiones en la aplicación de estrategias tales como la aplicación de agentes electrofísicos (EPAs) para algunas patologías frecuentes atendidas en el ámbito profesional.

Para facilitar la exposición de los contenidos de la presente tesis, a continuación, se desarrollan una serie de conceptos con el fin de tener un marco que clarifique los estudios llevados a cabo.

- El ámbito laboral en España.
- La mano y su patología.
- Importancia de la patología de la mano en el ámbito laboral.
- Terapia de la mano: recursos humanos y tratamiento.

- Fisioterapia basada en la evidencia.

1.1 EL AMBITO LABORAL

El mundo laboral tiene características propias que se diferencian del ámbito asistencial que normalmente se desarrolla en la fisioterapia, es por ello que es importante introducir una serie de conceptos.

1.1.1 MUTUA DE ACCIDENTES DE TRABAJO Y ENFERMEDADES DE LA SEGURIDAD SOCIAL

Según la Ley de Prevención de Riesgos Laborales, cuando se produce una lesión en un trabajador, los empresarios son los responsables de las personas que trabajan para ellos y velar por su seguridad y salud, según se recoge en los artículos; 14.1 "*En cumplimiento del deber de protección, el empresario deberá garantizar la seguridad y la salud de los trabajadores a su servicio en todos los aspectos relacionados con el trabajo*", y 14.2 "*deben cumplir las obligaciones establecidas en la normativa sobre prevención de riesgos laborales*"[5].

Para cumplir con dichas obligaciones se crearon las Mutuas de Accidentes de Trabajo y Enfermedades Profesionales de la Seguridad Social (MATEPSS). El origen de estas entidades tuvo lugar hace más de un siglo[6]. Concretamente el 30 de enero de 1900, con la Ley de Accidentes de Trabajo, también conocida como "Ley Dato"[7].

Desde una perspectiva histórica, durante la década de los años 60, las Mutuas Patronales se transformaron además en entidades colaboradoras en la

gestión del nuevo Sistema de Seguridad Social, donde se ampliaron sus servicios no sólo a la prestación económica sino también a los servicios sanitarios, preventivos y rehabilitadores[7]. Actualmente son entidades colaboradoras de la Seguridad Social, que funcionan bajo la tutela y vigilancia del Ministerio de Trabajo y Asuntos Sociales[8].

En el artículo 68.1 de la Ley General de la Seguridad Social (LGSS)/1998, en la redacción dada al mismo por la Ley 66/1997 de 30 de diciembre las Mutuas de Accidentes se definen como:

"*Se consideraran mutuas de accidentes de trabajo y enfermedades profesionales de la Seguridad Social las asociaciones debidamente autorizadas por el Ministerio de Trabajo y Asuntos Sociales que con tal denominación se constituyan, sin ánimo de lucro y con sujeción a las normas reglamentarias que se establezcan, por empresarios que asuman al efecto una responsabilidad mancomunada y con el principal objeto de colaborar en la gestión de la Seguridad Social, sin perjuicio de la realización de otras prestaciones, servicios y actividades que le sean legalmente atribuidas.*"

Dado que estos servicios se derivan de nuestro sistema de Seguridad Social, deben orientarse a cumplir sus fines[9]. Son entidades sin ánimo de lucro y se rigen por la normativa de Seguridad Social (Real Decreto (RD) Legislativo 1/ 1994, de 20 de junio (LGSS) y por el Reglamento de colaboración de las MATEPSS aprobado por RD 1993/1995, de 7 de diciembre[10].

Las Mutuas colaboradoras con la Seguridad Social prestan los siguientes servicios:

- Protección integral en la cobertura de los riesgos profesionales: accidente de trabajo y enfermedad profesional, la prevención de riesgos laborales y la mejora de las condiciones de trabajo y salud en las empresas.
- Gestión de la Incapacidad Temporal por enfermedad común y accidente no laboral.
- Protección por cese de actividad de los trabajadores autónomos o por cuenta propia.

A las Mutuas Colaboradoras se le atribuyen legalmente diversas coberturas con la Seguridad Social mediante la colaboración con el Ministerio de Trabajo, Migraciones y Seguridad Social, destacan el atender las contingencias profesionales y las contingencias comunes. Una contingencia es la materialización de un riesgo que provoca un estado de necesidad protegido por la Seguridad Social.

1.1.2 CONTINGENCIAS PROFESIONALES

Las contingencias profesionales derivan directa o indirectamente del trabajo, son los accidentes de trabajo y las enfermedades profesionales. Ambos términos se engloban dentro de la siniestralidad laboral. A continuación, se describe que es cada una de las contingencias existentes en nuestro país:

Accidente de trabajo

La contextualización de un accidente de trabajo se determina a través del artículo 156 del RD 8/2015, del 30 de octubre, en el que se publica un texto basado en la LGSS. En dicho decreto se determina que un accidente de trabajo se entiende como: "*toda lesión corporal que el trabajador sufra con ocasión o por*

consecuencia del trabajo que ejecute por cuenta ajena". Desde la aprobación de la Ley 20/2007, para los trabajadores autónomos o por cuenta propia que coticen por contingencia profesional, esta definición también es válida:" Se *entenderá como accidente de trabajo del trabajador autónomo el ocurrido como consecuencia directa e inmediata del trabajo que realiza por su propia cuenta y que determina su inclusión en el campo de aplicación de este régimen especial".*

Artículo 156. Concepto de accidente de trabajo.

1. Se entiende por accidente de trabajo toda lesión corporal que el trabajador sufra con ocasión o por consecuencia del trabajo que ejecute por cuenta ajena.

2. Tendrán la consideración de accidentes de trabajo:

a) Los que sufra el trabajador al ir o al volver del lugar de trabajo.

b) Los que sufra el trabajador con ocasión o como consecuencia del desempeño de cargos electivos de carácter sindical, así como los ocurridos al ir o al volver del lugar en que se ejerciten las funciones propias de dichos cargos.

c) Los ocurridos con ocasión o por consecuencia de las tareas que, aun siendo distintas a las de su grupo profesional, ejecute el trabajador en cumplimiento de las órdenes del empresario o espontáneamente en interés del buen funcionamiento de la empresa.

d) Los acaecidos en actos de salvamento y en otros de naturaleza análoga, cuando unos y otros tengan conexión con el trabajo.

e) Las enfermedades, no incluidas en el artículo siguiente, que contraiga el trabajador con motivo de la realización de su trabajo, siempre que se pruebe que la enfermedad tuvo por causa exclusiva la ejecución del mismo.

f) Las enfermedades o defectos, padecidos con anterioridad por el trabajador, que se agraven como consecuencia de la lesión constitutiva del accidente.

g) Las consecuencias del accidente que resulten modificadas en su naturaleza, duración, gravedad o terminación, por enfermedades intercurrentes, que constituyan complicaciones derivadas del proceso patológico determinado por el accidente mismo o tengan su origen en afecciones adquiridas en el nuevo medio en que se haya situado el paciente para su curación.

3. Se presumirá, salvo prueba en contrario, que son constitutivas de accidente de trabajo las lesiones que sufra el trabajador durante el tiempo y en el lugar del trabajo.

4. No obstante lo establecido en los apartados anteriores, no tendrán la consideración de accidente de trabajo:

a) Los que sean debidos a fuerza mayor extraña al trabajo, entendiéndose por esta la que sea de tal naturaleza que no guarde relación alguna con el trabajo que se ejecutaba al ocurrir el accidente.

En ningún caso se considerará fuerza mayor extraña al trabajo la insolación, el rayo y otros fenómenos análogos de la naturaleza.

b) Los que sean debidos a dolo o a imprudencia temeraria del trabajador accidentado.

5. No impedirán la calificación de un accidente como de trabajo:

a) La imprudencia profesional que sea consecuencia del ejercicio habitual de un trabajo y se derive de la confianza que este inspira.

b) La concurrencia de culpabilidad civil o criminal del empresario, de un compañero de trabajo del accidentado o de un tercero, salvo que no guarde relación alguna con el trabajo.

Figura 1*. Artículo 156. Accidente de Trabajo.*

Enfermedad profesional

En relación a la enfermedad profesional, el artículo 157 del texto refundido de la LGSS, aprobado por RD 8/2015, de 30 de octubre, determina que se entiende por "enfermedad profesional". Esta se define como "*la contraída a consecuencia del trabajo ejecutado por cuenta ajena en las actividades que se especifiquen en el cuadro que se apruebe por las disposiciones de aplicación y desarrollo de esta Ley, y que esté provocada por la acción de los elementos o sustancias que en dicho cuadro se indiquen para cada enfermedad profesional*". Esta definición también es válida para los trabajadores autónomos o por cuenta ajena.

Para que una enfermedad sea considerada como profesional deben darse los siguientes elementos:

- Que sea a consecuencia de las actividades que se especifiquen en el cuadro de enfermedades profesionales. Es un cuadro limitado, con un listado cerrado de enfermedades profesionales. Las enfermedades profesionales que no se encuentren descritas en él, pueden quedar incluidas en el concepto de accidente laboral, según establece el artículo 156, apartado "e", de la LGSS, pero no tendrán la consideración de enfermedad profesional. Para que una enfermedad sea calificada como enfermedad profesional, es necesario que figure en la "*Lista de Enfermedades Profesionales*" del RD 1299/ 2006, de 10 de noviembre, donde se aprueba el "*Cuadro de Enfermedades Profesionales*" en el Sistema de Seguridad Social. En este se establecen los criterios para su notificación y registro. La profesión ejercida por el trabajador, debe figurar en el citado cuadro para ser considerada.

- Que proceda de la acción de sustancias o elementos que en el cuadro de enfermedades profesionales se indiquen para cada enfermedad. Cuando se puede establecer una relación causal entre la exposición laboral y una enfermedad que no esté recogida en el cuadro de enfermedades profesionales, dicha enfermedad puede ser legalmente reconocida como accidente de trabajo (art. 156, punto 2, letra “e” de la LGSS).

1.1.3 CONTINGENCIAS COMUNES

Se considera contingencias comunes aquellas que no guardan relación con el desempeño de una actividad laboral. Engloban las enfermedades comunes y accidentes no laborales.

Accidente no laboral y enfermedad común

El artículo 158 del texto refundido de la LGSS se establece que:

- Se considerará accidente no laboral el que, conforme a lo establecido en el artículo 156 del texto refundido de la LGSS, no tenga el carácter de accidente de trabajo.
- Se considerará que constituyen enfermedad común las alteraciones de la salud que no tengan la condición de accidentes de trabajo ni de enfermedades profesionales, conforme a lo dispuesto en los artículos 156 y 157 de la LGSS.

1.2 LA MANO Y SU PATOLOGIA

Para comprender la complejidad de las lesiones de la mano es importante conocer bien la anatomía de la región, así como las causas que pueden producir su lesión[2].

1.2.1 ANATOMIA DE LA MANO

Osteología

El esqueleto óseo está formado por[11]:

- 8 huesos del carpo, dispuestos en 2 filas; el hueso escafoides, semilunar, piramidal y pisiforme, la fila distal seria trapecio, trapezoide grande y ganchoso. Cinco huesos metacarpianos.
- 14 falanges; 3 por cada dedo largo y dos para el primer dedo que carece de falange central.
- Además, existen pequeños huesos sesamoideos.
- Parte de este complejo lo formarían también el cubito y el radio.

Articulaciones

La mano consta de las siguientes articulaciones[11]:

- Articulación radiocubital
- Articulación radiocarpiana
- Articulación mediocarpiana
- Carpometacarpianas del 1º al 5º dedo
- Metacarpofalángicas del 1º al 5º dedo
- Interfalángicas

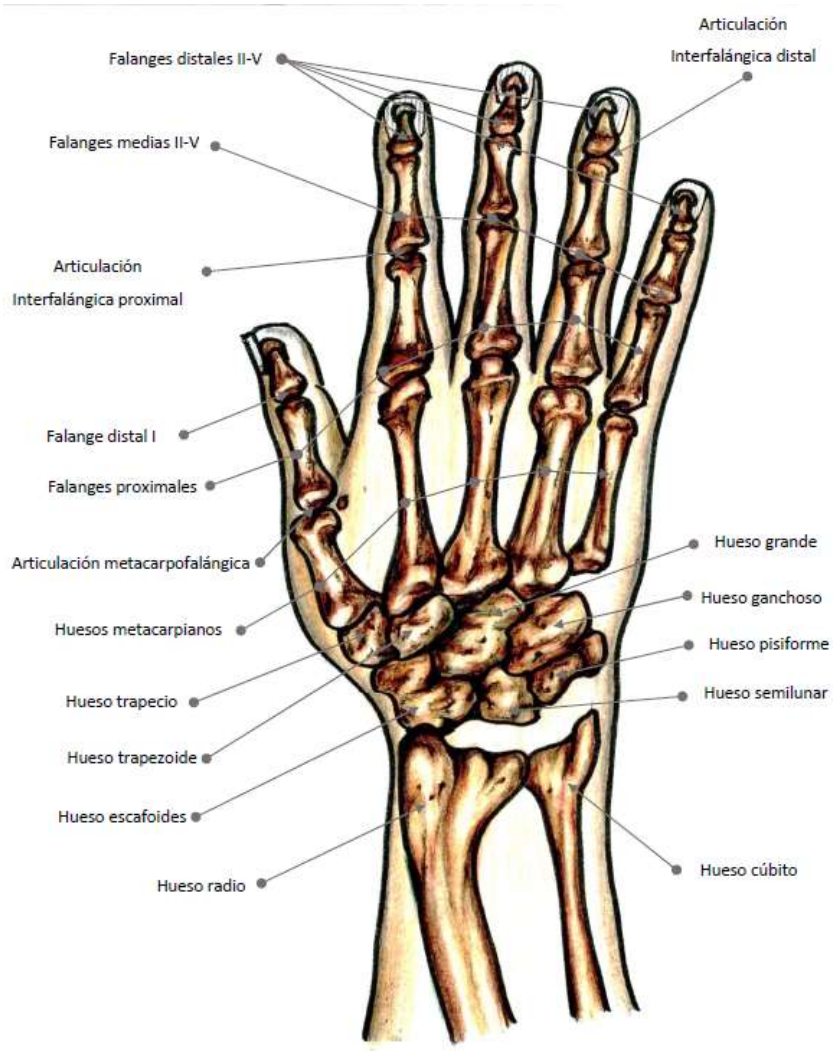


***Figura 2**. Anatomía ósea de la mano. Imagen cedida para esta tesis por José María Peris García*[12]*.*

Ligamentos

Existen multitud de ligamentos para conformar las citadas articulaciones[11]. Los ligamentos pueden ser capsulares o extracapsulares y su función es dar soporte y estabilidad.

Piel, sistema retinacular, compartimentos y otros

La piel de la palma de la mano es distinta que la piel del dorso. En la cara palmar pueden distinguirse dos eminencias, la eminencia tenar y la hipotenar.

La fascia forma múltiples compartimentos denominándose sistema retinacular; estos compartimentos son el compartimento tenar, el hipotenar, aductor-interóseo y central, los cuales albergan músculos y otras estructuras[11].

Existen unas estructuras, denominadas placas volares. Son estructuras de fibrocartílago cuya función, entre otras, es aportar mayor estabilidad[11].

Musculatura intrínseca de la mano

En la eminencia hipotenar encontramos el palmar cutáneo, el flexor corto el abductor y el oponente del quinto dedo.

En la región tenar se encuentran el abductor corto, el flexor corto, el oponente y el aductor.

Además, encontramos otros que se encuentran entre los metacarpianos; interóseos y los lumbricales[13].

Musculatura extrínseca de la mano

Son músculos que se originan en el antebrazo y se insertan en la mano. Algunos tendones se sirven de las poleas; 5 poleas tipo A (annular) y 3 tipo C (cruciate)[13].

- Extensores de los dedos; extensor propio del meñique, extensor común, extensor propio largo del pulgar, extensor propio del índice.
- Flexores de los dedos; flexor común profundo, flexor común superficial, flexor propio largo del pulgar.
- Extensores, flexores y pronosupinadores de la mano.

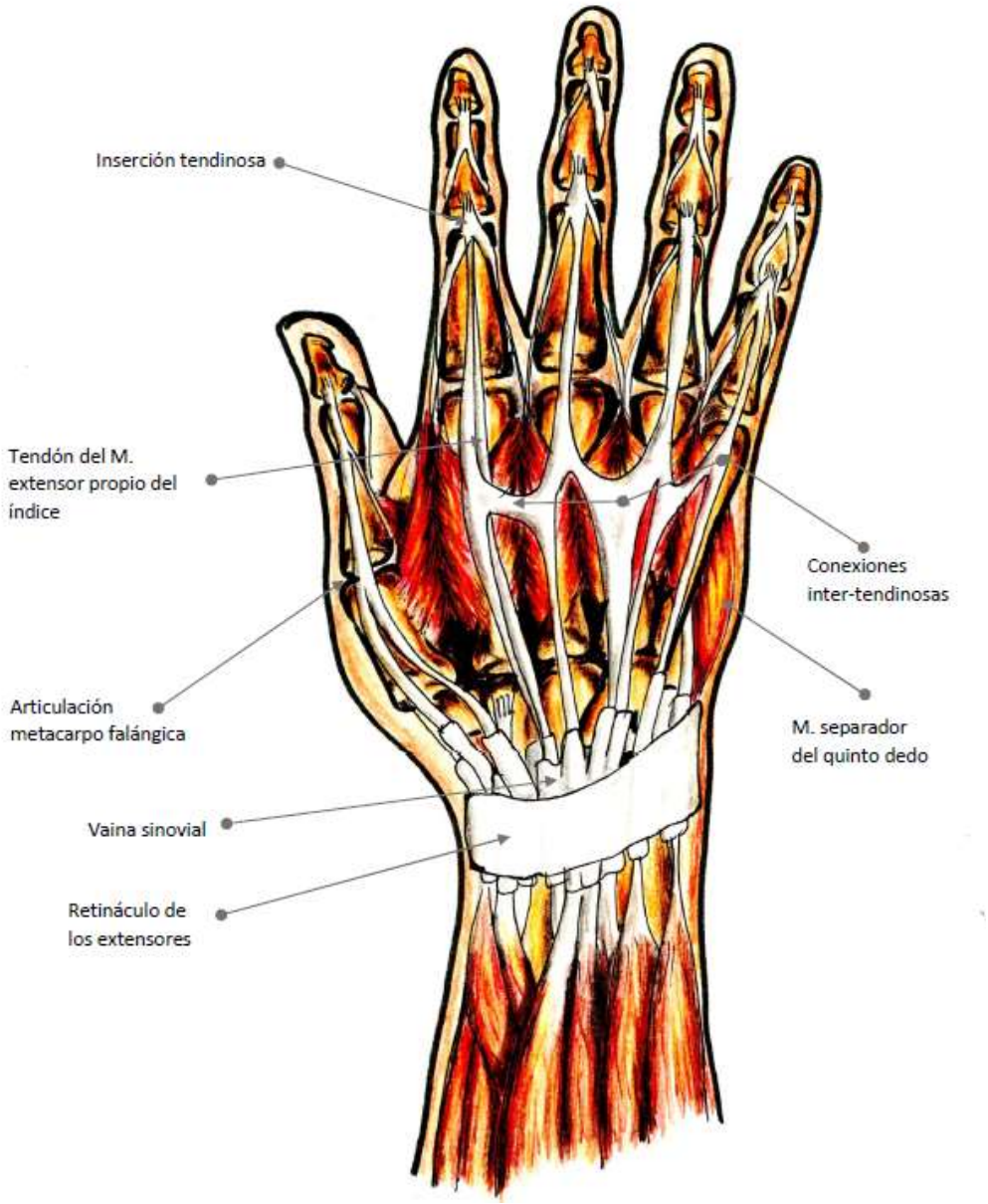


***Figura 3**. Anatomía de la mano. Imagen cedida para esta tesis por José María Peris García*[14].

Inervación

La mano se encuentra inervada por tres troncos nerviosos periféricos, el radial, el mediano y el ulnar[15].

Irrigación

Esta irrigada por la arteria radial y la cubital que a su vez son ramas de la arteria braquial[15].

1.2.2 BIOMECANICA DE LA MANO

Este órgano ejecuta tres funciones básicas, puede agarrar en una infinita variedad de formas, es un órgano sensorial sutil, puede expresar un espectro completo de emociones[16]. La lesión impide a la mano todas estas funciones fundamentales produciendo en el mejor de los casos una alteración de sus patrones de uso y en el peor una mano discapacitada[17].

1.2.3 CLASIFICACION DE LA PATOLOGIA DE LA MANO

Podríamos clasificar las patologías de la mano según distintos criterios, como pueden ser:

- La localización de la lesión; bien sea por la región o la estructura anatómica lesionada.
- Por el mecanismo lesional
- La severidad de la lesión
- Por el tipo de lesión.

En la siguiente tabla constan las distintas patologías de la mano clasificadas por el tipo de lesión.

***Tabla 1**. Patología de la mano clasificada por el tipo de lesión.*

PATOLOGIAS
• Quemaduras
• Patología de nervio periférico
• Heridas
• Contusiones
• Fracturas
• Inestabilidades
• Tendinopatías, tenosinovitis, sinovitis
• Esguinces y deformidades
• Roturas y transferencias de tendón
• Rotura poleas
• Mano Reumática: Artritis/artrosis
• Infecciones
• Amputaciones
• Gangliones y tumores
• Mano catastrófica
• Dupuytren
• Mano neurológica
• Síndrome por vibración
• Síndrome de dolor regional complejo

1.3 IMPORTANCIA DE LA PATOLOGIA DE LA MANO EN EL AMBITO LABORAL

1.3.1 IMPACTO ECONOMICO Y SOCIOSANITARIO DE LA INCAPACIDAD LABORAL

Cuando se produce un quebranto de la salud, este hecho puede derivar en una incapacidad temporal o permanente en diferentes grados (parcial, total, absoluta y gran invalidez), las cuales están definidas en la LGSS. Tanto la

Incapacidad temporal como la permanente son prestaciones de la Seguridad Social reguladas por la Ley 42/94 de 30 de diciembre.

La incapacidad temporal cubre el riesgo de pérdida de ingresos por problemas de salud sobrevenidos, los cuales pueden estar causados por una enfermedad común, o profesional, accidente laboral o no laboral. En esta situación, el accidentado no se encuentra en condiciones para realizar su trabajo habitual, por lo que causa baja laboral de forma temporal[8].

La incapacidad permanente puede ser debida a una contingencia profesional (accidente de trabajo o enfermedad profesional) o a una contingencia común (accidente no laboral o enfermedad común). Este tipo de incapacidad tiene lugar:

- Una vez agotadas las posibilidades terapéuticas.
- Cuando el paciente causa alta con limitaciones o lesiones anatómicas y/o funcionales definitivas que lo incapacitan para el desempeño de su profesión habitual[8].

La Mutua que tenga contratadas las coberturas de accidentes profesionales será el organismo responsable de las prestaciones económicas cuando se produzca una incapacidad temporal, permanente y de las lesiones permanentes no invalidantes. Estas últimas son lesiones residuales o secuelas producidas por un accidente laboral o enfermedad profesional. Las lesiones permanentes no invalidantes pueden llegar a repercutir en su calidad de vida, aunque no le incapacitan para el trabajo[8].

La lesión de cualquier trabajador supone para la empresa una serie de costes directos e indirectos[18]. Los costes en cuanto a siniestralidad laboral se

estiman en torno al 1,75% y 1,8% del producto interior bruto (PIB). Según la Asociación Nacional de Entidades Preventivas Acreditadas, en España, los accidentes laborales y las enfermedades profesionales suponen al año unos 12.000 millones de euros, el 1,75% del PIB español. De esta cantidad, 1.500 millones corresponden a la pérdida de jornadas laborales y 5.000 millones obedecen a la cobertura de los riesgos profesionales mediante cotizaciones sociales. Desde el año 2002, el coste social con gastos comprobables, supone en términos de PIB un incremento del 1,57% correspondiente a 2002 y se sitúa en torno al 1,8% en 2005. En Europa, la Agencia Europea de Salud Laboral ha realizado estimaciones de todos los costes que pueden suponer la accidentalidad y eleva los costes hasta entre el 2,5% y el 3% del PIB[5].

Los costes que asume el trabajador son de difícil cuantificación económica por el prejuicio humano que puede generar desde el punto de vista personal, económico y familiar[5].

1.3.2 LESION DE LA MANO EN EL AMBITO LABORAL

En el mundo laboral, las manos son la parte del cuerpo más vulnerables y expuestas, sufriendo frecuentes lesiones[19]. Las lesiones en las manos suponen, según numerosos estudios, un tercio de las lesiones laborales totales, con una cuarta parte de las bajas laborales y una quinta parte del total de las incapacidades[19].

Según la Administración de Salud, Higiene y Seguridad Ocupacional Norteamericana, de los 2 millones de trabajadores norteamericanos que son

incapacitados anualmente, alrededor de 400.000, sufren lesiones en las manos, localizándose el 72% de las mismas en los dedos[20].

En España, las lesiones traumáticas de la mano, dentro de los accidentes laborales, ocupan los primeros lugares en incidencia. Aproximadamente un tercio de ellos ocasionan el 25% de las bajas laborales y causan el 20% de las incapacidades laborales[19]. En los datos aportados por el Ministerio de Empleo y Seguridad Social aparece que, en el año 2010 se registraron 645.964 accidentes de trabajo que causaron incapacidad temporal. De estos accidentes, 569.523 se produjeron durante la jornada de trabajo (88,2% del total) y 76.441 fueron accidentes *in itinere* (11,8% del total)[8]. Del total de los accidentes laborales ocurridos en el año 2010, la mayor frecuencia se registró en las "extremidades superiores", con el 35,3% de los casos. De ese porcentaje, el 12,1% y el 7,1% correspondieron a los "dedos" y las "manos", respectivamente[8].

En 2018, un 37% de los accidentes totales en jornada de trabajo con baja han correspondido a lesiones en miembros superiores. En segundo lugar, los dedos y manos aglutinaron el 54% de los accidentes, presentando una frecuencia de 36% y 18%, respectivamente. En tercer lugar, el hombro acumuló un 15% de frecuencia de los accidentes registrados, seguido del brazo con un 15% y la muñeca con un 12% [21].

Sólo las manos y los dedos suponen un 20,7% del total de accidentes con baja en jornada que se producen en España. En las lesiones de las manos, las bajas laborales tras un accidente han pasado de tener una duración media de 20,1 días en 2008 a 26,2 días en 2018. Si atendemos a la duración media de las bajas debida a las lesiones en los dedos, esta ha aumentado de 21,4 días en

2008 a 26,9 en 2018, lo que implica un incremento de la duración media de las bajas de un 30,3% para las manos y de un 25,7% para los dedos[21].

La importancia de la lesión en esta región anatómica en el ámbito laboral, no sólo radica en su frecuencia, que es bastante elevada, ni en los altos costes que generan, sino también en las importantes secuelas anatómicas, funcionales y psicológicas que pueden producir a quien lo sufre. Este tipo de lesión puede producir además diferentes grados de limitaciones e incapacidades que impiden su desempeño laboral y social [3].

Por otra parte, las lesiones de la mano adquieren gran importancia en el ámbito profesional[22], dado que la mano es una región anatómica y funcional de excepcional valor. La mano suele estar involucrada en el desempeño de casi todas las profesiones u ocupaciones existentes en la actualidad. A nivel profesional, la mayoría de los trabajos manuales requieren el empleo de maquinaria potencialmente peligrosa. Dentro de las ocupaciones, las manos son fundamentales para la realización de la actividad cotidiana, desde la más rudimentaria a la más técnica y sofisticada.

Ya que aproximadamente un tercio de los accidentes de trabajo comprometen antebrazos y manos es necesaria una atención oportuna y adecuada de las lesiones a estas áreas del cuerpo. Una adecuada estrategia terapéutica es imperativa ya que disminuye los tiempos de recuperación, así como la incidencia de complicaciones y secuelas, la repercusión económica, psicológica y social de largo plazo. La elección en el tratamiento que se haga para la atención inicial tiene, en el caso de esta región anatómica, especial influencia en el resultado funcional final.

La rehabilitación la persona que ha sufrido un trauma con afectación de la extremidad superior constituye un capítulo de vital importancia para aseguradores, empresarios e instituciones de seguridad social debido a la curva creciente del índice de accidentalidad en dicha región[21].

Las lesiones laborales en la patología de la mano suponen un gran coste, no sólo por los costes de la baja laboral, como ya se indicó anteriormente, sino por las graves lesiones producidas y porque los trabajadores que requieren habilidades manuales para volver al trabajo necesitan un mayor nivel de rehabilitación para desarrollar de nuevo su trabajo habitual. El verdadero impacto de estas lesiones, suele estar subestimado[23].

Todas las lesiones de la mano terminan influyendo de una forma negativa a la funcionalidad de la misma, produciendo en el aspecto laboral períodos de baja temporal que pueden ser prolongados[24]. Varios estudios demuestran que a mayor tiempo de incapacidad laboral temporal mayor es la disminución de la probabilidad de volver al trabajo[24]. Por otra parte, la duración de la baja médica viene determinada no sólo por las consecuencias físicas y biomédicas sino también por determinantes relativos al trabajo y psicosociales[24].

1.3.3 CAUSAS DE LESION EN LA MANO EN EL AMBITO LABORAL

Algunas de las causas que aumenta la probabilidad de la aparición de las patologías de miembro superior en el ámbito laboral son:

- Trabajo repetitivo prolongado, especialmente si se usa la misma extremidad o la misma acción.
- Posturas incómodas y falta de higiene postural.

- Esfuerzos excesivos o mantenidos.
- Realización de tareas prolongadas sin realización de pausas o descansos.
- Trabajos con herramientas eléctricas manuales durante largos periodos de tiempo.
- Entorno de trabajo deficiente, incluida temperatura e iluminación.
- Organización del trabajo deficiente, gran carga laboral, sobredemandas respecto a las capacidades musculo-esqueléticas y ausencia de descansos.
- Diferencias individuales y vulnerabilidad personal.

1.3.4. PATOLOGIAS DE MANO ATENDIDAS EN LAS MUTUAS

Las mutuas atienden una gran variedad de patologías. Sin embargo, si nos centramos en las lesiones de la mano, en las mutuas suelen atenderse tanto aquellas que sean traumáticas o no, o la lesión sea por una consecuencia directa o indirecta del traumatismo.

Como se ha mencionado anteriormente en la clasificación mostrada en la tabla 1, son muchas las patologías susceptibles de ser atendidas en las mutuas de accidentes laborales. En la presente tesis se va a abordar dos de ellas por su especial prevalencia e incidencia: el síndrome del túnel carpiano y la artrosis/osteoartritis de mano.

Entre los trastornos músculos-esqueléticos más frecuentes que afectan al miembro superior, se encuentran el síndrome del túnel carpiano y las tenosinovitis de la mano y la muñeca que, en España, ocupan el 15,1% y el 13,4%, respectivamente. Estas alteraciones suelen producir elevados índices de

absentismo laboral, tal y como se indican en algunos estudios realizados por el Instituto de Nacional de Seguridad e Higiene en el Trabajo[3,8].

El Síndrome del Túnel Carpiano (STC), codificado en la tabla de enfermedades profesionales como 2F0201, está clasificado dentro de las enfermedades provocadas por posturas forzadas y movimientos repetitivos en el trabajo y la parálisis de los nervios debido a la presión.

El atrapamiento del nervio mediano a la altura de la muñeca es denominado el síndrome del túnel del carpo. Esta descrita como la mononeuropatía periférica más común aunque poco se sabe de la prevalencia en la población general[25].

La sintomatología que produce suele ser hipoestesia o parestesias en la distribución del nervio mediano a la altura de la mano o debilidad o parálisis en el abductor pollicis brevis o oponnens pollicis[26]. Las causas pueden ser diversas, desde enfermedades crónicas, defectos congénitos, traumatismos agudos, embarazo[26]. Existen factores ocupacionales que han sido asociados a este síndrome, entre los cuales se incluyen las vibraciones el estrés mecánico en la palma de la mano y movimientos forzados y repetitivos de manos[27]. El síndrome del túnel del carpo derivado del trabajo es una de las patologías de miembro superior más costosa e invalidante, que genera una gran pérdida de días de trabajo y como consecuencia un mayor coste[28].

El diagnostico puede ser mediante el examen clínico, evaluando el dolor, parestesias, signos de Tinel y Phalen y debilidad. Los estudios de conducción nerviosa sensitiva y motora del nervio mediano confirman el diagnóstico clínico del STC con un alto grado de sensibilidad y especificidad[29].

Actualmente el tratamiento para este síndrome suele ser quirurgico[30],ya que distintas publicaciones ensalzan este tratamiento[31]. No obstante, existe evidencia de la efectividad del tratamiento conservador para esta patologia[32] aunque es preciso analizar los tratamientos conservadores que se realizan en profundidad ya que algunas técnicas en concreto han demostrado evidencias conflictivas[33,34].En las últimas publicaciones se han visto resultados favorables del tratamiento conservador a largo plazo comparativamente con el abordaje quirúrgico[35]. Una combinación de educación, ferulaje nocturno y ejercicios domiciliarios puede reducir la necesidad de cirugía en un 21% de los pacientes que están en lista de espera para cirugía[36].

El tratamiento conservador en la compresión crónica del nervio mediano debe buscar reducir la presión en el túnel del carpo, mejorar el flujo de sangre a través del túnel y restaurar la excursión del nervio[37].

Dentro de la terapia conservadora numerosas técnicas han sido estudiadas y demostrada su efectividad como el ferulaje[38], ejercicio de deslizamiento tendinoso[39], neurodinamia[40], laser[41].

El ultrasonido ha sido ampliamente utilizado en el tratamiento de esta patologia[42–45],demostrando la mejora en esta patologia[46–48]. No obstante existen estudios donde se concluye que su uso no es eficaz[49].

Por otra parte, la osteoartritis de pulgar no está codificada en esté listado ya que existe controversia en cuanto al origen de dicha patología, pero también es tratada en las mutuas de forma frecuente, si no como contingencia profesional como contingencia común.

La osteoartrosis (OA) de mano es una enfermedad altamente prevalente asociada a unos costes sociales y económicos muy elevados [50]. La articulación más afectada es la carpo metacarpiana del primer dedo, afectando en torno a un 13%-26% de los adultos mayores de 30 años y a un 66% de las mujeres mayores de 55 años [51,52]. Aunque se desconoce la etiología exacta de la OA, se sabe que es multifactorial, incluyendo causas mecánicas, químicas, inmunológicas, genéticas y/o ambientales. El cartílago hialino recubre las articulaciones diartrodiales y junto con el resto de estructuras blandas que componen la articulación le confiere la capacidad de distribuir y transmitir fuerzas, amortiguar cargas y lubricar las superficies articulares. Los procesos de degeneración del cartílago y el envejecimiento se asocian a una disminución de los proteoglicanos, a un menor número de condrocitos, una disminución del contenido de agua y a un aumento de la rigidez del mismo [53]. Por ello, se hace necesario el tratamiento dirigido a dicha degeneración y a los síntomas que esta provoca.

El tratamiento en la OA en sus fases precoces constituye a día de hoy un gran reto en la práctica clínica, siendo importante frenar la evolución de este proceso degenerativo e incapacitante. El no tratamiento suele generar más dolor y discapacidad en los adultos mayores [54]. Cualquier tratamiento realizado debe cumplir varios criterios, tales como que sea seguro a nivel articular y sistémico, y que sea eficaz en el alivio del dolor, en la mejora de la capacidad funcional y a ser posible que retrase la evolución de la enfermedad. Las posibles intervenciones pueden agruparse en conservadoras (no farmacológicas y farmacológicas) y quirúrgicas. Un gran porcentaje de casos finalizará con tratamiento quirúrgico, suponiendo una de las primeras causas de cirugías de reemplazo articular [55]. Hasta el momento, no existe un tratamiento conservador

de la OA que haya demostrado ser eficaz en la detección completa o en la disminución del avance de su progresión [56]. Las últimas revisiones sistemáticas han mostrado evidencia sobre el uso de multitud de acciones terapéuticas conservadoras comúnmente utilizadas en la práctica clínica en terapia de mano para mejorar la función y disminuir el dolor [57–62]. Además, existe evidencia que señala que los pacientes sometidos a regímenes de tratamiento conservador se asocian a una tasa inferior de intervención quirúrgica [63,64]. Para la disminución de la sintomatología y la mejora funcional, han mostrado una evidencia sólida el uso de órtesis [65], el ejercicio terapéutico de mano [66–68], la masoterapia [69], así como otras técnicas manuales [70–74]. Por otra parte, se puede afirmar que las intervenciones multimodales de fisioterapia y terapia ocupacional para el tratamiento del dolor y la función en los pacientes con trapecio-metacarpiana OA varía en un rango de moderada a alta [75].

1.4 REHABILITACION DE LA PATOLOGÍA DE MANO

Para el estudio y la especialización en la rehabilitación de la mano es preciso, tal y como apunta el Dr. M. García Elías[76], que se tengan en cuenta diferentes razones por la clínica de la mano no mejora o evoluciona tras la implementación de terapia. Tal y como indica este autor, en muchos países, refiriéndose a España, entre otros, el resultado tras la rehabilitación para los pacientes cuya lesión pueda causar una discapacidad sólo puede mejorar si se reorganizan los recursos que existen y mejoran los estándares de la terapia de la mano. Se ha estimado que una rehabilitación específica de mano tiene un enorme impacto en la calidad de los resultados obtenidos después de esa clase de lesiones.

Para poder llevar a cabo cualquier tipo de tratamiento sobre la mano es necesario contar con personal formado y cualificado en este tipo de terapia, además de investigaciones de alta calidad metodológica y rigor científico accesibles para los terapeutas que trabajan en el ámbito clínico[4]. El complejo tratamiento de la mano lesionada en los centros especializados permite acortar la duración del tratamiento, mejorar los resultados del tratamiento y reducir los gastos indirectos[77].

1.4.1 RECURSOS HUMANOS PARA EL TRATAMIENTO DE LA MANO

La patología de la mano en el ámbito laboral debe ser atendida por un equipo de rehabilitación que debe estar constituido entre otros por los profesionales que se citan en la Tabla 2.

***Tabla 2**. Miembros del equipo de rehabilitación de la mano.*

EQUIPO DE REHABILITACION
• Médico especialista del Trabajo
• Médico especialista en Ortopedia y Traumatología
• Médico especialista en Cirugía Plástica y Estética
• Médico especialista en Medicina Física y Rehabilitación
• Médico especialista en Psiquiatría
• Fisioterapeuta
• Enfermero
• Terapeuta ocupacional
• Psicólogo

1.4.2 TRATAMIENTO

El abordaje médico de la patología de la mano puede ser quirúrgico o conservador. Para su tratamiento pueden ser necesarios medios químicos, físicos o ambos. El tratamiento fisioterápico general puede ser invasivo o conservador. El tratamiento invasivo puede realizarse mediante técnicas como la punción seca[78] o neuromodulación.

Tratamientos conservadores habituales en terapia de mano

Dentro de las estrategias terapéuticas conservadoras que se suelen utilizar de forma más frecuente en la terapia de la mano se encuentran[79]:

- Cinesiterapia: agrupación de técnicas fisioterápicas destinadas a provocar la prevención o curación de enfermedades a través o usando como medida el movimiento.
- Ejercicio terapéutico: consiste en un régimen o plan de ejercicios o actividades físicas diseñadas y prescritas con unos objetivos terapéuticos específicos.
- Termoterapia: terapia basada en la aplicación de calor en el organismo con fines terapéuticos mediante agentes térmicos.
- Crioterapia: descenso localizado y temporalmente limitado de la temperatura de los tejidos con fines terapéuticos.
- Fototerapia: procedimiento que utiliza la luz como agente terapéutico y preventivo.
- Hidroterapia: utilización del agua como agente terapéutico, en cualquier forma, estado o temperatura. Para que el agua se defina como agente

terapéutico debe actuar a través de determinados factores fisicoquímicos, factor mecánico, térmico o químico.

- Masoterapia: conjunto de maniobras manuales o mecánicas aplicadas de forma metódica a una parte del cuerpo o a su totalidad, con el objetivo de producir modificaciones mecánicas o reflejos que se traducen en efectos terapéuticos.
- Fisioterapia manual: agrupación de técnicas manuales con fines terapéuticos como por ejemplo estiramientos miotendinosos, manipulaciones articulares y tracciones vertebrales.
- Métodos específicos de fisioterapia: técnicas de facilitación neuromuscular propioceptiva (Kabat), Bobath, Perfetti, Mckenzie, neurodinamia, terapia miofascial etc.)
- Métodos de contención: productos sanitarios que se colocan externamente para evitar una deformidad o mejorar una función.
- Agentes electrofísicos: ultrasonoterapia, laserterapia, electroterapia, ondas de choque, magnetoterapia, etc.

Agentes electrofísicos

Los agentes electrofísicos podemos definirlos como todas las modalidades de electroterapia, a excepción del biofeedback, que suponen la introducción de alguna energía física, bien sea lumínica, eléctrica, sonora, térmica o mecánica, en un sistema biológico. Esta energía aporta uno o más cambios fisiológicos que son usados para con fines terapéuticos[80]. El concepto de electroterapia inicial ha ido variando gradualmente adoptando un término más amplio, agentes electrofísicos, denominado en inglés como *Elecrophysical Agents* (EPAs). Aunque los EPAs incluyen diferentes modalidades con distintos

mecanismos de acción, todos ellos compartes aspectos comunes, lo cual posibilita que se puedan englobar bajo la misma categoría[80]. Las terapias que se engloban bajo la dimensión de los EPAs son terapias de calor, frio, laser, luz, electroterapias (modalidades de estimulación eléctrica), aplicaciones electromagnéticas, ultrasonidos, y tratamientos de base mecánica (vibración, compresión neumática intermitente y otras)[81].

Los EPAs son ampliamente utilizados en la práctica clínica de la fisioterapia convencional. Por lo tanto, es necesario dotar a estos profesionales de evidencia en cuanto a la efectividad de su uso y la dosimetría óptima de los mismos. Conocer que medidas terapéuticas, en concreto si los EPAs, son eficaces y trasladar estos hallazgos al ámbito clínico es fundamental para dotar a los profesionales de herramientas fiables para poder atender mejor a los pacientes. Es así mismo fundamental conocer las implicaciones económicas y humanas a las que pueden afectar en el ámbito laboral.

1.5 FISIOTERAPIA BASADA EN LA EVIDENCIA

1.5.1 PRACTICA CLINICA BASADA EN LA EVIDENCIA

El modelo actual de actuación en el ámbito sociosanitario y en la práctica clínica se suele denominar como “fisioterapia basada en la evidencia”, y se caracteriza por integrar los avances científicos y del conocimiento en este ámbito. Lo que entendemos ahora como fisioterapia basada en la evidencia se inició con el concepto de Medicina basada en la evidencia, término acuñado por Gordon Guyatt[82], concepto que ha ido evolucionando. Sackett la definió como la

utilización consciente, explícita y juiciosa de la mejor evidencia clínica disponible para tomar decisiones sobre el cuidado de cada paciente[83].

Existen nuevos enfoques para este modelo de actuación, en el cual se integra el conocimiento a partir del análisis y la síntesis propuesta en los estudios de metasíntesis cuantitativa y cualitativa. Este diseño, denominado metasíntesis, permite que se añada las peculiaridades sociales, culturales o institucionales en las que se usa el conocimiento, entre otras variables de interés[84].

La fisioterapia basada en la evidencia es clave para aportar al clínico recursos para aumentar su desarrollo profesional, mejorar su práctica clínica habitual y su excelencia profesional. La aplicación de la evidencia en la práctica clínica, requiere, usar como referencia los resultados obtenidos en ensayos clínicos aleatorizados, revisiones sistemáticas o meta-análisis previos[85,86].

1.5.2. META-ANALISIS

El fisioterapeuta necesita buscar las mejores fuentes de información disponibles, entendiendo como tales, aquellas que dan continuidad desde los resultados de la investigación a su aplicación inmediata en su propia práctica asistencial. Las iniciativas para satisfacer esta demanda han tratado de ser cubiertas de varias formas, entre ellas la Colaboración Cochrane[87].

Existe una gran cantidad de información biomédica, a veces de difícil accesibilidad y en otras ocasiones de escasa o dudosa fiabilidad[87]. Para categorizar los niveles de evidencia habitualmente se utiliza la clasificación de Sackett[88]. Teniendo en cuenta esta clasificación el meta-análisis estaría incluido en el grado de recomendación A, en el nivel 1a, lo que supone el más alto nivel

de evidencia científica. Existen otras muchas clasificaciones para los niveles de evidencia científica; La Canadian Task Force on Preventive Health Care, Centre for Evidence-Based Medicine de Oxford, Scottish Intercollegiate Guidelines Network entre otras.

Los estudios de investigación pueden ser clasificados en estudios descriptivos y estudios analíticos. Los estudios analíticos a su vez pueden dividirse en estudios observacionales (estudio de cohortes, casos y controles) y estudios experimentales (ensayos clínicos, ensayos comunitarios aleatorizados y ensayos comunitarios no aleatorizados.

Una revisión sistemática tiene por objetivo reunir toda la evidencia empírica que cumple unos criterios de elegibilidad previamente establecidos, con el fin de responder una pregunta de investigación[89]. Utiliza métodos sistemáticos y explícitos, que se eligen con el fin de minimizar sesgos, aportando así resultados más fiables a partir de los cuales se puedan extraer conclusiones y tomar decisiones[90].

Acorde al Manual Cochrane[91] los elementos fundamentales de una revisión sistemática serian:

- Un conjunto de objetivos claramente establecidos, con criterios de elegibilidad de estudios previamente definidos.
- Una metodología explícita y reproducible.
- Una búsqueda sistemática que identifique todos los estudios que puedan cumplir los criterios de elegibilidad.
- Una evaluación de la validez de los resultados de los estudios incluidos, por ejemplo, mediante la evaluación del riesgo de sesgos.

- Una presentación sistemática y una síntesis de las características y resultados de los estudios incluidos.

Muchas revisiones se ven implementadas mediante los metaanálisis. En el metaanálisis se combina la información de los estudios relevantes por lo que se puede obtener una estimación más precisa que en los estudios individuales, así como permitir investigar la consistencia de la evidencia entre los estudios que lo integran y las diferencias entre ellos[4]. El metaanálisis consiste en la aplicación de métodos estadísticos para resumir los resultados de estudios independientes[92]. Por estas razones, una forma de conocer la mayor evidencia científica sobre un tratamiento es realizar un meta-análisis.

Posteriormente habrá que darle un valor a esta evidencia, para ello se utilizará la clasificación que más se ajuste a la necesidad, para dar las recomendaciones más adecuadas al entorno asistencial y poblacional[93]. Así se dispone de clasificaciones amplias, con una propuesta distinta para diferentes escenarios (CEBM, NHMRC, etc.), como de clasificaciones más específicas (CTFPHC, SIGN, etc.) y otras como Grading of Recommendations, Assessment, Development and Evaluation (GRADE) utilizada para evaluar la calidad de la evidencia disponible, realizar recomendaciones y generar guías de práctica clínica basadas en la evidencia[94].

Existen numerosas publicaciones de alta evidencia científica sobre el tratamiento de la mano[32]. Así es preciso contar con la evidencia adecuada disponible para lograr maximizar la calidad de la atención y conseguir unos resultados óptimos, tal y como sugieren la American Society of Hand Therapists[79].

Por lo tanto, es preciso evaluar la literatura existente que aporte conocimiento e información de calidad sobre la efectividad de los tratamientos aplicados mediante EPAs en diversas afecciones de la mano en el ámbito laboral y que esta información pueda ser fácilmente trasladada al ámbito clínico y aplicada de forma sencilla en la práctica clínica habitual. Para ello se deberían llevar a cabo diferentes meta-análisis que arrojen un nivel de evidencia más alta en relación a este tema de interés.

1.6 INTRODUCTION

1.6.1 HAND OSTEOARTHRITIS

Electrophysical agents (EPAs) include different modalities with diverse mechanisms of action; however, all of them share various common aspects becoming them a group sharing a same category[81]. All EPAs involve the application of some type of energy (whether electrical, light, sound, thermal, or mechanical) into a biological system. This energy usually causes one or more changes at a physiological level, generating some therapeutic benefit. The first step includes going back through the model and identify which are the physiological events/processes susceptible to be modified or stimulated to obtain the desired therapeutic outcome. A gradual shift has occurred the last years from the clinical concept "electrotherapy" to a more encompassing construct EPAs. The more accepted concept of EPAs includes therapeutic approaches such as *"heat and cold, laser and light therapies, the 'classic' electrotherapies (electrical stimulation modalities), various electromagnetic applications (e.g. pulsed shortwave therapy), ultrasound therapy, and a variety of mechanical therapies (including vibration therapy and intermittent pneumatic compression therapy among others)"*[80]. The International Society for EPAs is an official organism that

reflects and supports the substantial changes produced in terms of terminology in this area. This society is taking place around the world, although not at the same speed in all countries. There is a wealth of published evidence on EPAs; however, some authors report that "*some of the research can appear daunting and a substantial proportion is not published in the physical therapy journals per se, which can make access more problematic; however, the evidence is there*"[80]. For these reasons, although it is well-known that the combination of therapeutic approaches enhances its efficacy, it is also important to know what their individual contribution is. These findings may help to make better clinical decision and to design optimal interventions in the near future. There are numerous systematic reviews that analyse the benefit of conservative therapies in the management of hand osteoarthritis (OA). In some studies all available conservative therapies are evaluated[57–59,62,75,95–99]. Multimodal interventions have been also shown to be particularly effective in reducing pain in patients with trapeziometacarpal OA[75]. Another recent systematic review also confirms the benefit of multimodal and unimodal physical therapies[99]. However, in this synthetic review and meta-analysis only EPAs are considered as therapeutic approach of interest.

In relation to some examples of the efficacy of EPAs, low intensity ultrasound has shown to increase protein synthesis at physiological level[100]. Low level laser therapy seems to stimulate cell function[101]. The use of TENS has shown to reduce pain[102]. Magnetotherapy has shown to be effective in treating several symptoms of OA[103], while low level laser[104] and magnetotherapy[105] have demonstrated to be effective in treating hand OA. Another recent study evaluating the efficacy of shock wave therapy in hand OA reported that this approach improves pain, hand strength and function. Improvements in dosing, and positive

findings in different OA body sites have prompted clinicians to conduct clinical trials to evaluate the efficacy of these agents in treating hand OA[106]. This is why EPAs are becoming nowadays a fundamental part of the clinical practice of physiotherapy. When EPAs are used in line with the evidence, their efficacy can be demonstrated. The use unwisely or inappropriately may result either do no good at all or possibly make matters worse[80].

Given the variety of EPAs modalities used in the clinical trials published so far, there is a need to summarise the state of the evidence with regard to the efficacy of EPAs in treating pain, impaired function and loss of muscle strength in the region distal to the upper limbs (grip and pinch strength) in patients with hand OA. This involves describing the quality of the treatment currently given to these patients, the type of therapy administered and the dosimetric values. Performing a systematic review and meta-analysis will allow to synthesize the current information on the efficacy of EPAs on hand OA, and will let to describe the heterogeneity between published studies.

1.6.2 CARPAL TUNNEL SYNDROME

Carpal Tunnel Syndrome (CTS) refers to the set of symptoms and signs associated with the compression of the median nerve at the wrist. This syndrome is the most common peripheral neuropathy. The symptoms that it produces are usually hypoesthesia or paresthesia in the median nerve distribution in the hand or weakness or paralysis in the abductor pollicis brevis or opponens pollicis. There are occupational factors that have been associated with this syndrome, including vibrations, mechanical stress on the palm, and forceful repetitive hand motions[27]. CTS derived from work is one of the most disabling and costly upper extremity disorders, resulting in lost work days and consequently, represents a

major cause of workers compensation cost[107].

The diagnosis of CTS is usually done through clinical examination by assessing pain, paresthesia, Tinel and Phalen signs, function and weakness[108]. The diagnosis and the grade of CTS is usually based on a high degree of sensitivity and specificity and is established by demonstrating damage to the sensory and motor fibers and, occasionally even, vegetative fibers of the median nerve[109–112].The approaches to assess the median nerve function often involve sensory and motor studies[113]. The most common sensory parameters in the CTS diagnosis are the sensory distal latency (SDL), sensory conduction velocity and amplitude of the sensory nerve action potential[111].

In terms of sensory techniques of the median nerve, one of the most frequently used is those which explore the fibers that run from the index finger to the wrist and elbow. This exploration is developed antidromically or orthodromically, depending on whether the potential is recorded on the finger (Antidromic) or on the wrist (Orthodromic) and whether it is stimulated at the finger (Orthodromic) or at the wrist (Antidromic)[109,111,114]. The most important motor parameters in the CTS screening are: (i) compound muscle action potential amplitude, (ii) motor distal latency (MDL) of compound muscle action potential, and (iii) the motor conduction velocity. The motor conduction velocity is usually measured in the branch for the thenar muscles of the median nerve, recording the potential at the abductor pollicis brevis muscle and stimulating at the wrist and elbow[114–116].

Currently, the usual treatment for this syndrome is surgical; however, this intervention can generate complications, as a high incidence of associated

complications has been attributed to this treatment [31]. Recent publications have shown favorable results from long-term conservative treatment compared to the surgical approach[35,117]; nevertheless, some of these techniques have shown heterogeneity in their results[118–124]. A combination of education, night splinting and home exercises appears to reduce the need for surgery in 21% of patients remaining on the waiting list for surgery[38]. Conservative treatment of chronic median nerve compression seeks to reduce pressure in the carpal tunnel, improve blood flow through the tunnel, and restore nerve excursion[125]. On the other hand, splinting[38], gliding exercises[39], neurodynamics[40] or laser[41] have also been shown to be effective conservative therapies. However, ultrasound (US) is the technique most commonly used in rehabilitation area for the treatment of CTS[126–132].

US is a conservative electrophysical intervention that requires little time with easy use and no severe adverse effects have been described. Some studies have shown improvements after its application on patients of this syndrome[131,133,134]. There are also other studies that conclude that its use is not effective or question its effectiveness[135,136], and various systematic reviews and meta-analysis have indicated this[117,120] for cases other than CTS. For this reasons, it is necessary to perform a meta-analysis to show the existing evidence on the efficacy of the US application on clinically relevant variables such as pain, severity of symptoms, functionality, strength and conductivity of the nerve in patients with CTS[137]. In line, synthesized information is required to confirm the evidence that exists in relation to this therapy. This knowledge will facilitate decision making process about which physical devices are effective in CTS.

At the neurophysiological level, carpal tunnel syndrome (CTS) compromises median nerve conduction, generating pain, a prickling feeling and a loss of strength, which, combined with the associated symptoms, usually results in a loss of function. The diagnosis is usually achieved through a clinical examination, evaluating pain, paraesthesia, Tinel's sign, Phalen's sign, function and weakness[29]. The neurophysiological diagnosis and degree of CTS can be established with a high degree of sensitivity and specificity by demonstrating damage to the sensory and motor fibres and occasionally to the vegetative fibres of the median nerve[112,115,138,139].

The most commonly employed sensory parameters when assessing median nerve function during the CTS diagnosis are sensory distal latency (SDL), sensory conduction velocity and amplitude of the sensory nerve action potential[115]. In terms of sensory techniques for the median nerve, the most widely used are those that examine the fibres running from the index finger to the wrist and to the elbow[115,138,140]. When screening for CTS, the most important motor parameters are motor conduction velocity, compound muscle action potential and the motor distal latency (MDL) of compound muscle action potential, which are typically measured in thenar muscle branch of the median nerve by recording the potential at the abductor pollicis brevis muscle and providing stimuli at the wrist and elbow[115,140,141]. Potential sources of bias should be controlled when comparing the results among patients in electrophysiological studies (e.g., having the same physician perform all techniques, employing the same distances between stimulus and receptor, and controlling room and skin temperature)[115,142].

Within the therapies applied through ultrasound, sonophoresis is a transdermal drug delivery system that employs physical agents to enhance the

delivery of topically applied drugs[143]. In terms of CTS treatment, sonophoresis has been previously investigated[144–146], showing improvement in patients who underwent the therapy[147–149]. In terms of resource consumption when using ultrasound and sonophoresis in clinical practice, the two techniques are very similar in time and financial costs. The difference in this sense is in the cost between the conductive gel applied in ultrasonography and the drug selected for applying sonophoresis. However, the cost of drugs in sonophoresis is higher. Thus, the decision could be based on the costs of each therapy, if the two therapies were similar in effectiveness. However, there has been no meta-analysis to date that has generated evidence on the possible superiority in efficacy of one treatment over the other. A meta-analysis is needed that addresses this aspect on the main symptoms of CTS (pain, symptom severity and loss of functionality, and nerve conductivity)[150] to thereby select the best form of treatment considering the benefit-cost parameters.

Within the sonophoresis technique, it is important to know which of two most commonly employed drugs[143] (anti-inflammatory nonsteroidal drugs and corticosteroids) is superior in terms of benefits. Clinicians can thereby have more information for the decision-making process. Corticosteroids are synthetic derivatives of natural corticosteroids produced in the adrenal cortex and have genomic mechanisms (long-term) and nongenomic mechanisms, such as immunomodulatory, endocrine and anti-inflammatory effects[151–153]. Non-steroidal anti-inflammatory drugs (NSAIDs) are a group of drugs with analgesic, anti-inflammatory and antipyretic effects that inhibit enzyme cyclooxygenase 1 and 2[154,155]. Although the risks of oral corticosteroids and NSAIDs are well known, topical corticosteroids and NSAIDs have a better safety profile[156–158].

OBJETIVOS/ OBJETIVES

2. OBJETIVOS/ OBJETIVES

El objetivo general de esta tesis doctoral es examinar la evidencia científica relativa al tratamiento mediante EPAs en las afecciones de la mano más prevalentes en el ámbito laboral. Seguidamente se expondrán los objetivos específicos de cada estudio de forma independiente.

2.1 ESTUDIO I

El objetivo principal de este estudio fue la realización de una revisión sistemática y metaanálisis que evalúe la efectividad de los EPA sobre el dolor, la función y la fuerza en personas con artrosis de mano en comparación con un grupo de control.

Las preguntas de investigación en esta revisión sistemática y metaanálisis fueron:

1. ¿Son efectivos los EPA para reducir los niveles de dolor en la OA de la mano?
2. ¿Estos agentes mejoran la función de la mano en pacientes con artrosis de mano?
3. ¿Los EPA aumentan la fuerza de la mano en pacientes con artrosis de mano?

English version

The main aim of this systematic review and meta-analysis was to evaluate the effectiveness of EPAs on pain, function and strength in people with hand osteoarthritis in comparison with a control group.

Therefore, the research questions in this systematic review and meta-

analysis were:

1. Are EPAs effective in reducing pain levels in hand OA?
2. Do these agents improve hand function in patients with hand OA?
3. Do EPAs increase hand strength in patients with hand OA?

2.2 ESTUDIO II

El objetivo principal de la presente revisión sistemática y metaanálisis fue evaluar la eficacia del ultrasonido terapéutico sobre el dolor, la gravedad de los síntomas, la función y los parámetros electrofisiológicos, en comparación con ninguna terapia o terapia simulada.

La pregunta de investigación es: ¿es efectiva la aplicación de ultrasonido terapéutico sobre el dolor, la severidad de los síntomas, la función, la fuerza y los parámetros neurofisiológicos de la conducción del nervio mediano en pacientes con síndrome del túnel carpiano?

English version

The main aim of the present systematic review and meta-analysis was to evaluate the efficacy of therapeutic US on pain, severity of symptoms, function and electrophysiological parameters, in comparison with no therapy or sham therapy.

The research question is: is the application of US effective on pain, the severity of the symptoms, physical function, strength, and neurophysiological parameters of the median nerve conduction in patients with carpal tunnel syndrome?

2.3 ESTUDIO III

Los objetivos principales de la presente revisión sistemática y metaanálisis fueron:

- evaluar la efectividad de la terapia mediante ultrasonido versus fonoforesis en términos de dolor, severidad de los síntomas, función y parámetros electrofisiológicos MDL y SDL en individuos con STC y
- si la fonoforesis es eficaz, qué fármaco es más eficaz, los antiinflamatorios no esteroideos (AINEs) o los corticoesteroides.

Las preguntas específicas de investigación son:

1. ¿Es la fonoforesis más efectiva que el ultrasonido para la mejora en los parámetros de conducción nerviosa y los resultados clínicos?
2. ¿Es la fonoforesis más efectiva con AINEs que con corticoesteroides para la mejora en los parámetros de conducción nerviosa y los resultados clínicos?

English version

The main aims of the present systematic review and meta-analysis were

- to evaluate the effectiveness of ultrasound therapy versus phonophoresis in terms of pain, symptom severity, function and the electrophysiologic parameters MDL and SDL in individuals with CTS and
- if sonophoresis is effective, which drug is more effective, non-steroidal anti-inflammatory drugs (NSAIDs) or corticosteroids.

The research questions are:

1. Is sonophoresis more effective than ultrasound for nerve conduction parameters and clinical outcomes?
2. Is sonophoresis more effective with NSAIDs than with corticosteroids for nerve conduction parameters and clinical outcomes?

METODOLOGIA/

METHODS

3. METODOLOGIA/ METHODS

Para todos los estudios se han seguido las directrices generales de la guía Cochrane. Posteriormente se indican los materiales y los métodos de cada estudio de forma independiente.

3.1 ESTUDIO I

Design

This study has followed the Preferred Reporting Items for Systematic Reviews and MetaAnalyses (PRISMA) guidelines. The systematic review and meta-analysis was also conducted following general methods for Cochrane reviews.

Identification and selection of studies

Firstly, a search in Cochrane Plus, Cochrane Library, the Proquest Platform and Google Scholar was performed to find possible meta-analyses and systematic or narrative reviews on the same topic. We identified reviews on conservative treatment of hand and finger OA, but they were not focused on EPAs, so no study with the same objective as in our study was identified. Secondly, the primary database search was performed by two independent investigators using the following databases: Scopus, CINAHL, Web of Science (all databases, including Medline) and PEDro database. Grey literature was consulted by using TESEO (official Spanish database for PhD theses), ProQuest Dissertations and Theses Global, OATD (Open Access Theses and Dissertations), and Google Scholar. The following group of MESH terms and keywords were used: (osteoarthritis, osteoarthrosis, rhizarthrosis), (hand, thumb, “carpometacarpal join”, “trapeziometacarpal joint”), (“physical devices”,

"electrophysical agents", therapy, electrotherapy, laser, infrared, magnetotherapy, "magnetic fields", shockwave, paraffin). Thirdly, titles and abstracts were independently assessed against the eligibility criteria. Fourthly, full text of each trial was read and two reviewers (APM and JMPM) extracted independently the relevant data from the included studies, using a data extraction form (codebook).

The criteria used for the selection of the studies were:

- *Design*: randomized controlled trials or clinical trials.
- *Participants*: i) adults diagnosed with hand OA, affecting the proximal and distal interphalangeal joints in fingers 2-5, or the first interphalangeal, metacarpophalangeal and thumb-base joints (carpo-metacarpal and scapho-trapezoid) of the thumb; and ii) no other serious comorbid conditions of the hand or wrist.
- *Intervention*: patients being treated with EPAs, excluded multimodal treatment of EPAs with drugs (sonophoresis or iontophoresis).
- *Outcome measures*: pain, function and strength.
- *Comparison*: non-exposed control group or placebo.

Assessment of study characteristics

Risk of bias

The methodological quality of the trials was evaluated using the Physiotherapy Evidence Database — PEDro, an 11-item scale designed for rating the methodological quality of randomized clinical trials. This instrument has been validated and been shown to be reliable[159]. All items (except for item 1, relevant to the external validity) are scored 1 point. The total score ranges from 0 to 10 points. A high score indicates high quality. The quality of the studies was

evaluated by two independent investigators (APM and MCGR) to reduce inter-examiner bias. Any discrepancies in the scoring process were settled by consensus between the reviewers.

The analysis of the internal validity criteria was evaluated by following the guidelines for systematic reviews using the internal validity score (IVS)[160]. The positive scores of each 7 items related to internal validity (2, 3, and 5 to 9) from the PEDro Scale were added together to calculate the IVS. This result was classified into 3 categories: high methodological quality (from 6 to 7 points), moderate quality (from 4 to 5 points), and limited quality (from 0 to 3 points).

Participants

The samples in the studies included the following characteristics: a) patients with hand OA being treated by electrophysical agents[103–105,161–164]; b) adult with a diagnosis of a clinical hand OA affecting any of the main joints, such as the proximal and distal interphalangeal joints in fingers 2-5[103–105,161–164] and the first interphalangeal and metacarpophalangeal and thumb-base joints (carpometacarpal and scaphotrapezoid)[106,165]; c) OA exhibiting Heberden´s or Bouchard´s nodes [166].

Intervention

The electrophysical interventions used in the primary studies included in the present review were: low level laser[104,161,165,166], heat (paraffin baths)[162,163], magnetotherapy[103,105], shockwave[106], ultrasound[161], and infra-red radiation[164].

Outcome measures

The main outcome measures of this study are changes after the implementation of the interventions using EPAs in pain, hand function and

strength in patients with OA. All the instruments used in the studies included in this review are validated tools for the evaluation of hand OA patients. Pain was measured using the following instruments: Visual Analogue Scale (VAS), VAS pain at rest, VAS pain at motion, Pressure Pain Threshold, the Short Form 36 Health Survey (SF-36) Pain, and the AUStralian CANadian Osteoarthritis Hand Index (AUSCAN) Pain. The hand function was registered using the Duruöz Hand Index, range of movement (ROM), SF-36 scale, AUSCAN scale, and the Functional Index for Hand OsteoArthritis. To measure strength, primary studies used the Hand dynamometer and the Pinch Gauge.

Data extraction and analysis

The codebook for data extraction was also used to record the effect size (Cohen *d*). The effect sizes were calculated when they were not reported directly from the primary study[167]. When the published trials provided insufficient data for making this calculation, we contacted the authors to receive the information needed. If discrepancies were found between the 2 reviewers recording the effect size, a third one participated in this process. Outcome data were extracted from each study (measurements and timing of assessment). In addition, the characteristics of both the experimental and the control groups were included: sample size, age and gender of participants, and other intervention data such as type, duration, frequency and setting. This information is shown in Table 3.

In terms of statistical analysis, a two-stage process was followed. In the first stage (systematic review section), a summary statistic was calculated for each study, describing the observed intervention effect. This summary was performed for the mean difference (Cohen's d) between pre-post intervention and pre-follow-up. The Cohen's *d* was calculated when the studies included

descriptive data (sample size, pre and post-treatment and pre-follow-up mean and standard deviation values) in the intervention group compared to the control group for the main groups of variables[168]. When the information from primary sources was insufficient, different conversions of the available data were performed to find Cohen's *d*. In the second stage (meta-analytic section), a summary (pooled) intervention effect estimate was calculated as a weighted average of the intervention effects estimated in the individual studies, using Revman 5.3 software[169]. The meta-analyses for the different groups of outcomes were performed by calculating the standardized mean differences (SMD) for pain and hand function scores, and mean differences (MD) for strength scores (95% confidence interval). A fixed-effect model was used with the inverse variance method by including the means and standard deviations at post-intervention. Statistical heterogeneity was assessed using the I^2 statistic.

Table 3. *Characteristic of the clinical trials included in the systematic review and meta-analysis.*

Author/s (year of publication)	Variables/Outcome measurements	Experimental group	Control group	Technique	Intervention	Outcome measures/results
Ioppolo et al (2018)	Pain: VAS Function: Duruöz Hand Index Hand Index Strength: Grip Pinch	Sample: n = 28 hand OA Sex distribution: 16 women and 12 men Mean age: 68.03±9.04 years Range age: 40–80 years	Sample: n = 30 hand OA Sex distribution: 18 women and 10 men Mean age: 66.67±8.06 Range age: 42–78 years	Extracorporeal Shock Waves	Experimental group: Focused extracorporeal Shock Wave (low-energy) Each session: 2.400 consecutive pulses, 4Hz,EFD 0.09mJ/mm2 Once a week/3 weeks Control group: Intraarticular Hyaluronic acid injections 3 injections/0,5cm3 HA synovial Mini	The use of Extracorporeal Shock Waves reduced pain, improved pinch test performance and decreased hand disability at 6 months follow-up. Pain reduction was superior with Extracorporeal Shock Wave than with Hyaluronic acid injection, immediately

					Once a week/3 weeks	and after 6 months. Improvements in hand function and strength showed to be equal
Blatzer et al (2016)	Pain: VAS	Total Sample: N = 34 patients (16 suffered from Bouchard's OA, 12 from Heberden's OA, and 6 both) Sex distribution: 32 women Total Mean age: 61.21±2.13years *Group 1* Sample: n = 18pat /37joints Mean age: 61.94 +- 2.96 years *Group 2* Sample: n = 10pat /29joints Mean age: 57.90 +- 3.97 years *Group 3* Sample: n = 6pat /19 joints Mean age: 64.50+- 5.13 years	No placebo control group	Low Level Laser Therapy	Experimental group: Diode laser, 10 fibres, output power 40mW per fibre, continuous Two points per joint, power density 25W/cm2. 20 min. per joint Group 1- 5 Low Level Laser Therapy sessions Group 2 - 7 Low Level Laser Therapy sessions Group 3 - 10 Low Level Laser Therapy sessions	Low Level Laser biomodulation therapy increased ROM, reduced pain
Paolillo et al (2015)	Pain: Pressure pain threshold Strength: Grip	*Group 1* Sample: n = 13 hand OA	Sample: n = 11 hand OA	Ultrasound and Low Level Laser Therapy	Experimental group: Laser 72J-28J/cm2 per point. /total 360J-142J/cm2 per hand	The use of ultrasound and low level laser increased pain threshold

		Sex distribution: 13 women Mean age: 69±5years Range age: 60–80 years *Group 2* Sample: n = 13 hand OA Sex distribution: 13 women Mean age: 68±6 years Range age: 60–80 years	Sex distribution: 11 women Mean age: 72±6 years Range age: 60–80 years		3 min per point /5 points Ultrasound 1MHz/1W/cm2/duty cycle 50%/0.5 W/cm2 SATA.3.150Jtotal energy 3 min per point/ 5point in the hand Group 1 - ultrasound + low level laser Group 2 – ultrasound + low level laser + therapeutic exercises Control group: Did not perform therapeutic exercises, but the device with ultrasound and low level laser therapy without emitting electromagnetic or mechanical waves was applied (null dose)	
Kanat et al (2013)	Pain: 10-points Likert Scale Function: SF-36 Duruöz Hand Index AUSCAN Strength: Grip Pinch Joint stiffness	Sample: 25 hand OA Mean age: 64±13 Range age: 51–77 years	Sample: 25 hand OA Mean age: 62±12 Range age: 50–74 years	Magnetotherapy	Experimental group: Pulsed electromagnetic field was executed using flux intensity from 3.5 to 25mT, 450 pulse and 5-80 G Once a day /20 min per day/10 days Exercise: active range of motion and hand grip strengthening Control group: Received sham magnetotherapy for 20 min/day for the same duration combined with the same exercises	Significant improvement in favour of the applied electromagnetic intervention ($p < 0.05$) were achieved for SF-36 Pain, SF-36 Social Function, SF-36 Vitality, SF-36 General Health, Pain at rest, Pain at motion, Joint stiffness, Duruöz Hand OA Index and AUSCAN Hand OA Index. However, non-significant changes were observed for SF-36 Physical Function, SF-36 Physical Role Limitations, SF-36 Mental Health, SF-36 Emotional Role Limitations,

						Hand grip strength (Right), Hand grip strength (Left), Pinch grip strength (Right) vs Pinch grip strength (Left)
Dilek et al (2013)	Pain: VAS Function: AUSCAN DREISER ROM Strength: Grip Pinch	Sample: n = 29 hand OA (n = 24 analysed) Sex distribution: 20 women and 4 men Mean age: 58.87±9.47 years	Sample: n = 27 hand OA. (n = 22 analysed). Sex distribution: 20 women and 2 men Mean age: 59.95±8.71 years	Dip-wrap paraffin bath therapy	Experimental group: Daily drug (Paracetamol), plus Bath of paraffin: 50ºC/dipped 10 times/wait 15 min 5 days per week/3 weeks Control group: Daily drug: Paracetamol	Paraffin bath therapy reduced pain and alleviated the pain based on the AUSCAN in patients with hand OA at 12 weeks. However, data no statistically significant effect on function There were no significant differences of hand grip and pinch strength
Horvath et al (2012)	Pain: VAS Function: SF-36 Health Assessment Questionnaire Strength: Grip Pinch	*Group 1* Sample: n = 21 hand OA Sex distribution: 17 women and 4 men. Mean age: 63.5±4.7years Range age: 50–70 years *Group 2* Sample: n = 21 hand OA. Sex distribution: 16 women and 5 men. Mean age: 62.3±4.8 years Range age:	Sample: n = 21 hand OA Sex distribution: 18 women and 3 men. Mean age: 63.8±4.4 years Range age: 50–70 years	Magnetotherapy	Experimental groups: Groups 1, 2 and 3 received: Pulsed magnetic field therapy: 60Hz/20J 15 min/3times per week/for 3 weeks Groups 1 and 2 received: Pulsed magnetic field therapy+ head-out immersion in 36° or 38° thermal mineral water respectively. 20 min/5times per week/3 weeks	Thermal water improved handgrip strength, pinch grip strength compared with the control group. The treatment was more effective at 38° than 36°

		50–70 years				
Myrer et al (2011)	Pain: VAS Function: Functional Index for Hand OsteoArthritis	*Group 1* Sample: n = 19 hand OA Sex distribution: 13 women and 6 men. Mean age: 62.9±9.1years Range age: 40–80 years *Group 2* Sample: n = 16 hand OA Sex distribution: 14 women and 2 men. Mean age: 64.4±8.4 years Range age: 40–80 years		Paraffin baths	Experimental groups: Group 1: Paraffin (528C - 578C). Group 2: Paraffin+ Topical analgesic 3 times per week/ 4 weeks	Treatment group 2 showed better improvement on function and pain than group 1
Stange-Rezende et al (2006)	Pain: VAS Function: AUSCAN SF-36 Strength: Grip	Sample: n = 45 hand OA. Sex distribution: 42 women and 3 men. Mean age: 60±8 years	Randomized controlled crossover study Finished the study 35	Infrared radiation	Room with a heated tiled stove at 21ºC-24ºC. 3 hours/3times per week/3 weeks The same group underwent a period of treatment and a control period	The treatment group showed better results than the control group
Brosseau et al (2005)	Pain: VAS Function: AUSCAN	Sample: n = 42 hand OA. (n = 41 analysed) Sex distribution: 31 women and 11 men.	Sample: n=46 hand OA (n=45 analysed) Sex distribution:	Low Level Laser Therapy	Experimental group: Low Level Laser Therapy, 60mWcontinued emission/30mWmodulated emission/area of treatment 0.01cm2/power density 3J/cm2/energy	Treatment with Low Level Laser Therapy not produced statistically benefits versus placebo

	Strength: Grip Lateral pinch Three-finger chuck pinch	Mean age: 64.2±9.9 years Range age: 45–80 years	38 women and 8 men. Mean age: 65.1±10.2 years Range age: 45–80 years		density per point 3J/cm2./74 points. 20 min/3 times per week/6 weeks Control group: Sham laser	
Basford et al (1987)	Pain: Medication use Function: SF-36 Duruöz Hand Index AUSCAN Strength: Grip Pinch Three-finger chuck pinch	Sample: n = 47 thumb OA. Sex distribution: Mean age: Range age: 23–75 years	Sample: n = 34 thumb OA. Sex distribution: Mean age: Range age: 23–75 years	Low Energy He-Ne Laser	Experimental group: Low Energy He, NE Laser Therapy, 0.9mWcontinued emission/area of treatment 0.01cm2/ 15 sec per point/4 points 3 times per week/3 weeks Control group: Sham laser	He-Ne Laser Irradiation was not effective in the treatment of thumb osteoarthritis

3.2 ESTUDIO II

Design

This study has followed the Preferred Reporting Items for Systematic Reviews and MetaAnalyses (PRISMA) guidelines. The systematic review and meta-analysis was also performed following general methods for Cochrane reviews.

Identification and selection of studies

The database search was performed by two independent investigators in the following databases: Scopus, CINAHL, Web of Science and PEDro database.

The following MESH terms or keywords were used: Ultrasound, Carpal, Tunnel Syndrome, Physical Therapy. The search strategy used was (ultrasound OR "physical therapy") AND (carpal OR tunnel OR syndrome). Firstly, we perform a search for meta-analysis, systematic or narrative revisions on the same topic, consulting in Cochrane Plus, Cochrane Library, the Proquest Platform and Google Scholar. There were 4 revisions about physical therapy's conservative treatment using ultrasound on carpal tunnel syndrome[41,117,120,170]. One of the reviews compares the effect of ultrasound with low level laser therapy[41]. Two reviews include various techniques related to physical therapy such as ultrasound, but excluded relevant articles[117,170]. Another review performs an extensive systematic review on the specific use of US[120], but it was published in 2013 and new clinical trials have been conducted since then. Therefore, no study with the same characteristics of the present study was identified. Secondly, the titles and abstracts were independently assessed against the eligibility criteria. Thirdly, two reviewers (APM and JMPM) independently extracted data from the full text of the included studies using a data extraction form (codebook). The selection criteria of the included studies are shown in Figure 4.

Box 1. Inclusion criteria.
Design Randomized controlled trials, clinical trials. **Participants** Adults with a confirmed diagnosis of STC and no other serious comorbid conditions of the hand or wrist. **Intervention** Trials were patients being treated by using US. **Outcome measures** Pain, Severity of symptoms, Function, strength, MDL and SDL. **Comparison** Will be compared with non-exposed control group, US versus sham, US and conventional treatment or other therapy versus conventional treatment or the other therapy alone.

Figure 4*. Selection criteria of the included studies.*

Assessment of characteristics of studies

Methodological quality and risk of bias

The Physiotherapy Evidence Database (PEDro) scale, an 11-item scale, was used to evaluate and ascertain the methodological quality of the trials, as they are randomized controlled trials (Physiotherapy Evidence Database Physiotherapy Evidence Database). This instrument was utilized due to its validation and reliability[159,171]. Almost all items (with exception of item 1, which is of relevance to external validity) were awarded 1 point, with the total score ranging from 0 to 10 points. It is important to note that a high score indicates high quality. With the purpose of reducing inter-examiner bias, the studies were evaluated by two independent investigators (APM and MCGR) to ascertain the level of quality. The reviewers then proceeded to settle any discrepancies in the scoring process by consensus.

The PEDro Scale was also used to evaluate the internal validity criteria[160]. With the use of this method, a quantitative analysis of the methodological quality of a study can be performed. Internal validity score (IVS) was calculated using 7 items related to internal validity (2, 3, and 5 to 9) by adding the positive scores of each of the 7 items together to calculate the IVS. The result of this calculation was then classified into 3 categories: high methodological quality (from 6 to 7 points), moderate quality (from 4 to 5 points), and limited quality (from 0 to 3 points).

The risk of bias was measured by RoB2, the revised version of the Cochrane tool recommended when randomized trials are included[172].

Quality of evidence

As recommended by Cochrane Handbook for Systematic Reviews of Interventions, the quality of evidence must be measure by using GRADE tool. GRADE approach provides a specific definition of the quality of evidence to summarize the findings of a systematic review[172].

Participants

The participants included in the original studies have the following characteristics: a) patients with clinical and electrophysiological evidence of mild or moderate idiopathic CTS[145,173–176]; b) over 18 years old; c) unilateral[173] or bilateral[177] wrist involvement.

Intervention

Therapeutic ultrasound.

Outcome measures

The main outcome measures registered for this study are: pain, severity of symptoms, function and median nerve conduction. All of the instruments included in the primary studies have been validated tools for CTS patients. Pain was evaluated by Visual Analogue Scale (VAS)[178]. Severity of symptoms was evaluated using the Boston carpal tunnel Questionnaire and the symptom severity subscale (SSS). Function was evaluated by Boston carpal tunnel Questionnaire, functional status subscale (FSS) and Health Assessment Questionnaire[179]. Hand grip and finger pinch were used for assessing strength. According to the recommendation of the American Association of Electrodiagnostic Medicine guidelines, the electrophysiological assessment of Median Nerve involved parameters used in routinary electroneuromyography

studies, such as MDL, motor conduction velocity, amplitude of compound muscle action potential, SDL, sensory conduction velocity and amplitude of sensory nerve action potential[115]. Finally, the main outcomes studied for median nerve conduction were MDL and SDL.

Data extraction and analysis

Codebook, a form of data extraction, was elaborated to register the effect sizes (Cohen's d) or essential statistical information required for its calculation, from each study. When data was found to be insufficient in the published trials, the authors were contacted via available means of communication to request the collection of missing data to enable the calculation of the size effects. Pilot testing of the fulfillment of the codebook was implemented on several trials and modified according to the arising need. The reviewers divided their tasks as the first (APM) independently extracted the data while the second (JMPM) confirmed the accuracy of this extracted data. The data extraction from each study was based on outcome data (measurements and timing of assessment), sample characteristics data from each group (therapeutic US vs control group) such as sample size, age and gender of participants, as well as a description of interventions (type, duration, frequency, setting) and trial results, as shown in table 4. The reviewers revised this data again upon any flagged discrepancies.

A two-stage process has been followed to conduct the systematic review and meta-analysis. In the first stage, a summary statistic has been calculated for each study, describing the observed intervention effect. This summary was performed for the mean differences (Cohen's d) from pre-post intervention and pre-follow-up. Cohen's d was calculated when the studies included descriptive data (sample size, pre and post-treatment and from pre-follow-up mean and

standard deviation values) in the intervention group which was compared to the control group for the main groups of variables [54]. When insufficient information was obtained from primary sources, a conversion of the available data was performed to find Cohen's d.

In the second stage, a summary (pooled) intervention effect estimate was calculated as a weighted average of the intervention effects estimated in the individual studies, with the use of Revman 5.4 software[180]. A fixed-effect model was used with the inverse variance method by including the means and standard deviations at post-intervention. The meta-analyses for the different groups of outcomes were performed by the calculation of mean differences (MD) for pain, symptom severity, motor distal latency and sensory distal latency, and the standardized mean differences (SMD) for function, and 95% confidence intervals. The strength of the SMD was determined using Cohen's d criteria[181]. Statistical heterogeneity was assessed using the I^2 statistic. This heterogeneity responds to the variability in the intervention effects being evaluated in the different studies. The most common data collection time was chosen where outcome data were measured at different time points between the trials.

***Table 4**. Características de los estudios incluidos en la revisión sistemática y meta-análisis.*

Author/s (year of publication)	Variables/Outcome measurements	Experimental group	Experimental group	Control group	Technique	Intervention	Outcome measures/results
Oztas et al (1998)	Pain: VAS Electrophysiological parameters: Motor distal latency Sensory distal latency Motor nerve conducity velocity Sensory nerve conducity velocity	1.Sample: n patient = 7. n wirst= 10. Sex distribution: women Mean age: (53.2±6.5) Range age: 45-61	2.Sample: n patient = 9. n wirst= 10. Sex distribution: women Mean age: (51.3±7.2) Range age: 37-66	3.Sample: n patient = 9. n wirst= 10. Sex distribution: women Mean age: (49.0±6.3) Range age: 41-59	Ultrasound Sham	1.Experimental group: Continuous US therapy. Each session: 3 MHz, 1,5W/cm. Five a week/2weeks. 5min. 10 sessions. 2.Experimental group: Continuous US therapy Each session: 3 MHz, 0,8W/cm. Five a week/2weeks. 5min. 10 sessions. 3.Control group: Sham US therapy	All group, sham included, improved symptoms. Therapeutic ultrasound groups showed slight nonsignificant decrease in motor nerve conducity velocity.

Ebenbichleret al (1998)	Pain: VAS Strength: Hand grip. Pinch. Electrophysiological parameters: Motor distal latency Motor nerve conducity velocity	1.Sample: n = 34.		2.Sample: n = 34.	Ultrasound. Sham	1.Experimental group: Pulsed US therapy Each session: 1 MHz, 1W/cm,1:4 duty cycle. Five a week/2weeks. Twice a week/5weeks 20 sessions. 2.Control group: Sham US therapy	Ultrasound showed good short term effectiveness.
Baysal et al (2006)	Pain: VAS Boston Questionnaire, Symptom severity score. Function: Boston Questionnaire, Functional status score. Boston Questionnaire, Symptom severity score. Others: Tinel´s. Phalen´s. Sensibility: 2-point discrimination. Strength: Hand grip. Pinch. Electrophysiological parameters: Motor distal latency. Sensory distal latency.	1.Sample: n patient= 12. n wirst= 24. Mean age: (47.8±5.5)	2.Sample: n patient= 12. n wirst= 16. Mean age: (50.1±7.3)	3.Sample: n patient= 12. n wirst= 16. Mean age: (51.4±5.2)	Ultrasound. Splint. Exercise.	1.Experimental group: Splint + Exercise. 2.Experimental group: Splint +Pulsed US therapy Each session: 1 MHz, 1W/cm,1:5 duty cycle,15 min. Five a week/3weeks. 3.Control group: Splint +Pulsed US therapy+ Exercise. Each session: 1 MHz, 1W/cm,1:5 duty cycle,15 min. Five a week/3weeks.	All groups showed improvement immediately and at 8 weeks.
Dincer et al (2009)	Pain: VAS. Boston questionnaire. Function: Boston questionnaire. Patient satisfaction inquiry Electrophysiological parameters: Motor distal latency. Nerve sensory velocity.	1.Sample: n wirst= 34. Mean age: (51.8±6.6)	2.Sample: n wirst = 30. Mean age: (49.7±9.5)	3.Sample: n wirst = 36. Mean age: (52.2±9.1)	Ultrasound. Splint. Low Level Laser.	1.Experimental group: Splint 2.Experimental group: Continuous US therapy+splint Each session: 3 MHz, 1W/cm,1:4 duty cycle. 3min. Five a week/2weeks. 10 sessions. 3.Experimental group: Low level laser+splint Each session: 1 J, 5 points. Five a week/2weeks. 10 sessions.	The study demonstrated the effectiveness of conservative treatments, especially if they were combined.
Yildiz et al (2011)	Pain: VAS Boston Questionnaire, Symptom severity score. Function: Boston Questionnaire, Functional status score. Boston Questionnaire, Symptom severity score. Electrophysiological parameters: Motor distal latency. Sensory distal latency.	1.Sample: n = 26. Mean age: (48.7±10.9)		2.Sample: n = 25. Mean age: (47.5±8.3)	Ultrasound. Phonophoresis Sham Splinting	1.Experimental group: Splinting and pulsed US therapy Each session: 1 MHz, 1W/cm,1:4 duty cycle. 15min. Five a week/2weeks. 10 sessions. 2.Control group: Splinting and sham ultrasound.	Ultrasound appears not to be effective in addition to splinting.
Duymaz et al (2012)	Pain: VAS Boston Questionnaire, Symptom severity score. Function: Health Assessment Questionnaire. Boston Questionnaire, Functional status score. Electrophysiological parameters: motor distal latency sensory distal latency	1.Sample: n =20. Mean age: (51.2±6.8)		2.Sample: n =18. Mean age: (30.19±5.4)	Ultrasound. Iontophoresis. Sham. Exercise. Splint.	1.Experimental group: US therapy+ exercise+splint. Each session: 1 MHz, 0.8W/cm,1:4 duty cycle. 5min. Five a week/2weeks. 2.Experimental group: Sham iontophoresis + exercise + splint.	Active treatment modalities were superior to sham.
Armagan et al (2014)	Pain: VAS Boston Questionnaire, Symptom severity score. Function: Boston Questionnaire, Functional status score. Electrophysiological parameters: motor distal latency sensory distal latency Motor nerve conduction velocity Palm to wrist sensory nerve conduction.	1.Sample: n = 15. Mean age: (45.2±2.9)	2.Sample: n =16. Mean age: (43.31±2.7)	3.Sample: n =15. Mean age: (44.5±2.3)	Ultrasound Splint	1.Experimental group: Splinting and continuous US therapy Each session: 1 MHz, 1W/cm. Five a week/3weeks. 2.Experimental group: Splinting and pulsed US therapy. Each session: 1 MHz, 1W/cm,1:4 duty cycle. Five a week/3weeks. 3.Control group: Splinting and sham US therapy.	The use of splinting in combination with US, continuous or pulsed, improves electrophysical parameters.
Lazovic et al (2018)	Pain: VAS. Others: Tinel test. Electrophysiological parameters: motor distal latency. Sensory nerve action potential. Median sensory nerve conduction velocity	1.Sample: n patient=20. Mean age: (53.5±8.3)		2.Sample: n patient=20. Mean age: (52.6±8.7)	Ultrasound. Sham.	1.Experimental group: US therapy + exercise. Each session: 1 MHz, 1W/cm, 1:4 pulsed. 15min. 20 sessions. 2.Control group: Sham US + exercise.	Ultrasound exercises had positive effects on clinical and electrophysiological parameters.
Catalbas et al (2018)	Pain: VAS Boston Questionnaire, Symptom severity score. Function: Boston Questionnaire, Functional status score. Strength: Hand grip. Electrophysiological parameters: motor distal latency sensory distal latency	1.Sample: n = 31. Mean age: (51.1±10.1)	2.Sample: n =31. Mean age: (46.8±11.2)	3.Sample: n =30. Mean age: (46.3±8.8)	Ultrasound Splint	1.Experimental group: Splinting and continuous US therapy Each session: 1 MHz, 1W/cm. 10 sessions. 2.Experimental pulsed group: Splinting and pulsed US therapy Each session: 1 MHz, 1W/cm,1:4 duty cycle. 10 sessions. 3.Control group: Splinting and sham US therapy.	The use of splinting in combination with US, continuous or pulsed, has short-term positive effects on electrophysical, morphological and clinical parameters.

Jothi et al (2019)	Pain: Boston questionnaire. function: Boston questionnaire. Electrophysiological parameters: motor distal latency. Cross -sectional area. Sensory conduction velocity.	1.Sample us: n patient=19. Mean age: (53.46±10.71)	2.Sample sham: n patient=19. Mean age: (58.27±10.84)	Ultrasound. Splint.	1.Experimental group: Pulsed US therapy + splint. Each session: 1MHz, 1W/cm, pulsed, 15min. Five a week/2weeks. Twice a week/5weeks. 20 sessions. 2.Control group: Sham US therapy + splint.	The use of US in addition to splinting showed no significant benefit compared to sham US.

3.3 ESTUDIO III

Design

The study was conducted according with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, with the systematic review and meta-analysis following the general methods for Cochrane reviews.

Study identification

Two independent investigators performed the database search in Scopus, CINAHL, PUBMED, Web of Science and PEDro database using the following MESH terms or keywords: Ultrasound, Carpal, Tunnel Syndrome, Physical Therapy. The search strategy was (ultrasound OR physical therapy) AND (carpal OR tunnel OR syndrome). We first conducted a search of meta-analyses and systematic or narrative revisions on the same topic, consulting the Cochrane Plus, Cochrane Library, the Proquest Platform and Google Scholar. We then independently assessed the titles and abstracts against the eligibility criteria. Two reviewers (APM and JMPM) then independently extracted the data from the full text of the included studies using a data extraction form (codebook), available upon request from the corresponding author.

Selection criteria

The selection criteria for the included studies were: 1) Design: randomised controlled trials, clinical trials; 2) Samples: adults with a confirmed diagnosis of CTS and no other serious comorbid conditions of the hand or wrist; 3) Interventions: trials with patients treated using sonophoresis, trials using sonophoresis versus ultrasound, and trials using sonophoresis-NSAIDS versus sonophoresis-corticosteroids; 4) Outcome measures: MDL and SDL, pain, symptom severity, and function; 5) Comparison: comparing ultrasound versus sonophoresis, ultrasound and conventional therapy or other therapy versus sonophoresis and the same therapies, trials with sonophoresis-NSAIDs versus sonophoresis-corticosteroids and sonophoresis-NSAIDs plus conventional treatment or other therapy versus sonophoresis-corticosteroids and the same therapies.

Assessment of the studies characteristics

Risk of bias

We evaluated the trials methodological quality using the Physiotherapy Evidence Database (PEDro) scale, an 11-item scale designed for rating the methodological quality of randomised controlled trials, which has been validated and shown to be reliable[159,171]. All items (except for item 1 regarding external validity) are assigned 1 point, and the total score ranges from 0 to 10, with a high score indicating high quality. To reduce interexaminer bias, two independent investigators (A.P.M and M.C.G.R) evaluated the quality of the studies. Any discrepancies in the scoring process were settled by consensus between the reviewers.

We evaluated the analysis of the internal validity criteria by following the guidelines for systematic reviews[160], which allows for a quantitative analysis of a study's methodological quality. We calculated the internal validity score using the 7 items related to internal validity (2, 3, and 5 to 9) from the PEDro Scale. We added up the positive scores of each of these 7 items to calculate the internal validity score and classified the result into 3 categories: high methodological quality (from 6 to 7 points), moderate quality (from 4 to 5 points), and limited quality (from 0 to 3 points). (Table 9).

Participants

The study populations of the original studies of the present meta-analysis had the following characteristics: a) clinical and electrophysiological evidence of mild to moderate idiopathic CTS[144–147,182,183], b) early mild CTS[184], c) adult age and d) unilateral or bilateral CTS.

Intervention

The conservative electrophysical interventions of the primary studies, included in the present systematic review, were based on ultrasound versus sonophoresis therapy.

Outcome measures

The main outcome measures registered for this study belong to the areas of pain, symptom severity, function, and median nerve conduction. All of the instruments included in the primary studies were tools validated for the evaluation of CTS. The primary outcome was pain, measured with the visual analogue scale[185]. Secondary outcomes included symptom severity, measured with the Boston Carpal Tunnel Questionnaire symptom severity subscale. For function,

data was collected from the questionnaire's functional status subscale and the Health Assessment Questionnaire[186]. The electrophysiological assessment of the median nerve involved parameters employed in routine electroneuromyography studies such as MDL, motor conduction velocity, compound muscle action potential amplitude, SDL, sensory conduction velocity and amplitude of the sensory nerve action potential, according to the recommendations of the American Association of Neuromuscular and Electrodiagnostic Medicine guidelines[115]. For the median nerve conduction studies, the primary endpoints included were MDL and SDL.

Data extraction and analysis

We prepared a data extraction form (codebook) to record the effect sizes (Cohen d) from each study and the essential statistical information needed to calculate the sizes. When the data were insufficient in the published trials, we contacted the authors via email for permission to request, collect and calculate the effect sizes. The completion of the codebook was pilot tested on several trials and modified accordingly. One reviewer (A.P.M) independently extracted the data, and the second reviewer (J.M.P.M) checked the accuracy of the extracted data. If there were any discrepancies, the reviewers once again reviewed the original trial. Information was extracted from each study on the outcome data (measurements and timings of the assessments), as well as data on the sample characteristics of each group (experimental vs. control groups) such as sample size, participant age and sex, a description of the interventions (type, duration, frequency and setting) and the results of the trial (Table 10).

Using RevMan 5.4 software, we estimated a summary (pooled) intervention effect as a weighted average of the intervention effects estimated in

the individual studies.[169] We performed the meta-analyses for the various outcome groups by calculating the mean differences for pain, symptom severity subscale, MDL and SDL, standardized mean differences (SMD) for functional status subscale, and 95% confidence intervals. For these analyses, we employed fixed and random effects models with inverse variance methods by including post-intervention means, standard deviations and sample sizes for each intervention group. The inverse variance methods minimise the imprecision (uncertainty) of the pooled effect estimate. We assessed statistical heterogeneity using the I^2 statistic. To avoid double-counts and eliminate unit-of-analysis errors, we combined groups (when the primary studies had a multi-arm design) to create a single pair-wise comparison, according to Cochrane Handbook (section 23.4)[172].

RESULTADOS/ RESULTS

4. RESULTADOS/ RESULTS

Los resultados obtenidos en los tres estudios son dispares por lo que a continuación se detallan los mismos de forma individualizada.

4.1 ESTUDIO I

Stages of the systematic review

Published clinical trials and randomized control trials evaluating the efficacy of physical therapy devices on hand OA for pain, function and strength have been included in this review. Two reviewers applied inclusion and exclusion criteria. The initial search by title identified 3006 potentially relevant papers (after eliminating duplicates). When the abstracts were read, 224 trials were assessed for eligibility. Ten of those studies met all the eligibility criteria. The flow diagram depicting the studies selection process is shown in Figure 5. The exclusion of two studies was based on the language they were reported[187,188].

In the meta-analytic section, 6 clinical trials with a total of 1582 participants with hand OA were included. From the total of participants with hand OA, 425 were retrieved for their inclusion in the analysis of pain outcomes, 453 for function, and 677 for strength. The reasons because the meta-analysis only included 6 of the 10 papers were the following: i) insufficient information about the outcomes (reporting of insufficient data);[105,166] and ii) lack of a control group (uncontrolled trials)[163,164]. Three studies were included but partially, due to the use of different type of measurement not compatible with the rest of the trial data[106,161,165]. Some pain and function outcomes were not included[103] because they were scored inversely with respect to the other studies included in the meta-analysis. The

outcomes scoring in the same direction with respect to the rest of the studies were maintained.

Characteristics of the studies

Risk of bias

Several studies[103,162,164] were rated 7/10 on the PEDro scale, while others scored 8/10[104–106,163,165]. Table 5 shows the PEDro scores and IVS of each study included in the review. All except 2 studies in the meta-analysis showed moderate evidence [161,166] according to the IVS scale.

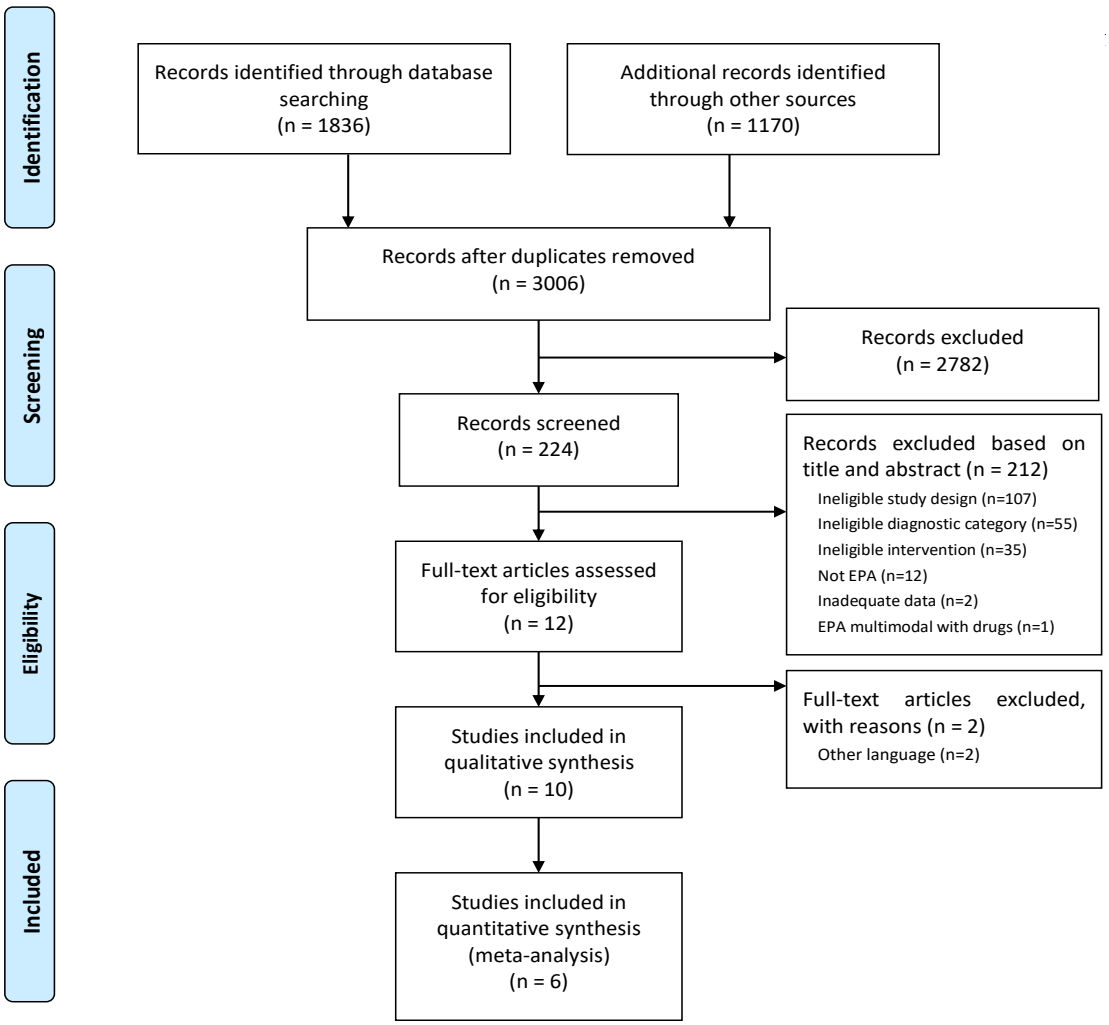


Figure 5. *Flow diagram of the studies selection process.*

Table 5. *PEDro score and IVS of included trials. PEDro = Physiotherapy Evidence Database, IVS = Internal Validity Score, Y = yes, N = no.*

Author (year of publication)	1	2	3	4	5	6	7	8	9	10	11	Total PEDro Score	IVS
Ioppolo (2018)	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	8/10	4/7 Moderate
Blatzer (2016)	Y	N	N	Y	N	N	N	Y	Y	Y	Y	6/10	2/7 Limited
Paolillo (2015)	N	Y	N	Y	N	N	N	N	N	Y	N	3/10	1/7 Limited
Kanat (2013)	N	Y	N	Y	Y	N	N	Y	Y	Y	Y	7/10	4/7 Moderate
Dilek (2013)	Y	Y	Y	Y	N	N	Y	N	Y	Y	Y	7/10	4/7 Moderate
Horvath (2012)	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8/10	5/7 Moderate
Myrer (2011)	Y	Y	Y	N	Y	N	Y	Y	N	Y	Y	8/10	5/7 Moderate
Stangerev (2006)	Y	N	Y	N	N	N	Y	Y	Y	Y	Y	7/10	4/7 Moderate
Brosseau (2005)	Y	Y	N	Y	Y	N	Y	Y	Y	Y	Y	8/10	5/7 Moderate
Basford (1987)	Y	Y	N	Y	Y	Y	Y	Y	N	Y	Y	8/10	5/7 Moderate

Participants

Table 3 shows the characteristic of the clinical trials included in the systematic review and meta-analysis.

Interventions

The descriptive information on interventions in all the primary studies included in the systematic review and meta-analysis are shown in Table 3. Six studies were included in the meta-analysis; one used shock wave therapy[106], two laser therapy[104,165], another included a prototype that combines ultrasound and laser therapy[161], another used magnetotherapy[103] and another paraffin[162].

Outcome measures

The outcome measures used in the studies included are also listed in Table 3.

Effect of EPAs on hand osteoarthritis

Effect of EPAs on pain

With regard to pain, the between group analysis after applying EPAs in the experimental group compared to the control group showed a statistically significant difference (SMD = -0.35; 95% CI = -0.54, -0.15; *p* = 0.0004), in favour of the experimental group (Fig. 6). Regarding immediate individual improvement in the experimental group, Cohen *d* effect size ranged between 0.720 and 8.181. Regarding the short-term effect of EPAs, the effect size varied from 0.668 to 1.150, while a study reported an effect size of 0.552 for long-term improvement (*see* Table 6).

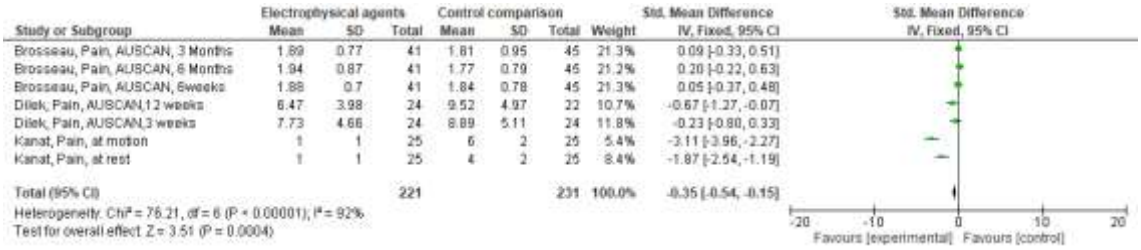


Figure 6*. Forest plot of the effect of the electrophysical agents vs. controls for the outcome pain intensity.*

Effect of EPAs on hand function

In terms of hand function, the between group analysis after applying EPAs in the experimental group compared to the control group showed a statistically significant difference (SMD = -1.45; 95% CI = -1.65, -1.25; *p* = 0.00001) in favour of the experimental group (Fig. 7). Regarding immediate individual improvement in the experimental group, studies obtained a Cohen *d* effect size ranging from 0.720 to 12.66. In short-term, it was observed an improvement with a Cohen *d*

ranging between 0.240 and 0.378. A study reported an effect size of 0.384 for long-term improvement in the experimental group (Table 6).

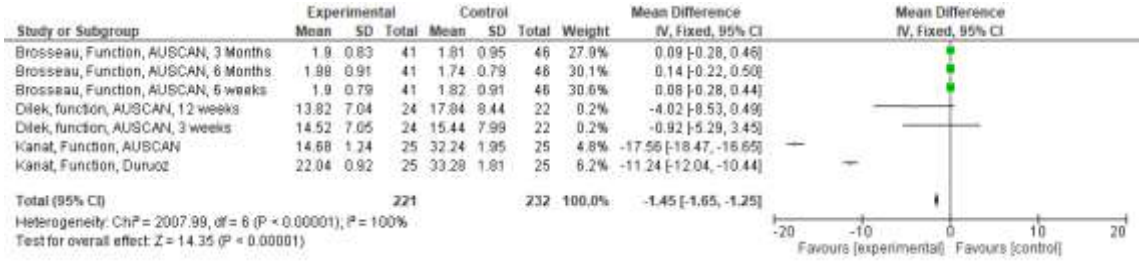


Figure 7. *Forest plot and meta-analysis of the effect of the electrophysical therapy vs. controls, showing improvement in self-reported hand function.*

Effect of EPAs on hand grip and pinch strength

Regarding grip strength, the between group analysis after applying EPAs in the experimental group compared to the control group showed a statistically significant difference (MD = 0.99; 95% CI = 0.35, 1.63; p = 0.003) in favour of the control group (Fig. 8). The clinical interpretation of this finding is interpreted as a significant increase in strength in the experimental group in comparison with the control group. In terms of immediate individual improvement in the experimental group, an effect size of between 0.140 and 3.582 was obtained; in short-term, one study obtained an effect size of 0.765; and in long-term an effect size of 0.966 was obtained (Table 6).

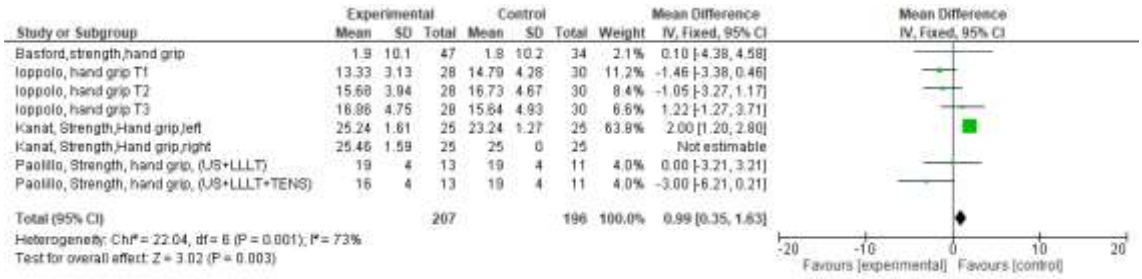


Figure 8 *Forest plot of the effect of the electrophysical therapy vs. controls for the outcome grip strength (kg).*

Regarding pinch strength, post-treatment improvement in the experimental group vs. the control did not differ significantly (MD = - 0.18; 95% CI = -0.41, 0.05; *p* = 0.12) (Fig. 9). In the experimental group, the repeated measures analysis showed an immediate improvement with a Cohen *d* ranging from 0.979 to 6.043; in short-term, one study also obtained improvements with an effect size of 0.239, and in long-term of 0.716 (Table 6).

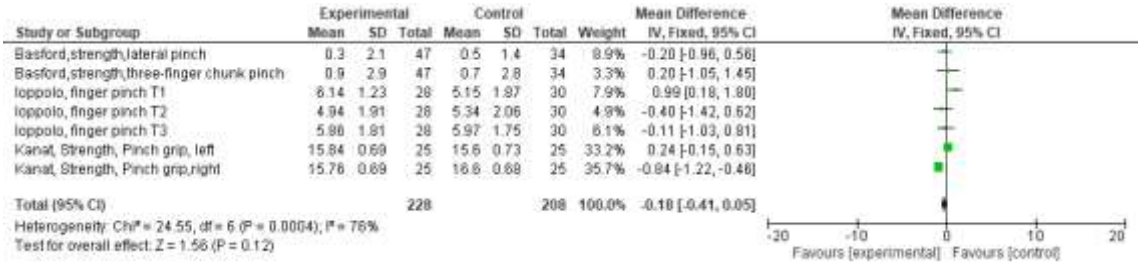


Figure 9. *Forest plot of the effect of the electrophysical agents vs. control for the outcome pinch strength (kg).*

Table 6. *Pre, post-intervention, follow-up values and effect-sizes for pain, function and strength.*

Author (year)	Intervention group	Variable	Outcome measures	Pre-intervention Mean (SD)	Post-intervention Mean (SD)	Following-up		Cohen d Pre-post	Cohen d Pre-following-up	
						First following-up Mean (SD)	Second following-up Mean (SD)		First following-up	Second following-up
Ioppolo et al (2018)	Sockwave	Pain	VAS	8.01 (1.11)						
		Function	Duruöz Hand Index	50.89 (13.50)						
		Strength	Finger pinch strength	4.46 (2.09)	6.14 (1.23)	4.94 (1.91)	5.86 (1.81)	0.979	0.239	0.716
			Hand grip strength	12.87 (3.39)	13.33 (3.13)	15.68 (3.94)	16.86 (4.75)	0.140	0.765	0.966
	Control	Pain	VAS	7.62 (1.34)						
		Function	Duruöz Hand Index	51.56 (14.04)						
		Strength	Finger pinch strength	4.59 (2.17)	5.15 (1.87)	5.34 (2.06)	5.97 (1.75)	0.276	0.354	0.700
			Hand grip strength	12.46 (3.57)	14.79 (4.28)	16.73 (4.67)	15.64 (4.93)	0.591	1.027	0.738
Blatzer et al (2016)	Laser (total)	Pain	VAS	5.78 (0.26)	4.60 (0.28)			0.773		
		Function	ROM	64.51 (2.88)	72.35 (2.94)			0.840		
			Ring Size	61.32 (0.77)	60.27 (0.75)			0.352		
	Laser (5 sessions)	Pain	VAS	5.97 (0.31)	4.22 (0.39)					
		Function	ROM	63.19 (3.93)	71.76 (4.53)					

			Ring Size	61.27 (1.06)	60.35 (1.03)			
	Laser (7 sessions)	Pain	VAS	4.72 (0.52)	2.86 (0.49)			
		Function	ROM	54.48 (4.97)	70.17 (4.07)			
			Ring Size	60.10 (1.34)	58.69 (1.37)			
	Laser (10 sessions)	Pain	VAS	7.00 (0.50)	5.95 (0.55)	5.16 (0.58)		
		Function	ROM	82.37 (5.33)	88.42 (5.22)	88.95(5.28)		
			Ring Size	63.26 (1.82)	61.74 (1.84)	61.63(1.85)		
Paolillo et al (2015)	Ultrasound + Low Level Laser	Pain	Pressure Pain Threshold					
		Strength	Grip Strength	19 (5)	19 (4)		0.000	
	Ultrasound +Low Level Laser +TENS	Pain	Pressure Pain Threshold					
		Strength	Grip Strength	16 (4)	17 (3)		0.282	
	Control	Pain	Pressure Pain Threshold					
		Strength	Grip Strength	19 (3)	19 (4)		0.000	
Kanat et al (2013)	Magnetotherapy + Exercise	Pain	SF-36 Pain	43.20 (3.09)	77.60 (5.08)		8.181	
			Pain at rest	4 (2)	1 (1)		1.897	
			Pain at motion	7 (2)	1 (1)		3.794	
		Function	Duruöz Hand Index	34.92 (1.83)	22.04 (0.92)		8.89	
			AUSCAN Hand OA Index	32.88 (1.61)	14.68 (1.24)		12.66	
			SF-36 Physical Function	50.40 (4.05)	55 (3.55)		1.207	
		Strength	Hand grip strength (right)	20.52 (1.52)	25.46 (1.59)		3.176	
			Hand grip strength (left)	19.40 (1.65)	25.24 (1.61)		3.582	
			Pinch grip strength (right)	13 (0.58)	15.76 (0.69)		4.330	
			Pinch grip strength (left)	11.64 (0.70)	15.84 (0.69)		6.043	
	Control	Pain	SF-36 Pain	41.60 (3.54)	45.20 (3.47)		1.027	
			Pain at rest	4 (2)	4 (2)		0.000	
			Pain at motion	7 (3)	6 (2)		0.392	
		Function	Duruöz Index	36.72 (2.02)	33.28 (1.81)		1.793	
			AUSCAN	35.32 (2.15)	32.24 (1.95)		1.500	
			SF-36 Physical Function	58.60 (4.49)	59.20 (4.41)		0.134	
		Strength	Hand grip strength (right)	19.80 (1.06)	25 (1.37)		4.245	
			Hand grip strength (left)	19.20 (1.18)	23.24 (1.27)		3.295	
			Pinch grip strength (right)	12.72 (0.80)	16.60 (0.68)		5.226	
			Pinch grip strength (left)	12.36 (0.68)	15.60 (0.73)		4.592	
Dilek et al (2013)	Paraffin	Pain	AUSCAN	10.65 (3.25)	7.73(4.66)	6.47 (3.98)	0.726	1.150
		Function	AUSCAN	16.17 (6.69)	14.52 (7.05)	13.82 (7.04)	0.240	0.342
	Control	Pain	AUSCAN	9.78 (5.69)	8.89 (5.11)	9.52 (4.97)	0.166	0.048
		Function	AUSCAN	17.10 (9.21)	15.44 (7.99)	17.84 (8.44)	0.192	0,0837
Horvath et al (2012)	Magnetotherapy + Bath 36º	Pain	VAS I				-28.91	-20.31
		Function	SF-36				5.51	5.11
			HAQ				-0.21	-0.21
		Strength	Hand grip Strength (right)				3.81	3.71
			Hand grip Strength (left)				2.991	2.71
			Pinch grip Strength (right)				0.61	0.41
			Pinch grip Strength (left)				0.31	0.31
	Magnetotherapy + Bath 38º	Pain	VAS I				-21.51	-17.71
		Function	SF-36				-0.51	-0.41
			HAQ				6.31	4.91
		Strength	Hand grip Strength (right)				3.51	4.01
			Hand grip Strength (left)				2.71	4.41

			Pinch grip Strength (right)					0.71	0.61	
			Pinch grip Strength (left)					0.61	0.41	
	Magnetotherapy	Pain	VAS I					-11.41	-4.81	
		Function	SF-36					-0.11	-0.11	
			HAQ					2.01	1.81	
		Strength	Hand grip Strength (right)					-0.11	0.31	
			Hand grip Strength (left)					0.61	-0.11	
			Pinch grip Strength (right)					0.11	0.031	
			Pinch grip Strength (left)					0.31	0.11	
Myrer et al (2011)	Paraffin	Pain	VAS							
	Control	Pain	VAS							
Stange-Rezende et al (2006)	Stove period (IR) + Control period	Pain	VAS	54.3 (25.7)	-4.11 (21.76)			2.453		
			Pain in hand	58.0 (26.2)	-5.02 (17.99)			2.804		
			SF-36 Bodily pain	33.3 (17.0)	-6.07 (11.90)			2.683		
			AUSCAN	11.6 (4.0)	0.62 (1.84)			3.526		
		Function	VAS Function	47.8 (27.3)	-1.64 (14.80)			2.243		
			AUSCAN	20.2 (7.7)	0.24 (3.71)			3.302		
		Strength	Grip strength	0.4 (0.2)	0.01 (0.11)			2.416		
	Control period + Stove period (IR)	Pain	VAS	54.3 (25.7)	-0.13 (17.52)			2.474		
			Pain in hand	58.0 (26.2)	-3.32 (18.83)			2.687		
			SF-36 Bodily pain	33.3 (17.0)	-2.64 (15.23)			2.226		
			AUSCAN	11.6 (4.0)	-0.33 (2.70)			3.495		
		Function	VAS Function	47.8 (27.3)	0.34 (20.30)			1.972		
			AUSCAN	20.2 (7.7)	1.00 (3.85)			3.154		
		Strength	Grip strength	0.4 (0.2)	0.01 (0.08)			2.560		
Brosseau et al (2005)	Low Level Laser	Pain	AUSCAN	2.36 (0.63)	1.88 (0.70)	1.89 (0.77)	1.94 (0.87)	0.720	-0.668	-0.552
		Function	AUSCAN	2.22 (0.86)	1.90 (0.79)	1.90 (0.83)	1.88 (0.91)	0.387	-0.378	-0.384
	Control	Pain	AUSCAN	2.10 (0.65)	1.84 (0.78)	1.81 (0.95)	1.77 (0.79)	0.362	-0.356	-0.362
		Function	AUSCAN	2.06 (0.70)	1.82 (0.91)	1.78 (0.96)	1.74 (0.79)	0.295	-0.333	-0.295
Basford et al (1987)	Low Energy Laser	Strength	Grasp		1.9 (10.1)					
			Lateral Pinch		0.3 (2.1)					
			Three-finger chuck pinch		0.9 (2.9)					
	Control	Strength	Grasp		1.8 (10.2)					
			Lateral Pinch		0.5 (1.4)					
			Three-finger chuck pinch		0.7(2.8)					

4.2 ESTUDIO II

Flow of studies through the review.

The present review includes the published clinical trials evaluating the effectiveness of ultrasound on CTS, with the variables of pain intensity, severity of symptoms, function, strength, MDL and SDL. Two reviewers applied the inclusion and exclusion criteria. The initial search, which was conducted by

analyzing the title, identified 5509 potentially relevant papers. After eliminating duplicate papers and reading the abstracts of the relevant papers, 371 trials were obtained. From these results, 29 items were revised, of which 10 items met the inclusion criteria to be included in the present systematic review. The flow chart used to select the primary studies, according to the PRISMA guideline, is shown in Figure 10.

Two studies were excluded because they were published in a language other than those established in the inclusion criteria[189,190], while two others were excluded due to the lack of full text[191,192]. Despite the use of different strategies such as contacting the authors, the full texts could not be retrieved[175,176]. A number of other studies were discarded because they were superiority studies[44,126,127,129–131,133,134,193] or they included drug therapy[122,145,194].

In the meta-analysis of the present study, 8 clinical trials were finally included, with a total sample of 2069 wrist with CTS. These clinical trials included data on pain, severity of symptoms, function, strength evaluation, and the neurophysiological parameters of MDL and SD. A total sample of 314 wrists included a pain evaluation, 352 wrists the severity of symptoms, 414 wrists function, 202 wrists strength, 412 the MDL and 375 SDL.

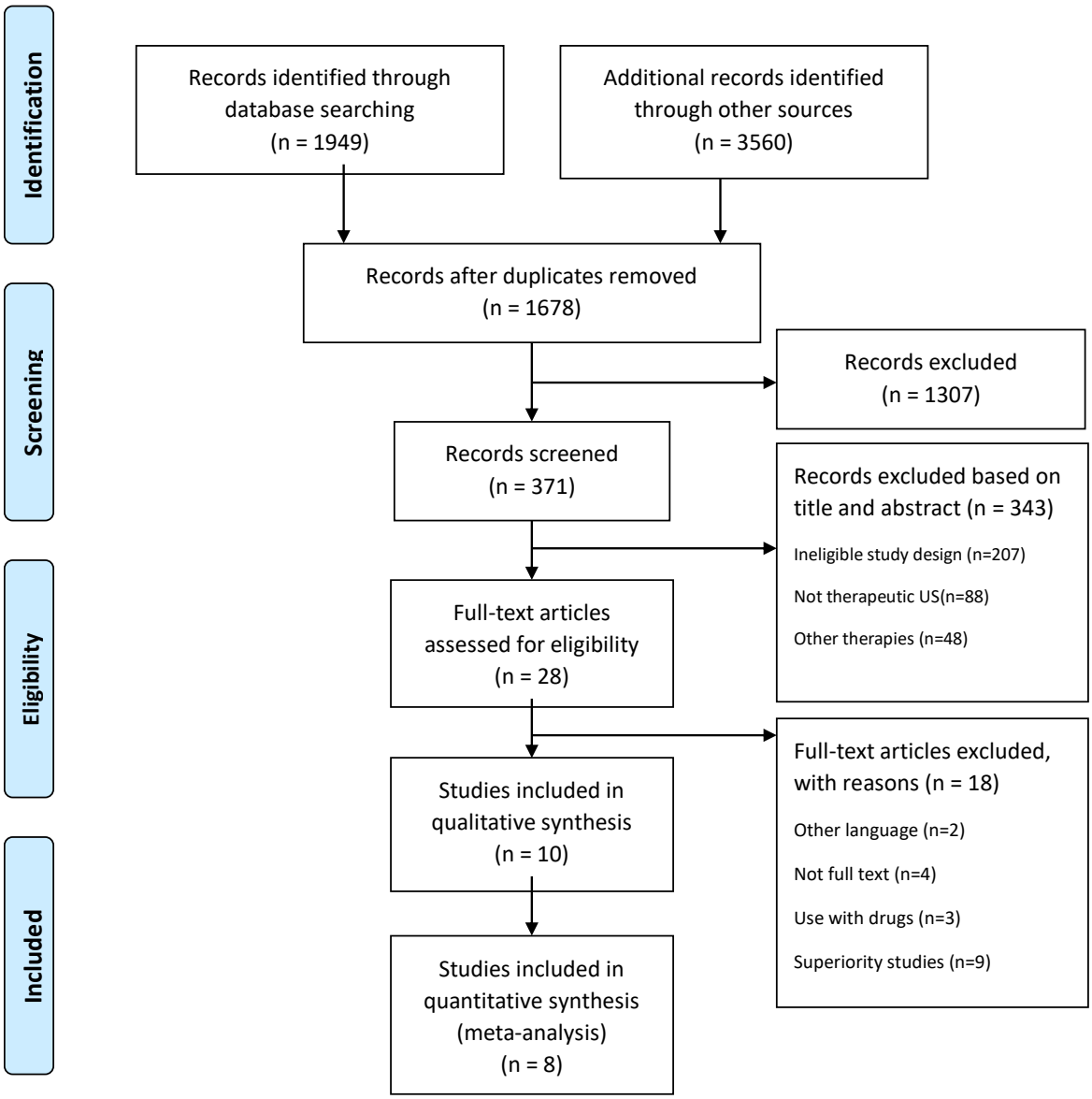


Figure 10. *PRISMA flow diagram. From: Moher D, Liberati A, Tetzlaff J, Altman DG. The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and MetaAnalyses: the PRISMA Statement. PLoS Med 6:e1000097. For more information, visit www.prisma-statement.org.*

Characteristics of studies

Methodological quality and risk of bias

Table 7 provides details about the PEDro scale of each trial and IVS scores. It can be seen that these studies[135,145] scored 9/10 on the PEDro scale. The study[175] received a score of 8/10, like the studies of [173,195] which received a score of 7/10, while the studies of [136,176,177] a score of 6/10 and the studies of [174,196] received a score of 4/10. Five studies showed limited methodological quality, three others showed moderate quality, while two of the included studies showed high quality. The risk of bias is shown in figure 11 and 12.

Table 7. *PEDro score and IVS of included trials.X=yes, PEDro=Physiotherapy Evidence Database, IVS=Internal Validity Score.*

Author (year of publication)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**Total PEDro Score**	**IVS**
Ebenbichler (1998)	x	x	x	x	x	x	x			x	x	8/10	5/7 Moderate
Oztas (1998)		x			x					x	x	4/10	2/7 Limited
Baysal (2006)	x	x	x	x			x			x	x	6/10	3/7 Limited
Dincer (2009)	x	x	x	x			x			x	x	6/10	3/7 Limited
Yildiz (2011)	x	x	x	x	x		x	x	x	x	x	9/10	6/7 Hight
Duymaz (2012)	x	x		x						x	x	4/10	1/7 Limited
Armagan (2014)	x	x	x	x	x	x				x	x	7/10	4/7 Moderate
Lazovic (2018)	x	x	x	x	x	x				x	x	7/10	4/7 Moderate
Catalbas (2018)		x		x			x	x		x	x	6/10	3/7 Limited
Jothi (2019)	x	x	x	x	x	x	x	x		x	x	9/10	6/7 Hight

Participants

The characteristics of the clinical trials included in the systematic review and meta-analysis are in Table 4.

Interventions

Amongst the 8 meta-analyzed studies, only one looked at therapeutic US versus placebo[175], while the other 7 looked at conventional therapy alone versus the same conventional therapy but with therapeutic US[135,136,145,173,176,177,195,196]. However, two other articles that met the inclusion criteria could not be used for the meta-analysis due to lack of data [174,175]. This information is detailed in Table 4 and 8.

Outcome measures

The outcome measures used for each primary study are listed in Table 4.

Table 8. *Pre, post-intervention, follow-up values and size effects for pain, function and strength*

Author (year)	Intervention group	Variable	Outcome measures	Pre-intervention Mean (SD)	Post-intervention Mean (SD)	Follow-up		Cohen's d Pre-post	Cohen's d Pre-follow-up	
						First follow-up Mean (SD)	Second follow-up Mean (SD)		First follow-up	Second follow-up
Ebenbichler et al (1998)	Ultrasound	Pain	VAS							
		Strength	Finger pinch strength							
			Hand grip strength							
		Electroneurography	MDL							
			SDL							
	Sham ultrasound	Pain	VAS							
		Strength	Finger pinch strength							
			Hand grip strength							
		Electroneurography	MDL							
			SDL							
Oztas et al (1998)	Ultrasound 1,5W	Pain	VAS	6.10 (2.50)	2.90 (1.69)			-0.108		
		Electroneurography	MDL	5.85 (1.87)	6.00 (1.95)			0.079		
			SDL	4.06 (1.39)	3.81 (1.39)			-0.18		
	Ultrasound 0,8W	Pain	VAS	7.10 (2.38)	3.60 (1.90)			-1.625		
		Electroneurography	MDL	5.90 (1.29)	6.10 (1.46)			0.145		
			SDL	3.64 (0.64)	3.53 (0.81)			-0.151		
	Ultrasound Sham 0,0W	Pain	VAS	7.90 (1.80)	4.00 (2.40)			-1.838		
		Electroneurography	MDL	5.60 (1.61)	5.36 (1.48)			-0.155		
			SDL	3.77 (0.89)	3.66 (1.05)			-0.113		
Baysal et al (2006)	Ultrasound+splint+exercise	Pain	VAS	5.60 (3.50)	1.30 (1.80)	0.80 (0.90)		-1.545	-1.878	
			Symptom Status Score	30.40 (12.10)	16.10 (4.8)	15.60 (4.70)		-1.554	-1.612	
		Function	Functional Status Score	20.50 (7.10)	11.70 (3.60)	12.60 (3.40)		-1.563	-1.419	
		Strength	Finger pinch strength	5.60 (1.40)	6.30 (2.10)	7.00 (2.20)		0.392	0.759	
			Hand grip strength	20.70(5.50)	21.70 (4.90)	22.30 (5.10)		0.192	0.302	
		Electroneurography	MDL	4.90 (1.90)	4.60 (2.00)	4.60 (2.30)		-0.154	-0.142	
			SDL	4.00 (0.90)	3.50 (0.60)	3.50 (0.50)		-0.654	-0.687	
	Splint+exercise	Pain	VAS	4.80 (2.30)	3.30 (2.90)	2.60 (2.80)		-0.573	-0.859	
			Symptom Status Score	28.00 (9.70)	19.70 (8.70)	20.20(10.40)		-0.901	-0.776	
		Function	Functional Status Score	20.60 (7.80)	14.80 (7.50)	14.90 (6.60)		-0.758	-0.789	
		Strength	Finger pinch strength	4.90 (2.50)	5.60 (1.80)	6.30 (1.70)		0.321	0.655	
			Hand grip strength	20.50(7.10)	21.10 (7.00)	22.70 (7.40)		0.085	0.303	
		Electroneurography	MDL	4.90 (1.50)	4.80 (1.60)	4.80 (1.40)		-0.064	-0.069	

			SDL	3.50 (0.50)	3.30 (0.40)	3.30 (0.50)		-0.442	-0.4	
Dincer et al (2009)	Ultrasound+splint	Pain	VAS	6.33 (1.49)						
			Symptom Status Score	3.26 (0.79)						
		Function	Functional Status Score	2.85 (0.85)						
		Electroneurography	MDL	4.26 (0.46)						
	Splint	Pain	VAS	6.11 (1.59)						
			Symptom Status Score	3.27 (0.30)						
		Function	Functional Status Score	2.90 (0.50)						
		Electroneurography	MDL	4.27 (0.37)						
Yildiz et al (2011)	Ultrasound+splint	Pain	VAS	4.96 (2.50)	2.41 (2.43)	2.77 (2.74)		-1.034	-0.835	
			Symptom Status Score	2.96 (0.62)	2.04 (0.61)	1.97 (0.65)		-1.496	-1.559	
		Function	Functional Status Score	2.56 (0.64)	1.93 (0.55)	1.98 (0.78)		-1.056	-0.813	
		Electroneurography	MDL	4.58 (0.56)	4.44 (0.58)	4.43 (0.55)		-0.246	-0.27	
			SDL	4.05 (0.21)	3.94 (0.22)	3.87 (0.29)		-0.511	-0.711	
	Sham ultrasound+splint	Pain	VAS	5.76 (2.45)	2.72 (2.07)	3.28 (2.74)		-1.34	-0.954	
			Symptom Status Score	2.88 (0.55)	1.94 (0.57)	2.08 (0.82)		-1.678	-1.146	
		Function	Functional Status Score	2.73 (0.73)	2.08 (0.78)	2.19 (0.89)		-0.86	-0.663	
		Electroneurography	MDL	4.53 (0.67)	4.29 (0.65)	4.32 (0.60)		-0.364	-0.33	
			SDL	4.23 (0.54)	3.98 (0.46)	3.94 (0.47)		-0.498	-0.573	
Duymaz et al (2012)	Ultrasound+splint+exercise	Pain	Symptom Severity Score	30.55 (8.84)	24.00 (9.76)	22.90 (9.74)		-0.703	-0.823	
		Function	Functional Status Score	21.05 (7.67)	17.55 (7.66)	16.85 (7.67)		-0.457	-0.548	
			Health Assessment Questionnaire	0.80 (0.67)	0.66 (0.61)	0.44 (0.51)		-0.219	-0.605	
	Sham+splint+exercise	Pain	Symptom Severity Score	26.40 (8.78)	19.75 (7.41)	17.70 (5.61)		-0.819	-1.181	
		Function	Functional Status Score	18.35 (8.42)	14.35 (4.81)	13.35 (5.07)		-0.583	-0.719	
			Health Assessment Questionnaire	0.80 (0.71)	0.42 (0.56)	0.37 (0.55)		-0.594	-0.677	
Armagan et al (2014)	Ultrasound continuous+splint	Pain	VAS	5.40 (2.32)	4.40 (2.32)			-0.431		
			Symptom Status Score	26.60 (8.11)	23.05 (8.13)			-0.437		
		Function	Functional Status Score	21.33 (7.37)	18.80 (7.34)			-0.344		
		Electroneurography	MDL	4.17 (0.70)	4.19 (0.82)			0.026		
			SDL	3.50 (0.72)	3.49 (0.96)			-0.012		
			SDL II	2.76 (0.55)	2.76 (0.72)			0		
	Ultrasound pulsed+splint	Pain	VAS	5.56 (1.75)	2.68 (1.92)			-1.568		
			Symptom Status Score	29.75 (7.71)	22.06 (8.73)			-0.934		
		Function	Functional Status Score	24.00 (5.58)	19.31 (9.42)			-0.606		
		Electroneurography	MDL	4.20 (0.90)	4.17 (0.86)			-0.034		
			SDL	3.46 (0.68)	3.51 (0.61)			0.077		
			SDL II	2.75 (0.55)	2.65 (0.62)			-0.171		
	Ultrasound sham+splint	Pain	VAS	5.20 (1.26)	3.53 (1.95)			-1.017		
			Symptom Status Score	25.93 (4.46)	19.66 (4.60)			-1.384		
		Function	Functional Status Score	19.00 (0.85)	14.20 (4.52)			-1.476		
		Electroneurography	MDL	4.60 (1.23)	4.45 (1.37)			-0.115		
			SDL	3.45 (0.58)	3.25 (0.69)			-0.314		
			SDL II	2.79 (0.60)	2.84 (0.57)			0.085		
Lazovic et al (2018)	Ultrasound+exercise	Electroneurography	MDL	4.70 (1.30)	4.50 (1.20)			-0.16		
	Ultrasound Sham+exercise	Electroneurography	MDL	5.00 (2.00)	5.00 (2.00)			0		
Catalbas et al (2018)	Ultrasound continuous+splint	Pain	VAS	5.5 (3.2)	2.8 (1.9)	2.0 (2.2)		-1.026	-1.275	
			Symptom Status Score	2.8 (0.8)	1.9 (0.7)	1.9 (0.7)		-1.197	-1.197	
		Function	Functional Status Score	2.5 (0.9)	1.8 (0.7)	2.4 (0.8)		-0.868	-0.117	
		Strength	Hand grip strength	23.50(8.70)	25.20 (9.50)	26.00 (6.90)		0.187	0.318	
		Electroneurography	MDL	4.3 (0.5)	4.2 (0.5)	4.2 (0.5)		-0.2	-0.2	
			SDL	4.0 (0.6)	3.9 (0.6)	3.8 (0.5)		-0.167	-0.362	
	Ultrasound pulsed+splint	Pain	VAS	5.4 (2.5)	2.9 (2.4)	2.1 (2.3)		-1.02	-1.374	
			Symptom Status Score	3.0 (0.8)	2.1 (0.7)	2.1 (0.9)		-1.197	-1.057	
		Function	Functional Status Score	2.4 (0.9)	1.9 (0.8)	1.9 (0.8)		-0.587	-0.587	
		Strength	Hand grip strength	26.10(9.30)	28.50 (8.70)	29.00 (9.50)		0.267	0.308	
		Electroneurography	MDL	4.2 (0.6)	4.2 (0.6)	4.1 (0.6)		0	-0.167	
			SDL	4.0 (0.5)	3.9 (0.5)	3.8 (0.5)		-0.2	-0.4	
	Ultrasound sham+splint	Pain	VAS	5.0 (2.5)	2.6 (2.1)	2.2 (2.0)		-1.04	-1.237	
			Symptom Status Score	2.8 (0.9)	2.2 (0.8)	2.2 (0.7)		-0.705	-0.744	
		Function	Functional Status Score	2.4 (0.8)	1.9 (0.6)	1.9 (0.7)		-0.707	-0.665	
		Strength	Hand grip strength	25.20(5.90)	26.80 (6.70)	26.40 (6.20)		0.253	0.198	
		Electroneurography	MDL	4.3 (0.6)	4.2 (0.6)	4.1 (0.6)		-0.167	-0.333	
			SDL	4.1 (0.4)	3.9 (0.4)	3.9 (0.4)		-0.5	-0.5	
Jothi and Bland (2019)	Ultrasound+splint	Pain	Symptom Severity Score	2.55 (0.70)	0.55 (0.73)	0.76 (0.97)	0.69 (0.90)	-2.797	-2.116	-2.307
	Ultrasound sham+splint	Pain	Symptom Severity Score	2.54 (0.80)	0.42 (0.74)	0.77 (0.73)	0.83 (0.93)	-2.751	-2.311	-1.971

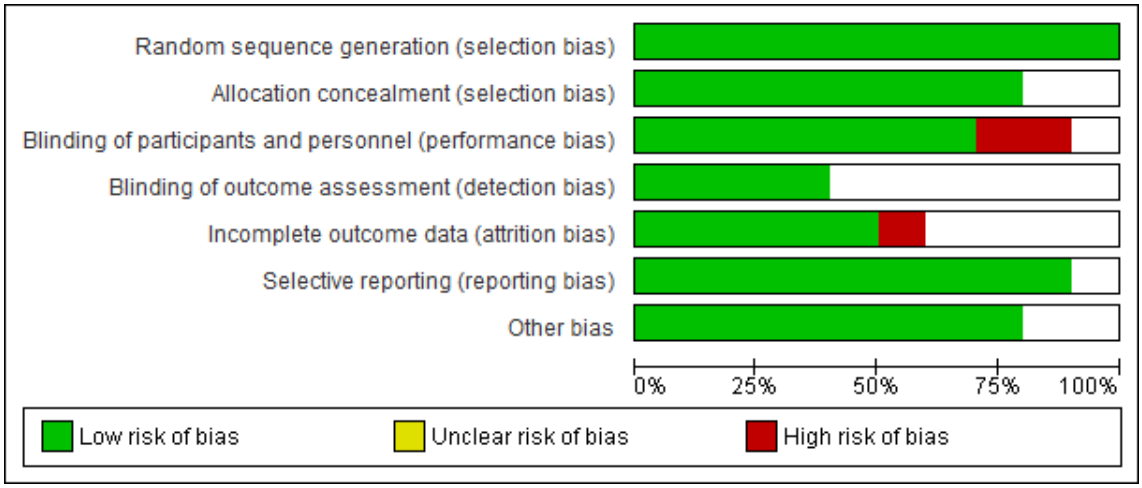


Figure 11. *Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.*

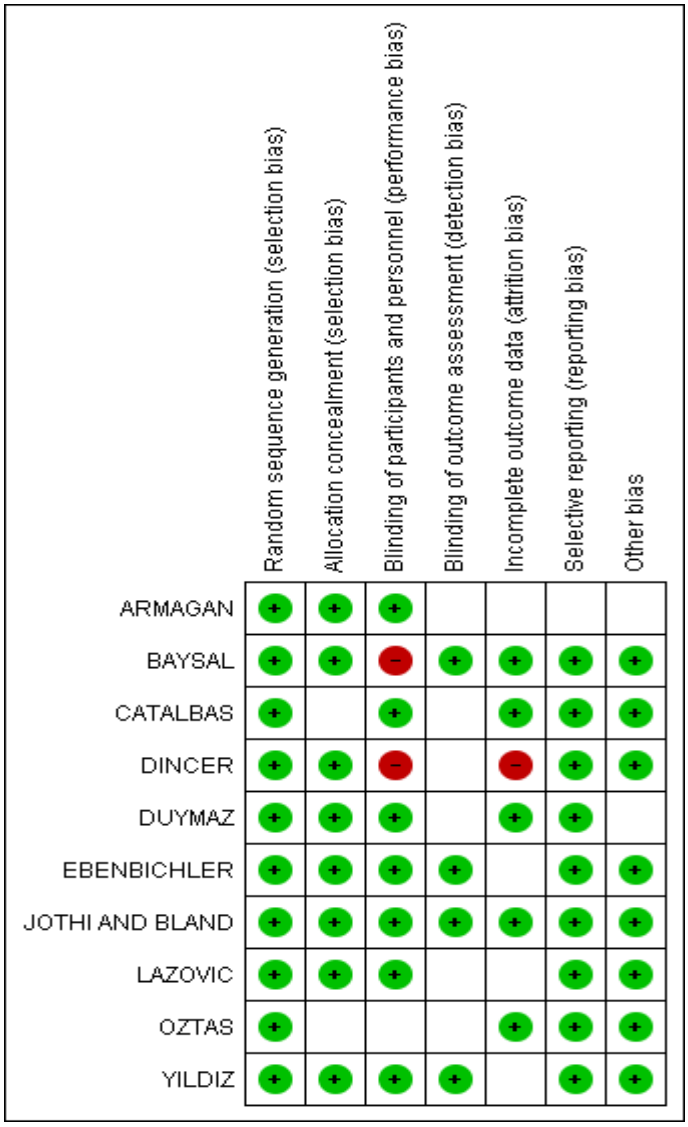


Figure 12. *Risk of bias summary: review authors' judgements about each risk of bias item for each included study.*

Effect of ultrasound on carpal tunnel syndrome

Effect of ultrasound on pain

There were no differences between the therapeutic US and the control group for pain (SMD = -0.25; fixed 95% CI = -0.73, 0.23; *p* = 0.31) (see Figure 13). For the effect of the US in the short term, the magnitude of the effect varied between 0.835 and 1.878. In relation to the pre-post-treatment differences of the therapeutic US group, an immediate effect size was obtained, using Cohen's d, that varied in a range from 0.108 to 1.625.

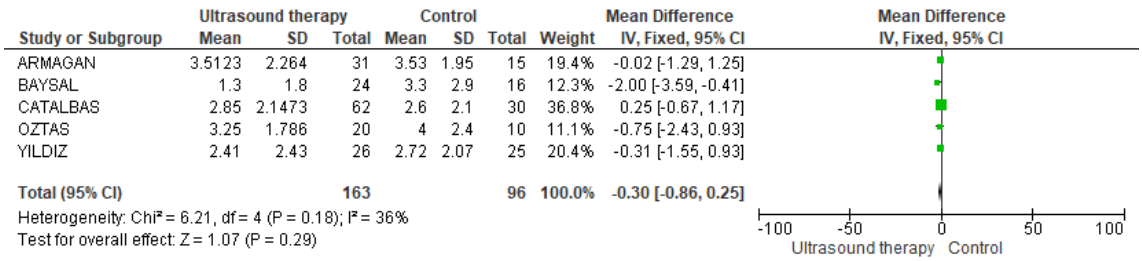


Figure 13. *Forest Plot Pain FE. Forest plot and meta-analysis of ultrasound treatment compared with control treatment for the outcome pain intensity.*

Effect of ultrasound on severity of symptoms

With respect to the severity of symptoms registered by the SSS, no differences were observed between the therapeutic US group and the control group (SMD = -0.03; fixed 95% CI = -0.22, 0.15; *p* = 0.72) (see Figure 14). While in regards to the individual improvement of the therapeutic US group, the studies immediately reported an effect size, with a Cohen's d, that varies in a range from 0.437 to 2.797. For short-term improvement, an effect size between 0.823 and 2.116 was found. One of the studies had an effect size of 2.307 in relation to the individual improvement of the therapeutic US group in the long term (see Table 8).

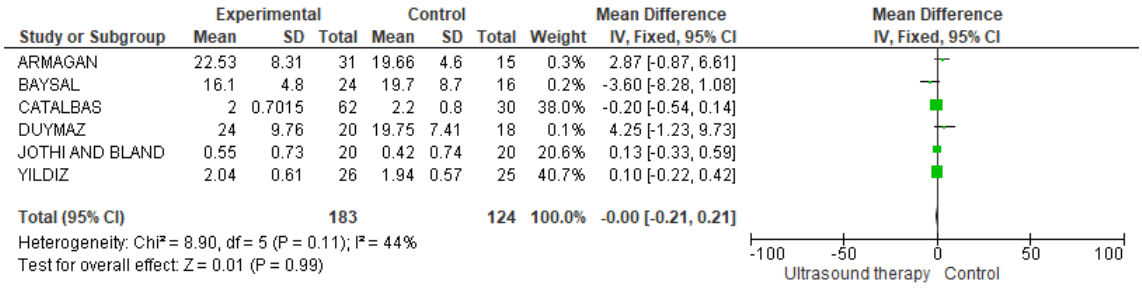


Figure 14. *Forest Plot SSS FE. Forest plot and meta-analysis of ultrasound therapy compared with control treatment illustrating the improvement in self-reported severity of symptoms.*

Effect of ultrasound on Function

There were no observed differences between the therapeutic US group and control group in regards to function registered by the FSS (SMD = 0.09; fixed 95% CI = -0.12, 0.31; p = 0.39) (see Figure 15). An immediate effect size that varied in a range from 0.219 to 1.563 was derived in relation to the individual improvement of the therapeutic US group, in the short term, one study had an effect size that varied in a range between 0.110 and 1.419 (see Table 8).

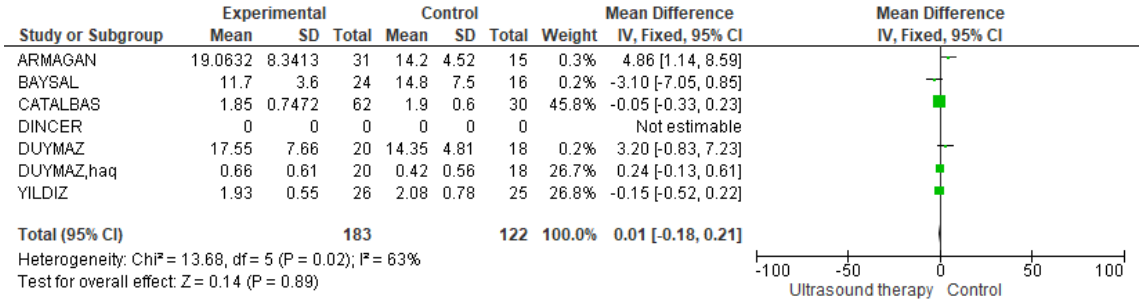


Figure 15. *Forest Plot FSS FE. Forest plot and meta-analysis of ultrasound therapy compared with control treatment illustrating the improvement in self-reported function.*

Effect of ultrasound on strength

Regarding the strength variant, no differences were observed between the therapeutic US group and control group (SMD = 0.61; fixed 95% CI = -0.46, 1.69;

p = 0.27) (see Figure 16). An immediate effect size for the independent improvement of the therapeutic US group, varying in a range from 0.187 to 0.392, was obtained using Cohen's d. The effect of ultrasound in the short term had a magnitude of the effect that varied between 0.302 and 0.759 (see Table 8).

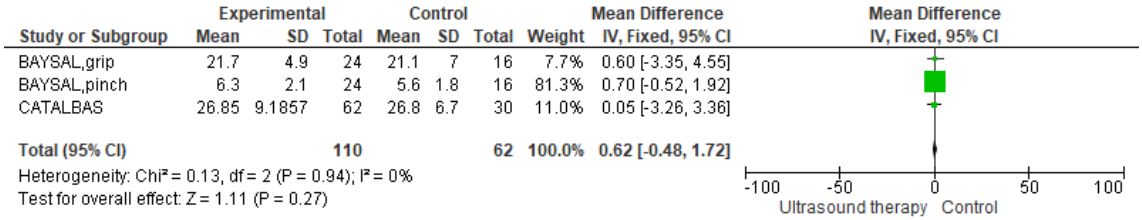


Figure 16. *Forest Plot strength FE. Forest plot and meta-analysis of ultrasound therapy compared with control treatment illustrating the improvement in self-reported pinch and grip strength.*

Effect of ultrasound on MDL

In the case of MDL, a significant difference was observed between the therapeutic US group and the control group, this being in favor of the therapeutic US group (SMD = 0.09; fixed 95% CI = -0.19, 0.00; p = 0.05) (see Figure 17). The therapeutic US group effect size varies between 0.000 y 0.246 y and for a short term between 0.142 y 0.270 (see Table 8).

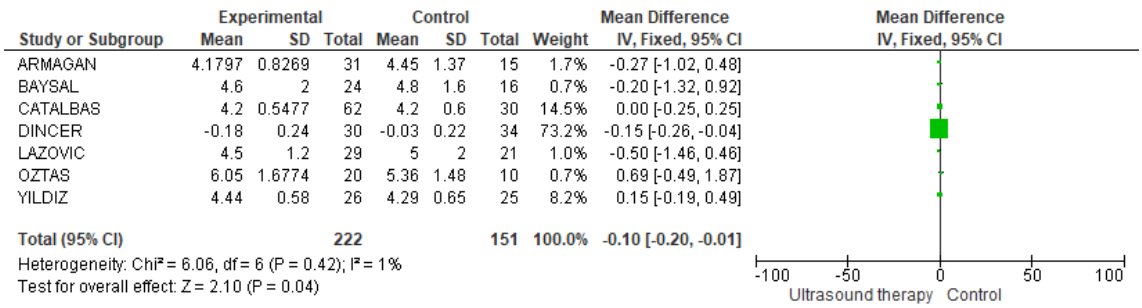


Figure 17. *Forest Plot MDL FE. Forest plot and metaanalysis of ultrasound treatment compared with control treatment for the outcome motor distal latency.*

Effect of ultrasound on SDL

In respect to the SDL, the therapeutic US and control groups do not show statistically significant differences in post-treatment improvement (SMD = 0.02; fixed 95% CI = -0.09, 0.12); *p* = 0.78) (see Figure 18). Specifically, the therapeutic US group immediately obtained a Cohen's d ranging between 0 and 0.654; in the short term, and the effect size ranged between 0.362 and 0.711 (see Table 8).

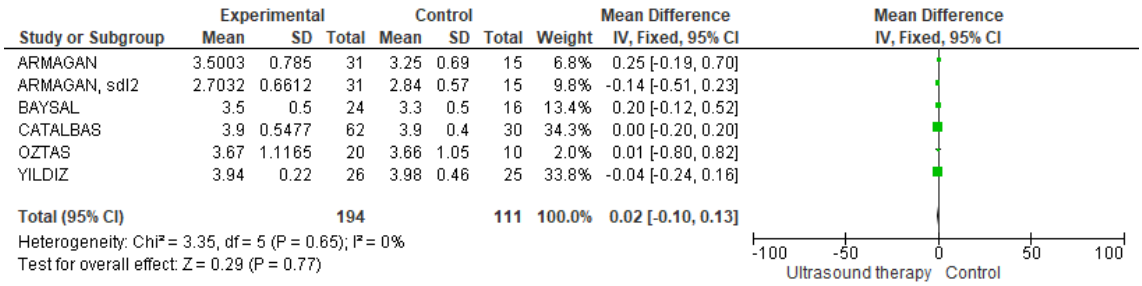


Figure 18. *Forest Plot SDL FE. Forest plot and metaanalysis of ultrasound treatment compared with control treatment for the outcome sensory distal latency.*

4.3 ESTUDIO III

Flow of studies through the review

The present review included the published clinical trials that evaluated the effectiveness of ultrasound versus sonophoresis on CTS in terms of pain intensity, symptom severity, function, MDL and SDL. The initial search using the title analysis identified 5509 potentially relevant papers. After eliminating duplicates and reading the abstracts, we obtained 371 trials. From these results, 36 items were reviewed, 10 of which met the criteria for inclusion in the present systematic review. Figure 19 shows the diagram for the flow of studies under the PRISMA statement. Studies were excluded for 1) not including the two experimental

groups[42,43,175–177,193,195–199,44–49,173,174], 2) publishing in a language different from that established in the inclusion criteria and lacking either group[189,190,200] and 3) lacking the complete text and lacking either group[191,192,201] and 4) lacking the complete text[202]. The remaining 10 studies included treatment with ultrasound and sonophoresis or the 2 sonophoresis groups, of which 4 articles were excluded for having insufficient data for performing the meta-analysis (one used sonophoresis-NSAIDs and the other sonophoresis-corticosteroids)[183,184,203,204].

For each global research question, we performed several meta-analyses, one for each recorded clinical variable. For the first question regarding the effectiveness of ultrasound versus sonophoresis in the studies that used sonophoresis[144–149,182–184,204], we excluded several studies[148,149,182–184,204] for not having an ultrasound group. Therefore, this first submeta-analysis group included 4 clinical trials. The studies covered a total sample of 935 wrists with CTS for the neurophysiological parameters, of which 211 included MDL and 171 included SDL. Other electrophysiological parameters could not be employed for various reasons. First, there is currently a lack of data to compare them, such as in the case of motor conduction velocity and motor and sensory amplitude of the potentials. There are also methodological differences in how the tests were performed, which made it impossible to homogenise the data without entailing biases, such as for example, assessing the sensory conduction velocity of the median nerve in the palm-wrist section through which sensory and motor fibres pass, making this an assessment of mixed nerve conduction and not purely sensory[140,141,205]. We also evaluated the pain variables, symptom severity and function in this group. The pain sample consisted of 145 wrists, the symptom severity sample of 157 wrists, and the function sample of 157 wrists.

For the second question regarding the greater effectiveness of applying sonophoresis with NSAIDs versus applying sonophoresis with corticosteroids, we included 3 clinical trials[146,148,149], with a total sample size of 381 wrists with CTS for the neurophysiological parameters listed above, MDL, SDL and function. The three sample groups (MDL, SDL and function) consisted of 127 wrists each.

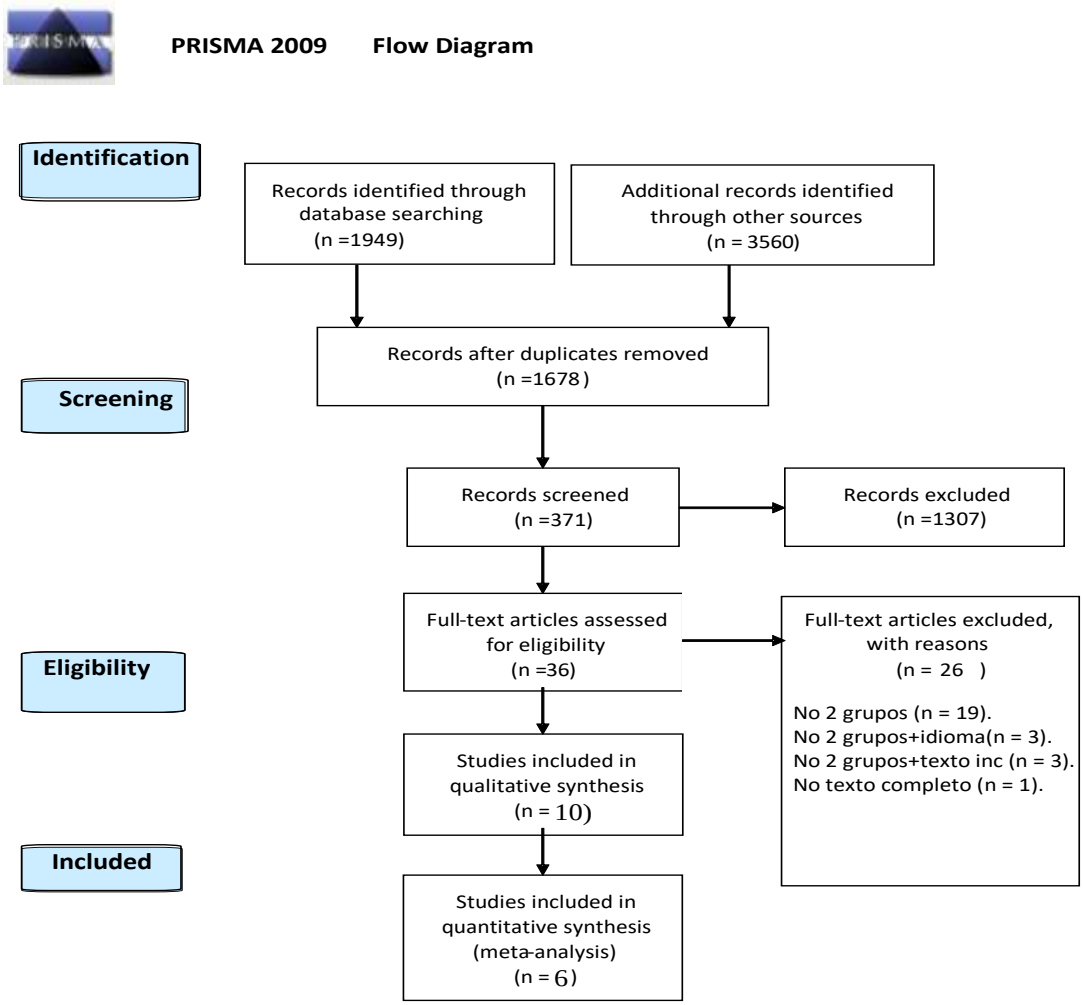


Figure 19. *PRISMA flow diagram. From: Moher D, Liberati A, Tetzlaff J, Altman DG. The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and MetaAnalyses: the PRISMA Statement. PLoS Med 6:e1000097. For more information, visit www.prisma-statement.org*

Study characteristics

Methodological quality

In terms of PEDro scores, 1 study[146] achieved a score of 10/10, 1 study[145] achieved 9/10, 2 studies[148,149] achieved 8/10, and 2 studies[144,147] achieved 7/10. Four studies showed moderate evidence, and 2 of the included studies showed high evidence. Table 9 provides details on the PEDro score for each trial, as well as the internal validity score.

Table 9. *PEDro score and IVS of included trials.*
X=yes, PEDro=Physiotherapy Evidence Database, IVS=Internal Validity Score.

Author (year of publication)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**Total PEDro Score**	**IVS**
Yildiz (2011)	x	x	x	x	x		x	x	x	x	x	9/10	6/7 Hight
Soyupek 1 (2012)	x	x	x	x		x	x	x		x	x	8/10	5/7 Moderate
Soyupek 2 (2012)	x	x	x	x		x	x	x		x	x	8/10	5/7 Moderate
Boonhong (2019)	x	x	x	x	x	x	x	x	x	x	x	10/10	7/7 Hight
Okan (2020)	x	x		x			x	x	x	x	x	7/10	4/7 Moderate
Elgendy (2020)	x	x	x	x				x	x	x	x	7/10	4/7 Moderate

Participants

Table 10 lists the characteristics of the participants included in the systematic review and meta-analysis.

Interventions

For the first question, we analysed 4 trials that compared ultrasound versus sonophoresis. For the second question, we were able to analyse 3 trials that comparatively studied sonophoresis-NSAIDs versus sonophoresis-corticosteroids. Table 2 also shows this information.

Outcome measures

Table 10 also lists the outcome measures used in the studies included in the systematic review and meta-analyses.

Table 10. *Characteristic of the clinical trials included in the systematic review and meta-analysis.*

Author/s (year of publication)	*Variables/Outcome measurements*	*Ultrasound group*	*Phonophoresis*	*Phonophoresis*	*Technique*	*Intervention*	*Outcome measures/results*
Yildiz et al (2011)	*Pain:* *VAS.* *Boston Questionnaire, Symptom severity score.* *Function:* *Boston Questionnaire, Functional status score.* *Boston Questionnaire, Symptom severity score.* *Electrophysiological parameters:* *Motor distal latency.* *Sensory distal latency.*	*Sample US:* *n = 26.*	*Sample SP:* *n = 25.*		*US.* *SP-NSAI.* *Sham.* *Splinting.*	*US group:* *Splinting and pulsed US therapy* *Each sesión:* *1 MHz, 1W/cm,1:4 duty cycle. 15min.* *Five a week/2 weeks.* *10 sessions.* *SP group:* *Splinting and pulsed US therapy with Ketoprofen 2.5%* *Each sesión:* *1 MHz, 1W/cm,1:4 duty cycle. 15min.* *Five a week/2 weeks.* *10 sessions.*	*Ketoprofen SP in addition to splinting was superior than US and splinting.*
Soyupek et al. 1 (2012)	*Pain:* *VAS.* *Function:* *Duruoz Hand Index.* *Electrophysiological parameters:* *Motor distal latency* *Sensory distal latency*		*Sample SP:* *n =20.*	*Sample SP:* *n =22.*	*SP-CS* *SP-NSAI* *Splint.* *Local CS injenction.*	*SP-NSAI group:* *SP therapy with diclofenac diethylammonium jel* *Each sesión:* *3 MHz, 1.5W/cm. 10min.* *Five a week/3 weeks.* *15 sessions.* *SP-CS group:* *SP therapy with betamethasone valerate 0.1%.* *Each sesión:* *3 MHz, 1.5W/cm. 10min.* *Five a week/3 weeks.* *15 sessions.*	*SP-CS showed marked improvement in electrophysiological studies, but not in subjective symptom.*
Soyupek et al. 2 (2012)	*Pain:* *VAS* *Boston Questionnaire, Symptom severity score.* *Function:* *Boston Questionnaire, Functional status score.* *Electrophysiological parameters:* *Motor distal latency* *Sensory distal latency*		*Sample SP:* *n =23.*	*Sample SP:* *n =28.*	*SP-CS.* *SP-NSAI.* *Splint.*	*SP-NSAI group:* *SP therapy with diclofenac diethylammonium jel* *Each sesión:* *3 MHz, 1.5W/cm. 10min.* *Five a week/3 weeks.* *15 sessions.* *SP-CS group:* *SP therapy with betamethasone valerate 0.1%.* *Each sesión:* *3 MHz, 1.5W/cm. 10min.* *Five a week/3 weeks.* *15 sessions.*	*The most effective treatment was SP-CS.*
Boonhong et al (2019)	*Pain:* *Boston Questionnaire, Symptom severity score.* *Function:* *Boston Questionnaire, Functional status score.* *Electrophysiological parameters:* *Motor distal latency* *Sensory distal latency*	*Sample US:* *n patient=16.*	*Sample SP:* *n patient=17.*	*Sample SP:* *n patient=17.*	*US.* *SP-CS.* *SP-NSAI.*	*US group:* *US therapy* *Each sesión:* *1 MHz, 1 W/cm. Continuous. 10min.* *3 a week/2 weeks and 2 a week/3 weeks* *12 sessions.* *SP-NSAI group:* *SP therapy with piroxicam gel 0.5%* *Each sesión:* *1 MHz, 1 W/cm. Continuous. 10min.* *3 a week/2 weeks and 2 a week/3 weeks* *12 sessions.* *SP-CS group:*	*Neither US or SP improved electrophysiological parameters but improved clinical parameters without between groups statical differences*

					SP therapy with dexamethasone sodium phosphate gel 0.4%. *Each sesión:* *1 MHz, 1 W/cm. Continuous. 10min.* *3 a week/2 weeks and 2 a week/3 weeks* *12 sessions.*	
Okan et al (2020)	*<u>Pain</u>:* *VAS* *Boston Questionnaire, Symptom severity score.* *<u>Function:</u>* *Boston Questionnaire, Functional status score.* *<u>Electrophysiological parameters:</u>* *Motor distal latency*	*<u>Sample US</u>:* *n = 20.*	*<u>Sample SP</u>:* *n =20.*	*US.* *SP.* *Exercise.* *Splint.*	*<u>US group</u>:* *Splinting, exercise and continuous US therapy* *Each sesión:* *1 MHz, 1.5W/cm.5min* *10 sessions.* *<u>SP group</u>:* *Splinting,exercise and SP with mucopolysaccharide polysulphate therapy* *Each sesión:* *1 MHz, 1W/cm,* *10 sessions.*	*The use of SP with MPS was efficient in treatment of CTS.*
Elgendy et al (2020)	*<u>Pain:</u>* *VAS.* *<u>Electrophysiological parameters:</u>* *Motor distal latency.* *Sensory distal latency.*	*<u>Sample US:</u>* *n =27.*	*<u>Sample SP:</u>* *n =27.*	*US.* *SP.* *Splint.* *Exercise.*	*<u>US group</u>:* *Splinting, exercise and pulsed US therapy* *Each sesión:* *1 MHz, 1 W/cm. 1:4 duty cycle. 5min* *3 a week/5 weeks.* *15 sessions.* *<u>SP group</u>:* *Splinting,exercise and SP with chitosan nanoparticles.* *Each sesión:* *1 MHz, 1 W/cm. 1:4 duty cycle. 5min* *3 a week/5 weeks.* *15 sessions*	*They found marked improvement in clinical and electrophysiological studies with better result for SP with chitosan nanoparticles.*

Effect of ultrasound on carpal tunnel syndrome

Effect of sonophoresis versus ultrasound on motor distal latency

In terms of MDL, the group treated with sonophoresis presented a significant SMD compared with the group treated using ultrasound (MD: 0.44; 95% CI 0.33–0.55; p<0.00001) (Fig.20).

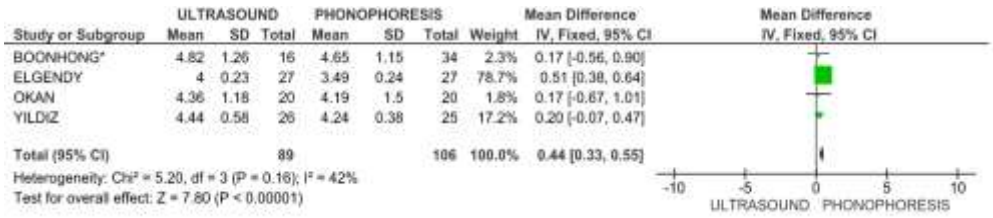


Figure 20. *Forest Plot MDL. FE. Forest plot and meta-analysis of ultrasound therapy compared with phonophoresis treatment illustrating the improvement in MDL.*

Effect of sonophoresis versus ultrasound on sensory distal latency

With regard to SDL, the sonophoresis group showed statistically significant differences compared with the ultrasound group (MD: 0.25; 95% CI 0.11–0.38; *p* = 0.0003) (Fig. 21).

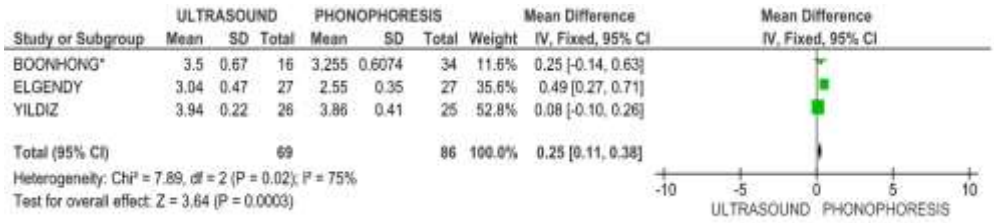


Figure 21*. Forest Plot SDL. FE. Forest plot and meta-analysis of ultrasound therapy compared with phonophoresis treatment illustrating the improvement in SDL.*

Effect of sonophoresis versus ultrasound on pain

In terms of pain, the analysis of the mean effect size of the sonophoresis group compared with the ultrasound group showed a significant MD (MD: 2.05; 95% CI -1.50-2.59; p<0.00001) (Fig. 22).

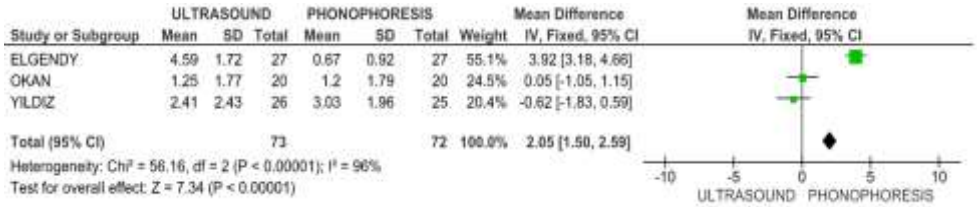


Figure 22. *Forest Plot Pain. FE. Forest plot and meta-analysis of ultrasound therapy compared with phonophoresis treatment illustrating the improvement in pain.*

Effect of sonophoresis versus ultrasound on the symptom severity subscale

In terms of symptom severity subscale, the analysis of the mean effect size of the sonophoresis group compared with the ultrasound group showed a nonsignificant MD (MD: 0.06; 95% CI -0.14-0.26; *p*=0.54) (Fig. 23).

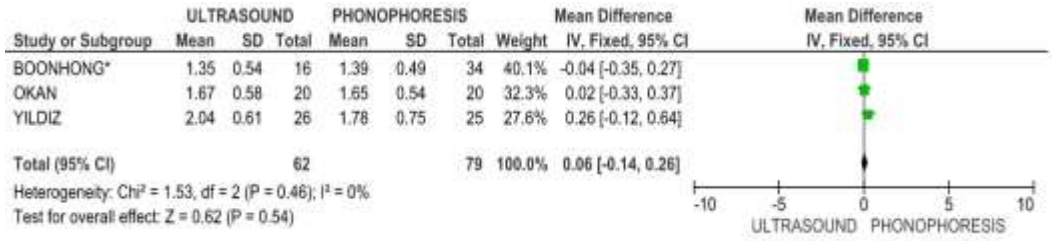


Figure 23. *Forest Plot SSS. FE. Forest plot and meta-analysis of ultrasound therapy compared with control treatment illustrating the improvement in self-reported severity of symptoms.*

Effect of sonophoresis versus ultrasound on functional status subscale

In terms of functional status subscale, the analysis of the mean effect size of the sonophoresis group compared with the ultrasound group showed a nonsignificant MD (MD: -0.10; 95% CI -0.28-0.07; p=0.26) (Fig. 24).

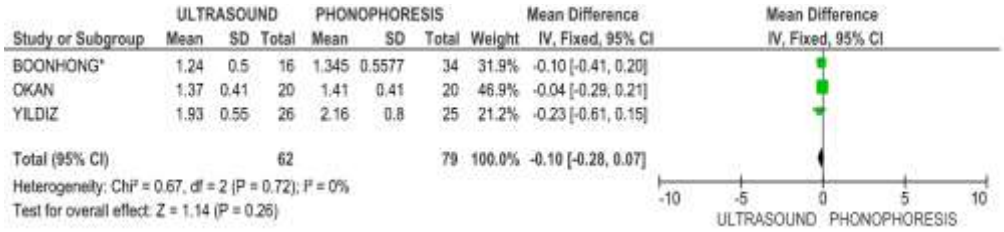


Figure 24. *Forest Plot FSS FE. Forest plot and meta-analysis of ultrasound therapy compared with control treatment illustrating the improvement in self-reported function.*

Effect of sonophoresis-NSAIDs versus sonophoresis-corticosteroids on motor distal latency

In terms of MDL, the analysis of the mean effect size of the sonophoresis-NSAIDs group compared with the sonophoresis-corticosteroid group showed a nonsignificant MD (MD: 0.23; 95% CI -0.31-0.78; *p*=0.40) (Fig. 25).

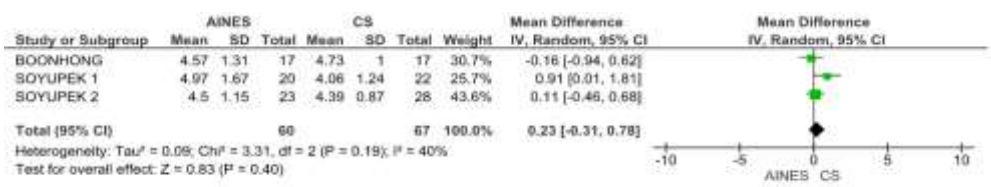


Figure 25. *Forest Plot MDL. Forest plot and metaanalysis of SP-AINES versus SP-CS treatment for the outcome MDL.*

Effect of sonophoresis-NSAIDs versus sonophoresis-corticosteroids on sensory distal latency

In terms of SDL, the analysis of the mean effect size of the sonophoresis-NSAIDs group compared with the sonophoresis-corticosteroid group showed a nonsignificant MD (MD: 0.35; 95% CI -0.10-0.81; *p*=0.13) (Fig. 26).

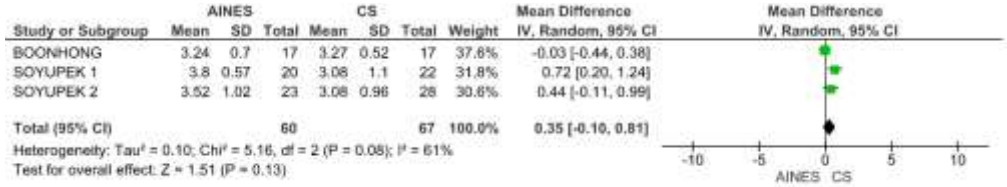


Figure 26*. Forest Plot SDL. Forest plot and metaanalysis of SP-AINES versus SP-CS treatment for the outcome SDL*

Effect of sonophoresis-NSAIDs versus sonophoresis-corticosteroids on functional status subscale

In terms of functional status subscale, the analysis of the mean effect size of the sonophoresis-NSAIDs group compared with the sonophoresis-corticosteroid group showed a nonsignificant SMD (SMD: 0.29; 95% CI -0.35-0.94; *p*=0.37) (Fig. 27).

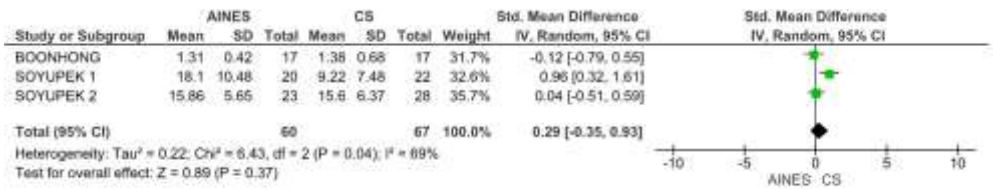


Figure 27*. Forest Plot function. Forest plot and metaanalysis of SP-AINES versus SP-CS treatment for the outcome function.*

DISCUSION/
DISCUSSION

5. DISCUSION/ DISCUSSION

Los tres estudios tienen objetivos muy diferentes, lo que implica que la discusión se exponga de manera individualizada.

5.1 ESTUDIO I

This systematic review and meta-analysis evaluates the available scientific evidence for the efficacy of EPAs in pain, hand function, and grip and pinch strength in patients with hand OA. Considerable heterogeneity was observed in the research methods used in the included trials in terms of design, modality of EPA, specific dose and evaluation instruments. These therapies have been associated with little or no adverse effects, and no cases of serious damage arising from their use have been reported. The variables recorded in the primary studies are reliable instruments that have been validated in this population. In summary, a total of 10 trials were included in the systematic review. Of these, 6 clinical trials with a total of 1582 participants were included in the meta-analysis. The methodological quality of the included studies ranged from limited (2 trials) to moderate (8 trials). After evaluating the risk of bias using PEDro scale and IVS index, it was observed that, according to the design of the clinical trials, some of them were unblinded. All therapists who administered the therapy were unblinded in nine of the ten studies included in the review. As PEDro scale describe: "*when therapists have been blinded, the reader can be satisfied that the apparent effect (or lack of effect) of treatment was not due to the therapists' enthusiasm or lack of enthusiasm for the treatment or control conditions*"[159]. For this reason, we highlight the need of blinding all the participants, the therapists and researchers who measures key outcomes in the future studies conducted on this topic. On

the other hand, in the systematic review section, some trials included lake an adequate control group; for example, Horvath et al. (2012)[105] compare two EPAs in the intervention group to one EPA in the control group, or Myrer et al. (2011)[163] assess the use of add on analgesics instead of the EPA. These trials were excluded from the meta-analysis.

In terms of pain levels, the experimental group showed a significantly higher improvement after application of EPAs compared to controls, showing a small difference between groups. An effect size ranging from moderate to large was obtained for immediate and short-term improvement in the experimental group after the application of EPAs, while moderate improvement was observed in the long-term. These results may be due to the fact that EPAs, as reported in previous studies, stimulate cell growth, modulate their metabolism[206], and regenerate tissue[207]. These physiological changes may have contributed to a structural improvement of the intra- and periarticular tissues. These changes at the molecular, cellular, and structural levels modulate some inflammatory processes. Hence, improvement in the group that received treatment with EPAs could be also due to their anti-inflammatory action[100].

Regarding hand function, the experimental group showed a large difference with respect to controls after the application of EPAs. Immediate improvement after application of EPAs ranged from minor to large; however, the short- and long-term improvement efficacy was lower after a free-time of intervention. These results can be explained by the physiological mechanisms on which EPAs act. Lower levels of pain after the intervention could in turn diminish the patient's kinesiophobia and boost their confidence in their ability to start and complete different movements, tasks or activities[208] in their daily living. On the

other hand, the relationship between function, radiographic OA severity, hand strength, and patient gender can lead to different interpretations of the results in patients hand OA[209].

Regarding grip strength, a significant difference was observed after the interventions between the experimental and control groups, with the experimental groups presenting higher average muscle strength. The effect-size for immediate and long-term improvement in the group receiving EPAs was large, and moderate in short-term. No differences in pinch strength were observed between groups at posttreatment. However, the group that received the treatment with EPAs showed a significantly improvement in mean pinch strength immediately after treatment, with minor and moderate improvements in the short and long term. Both interventions probably improved this type of strength in the same way they improved grip strength. The differences observed between groups in pain, hand function and grip strength but not in pinch strength may be due to the fact that the behaviour of the muscle groups involved in proximal versus distal movements is different. Additionally, the effect of EPAs on musculoskeletal structures depend on several factors such as tissue depth, the acoustic window, the structure of the tissue, or whether the pathology is chronic or acute[80]. Similarly, the more distal joints are likely to experience more overload during the performance of the activities of daily living. That is why despite EPAs treatment on the distal musculoskeletal structures, these body parts are at a higher risk of being damaged, and the symptoms of hand OA may exacerbated with a higher probability on a daily basis.

The study has several limitations that should be taken into account when interpreting the findings. First, there is considerable heterogeneity between the

studies included in the review. However, at a statistical level we have made an effort to homogenize the data and minimise heterogeneity using meta-analytic tools such as summarizing outcomes by forest plots. Second, some EPAs were unconsidered (such as ultrasound, diathermy, short wave, microwave, or other forms of shock wave therapy), due to the lack of studies evaluating the efficacy of their use in hand OA. Third, several studies had to be excluded from the meta-analysis either because of the lack of sufficient evidence of their effectiveness[105,166], or because they lacked a control group[164,163]. Some primary studies have only been partially included due to insufficient data, because they used a different type of measurement variable, or because not all the outcome measures were included in the design[106,161,165]. In a study evaluating a prototype laser and ultrasound device[161] with or without exercises[103], the therapies used could not be evaluated separately. Other studies in which electrophysical devices such as iontophoresis or sonophoresis were applied have also been excluded[210] because they combine EPA with pharmacological therapy and are not specific for OA. It is also important to note that long-term effects (at least 12 months after the end of the intervention) were evaluated in most of the studies reviewed. Fourthly, some studies report that women perceive sensations differently than men[209]. Given that most studies include a higher proportion of women, this factor should be taken into account when interpreting the results obtained from the different studies included in the review[97]. Finally, some other possible terms related to osteoarthritis conditions, such as “interphalangeal osteoarthritis”, were not included in search equation. This could be lead to a search bias; however, the majority of the related terms are retrieved after including the term “osteoarthritis”.

Regarding the implications for research and practice, the included studies show the intensity, duration and frequency of the different EPAs, making them easy to be reproduced. However, the cost-benefit ratio of these therapies should be evaluated in future studies in order ascertain whether they are feasible in clinical practice. Moreover, it would be particularly interesting to conduct superiority studies to evaluate the effect of EPAs against other emerging pain control therapies, such as neuropedagogy, cognitive behavioural therapies, or motor graded imagery. We also encourage to clinicans and researchers to integrate EPAs into multimodal interventions. Conservative therapy has proven to be effective with orthotics, hand exercises, joint protection principles and patient education[95]. Multimodal interventions have been shown to be effective in reducing pain in patients with trapeziometacarpal OA[75]. Another recent systematic review also confirms the benefit of multimodal and unimodal physical therapies[99].

5.2 ESTUDIO II

The main purpose of this systematic review and meta-analysis has been to evaluate the available scientific evidence about the effectiveness of the use of ultrasound in patients with CTS. The studies involved in this meta-analysis showed a methodological quality that varied between limited and high. The clinical relevance of the present review is based on the changes recorded for motor distal latency after the application of the therapeutic US. These changes suggest a partial improvement and a reduction of the degree of neurophysiological severity of the CTS. All the randomized controlled trials had a

moderate-high methodological quality and the sample populations from the primary studies were similar within the systematic review (idiopathic CTS). The quality of evidence for MDL and SDL is moderate due to the indirectness of evidence in terms of differences in interventions (applicability)[172]. Interventions may have been delivered differently since the calibration in the application of the therapeutic US is unknown. On the other hand, the application of the neurophysiological measures in some primary studies was unrecorded; therefore the implementation of this outcome measure could be heterogeneous. Similarly, the quality of evidence for pain, severity of symptoms, function, and strength is moderate due to possible imprecision related to the sample size of the studies[172].

In relation to the differences between groups in the studies which were meta-analyzed, the therapeutic US group showed a lower Median Nerve Motor Distal Latency after the application of ultrasound compared to a control group. The difference between both groups had a mean effect size of 0.09 milliseconds. The immediate improvement recorded after the application of ultrasound was of an effect size that varied between negligible and null. However, in the short term, an improvement that ranged from negligible to small was observed. Taking into account the different neurophysiological severity scales of CTS, the interpretation of a control neurophysiological study in which a decrease in MDL values is detected within normality in the set parameters (in comparison to a previous pathological study but with persistence of slowing down in the sensitive studies) probably generating a partial improvement of the degree of severity of the CTS. This interpretation is due to the fact that the different scales, although with disparity in degrees, classify with less severity only sensory slowdowns of median nerve conduction. They also show, with mixed intermediate severity, sensitive

and motor slowdowns, and with greater severity, the absence of action potential, especially motors[211–215]. On the other hand, the effect of US on musculoskeletal structures can vary depending on a multitude of factors such as if the pathology is chronic or acute, the depth of the tissues, the acoustic windows, tissue structure, among many other factors[80].

Regarding the rest of the electrophysiological parameters recorded in the primary studies, the difference found for the SDL and the sensory conduction speed (index finger-wrist) between the groups was not significant. Although this finding could be considered a discrepancy with that found for motor nerve conduction of the median nerve, it can be explained by the following reasons; i) there is a relationship between extreme values of MDL and the absence of the sensory nerve action potential, but this relationship is often seen in severe degrees of CTS. ii) this relationship can be altered by rare anatomical defects that affect the recurrent branch of the median nerve of the thenar muscles, with the exclusive involvement of sensory conduction being more common as an early and less severe finding[216]. The improvement of these parameters can occur after more than a year post injury, so a longer duration of the treatments of the meta-analyzed studies could realize significant findings also in sensory conduction[114,116,212,213,216].

No significant differences were observed between groups for pain, severity of symptoms, function, or strength. It should be taken into account that the primary symptoms such as numbness, tingling and nocturnal symptoms are generally considered more specific to the nerve injury, and therefore tend to have a greater correlation with the electrophysiological parameters. While the

secondary symptoms such as pain, weakness or clumsiness are typical associated with soft tissue and other musculoskeletal injuries[114,116,217,218].

Specifically, in relation to pain levels, the therapeutic US group did not show a significant improvement greater than the control group, after the application of ultrasound. Their effect size varied from nule and large. However, in the short term, a long improvement was observed for both groups. The results found may be due to the fact that biologically there is an increase in cellular production or their metabolism is modulated[219], tissue regeneration[207], or it could be due to how they inhibit inflammation[100]. Hence, it is possible that these changes at the molecular and cellular level reduce pain and inflammation and contribute to the structural improvement of damaged tissues.

In relation to the severity of the symptoms and the degree of function of the upper limb, the therapeutic US group did not show a significant difference higher than the control group. However, for severity of symptoms in the therapeutic US group, a small-large improvement was observed immediately and a large improvement in the short term.

With regard to function, a similar improvement was observed after the intervention, and a negligible improvement in the long term and short term. These results can be explained by the same physiological mechanisms on which ultrasound acts. As there are lower levels of pain, it is likely that there is in turn a decrease in the symptoms that accompany this pathology and patients are able to better perform normal activities[208].

The grip and pinch strength sample showed no significant difference between the therapeutic US and control groups after the intervention. For the improvement recorded in the therapeutic US group, the effect ranged from negligible to small immediately, then from negligible to moderate, in the short term.

Very low heterogeneity has been observed in the research methods, reaching a value of 0% for some variables studied. No adverse effects have been observed with this technique as in no case have serious effects been reported with the application of US. The methods and variables recorded in the primary studies have been evaluated using validated and reliable instruments.

In regards to the main critical points, several aspects have been identified that should be taken into account when interpreting the evidence found. First of all, it was not possible to include all the studies that rigorously analyzed the effect of ultrasound due to language[189,190] or as a result of incomplete text[191,192]. Two studies were excluded due to lack of data in the full text[175,176] or because the articles were not accessible in full text. In order to maintain the greatest possible stringency in this synthetic review and meta-analysis, we only included ultrasound as therapy. We have not included clinical trials in which other types of therapies were associated, nor have superiority trials been taken into account in which the action of ultrasound versus another therapeutic technique was evaluated. More recent studies that had not been taken into account in previous systematic reviews have been included in this review, some of them with high methodological quality, and the results obtained have been meta-analyzed. On that note, the present review also aims to serve as a relevant contribution to

different areas such as clinical, research or even political. All articles related to sonophoresis have been excluded, although ultrasound is used for the application of this technique, as a pharmacological compound is also associated. It must also be considered that the long-term effects (at least 12 months after the end of the intervention) have not been evaluated in most of the included studies. Furthermore, other electrophysiological parameters could not be used, due to lack of data to compare them (motor conduction speed or the motor and sensory amplitude of potentials), as well as, due to methodological differences in the performance of the tests that made it impossible to homogenize the data without committing biases. An example is assessing the sensory conduction velocity of the Median nerve in the palm-wrist stretch, through which sensory and motor fibers pass. This being an assessment of mixed nerve conduction and not purely sensitive[116,205].

As regards to the implications for practice, the included studies reflect the parameters of intensity, duration and frequency of ultrasound that make it possible to easily replicate it in clinical practice. However, given the data obtained, it is necessary to delve into the dose of its application, either the frequency, the intensity or the time. Also, the cost-benefit of these therapies should be evaluated in future studies in order to know if it is profitable to perform them in clinical practice. On the other hand, it would be interesting to carry out superiority studies where the mixed effect of ultrasound is evaluated along with other emerging therapies for pain control, such as the treatment of chronic pain from neuropedagogy, cognitive behavioral therapies, motor graded imagery or including desensitization maneuvers of the central nervous system[35]. Other neurophysiological parameters that have not been developed in the meta-

analyzed studies could reinforce the finding of the reduction in MDL. A needle EMG examination of the APB muscle is recommended and the number of motor units should also be estimated[220,221]. On the other hand, in the meta-analyzed studies, the somatic innervation of the median nerve (motor and sensory) has been recorded, but the autonomic efferents and afferents responsible for the innervation of the sweat glands and for collecting pain or temperature has not been included. These fibers are more susceptible to anoxia than compression and have also been the subject of neurophysiological study in CTS using nerve conduction techniques such as the sympathetic cutaneous response, or evoked potential techniques, in this case, by laser[112,222,223].

5.3 ESTUDIO III

The main purpose of this meta-analysis was to assess the available scientific evidence on the superiority of sonophoresis therapy over ultrasound in patients with CTS. The meta-analysed studies showed a methodological quality that varied between moderate and high. With regard to the differences between the groups of meta-analysed studies, the sonophoresis group showed lower MDL, SDL and pain after applying the sonophoresis treatment compared with the group treated with ultrasound. In terms of neurophysiology, the post-treatment examination should be compared with normal MDL and SDL values to determine the degree to which the CTS is resolved in electrodiagnostic terms[211,212,215,224–226]. In terms of pain levels, the sonophoresis group showed significantly greater improvement than the ultrasound group after the therapy. The differences between these 2 therapies could be due to the fact that biologically there was an increase in cell production or modulation of the metabolism necessary for this

change[206]. A change in these processes has been related to tissue regeneration[207] and to a beneficial effect on the inhibition of inflammation[100]. Moreover, it is possible that these changes at the molecular and cellular level were sufficient for modulating the pain and inflammation, contributing to the structural improvement of the damaged tissues.

The lack of significance in severity of symptoms and functional status evaluated in the present study could be considered a discrepancy with the neurophysiological findings found for motor and sensory nerve conduction of the median nerve and pain. However, we should consider that the primary symptoms (such as numbness, tingling and nocturnal symptoms) are generally considered more specific for nerve injury and therefore tend to correlate closely with electrophysiological parameters. Other secondary symptoms such as weakness and clumsiness are typical of soft tissue and other musculoskeletal injuries and less correlated with findings from nerve conduction studies[140,141,217,218]. The effect of ultrasound on musculoskeletal structures can vary depending on a multitude of factors such as tissue depth, acoustic window, tissue structure, and whether the condition is chronic or acute[80]. It is important to consider that when talking about sonophoresis, ultrasound is used as a vehicle for a drug, and its effectiveness and efficacy will vary depending on the drug being employed. We need to continue investigating different drugs that can be transported by sound waves to achieve greater benefits in the target structures. There is a need to continue deepening our understanding of emerging drugs such as those assessed in 2 of the studies[144,147], which have led to good results.

The value of the following review is that it has recompiled, organised and synthesised the current evidence on the effectiveness of ultrasound versus

sonophoresis. It is worth noting that we were highly rigorous in selecting the articles included in the review, admitting only those that rigorously assessed the superiority of sonophoresis over ultrasound. We observed very low heterogeneity in the research methods, arriving at a value of 0% for a number of study variables. We observed no adverse effects with these techniques. No case reported severe effects with the application of ultrasound or sonophoresis. The variables recorded in the studies included in the review have been evaluated using validated and reliable instruments for the populations included in these studies. Other strong points of the present work are that the protocol is registered in the international PROSPERO repository, that we followed the PRISMA directives for the design, preparation and presentation of the review and that we performed an assessment of the methodological quality of the primary studies. We did not include clinical trials in which another type of therapy was added unless both groups underwent the same therapy. The present review serves as a relevant contribution for various settings including clinical, research and even policy.

In terms of the implications for practice, the included studies reflect the parameters of intensity, duration and frequency of ultrasound and sonophoresis, which makes it possible to easily replicate them in clinical practice. This study serves as a method for deepening our understanding of the efficacy of these therapies. Given the data obtained, however, further research is needed into the various drugs that can be vehicularised by ultrasound and which of them are most effective. Future studies should assess the benefit-cost of these therapies to thereby determine whether they are cost-effective in clinical practice. Moreover, it would be interesting to conduct superiority studies that evaluate the mixed effect of sonophoresis along with other emerging therapies for pain control such as the

treatment of chronic pain from neuropedagogy, cognitive behavioural therapies, motor graded imagery and even desensitisation manoeuvres of the central nervous system.[35] In clinical practice, these results are important because they indicate the improvement achieved for certain neurophysiological parameters and pain. However, these data need to be associated with severity of symptoms, functional status, and a degree of patient satisfaction.

Several limitations have been identified that should be considered when interpreting the evidence. For a number of the studies, we were able to use them only partially due to a lack of sufficient data for certain variables. It needed to be considered that most of the included studies did not evaluate the long-term effects (at least 12 months after completing the therapy).

CONCLUSIONES/ CONCLUSIONS

6. CONCLUSIONES/ CONCLUSIONS

Se detalla a continuación la conclusión de cada estudio de forma independiente.

6.1 ESTUDIO I

Los EPAs han mostrado una mayor mejora en el dolor, la función y el agarre de la mano en comparación con los controles en pacientes con OA de la mano; sin embargo, la fuerza de pinza resultó en valores similares después de las intervenciones de grupos control y EPAs. Por lo tanto, el dolor, la función y el agarre de la mano parecen mejorar significativamente inmediatamente después de la aplicación de EPA. La mejora de estos síntomas en las personas con artrosis de manos les permite vivir en mejor armonía con su entorno, realizar actividades significativas de la vida diaria y permanecer activos en la comunidad.

English version

EPAs have shown greater improvement in pain, function and hand grip compared to controls in patients with hand OA; however, pinch strength resulted in similar values after EPAs and control groups interventions. Hence, pain, function and hand grip seem to improve significantly immediately after the application of EPAs. Improvement of these symptoms in people with hand OA let them to live in better harmony with their surroundings, to perform meaningful activities of daily living, and to remain active in the community.

6.2 ESTUDIO II

En conclusión, el ultrasonido terapéutico ha demostrado una mejora superior después del tratamiento en la MDL en comparación con los grupos control utilizados en los estudios primarios realizados hasta el momento. Esto podría conducir a una reducción del grado de severidad en las escalas neurofisiológicas del CTS. Sin embargo, la aplicación de terapia mediante ultrasonido no parece tener un efecto terapéutico sobre el dolor, la gravedad de los síntomas, la fuerza, la función, la velocidad de conducción nerviosa y la SDL.

English version

In conclusion, ultrasound has shown a superior post-treatment improvement in motor distal latency compared to the control groups used in the primary studies carried out so far. This could lead to a reduction in the degree of severity in the neurophysiological scales of the CTS. However, the application of ultrasound does not appear to have a therapeutic effect on pain, severity of symptoms, strength, function, sensory conduction velocity and sensory distal latency.

6.3 ESTUDIO III

En conclusión, el uso de la fonoforesis ha mostrado una mejoría post-terapia mayor que el ultrasonido para los parámetros electrofisiológicos relacionados con la conducción del nervio mediano: MDL, SDL, y dolor. Sin embargo, la literatura no ha podido probar que la fonoforesis tuviera un efecto significativo en la función y la gravedad de los síntomas. No hubo diferencias

significativas entre la aplicación de fonoforesis-AINEs y fonoforesis-corticoesteroides en términos de función, MDL y SDL.

English version

In conclusion, the use of sonophoresis has shown a post-therapy improvement greater than ultrasound for the electrophysiological parameters related to median nerve conduction: MDL and SDL, and pain. However, literature has been unable to prove that sonophoresis had a significant effect function and symptom severity. There were non-significant differences between the application of sonophoresis-NSAIDS and sonophoresis-corticosteroids in terms of function, MDL and SDL.

Por lo tanto, podemos concluir tras la realización de los tres meta-análisis incluidos en la tesis, la necesidad de realizar más estudios que puedan ampliar y dar un mayor respaldo científico en el uso de los agentes electrofísicos en la patología de la mano, así como evaluar la relación coste beneficio de estos tratamientos.

MENSAJES CLINICOS/

CLINICAL MESSAGES

7. MENSAJES CLINICOS/ CLINICAL MESSAGES

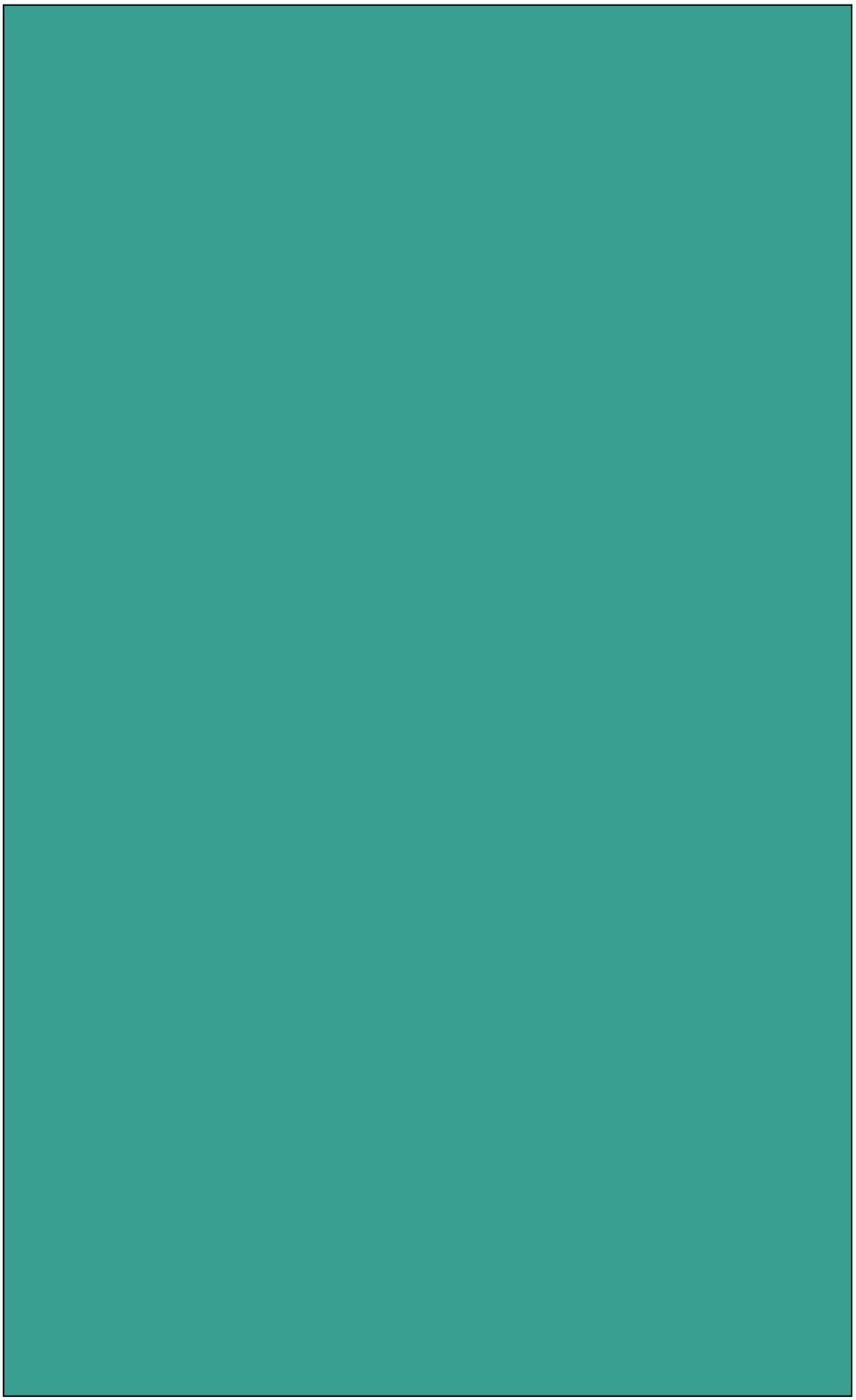
La importancia de este trabajo radica en el esfuerzo por aunar y sintetizar la literatura relativa a la evidencia científica acerca del uso de los agentes electrofísicos en la osteoartrosis de mano y el uso del ultrasonido terapéutico y la fonoforesis en el síndrome del túnel del carpo, sirviendo esta información para agilizar y facilitar la toma de decisiones clínicas de dichas patologías comúnmente atendidas en ámbito laboral.

No obstante, pese al gran número de estudios que existen, son pocos los que se encuentran centrados en el ámbito laboral, por lo que sería necesario realizar un ensayo clínico amplio desde las mutuas de accidentes laborales.

English version

The main point of this work is the effort to combine and synthesize the literature on the scientific evidence on the use of electrophysical agents in hand osteoarthritis and the use of therapeutic ultrasound and phonophoresis in carpal tunnel syndrome, serving this information to streamline and facilitate clinical decision-making for these common work- related pathologies.

However, despite the large number of studies that exist, few are focused on the occupational injuries, so it would be necessary to carry out a large clinical trial from the mutual insurance companies for occupational accidents.



8. LISTA DE TABLAS/ TABLES LIST

9. LISTA DE FIGURAS/ FIGURES LIST

Figure 14. *Forest Plot SSS FE. Forest plot and meta-analysis of ultrasound therapy compared with control treatment illustrating the improvement in self-reported severity of symptoms.*

Figure 15. *Forest Plot FSS FE. Forest plot and meta-analysis of ultrasound therapy compared with control treatment illustrating the improvement in self-reported function.*

Figure 16. *Forest Plot strength FE. Forest plot and meta-analysis of ultrasound therapy compared with control treatment illustrating the improvement in self-reported pinch and grip strength.*

Figure 17. *Forest Plot MDL FE. Forest plot and metaanalysis of ultrasound treatment compared with control treatment for the outcome motor distal latency.*

Figure 18. *Forest Plot SDL FE. Forest plot and metaanalysis of ultrasound treatment compared with control treatment for the outcome sensory distal latency.*

Figure 19. *PRISMA flow diagram. From: Moher D, Liberati A, Tetzlaff J, Altman DG. The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and MetaAnalyses: the PRISMA Statement. PLoS Med 6:e1000097. For more information, visit www.prisma-statement.org*

Figure 20. *Forest Plot MDL. FE. Forest plot and meta-analysis of ultrasound therapy compared with phonophoresis treatment illustrating the improvement in MDL.*

Figure 21*. Forest Plot SDL. FE. Forest plot and meta-analysis of ultrasound therapy compared with phonophoresis treatment illustrating the improvement in SDL.*

Figure 22. *Forest Plot Pain. FE. Forest plot and meta-analysis of ultrasound therapy compared with phonophoresis treatment illustrating the improvement in pain.*

Figure 23. *Forest Plot SSS. FE. Forest plot and meta-analysis of ultrasound therapy compared with control treatment illustrating the improvement in self-reported severity of symptoms.*

Figure 24. *Forest Plot FSS FE. Forest plot and meta-analysis of ultrasound therapy compared with control treatment illustrating the improvement in self-reported function.*

Figure 25. *Forest Plot MDL. Forest plot and metaanalysis of SP-AINES versus SP-CS treatment for the outcome MDL.*

Figure 26*. Forest Plot SDL. Forest plot and metaanalysis of SP-AINES versus SP-CS treatment for the outcome SDL*

Figure 27*. Forest Plot function. Forest plot and metaanalysis of SP-AINES versus SP-CS treatment for the outcome function.*

REFERENCIAS/ REFERENCES

10. REFERENCIAS/ REFERENCES

1. Sorock G., Lombardi D., Courtney T., Cotnam J., Mittleman M. Epidemiology of occupational acute traumatic hand injuries: a literature review. *Saf Sci*. 2001;38(3):241-256. doi:10.1016/S0925-7535(01)00004-2

2. Barr AE, Barbe MF, Clark BD. Work-Related Musculoskeletal Disorders of the Hand and Wrist: Epidemiology, Pathophysiology, and Sensorimotor Changes. *J Orthop Sport Phys Ther*. 2004;34(10):610-627. doi:10.2519/jospt.2004.34.10.610

3. Ministerio de Empleo y Seguridad Social. Anuario de Estadísticas Laborales y de Asuntos Sociales. Observatorio Estatal de Condiciones de trabajo.

4. Marín Martínez F, Sánchez Meca J, López López JA. El metaanálisis en el ámbito de las Ciencias de la Salud: una metodología imprescindible para la eficiente acumulación del conocimiento. *Fisioterapia*. 2009;31(3):107-114. doi:10.1016/j.ft.2009.02.002

5. Galindo MPG. MN-17 “Trabajadores accidentados: costes que asumen.” *Monogr Tec Inst Segur y Salud Laboral*. 2007.

6. Fernando Rodrigo. Las Mutuas, esas grandes desconocidas. *Arch Prev Riesgos Labor*. 2007;10(4):192-194.

7. Mercader Uguina JR. *Mutua de Accidentes de Trabajo y Enfermedades Profesionales.* La Ley; 2007.

8. Rollock. CCM. INCIDENCIA DE LAS LESIONES TRAUMÁTICAS DE LA MANO Y LA MUÑECA DE ORIGEN LABORAL: ESTUDIO DE CALIDAD DE VIDA. 2015.

9. Jiménez MG. LAS MUTUAS DE ACCIDENTES DE TRABAJO Y ENFERMEDADES PROFESIONALES: GESTIÓN PRIVADA DE LA SEGURIDAD SOCIAL. 2011.

10. Juan Ventura Victoria MESS. El papel de las mutuas de accidentes de trabajo en la gestión de los riesgos laborales. *Rev Astur Econ*. 2000;18:75-93.

11. Moran CA. Anatomy of the Hand. *Phys Ther*. 1989;69(12):1007-1013. doi:10.1093/ptj/69.12.1007

12. Jose M. Peris García. Anatomia 1. 2022.

13. Tubiana, R., Thomine, J. M., & Mackin E. *Examination of the Hand and Wrist.* CRC Press.; 1998.

14. Jose M. Peris García. Anatomía 2. 2022.

15. Terri M. Skirven OTR/L, CHT, A. Lee Osterman MD, Jane M. Fedorczyk

PT, PhD, CHT, Peter C. Amadio MD, Sheri B. Feldscher OTR/L C y EKSM. *REHABILITATION OF THE HAND AND UPPER EXTREMITY*. 7th ed.; 2021.

16. Engels. El papel del trabajo en la transformación del mono en hombre. *Die Neue Zeit*. 1895;Bd. 2, N°.

17. Evars Mc Collister C and C. *Surgery of the Musculoskeletal System VI, Section 2.* New York Churchill Livinstone; 1990.

18. Antonio Vicente Sempere Navarro MAM. Las infracciones y sanciones administrativas de las Mutuas de accidentes de trabajo y enfermedades profesionales en el texto refundido de la LISOS. *Rev del Minist Trab y Asuntos Soc Rev del Minist Trab e Inmigr*. 2008;78.

19. Lía Clara López Sullaez RER. Impact Occupational of Traumatic Amtutation In Fingers of the Hand by Work Accident. *Med Segur Trab (Madr)*. 2009;55(217):41-48. http://scielo.isciii.es/scielo.php?script=sci_arttext&pid=S0465-546X2009000400005&lng=es&tlng=es.

20. L. Escobar, A. Naranjo JAL. Epidemiología de las lesiones de punta de dedo. *Rev Colomb Ortop y Traumatol*. 2012;26:109-112.

21. Angulo JLC. Accidentabilidad laboral en España: estudio de la importancia de los accidentes de trabajo con baja en dedos y manos. 2020. https://www.seguridad-laboral.es/especiales-prl/proteccion-de-manos/accidentabilidad-laboral-en-espana-estudio-de-la-importancia-de-los-accidentes-de-trabajo-con-baja-en-dedos-y-manos_20200706.html.

22. MUGGLETON JM, ALLEN R, CHAPPELL PH. Hand and arm injuries associated with repetitive manual work in industry: a review of disorders, risk factors and preventive measures. *Ergonomics*. 1999;42(5):714-739. doi:10.1080/001401399185405

23. O'SULLIVAN ME, COLVILLE J. The Economic Impact of Hand Injuries. *J Hand Surg Am*. 1993;18(3):395-398. doi:10.1016/0266-7681(93)90072-N

24. Opsteegh L, Reinders-Messelink HA, Schollier D, et al. Determinants of Return to Work in Patients with Hand Disorders and Hand Injuries. *J Occup Rehabil*. 2009;19(3):245-255. doi:10.1007/s10926-009-9181-4

25. Ranstam J, Rose I. Prevalence of Carpal Tunnel Syndrome. 1999.

26. Hands. PGSTC-TSSYE in D and T of SH and FF. of Surgery. *J Bone Jt Surg*. 1966;48A: 2: 21.

27. Silverstein BA, Fine LJ, Armstrong TJ. Occupational factors and carpal tunnel syndrome. *Am J Ind Med*. 1987;11(3):343-358. doi:10.1002/ajim.4700110310

28. Foley M, Silverstein B, Polissar N. The economic burden of carpal tunnel

syndrome: Long-term earnings of CTS claimants in Washington State. *Am J Ind Med*. 2007;50(3):155-172. doi:10.1002/ajim.20430

29. AAEM Quality Assurance Committee, Jablecki CK, Andary CMT, So YT, Wilkins DE, Williams FH. Literature review of the usefulness of nerve conduction studies and electromyography for the evaluation of patients with carpal tunnel syndrome. *Muscle Nerve*. 1993;16(12):1392-1414. doi:10.1002/mus.880161220

30. Academy A, Board OS. MANAGEMENT OF CARPAL TUNNEL SYNDROME EVIDENCE-BASED CLINICAL PRACTICE GUIDELINE Adopted by the American Academy of Orthopaedic Surgeons Board of Directors. 2016.

31. Verdugo R, Salinas R, Castillo J, Cea J. Surgical versus non-surgical treatment for carpal tunnel syndrome. In: Verdugo R, ed. *Cochrane Database of Systematic Reviews*. Chichester, UK: John Wiley & Sons, Ltd; 2003. doi:10.1002/14651858.CD001552

32. Huisstede BM, Hoogvliet P, Franke TP, Randsdorp MS, Koes BW. Carpal Tunnel Syndrome: Effectiveness of Physical Therapy and Electrophysical Modalities. An Updated Systematic Review of Randomized Controlled Trials. *Arch Phys Med Rehabil*. 2018;99(8):1623-1634.e23. doi:10.1016/j.apmr.2017.08.482

33. Piazzini DB, Aprile I, Ferrara PE, et al. Clinical Rehabilitation. 2007. doi:10.1177/0269215507077294

34. Gerritsen AAM, Krom MCTFM De, Struijs MA, Scholten RJPM, Vet HCW De, Bouter LM. Conservative treatment options for carpal tunnel syndrome : a systematic review of randomised controlled trials. 2002:272-280.

35. Fernández-de-las-Peñas C, Arias-Buría JL, Cleland JA, Pareja JA, Plaza-Manzano G, Ortega-Santiago R. Manual Therapy Versus Surgery for Carpal Tunnel Syndrome: 4-Year Follow-Up From a Randomized Controlled Trial. *Phys Ther*. 2020;100(11):1987-1996. doi:10.1093/ptj/pzaa150

36. Lewis KJ, Coppieters MW, Ross L, Hughes I, Vicenzino B, Schmid AB. Group education , night splinting and home exercises reduce conversion to surgery for carpal tunnel syndrome : a multicentre randomised trial. *J Physiother*. 2020;66(2):97-104. doi:10.1016/j.jphys.2020.03.007

37. Topp KS, Boyd BS. Structure and Biomechanics of Peripheral Nerves : Nerve Responses to Physical Stresses and Implications for Physical Therapist Practice. 2006;86(1):92-109.

38. Lewis KJ, Coppieters MW, Ross L, Hughes I, Vicenzino B, Schmid AB. Group education, night splinting and home exercises reduce conversion to surgery for carpal tunnel syndrome: a multicentre randomised trial. *J Physiother*. 2020. doi:10.1016/j.jphys.2020.03.007

39. Kim S-D. Efficacy of tendon and nerve gliding exercises for carpal tunnel syndrome: a systematic review of randomized controlled trials. *J Phys Ther Sci*. 2015;27(8):2645-2648. doi:10.1589/jpts.27.2645

40. Hamzeh H, Madi M, Alghwiri AA, Hawamdeh Z. The long-term effect of neurodynamics vs exercise therapy on pain and function in people with carpal tunnel syndrome: A randomized parallel-group clinical trial. *J Hand Ther*. July 2020. doi:10.1016/j.jht.2020.07.005

41. Rayegani SM, Moradi-Joo M, Raeissadat SA, Bahrami MH, Seyed-Nezhad M, Heidari S. Effectiveness of Low-Level Laser Therapy compared to Ultrasound in Patients With Carpal Tunnel Syndrome: A Systematic Review and Meta-analysis. *J Lasers Med Sci*. 2019;10(5):S82-S89. doi:10.15171/jlms.2019.S15

42. Piazzini DB, Aprile I, Ferrara PE, et al. A systematic review of conservative treatment of carpal tunnel syndrome. *Clin Rehabil*. 2007;21(4):299-314. doi:10.1177/0269215507077294

43. Bakhtiary AH, Rashidy-pour A. Ultrasound and laser therapy in the treatment of carpal tunnel syndrome. *Aust J Physiother*. 2004;50(3):147-151. doi:10.1016/S0004-9514(14)60152-5

44. Kamel DM, Hamed NS, Abdel Raoof NA, Tantawy SA. Pulsed magnetic field versus ultrasound in the treatment of postnatal carpal tunnel syndrome: A randomized controlled trial in the women of an Egyptian population. *J Adv Res*. 2017;8(1):45-53. doi:10.1016/j.jare.2016.11.001

45. Wolny T, Saulicz E, Linek P, Myśliwiec A, Saulicz M. Effect of manual therapy and neurodynamic techniques vs ultrasound and laser on 2PD in patients with CTS: A randomized controlled trial. *J Hand Ther*. 2016;29(3):235-245. doi:10.1016/j.jht.2016.03.006

46. Ansar N, Adeel M, Liaqat S, Maqsood I, Ghafoor I. The Comparison of Therapeutic Ultrasound and Local Steroid Injection in Treatment of Mild to Moderate Carpal Tunnel Syndrome : A Randomized Controlled Trial. 2017;23(3):335-342.

47. Paoloni M, Tavernese E, Cacchio A, et al. Extracorporeal shock wave therapy and ultrasound therapy improve pain and function in patients with carpal tunnel syndrome. A randomized controlled trial. *Eur J Phys Rehabil Med*. 2015;51(5):521-528. http://www.ncbi.nlm.nih.gov/pubmed/25697763.

48. Ahmed OF, Elkharbotly AM, Taha N, Bekheet AB. Treatment of mild to moderate carpal tunnel syndrome in patients with diabetic neuropathy using low level laser therapy versus ultrasound controlled comparative study. *BBA Clin*. 2017;8(April):43-47. doi:10.1016/j.bbacli.2017.07.001

49. Jothi KP, Bland JDP. Ultrasound therapy adds no benefit to splinting in carpal tunnel syndrome. *Muscle Nerve*. 2019;60(5):538-543. doi:10.1002/mus.26651

50. Bijlsma JW, Berenbaum F, Lafeber FP. Osteoarthritis: an update with relevance for clinical practice. *Lancet*. 2011;377(9783):2115-2126. doi:10.1016/S0140-6736(11)60243-2

51. Zhang W, Doherty M, Leeb BF, et al. EULAR evidence-based recommendations for the diagnosis of hand osteoarthritis: report of a task force of ESCISIT. *Ann Rheum Dis*. 2009;68(1):8-17. doi:10.1136/ard.2007.084772

52. Haara MM, Heliovaara M, Kroger H, et al. Osteoarthritis in the carpometacarpal joint of the thumb - Prevalence and associations with disability and mortality. *J BONE Jt SURGERY-AMERICAN Vol*. 2004;86A(7):1452-1457. doi:10.2106/00004623-200407000-00013

53. Andaluza S. Traumatología y Ortopedia. 2013.

54. Haq I, Murphy E, Dacre J. I Haq, E Murphy, J Dacre. *Postgrad Med J*. 2003;79:377-383.

55. Van Heest AE, Kallemeier P. Thumb Carpal Metacarpal Arthritis. *J Am Acad Orthop Surg*. 2008;16(3):140-151. doi:10.5435/00124635-200803000-00005

56. Martínez R, Martínez C, Calvo R, Poblete F. Osteoartritis (artrosis) de rodilla. 2015;56(3).

57. Ye L, Kalichman L, Spittle A, Dobson F, Bennell K. Effects of rehabilitative interventions on pain, function and physical impairments in people with hand osteoarthritis: a systematic review. *Arthritis Res Ther*. 2011;13(1):R28. doi:10.1186/ar3254

58. Mahendira D, Towheed TE. Systematic review of non-surgical therapies for osteoarthritis of the hand: an update. *Osteoarthr Cartil*. 2009;17(10):1263-1268. doi:10.1016/j.joca.2009.04.006

59. Spaans AJ, van Minnen LP, Kon M, Schuurman AH, Schreuders AR (Ton), Vermeulen GM. Conservative Treatment of Thumb Base Osteoarthritis: A Systematic Review. *J HAND SURGERY-AMERICAN Vol*. 2015;40(1):16-U224. doi:10.1016/j.jhsa.2014.08.047

60. Valdes K, Marik T. A Systematic Review of Conservative Interventions for Osteoarthritis of the Hand. *J Hand Ther*. 2010;23(4):334-351. doi:10.1016/j.jht.2010.05.001

61. Bertozzi L, Valdes K, Vanti C, Negrini S, Pillastrini P, Villafane JH. Investigation of the effect of conservative interventions in thumb carpometacarpal osteoarthritis: systematic review and meta-analysis. *Disabil Rehabil*. 2015;37(22):2025-2043. doi:10.3109/09638288.2014.996299

62. Towheed TE. Systematic review of therapies for osteoarthritis of the hand. *Osteoarthr Cartil*. 2005;13(6):455-462. doi:10.1016/j.joca.2005.02.009

63. Berggren M, Joost-Davidsson A, Lindstrand J, Nylander G, Povlsen B. Reduction in the need for operation after conservative treatment of osteoarthritis of the first carpometacarpal joint: A seven year prospective study. *Scand J Plast Reconstr Surg Hand Surg*. 2001;35(4):415-417. doi:10.1080/028443101317149381

64. O'Brien VH, Giveans MR. Effects of a dynamic stability approach in conservative intervention of the carpometacarpal joint of the thumb: A retrospective study. *J HAND Ther*. 2013;26(1):44-52. doi:10.1016/j.jht.2012.10.005

65. Carreira ACG, Jones A, Natour J. Assessment of the effectiveness of a functional splint for osteoarthritis of the trapeziometacarpal joint of the dominant hand: A randomized controlled study. *J Rehabil Med*. 2010;42(5):469-474. doi:10.2340/16501977-0542

66. Dziedzic K, Nicholls E, Hill S, et al. Self-management approaches for osteoarthritis in the hand: A 2×2 factorial randomised trial. *Ann Rheum Dis*. 2015;74(1):108-118. doi:10.1136/annrheumdis-2013-203938

67. Rogers MW, Wilder F V. Exercise and Hand Osteoarthritis Symptomatology: A Controlled Crossover Trial. *J Hand Ther*. 2009;22(1):10-18. doi:10.1016/j.jht.2008.09.002

68. Stamm TA, Machold KP, Smolen JS, et al. Joint protection and home hand exercises improve hand function in patients with hand osteoarthritis: A randomized controlled trial. *Arthritis Care Res*. 2002;47(1):44-49. https://www.scopus.com/inward/record.uri?eid=2-s2.0-0036170437&partnerID=40&md5=978fd255f2f976ab7073f678e5f27512.

69. Field T, Diego M, Delgado J, Garcia D, Funk CG. Hand pain is reduced by massage therapy. *Complement Ther Clin Pract*. 2011;17(4):226-229. doi:10.1016/j.ctcp.2011.02.006

70. Villafañe JH, Silva GB, Diaz-Parreño SA, Fernandez-Carnero J. Hypoalgesic and Motor Effects of Kaltenborn Mobilization on Elderly Patients with Secondary Thumb Carpometacarpal Osteoarthritis: A Randomized Controlled Trial. *J Manipulative Physiol Ther*. 2011;34(8):547-556. doi:10.1016/j.jmpt.2011.08.005

71. Villafane JH, Silva GB, Fernandez-Carnero J. Effect of Thumb Joint Mobilization on Pressure Pain Threshold in Elderly Patients with Thumb Carpometacarpal Osteoarthritis. *J Manipulative Physiol Ther*. 2012;35(2):110-120. doi:10.1016/j.jmpt.2011.12.002

72. Villafane JH, Silva GB, Bishop MD, Fernandez-Carnero J. Radial Nerve Mobilization Decreases Pain Sensitivity and Improves Motor Performance in Patients With Thumb Carpometacarpal Osteoarthritis: A Randomized Controlled Trial. *Arch Phys Med Rehabil*. 2012;93(3):396-403. doi:10.1016/j.apmr.2011.08.045

73. Villafañe JH, Cleland JA, Fernández-De-Las-Peñas C. The Effectiveness

of a manual therapy and exercise protocol in patients with thumb carpometacarpal osteoarthritis: A randomized controlled trial. *J Orthop Sports Phys Ther*. 2013;43(4):204-213. doi:10.2519/jospt.2013.4524

74. Davenport BJ, Jansen V, Yeandle N. Pilot randomized controlled trial comparing specific dynamic stability exercises with general exercises for thumb carpometacarpal joint osteoarthritis. *Hand Ther*. 2012;17(3):60-67. doi:10.1258/ht.2012.012010

75. Aebischer B, Elsig S, Taeymans J. Effectiveness of physical and occupational therapy on pain , function and quality of life in patients with trapeziometacarpal osteoarthritis – A systematic review and meta-analysis. 2016;21(1):5-15. doi:10.1177/1758998315614037

76. Garcia-Elias M, Folgar MÁV. The management of wrist injuries: An international perspective. *Injury*. 2006;37(11):1049-1056. doi:10.1016/j.injury.2006.07.025

77. Trybus M, Lorkowski J, Brongel L, Hľadki W. Causes and consequences of hand injuries. *Am J Surg*. 2006;192(1):52-57. doi:10.1016/j.amjsurg.2005.10.055

78. Romero-Morales C, Bravo-Aguilar M, Abuín-Porras V, et al. Current advances and novel research on minimal invasive techniques for musculoskeletal disorders. *Disease-a-Month*. 2021;67(10):101210. doi:10.1016/j.disamonth.2021.101210

79. Takata SC, Wade ET, Roll SC. Hand therapy interventions, outcomes, and diagnoses evaluated over the last 10 years: A mapping review linking research to practice. *J Hand Ther*. 2016. doi:10.1016/j.jht.2017.05.018

80. Watson T. Key concepts with electrophysical agents. *Phys Ther Rev*. 2010;15(4):351-359. doi:10.1179/1743288X10Y.0000000009

81. Watson T. The role of electrotherapy in contemporary physiotherapy practice. *Man Ther*. 2000;5(3):132-141. doi:10.1054/math.2000.0363

82. Guyatt G RD. *User's Guide to the Medical Literature. Essentials of Evidenced Medicine Clinical Practice*. AMA Press, EE.UU; 2002.

83. Sackett DL, Rosenberg WMC, Gray JAM, Haynes RB, Richardson WS. Evidence based medicine: what it is and what it isn't. *BMJ*. 1996;312(7023):71-72. doi:10.1136/bmj.312.7023.71

84. Toro AG. Actualidad de la Enfermería Basada en la Evidencia. Superando la "Evidencia Científica": la Metasíntesis. *Index Enfermería [Index Enferm] (edición Digit*. 2003;40-41. http://www.index-f.com/index-enfermeria/40-41revista/40-41_articulo_7-8.php.

85. Evans D. Hierarchy of evidence: a framework for ranking evidence evaluating healthcare interventions. *J Clin Nurs*. 2003;12(1):77-84. doi:10.1046/j.1365-2702.2003.00662.x

86. Petrisor B, Bhandari M. The hierarchy of evidence: Levels and grades of recommendation. *Indian J Orthop*. 2007;41(1):11. doi:10.4103/0019-5413.30519

87. Francisco Javier Jimeno Serrano, V. Salinas Palacios FS. Fisioterapia basada en la evidencia y “The Cochrane Library.” *Rev Iberoam Fisioter y Kinesiol*. 2001;4:8-14.

88. Sackett DL, Wennberg JE. Choosing the best research design for each question. *BMJ*. 1997;315(7123):1636-1636. doi:10.1136/bmj.315.7123.1636

89. Higgins JPT, Altman DG, Gøtzsche PC, et al. The Cochrane Collaboration’s tool for assessing risk of bias in randomised trials. *BMJ*. 2011;343(7829):1-9. doi:10.1136/bmj.d5928

90. Antman EM. A Comparison of Results of Meta-analyses of Randomized Control Trials and Recommendations of Clinical Experts. *JAMA*. 1992;268(2):240. doi:10.1001/jama.1992.03490020088036

91. Higgins J, Green S, editors. Manual Cochrane de revisiones sistemáticas de intervenciones version 5.1.0 (edición online). *Cochrane Collab*. 2011;(March):1-639. https://es.cochrane.org/sites/es.cochrane.org/files/public/uploads/Manual_Cochrane_510_reduit.pdf.

92. Glass G V. Primary, Secondary, and Meta-Analysis of Research. *Educ Res*. 1976;5(10):3. doi:10.2307/1174772

93. Manterola C, Asenjo-Lobos C, Otzen T. Jerarquización de la evidencia: Niveles de evidencia y grados de recomendación de uso actual. *Rev Chil infectología*. 2014;31(6):705-718. doi:10.4067/S0716-10182014000600011

94. Guyatt GH, Oxman AD, Vist GE, et al. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. *BMJ*. 2008;336(7650):924-926. doi:10.1136/bmj.39489.470347.AD

95. Valdes K, Marik T. A systematic review of conservative interventions for osteoarthritis of the hand. *J Hand Ther*. 2010;23(4):334-350; quiz 351. doi:10.1016/j.jht.2010.05.001

96. Sayyid R, Uthman I. Hand Osteoarthritis: An Update on Therapy. *Arch Rheumatol*. 2015;30(2):150-158. doi:10.5606/ArchRheumatol.2015.4449

97. Bertozzi L, Valdes K, Vanti C, Negrini S, Pillastrini P, Villafan JH. Investigation of the effect of conservative interventions in thumb carpometacarpal osteoarthritis : systematic review and meta-analysis. 2014:1-19. doi:10.3109/09638288.2014.996299

98. Lue S, Koppikar S, Shaikh K, Mahendira D, Towheed TE. *Systematic Review of Non-Surgical Therapies for Osteoarthritis of the Hand: An*

Update. Vol 25.; 2017:1379-1389. doi:10.1016/j.joca.2017.05.016

99. Ahern M, Skyllas J, Wajon A, Hush J. The effectiveness of physical therapies for patients with base of thumb osteoarthritis: Systematic review and meta-analysis. *Musculoskelet Sci Pract*. 2018;35:46-54. doi:10.1016/j.msksp.2018.02.005

100. Maxwell L. Therapeutic Ultrasound: Its Effects on the Cellular and Molecular Mechanisms of Inflammation and Repair. *Physiotherapy*. 1992;78(6):421-426. doi:10.1016/S0031-9406(10)61528-3

101. Shirin Farivar 1, Talieh Malekshahabi 1 RS 2. Biological Effects of Low Level Laser Therapy. *J Lasers Med Sci*. 2014;5(2):58-62.

102. Vance CGT, Dailey DL, Rakel BA, Sluka KA. Using TENS for pain control: the state of the evidence. *Pain Manag*. 2014;4(3):197-209. doi:10.2217/pmt.14.13

103. Kanat E, Alp A, Yurtkuran M. Magnetotherapy in hand osteoarthritis: A pilot trial. *Complement Ther Med*. 2013;21(6):603-608. doi:10.1016/j.ctim.2013.08.004

104. Brosseau L, Wells G, Marchand S, et al. Randomized controlled trial on low level laser therapy (LLLT) in the treatment of osteoarthritis (OA) of the hand. *Lasers Surg Med*. 2005;36(3):210-219. doi:10.1002/lsm.20137

105. Horvath K, Kulisch A, Nemeth A, Bender T. Evaluation of the effect of balneotherapy in patients with osteoarthritis of the hands: a randomized controlled single-blind follow-up study. *Clin Rehabil*. 2012;26(5):431-441. doi:10.1177/0269215511425961

106. Ioppolo F, Saracino F, Rizzo RS, et al. Comparison between extracorporeal shock wave therapy and intra-articular hyaluronic acid injections in the treatment of first carpometacarpal joint osteoarthritis. *Ann Rehabil Med*. 2018;42(1):92-100. doi:10.5535/arm.2018.42.1.92

107. Foley M, Silverstein B, Polissar N. The economic burden of carpal tunnel syndrome: Long-term earnings of CTS claimants in washington state. *Am J Ind Med*. 2007. doi:10.1002/ajim.20430

108. AAEM Quality Assurance Committee, Jablecki CK, Andary CMT, So YT, Wilkins DE, Williams FH. Literature review of the usefulness of nerve conduction studies and electromyography for the evaluation of patients with carpal tunnel syndrome. *Muscle Nerve*. 1993. doi:10.1002/mus.880161220

109. Bland JDP. A neurophysiological grading scale for carpal tunnel syndrome. *Muscle and Nerve*. 2000. doi:10.1002/1097-4598(200008)23:8<1280::AID-MUS20>3.0.CO;2-Y

110. Alanazy MH. Clinical and electrophysiological evaluation of carpal tunnel syndrome: Approach and pitfalls. *Neurosciences*. 2017. doi:10.17712/nsj.2017.3.20160638

111. Stevens JC. AAEM minimonograph 26: The electrodiagnosis of carpal tunnel syndrome. *Muscle and Nerve*. 1997. doi:10.1002/(SICI)1097-4598(199712)20:12<1477::AID-MUS1>3.0.CO;2-5

112. Teijeira-azcona A, Valentín-huete A, Ayuga-loro F, López-reneo R, Teijeira-álvarez JM. Valor del reflejo cutáneo palmar en el diagnóstico del síndrome del túnel del carpo idiopático. 2011;53(8):463-469.

113. Padua L, LoMonaco M, Gregori B, Valente EM, Padua R, Tonali P. Neurophysiological classification and sensitivity in 500 carpal tunnel syndrome hands. *Acta Neurol Scand*. 1997. doi:10.1111/j.1600-0404.1997.tb00271.x

114. Funaba M, Kanchiku T, Imajo Y, et al. Relation between distal motor latency delay and sensory action potential absence of the median nerve in carpal tunnel syndrome. *Clin Neurol Neurosurg*. 2016. doi:10.1016/j.clineuro.2016.06.019

115. Stevens JC. AAEM minimonograph #26: The electrodiagnosis of carpal tunnel syndrome. *Muscle Nerve*. 1997;20(12):1477-1486. doi:10.1002/(SICI)1097-4598(199712)20:12<1477::AID-MUS1>3.0.CO;2-5

116. Park KM, Shin KJ, Park J, Ha SY, Kim SE. The usefulness of terminal latency index of median nerve and F-wave difference between median and ulnar nerves in assessing the severity of carpal tunnel syndrome. *J Clin Neurophysiol*. 2014. doi:10.1097/WNP.0000000000000041

117. Huisstede BM, Hoogvliet P, Franke TP, Randsdorp MS, Koes BW. Carpal Tunnel Syndrome: Effectiveness of Physical Therapy and Electrophysical Modalities. An Updated Systematic Review of Randomized Controlled Trials. *Arch Phys Med Rehabil*. 2018. doi:10.1016/j.apmr.2017.08.482

118. Piazzini DB, Aprile I, Ferrara PE, et al. A systematic review of conservative treatment of carpal tunnel syndrome. *Clin Rehabil*. 2007. doi:10.1177/0269215507077294

119. Gerritsen AAM, De Krom MCTFM, Struijs MA, Scholten RJPM, De Vet HCW, Bouter LM. Conservative treatment options for carpal tunnel syndrome: A systematic review of randomised controlled trials. *J Neurol*. 2002. doi:10.1007/s004150200004

120. Page MJ, O'Connor D, Pitt V, Massy-Westropp N. Therapeutic ultrasound for carpal tunnel syndrome. *Cochrane Database Syst Rev*. March 2013. doi:10.1002/14651858.CD009601.pub2

121. Wu YT, Ke MJ, Chou YC, et al. Effect of radial shock wave therapy for carpal tunnel syndrome: A prospective randomized, double-blind, placebo-controlled trial. *J Orthop Res*. 2016. doi:10.1002/jor.23113

122. Gurcay E, Unlu E, Gurcay AG, Tuncay R, Cakci A. Assessment of phonophoresis and iontophoresis in the treatment of carpal tunnel

syndrome: A randomized controlled trial. *Rheumatol Int*. 2012. doi:10.1007/s00296-010-1706-9

123. Frasca G, Maggi L, Padua L, et al. Short-term effects of local microwave hyperthermia on pain and function in patients with mild to moderate carpal tunnel syndrome: A double blind randomized sham-controlled trial. *Clin Rehabil*. 2011. doi:10.1177/0269215511400767

124. Incebiyik S, Boyaci A, Tutoglu A. Short-term effectiveness of short-wave diathermy treatment on pain, clinical symptoms, and hand function in patients with mild or moderate idiopathic carpal tunnel syndrome. *J Back Musculoskelet Rehabil*. 2015. doi:10.3233/BMR-140507

125. Topp KS, Boyd BS. Structure and Biomechanics of Peripheral Nerves: Nerve Responses to Physical Stresses and Implications for Physical Therapist Practice. *Phys Ther*. 2006;86(1):92-109. doi:10.1093/ptj/86.1.92

126. Sim SE, Gunasagaran J, Goh K-J, Ahmad TS. Short-term clinical outcome of orthosis alone vs combination of orthosis, nerve, and tendon gliding exercises and ultrasound therapy for treatment of carpal tunnel syndrome. *J Hand Ther*. 2019;32(4):411-416. doi:10.1016/j.jht.2018.01.004

127. Chang Y-W, Hsieh S-F, Horng Y-S, Chen H-L, Lee K-C, Horng Y-S. Comparative effectiveness of ultrasound and paraffin therapy in patients with carpal tunnel syndrome: a randomized trial. *BMC Musculoskelet Disord*. 2014;15(1):399. doi:10.1186/1471-2474-15-399

128. Kotb MA, Darwish AF. Comparison of splinting plus local steroid injection, And splinting plus ultrasound and low-level laser therapy outcomes in idiopathic mild to moderate carpal tunnel syndrome. *Egypt J Neurol Psychiatry Neurosurg*. 2014.

129. Saeed FUR, Hanif S, Aasim M. The effects of laser and ultrasound therapy on carpal tunnel syndrome. *Pakistan J Med Heal Sci*. 2012.

130. Bakhtiary AH, Rashidy-Pour A. Ultrasound and laser therapy in the treatment of carpal tunnel syndrome. *Aust J Physiother*. 2004;50(3):147-151. doi:10.1016/S0004-9514(14)60152-5

131. Ahmed OF, Elkharbotly AM, Taha N, Bekheet AB. Treatment of mild to moderate carpal tunnel syndrome in patients with diabetic neuropathy using low level laser therapy versus ultrasound controlled comparative study. *BBA Clin*. 2017;8:43-47. doi:10.1016/j.bbacli.2017.07.001

132. Bilgici A, Ulusoy H, Kuru O, Canturk F. The comparison of ultrasound treatment and local steroid injection plus splinting in the carpal tunnel syndrome: a randomized controlled trial. *Bratisl Lek Listy*. 2010;111(12):659-665. http://www.ncbi.nlm.nih.gov/pubmed/21384736.

133. Ansar, Nighat. Adeel, Muhammad. Liaqat, Sidrah. Maqsood, Iqra. Ghafoor I. The COmparison of Therapeautic Ultrasound and Local Steroid Injection in Treatment of Mild to Moderate Carpal Tunnel Syndrome: A Randomized

Controlled Trial. *Ann King Edward Med Univ*. 2017.

134. Paoloni M, Tavernese E, Cacchio A, et al. Extracorporeal shock wave therapy and ultrasound therapy improve pain and function in patients with carpal tunnel syndrome. A randomized controlled trial. *Eur J Phys Rehabil Med*. 2015;51(5):521-528. http://www.ncbi.nlm.nih.gov/pubmed/25697763.

135. Jothi KP, Bland JDP. Ultrasound therapy adds no benefit to splinting in carpal tunnel syndrome. *Muscle Nerve*. 2019;60(5):538-543. doi:10.1002/mus.26651

136. Çatalbaş N, Akkaya N, Atalay NS, Sahin F. Ultrasonographic imaging of the effects of continuous, pulsed or sham ultrasound treatments on carpal tunnel syndrome: A randomized controlled study. *J Back Musculoskelet Rehabil*. 2018;31(5):981-989. doi:10.3233/BMR-160652

137. Robertson VJ, Baker KG. A Review of Therapeutic Ultrasound: Effectiveness Studies. *Phys Ther*. 2001;81(7):1339-1350. doi:10.1093/ptj/81.7.1339

138. Bland JDP. A neurophysiological grading scale for carpal tunnel syndrome. *Muscle Nerve*. 2000;23(8):1280-1283. doi:10.1002/1097-4598(200008)23:8<1280::AID-MUS20>3.0.CO;2-Y

139. Alanazy M. Clinical and electrophysiological evaluation of carpal tunnel syndrome: approach and pitfalls. *Neurosciences*. 2017;22(3):169-180. doi:10.17712/nsj.2017.3.20160638

140. Funaba M, Kanchiku T, Imajo Y, et al. Relation between distal motor latency delay and sensory action potential absence of the median nerve in carpal tunnel syndrome. *Clin Neurol Neurosurg*. 2016;148:45-48. doi:10.1016/j.clineuro.2016.06.019

141. Park KM, Shin KJ, Park J, Ha SY, Kim SE. The Usefulness of Terminal Latency Index of Median Nerve and F-Wave Difference Between Median and Ulnar Nerves in Assessing the Severity of Carpal Tunnel Syndrome. *J Clin Neurophysiol*. 2014;31(2):162-168. doi:10.1097/WNP.0000000000000041

142. Baysal AI, Chang C-W, Oh SJ. Temperature effects on nerve conduction studies in patients with carpal tunnel syndrome. *Acta Neurol Scand*. 2009;88(3):213-216. doi:10.1111/j.1600-0404.1993.tb04219.x

143. Byl NN. The Use of Ultrasound as an Enhancer for Transcutaneous Drug Delivery: Phonophoresis. *Phys Ther*. 1995;75(6):539-553. doi:10.1093/ptj/75.6.539

144. Elmeligie M, Fahmy E. Efficacy of Phonophoresis with Chitosan Nanoparticles on Outcome of Patients with Carpal Tunnel Syndrome : A Randomized Controlled Trial. 2020;(May). doi:10.37200/IJPR/V24I8/PR280308

145. Yildiz N, Atalay NS, Gungen GO, Sanal E, Akkaya N, Topuz O. Comparison of ultrasound and ketoprofen phonophoresis in the treatment of carpal tunnel syndrome. *J Back Musculoskelet Rehabil*. 2011;24(1):39-47. doi:10.3233/BMR-2011-0273

146. Boonhong J, Thienkul W. Effectiveness of Phonophoresis Treatment in Carpal Tunnel Syndrome : A Randomized Double-blind , Controlled Trial. 2019:1-7. doi:10.1002/pmrj.12171

147. Okan S. Comparing The Efficiencies Of Ultrasound And Phonophoresis With Mucopolysaccharide Polysulphate Treatments In Patients With Carpal Tunnel Syndrome. *Eurasian J Med Investig*. 2019;4(3):320-326. doi:10.14744/ejmi.2019.43136

148. Soyupek F, Kutluhan S, Uslusoy G, Ilgun E, Eris S, Askin A. The efficacy of phonophoresis on electrophysiological studies of the patients with carpal tunnel syndrome. *Rheumatol Int*. 2012;32(10):3235-3242. doi:10.1007/s00296-011-2171-9

149. Soyupek F, Yesildag A, Kutluhan S, et al. Determining the effectiveness of various treatment modalities in carpal tunnel syndrome by ultrasonography and comparing ultrasonographic findings with other outcomes. *Rheumatol Int*. 2012;32(10):3229-3234. doi:10.1007/s00296-011-2173-7

150. Robertson VJ, Baker KG. A review of therapeutic ultrasound: effectiveness studies. *Phys Ther*. 2001;81(7):1339-1350. http://www.ncbi.nlm.nih.gov/pubmed/11444997.

151. Vandewalle J, Luypaert A, Bosscher K De, Libert C. Therapeutic Mechanisms of Glucocorticoids. *Trends Endocrinol Metab*. 2017;xx:1-13. doi:10.1016/j.tem.2017.10.010

152. Barnes PJ. Glucocorticosteroids: current and future directions. *Br J Pharmacol*. 2011;163(1):29-43. doi:10.1111/j.1476-5381.2010.01199.x

153. Panettieri RA, Schaafsma D, Amrani Y, Koziol-White C, Ostrom R, Tliba O. Non-genomic Effects of Glucocorticoids: An Updated View. *Trends Pharmacol Sci*. 2019;40(1):38-49. doi:10.1016/j.tips.2018.11.002

154. Bacchi S, Palumbo P, Sponta A, Coppolino MF. Clinical Pharmacology of Non-Steroidal Anti-Inflammatory Drugs: A Review. *Antiinflamm Antiallergy Agents Med Chem*. 2012;11(1):52-64. doi:10.2174/187152312803476255

155. Voloshyna I, Kasselman LJ, Carsons SE, et al. COX-2-dependent and independent effects of COX-2 inhibitors and NSAIDs on proatherogenic changes in human monocytes/macrophages. *J Investig Med*. 2017;65(3):694-704. doi:10.1136/jim-2016-000259

156. Guidelines/Outcomes Committee, Task Force. Guidelines of care for the use of topical glucocorticosteroids. *J Am Acad Dermatol*. 1996;35(4):615-619. doi:10.1016/S0190-9622(96)90690-8

157. White S. Topical non-steroidal anti-inflammatory drugs (NSAIDs) in the treatment of inflammatory musculoskeletal disorders. *Prostaglandins, Leukot Essent Fat Acids*. 1991;43(4):209-222. doi:10.1016/0952-3278(91)90033-2

158. Loza E. Revisión sistemática: ¿hay alguna razón para contraindicar el uso concomitante de antiinflamatorios no esteroideos y esteroides? *Reumatol Clínica*. 2008;4(6):220-227. doi:10.1016/S1699-258X(08)75542-6

159. de Morton NA. The PEDro scale is a valid measure of the methodological quality of clinical trials: a demographic study. *Aust J Physiother*. 2009;55(2):129-133. doi:10.1016/S0004-9514(09)70043-1

160. van Tulder M, Furlan A, Bombardier C, Bouter L. Updated Method Guidelines for Systematic Reviews in the Cochrane Collaboration Back Review Group. *Spine (Phila Pa 1976)*. 2003;28(12):1290-1299. doi:10.1097/01.BRS.0000065484.95996.AF

161. Paolillo AR, Paolillo FR, João JP, João HA, Bagnato VS. Synergic effects of ultrasound and laser on the pain relief in women with hand osteoarthritis. *Lasers Med Sci*. 2015;30(1):279-286. doi:10.1007/s10103-014-1659-4

162. Dilek B, Gozum M, Sahin E, et al. Efficacy of Paraffin Bath Therapy in Hand Osteoarthritis: A Single-Blinded Randomized Controlled Trial. *Arch Phys Med Rehabil*. 2013;94(4):642-649. doi:10.1016/j.apmr.2012.11.024

163. Myrer JW, Johnson AW, Mitchell UH, Measom GJ, Fellingham GW. Topical analgesic added to paraffin enhances paraffin bath treatment of individuals with hand osteoarthritis. *Disabil Rehabil*. 2011;33(6):467-474. doi:10.3109/09638288.2010.498552

164. Stange-Rezende L, Stamm TA, Schiffert T, et al. Clinical study on the effect of infrared radiation of a tiled stove on patients with hand osteoarthritis. *Scand J Rheumatol*. 2006;35(6):476-480. doi:10.1080/03009740600906719

165. Basford JR, Sheffield CG, Mair SD, Ilstrup DM. Low-energy helium neon laser treatment of thumb osteoarthritis. *Arch Phys Med Rehabil*. 1987;68(11):794-797. https://www.scopus.com/inward/record.uri?eid=2-s2.0-0023625943&partnerID=40&md5=06d0936257b0ea7a764055688a87a492.

166. Baltzer AWA, Ostapczuk MS, Stosch D. Positive effects of low level laser therapy (LLLT) on Bouchard's and Heberden's osteoarthritis. *LASERS Surg Med*. 2016;48(5):498-504. doi:10.1002/lsm.22480

167. Psychometrica. https://www.psychometrica.de/effect_size.html#dep.

168. Cohen J. *Statistical Power Analysis for the Behavioral Sciences, Second Edition*.; 1988. doi:10.1234/12345678

169. Copenhagen: The Nordic Cochrane Centre TCC. Review Manager (RevMan).

170. Muller M, Tsui D, Schnurr R, Biddulph-Deisroth L, Hard J, MacDermid JC. Effectiveness of hand therapy interventions in primary management of carpal tunnel syndrome: a systematic review. *J Hand Ther*. 2004;17(2):210-228. doi:10.1197/j.jht.2004.02.009

171. Maher CG, Sherrington C, Herbert RD, Moseley AM, Elkins M. Reliability of the PEDro scale for rating quality of randomized controlled trials. *Phys Ther*. 2003;83(8):713-721. http://www.ncbi.nlm.nih.gov/pubmed/12882612.

172. Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ WV, (editors). Cochrane Handbook for Systematic Reviews of Interventions version 6.2 (updated February 2021). *Cochrane*. 2021. www.training.cochrane.org/handbook.

173. Armagan O, Bakilan F, Ozgen M, Mehmetoglu O, Oner S. Effects of placebo-controlled continuous and pulsed ultrasound treatments on carpal tunnel syndrome: a randomized trial. *Clinics*. 2014;69(8):524-528. doi:10.6061/clinics/2014(08)04

174. Duymaz T. Efficacy of Some Combined Conservative Methods in the Treatment of Carpal Tunnel Syndrome: A Randomized Controlled Clinical and Electrophysiological Trial. *Turkish J Rheumatol*. 2012;27(1):38-46. doi:10.5606/tjr.2012.005

175. Ebenbichler GR, Resch KL, Nicolakis P, et al. Ultrasound treatment for treating the carpal tunnel syndrome: randomised “sham” controlled trial. *BMJ*. 1998;316(7133):731-735. doi:10.1136/bmj.316.7133.731

176. Dincer U, Cakar E, Kiralp MZ, Kilac H, Dursun H. The Effectiveness of Conservative Treatments of Carpal Tunnel Syndrome: Splinting, Ultrasound, and Low-Level Laser Therapies. *Photomed Laser Surg*. 2009;27(1):119-125. doi:10.1089/pho.2008.2211

177. Baysal O, Altay Z, Ozcan C, Ertem K, Yologlu S, Kayhan A. Comparison of three conservative treatment protocols in carpal tunnel syndrome. *Int J Clin Pract*. 2006;60(7):820-828. doi:10.1111/j.1742-1241.2006.00867.x

178. Carlsson AM. Assessment of chronic pain. I. Aspects of the reliability and validity of the visual analogue scale. *Pain*. 1983;16(1):87-101. doi:10.1016/0304-3959(83)90088-X

179. Levine DW, Simmons BP, Koris MJ, et al. A self-administered questionnaire for the assessment of severity of symptoms and functional status in carpal tunnel syndrome. *J Bone Jt Surg*. 1993;75(11):1585-1592. doi:10.2106/00004623-199311000-00002

180. The Nordic Cochrane Centre. Review Manager (RevMan). *Cochrane Collab*. 2014.

181. Chiu Y-H, Chang K-V, Chen I-J, Wu W-T, Özçakar L. Utility of sonoelastography for the evaluation of rotator cuff tendon and pertinent disorders: a systematic review and meta-analysis. *Eur Radiol*. 2020;30(12):6663-6672. doi:10.1007/s00330-020-07059-2

182. Gurcay E, Unlu E, Gurcay AG, Tuncay R CA. Assessment of phonophoresis and iontophoresis in the treatment of carpal tunnel syndrome: a randomized controlled trial. *Rheumatol Int*. 2012;32(717-22.).

183. Entrambasaguas M De, Máñez I, Girona G, Poyatos J. Infiltración de esteroides , férula de muñeca y fonoforesis en el síndrome del túnel carpiano. *Rehabilitación*. 2006;40(4):193-200. doi:10.1016/S0048-7120(06)74891-5

184. Saliha Karatay a RA b, A MAM a KY a MUAE, S¸enel SAK. The comparison of phonophoresis, iontophoresis and local steroid injection in carpal tunnel syndrome treatment. 2009;76(November 2007):2007-2009. doi:10.1016/j.jbspin.2009.02.003

185. Carlsson AM. Assessment of chronic pain. I. Aspects of the reliability and validity of the visual analogue scale. *Pain*. 1983;16(1):87-101. doi:10.1016/0304-3959(83)90088-X

186. Levine DW, Simmons BP, Koris MJ, et al. A self-administered questionnaire for the assessment of severity of symptoms and functional status in carpal tunnel syndrome. *J Bone Jt Surg*. 1993;75(11):1585-1592. doi:10.2106/00004623-199311000-00002

187. Chudinova OA, Fedorov AA, Venediktov DL, Samokhvalova GN, Il'ina MI, Budlianskaia S V. [Pulsed low-frequency electrotherapy of vibration disease associated with osteoarthrosis]. *Vopr Kurortol Fizioter Lech Fiz Kult*. 2010;(3):15-18. https://www.scopus.com/inward/record.uri?eid=2-s2.0-78049451842&partnerID=40&md5=95195af039f32bc8a39a2507840df49d.

188. Renklitepe N, Dogan N, Kayhan O ON. Rizartrozda TENS uygulamalarinda degisik elektrodlarin etkileri(Effects of different TENS electrode types in degenerative joint disease of the hands). *Fiz Tedavi Rehabil Derg*. 1995;19:204-208.

189. Ekim, Ayse and EC. "Ultrasound treatment in carpal tunnel syndrome: a placebo controlled study/Karpal tunel sendromunda ultrason tedavisi: plasebo kontrollu bir calisma." *Turkish J Phys Med Rehabil*. 2008:96-101.

190. Tikiz C, Cerrahoglu L. Karpal Tünel Sendromunda Düşük Enerjili Lazer ve Kesikli Ultrason Tedavi Etkinliklerinin Karşılaştırılması : Plasebo Kontrollü Bir Çalışma. *Türkiye Fiz Tıp ve Rehabil Derg*. 2013;(September). doi:10.4274/tftr.04764

191. Koyuncu F, Sahin U, Togay P UH. 1MHz - 3MHz ultrasound applications in carpal tunnel syndrome [Karpal tunel sendromunda 1MHz - 3MHz ultrason uygulamasi]. *Fiz Tedavi ve Rehabil Derg*. 1995;19:141-5.i.

192. Piravej K, Boonhong J. Effect of ultrasound thermotherapy in mild to moderate carpal tunnel syndrome. *J Med Assoc Thai*. 2004;87 Suppl 2:S100-6. http://www.ncbi.nlm.nih.gov/pubmed/16083171.

193. Bartkowiak Z, Eliks M, Zgorzalewicz-Stachowiak M, Romanowski L. The effects of nerve and tendon gliding exercises combined with low-level laser or ultrasound therapy in carpal tunnel syndrome. *Indian J Orthop*. 2019;53(2):347. doi:10.4103/ortho.IJOrtho_45_17

194. Bakhtiary A, Fatemi E, Emami M, Malek M. Comparing the effects of iontophoresis and phonophoresis of dexamethasone on the treatment of carpal tunnel syndrome. *Koomesh*. 2011;13:83-93. http://koomeshjournal.semums.ac.ir/article-1-1190-en.html.

195. Lazovic M, Kocic M, Hrkovic M, et al. Effectiveness of combined ultrasound and exercise therapy in the treatment of carpal tunnel syndrome - randomized, placebo-controlled investigation. *Srp Arh Celok Lek*. 2018;146(9-10):561-566. doi:10.2298/SARH180214050L

196. Oztas O, Turan B, Bora I, Karakaya MK. Ultrasound therapy effect in carpal tunnel syndrome. *Arch Phys Med Rehabil*. 1998;79(12):1540-1544. doi:10.1016/S0003-9993(98)90416-6

197. En S, Mbbs S, Gunasagaran J, et al. Short-term clinical outcome of orthosis alone vs combination of orthosis , nerve , and tendon gliding exercises and ultrasound therapy for treatment of carpal tunnel syndrome. *J Hand Ther*. 2018:3-7. doi:10.1016/j.jht.2018.01.004

198. Chang Y, Hsieh S, Horng Y-S, Chen H, Lee K, Horng Y. Comparative effectiveness of ultrasound and paraffin therapy in patients with carpal tunnel syndrome: a randomized trial. *BMC Musculoskelet Disord*. 2014;15(1):399. doi:10.1186/1471-2474-15-399

199. Çatalbaş N, Akkaya N, Atalay NS, Sahin F. Ultrasonographic imaging of the effects of continuous, pulsed or sham ultrasound treatments on carpal tunnel syndrome: A randomized controlled study. *J Back Musculoskelet Rehabil*. 2018;31(5):981-989. doi:10.3233/BMR-160652

200. Steroid L. ve Lokal Kortikosteroid Enjeksiyonu Tedavilerinin Klinik Etkinliğinin Karşılaştırılması. 2011;(March 2010):119-123.

201. Asheghan M, Khatibi Aghda A, Sobhani V, Ebrahim Hashemi S, Taghi Hollisaz M. A randomized comparative trial of corticosteroid phonophoresis, local corticosteroid injection, and low-level laser in the treatment of carpal tunnel syndrome. *LASER Ther*. 2020;29(1):11-17. doi:10.5978/islsm.20-OR-01

202. Aygül R, Ulvi H, Karatay S, Deniz O, Varoglu AO. Determination of sensitive electrophysiologic parameters at follow-up of different steroid treatments of carpal tunnel syndrome. *J Clin Neurophysiol*. 2005;22(3):222-230. http://www.ncbi.nlm.nih.gov/pubmed/15933496.

203. Gurcay E, Unlu E, Gurcay AG, Tuncay R, Cakci A. Assessment of phonophoresis and iontophoresis in the treatment of carpal tunnel syndrome: a randomized controlled trial. *Rheumatol Int*. 2012;32(3):717-722. doi:10.1007/s00296-010-1706-9

204. Bakhtiary AH, Fatemi E, Emami M, Malek M. Phonophoresis of Dexamethasone Sodium Phosphate May Manage Pain and Symptoms of Patients With Carpal Tunnel Syndrome. *Clin J Pain*. 2013;29(4):348-353. doi:10.1097/AJP.0b013e318255c090

205. Preston D CSBE. *Electromyography and Neuromuscular Disorders. Clinical- Electrophysiologic Correlations.*

206. Scriba PC, Fries M. Aminoacyltransferase stimulation of protein synthesis by pig adrenal polysomes. *Nature*. 1967;214(5083):91-92. doi:10.1038/214091a0

207. van de Laar M. Pain Treatment in Arthritis-Related Pain: Beyond NSAIDs. *Open Rheumatol J*. 2012;6(1):320-330. doi:10.2174/1874312901206010320

208. Milenkovic M, Kocic M, Balov B, Stojanovic Z, Savic N, Ivanovic S. Influence of kinesiophobia on activities of daily living of elder institutionalized persons with chronic pain. *Prax medica*. 2015;44(3):55-59. doi:10.5937/pramed1503055m

209. Allen KD, Jordan JM, Renner JB, Kraus VB. Relationship of global assessment of change to AUSCAN and pinch and grip strength among individuals with hand osteoarthritis. *Osteoarthr Cartil*. 2006;14(12):1281-1287. doi:10.1016/j.joca.2006.06.004

210. Jain R, Jain E, Dass AG, Wickstrom O, Walter N, Atkinson PJ. Evaluation of Transdermal Steroids for Trapeziometacarpal Arthritis. *J Hand Surg Am*. 2010;35(6):921-927. doi:10.1016/j.jhsa.2010.02.013

211. Padua L, LoMonaco M, Gregori B, Valente EM, Padua R, Tonali P. Neurophysiological classification and sensitivity in 500 carpal tunnel syndrome hands. *Acta Neurol Scand*. 2009;96(4):211-217. doi:10.1111/j.1600-0404.1997.tb00271.x

212. Vyšata O, Procházka A, Kunc P, et al. Age delays the recovery of distal motor latency after carpal tunnel syndrome surgery. *Acta Neurochir (Wien)*. 2014;156(7):1335-1339. doi:10.1007/s00701-014-2065-1

213. Padua L, LoMonaco M, Aulisa L, et al. Surgical prognosis in carpal tunnel syndrome: usefulness of a preoperative neurophysiological assessment. *Acta Neurol Scand*. 1996;94(5):343-346. doi:10.1111/j.1600-0404.1996.tb07077.x

214. Lee S, Kim D, Cho H-M, Nam H-S, Park D-S. Diagnostic Value of the Second Lumbrical-Interosseous Distal Motor Latency Comparison Test in Severe Carpal Tunnel Syndrome. *Ann Rehabil Med*. 2016;40(1):50.

doi:10.5535/arm.2016.40.1.50

215. Kanatani T, Fujioka H, Kurosaka M, Sumi M, Yamasaki K. Usefulness of Distal Motor Latency Measurement After Palmar Stimulation in Advanced Carpal Tunnel Syndrome. *J Clin Neurophysiol*. 2012;29(3):260-262. doi:10.1097/WNP.0b013e3182570ee3

216. Vahdatpour B, Khosrawi S, Chatraei M. The Role of median nerve terminal latency index in the diagnosis of carpal tunnel syndrome in comparison with other electrodiagnostic parameters. *Adv Biomed Res*. 2016;5(1):110. doi:10.4103/2277-9175.183671

217. Caliandro P, Giannini F, Pazzaglia C, et al. A new clinical scale to grade the impairment of median nerve in carpal tunnel syndrome. *Clin Neurophysiol*. 2010;121(7):1066-1071. doi:10.1016/j.clinph.2010.02.002

218. You H, Simmons Z, Freivalds A, Kothari MJ, Naidu SH. Relationships between clinical symptom severity scales and nerve conduction measures in carpal tunnel syndrome. *Muscle Nerve*. 1999;22(4):497-501. doi:10.1002/(SICI)1097-4598(199904)22:4<497::AID-MUS11>3.0.CO;2-T

219. Farivar S, Malekshahabi T, Shiari R. Biological effects of low level laser therapy. *J lasers Med Sci*. 2014;5(2):58-62. http://www.ncbi.nlm.nih.gov/pubmed/25653800%0Ahttp://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=PMC4291815.

220. Rubin DI, Dimberg EL. Needle EMG of Thenar Muscles in Less Severe Carpal Tunnel Syndrome. *J Clin Neurophysiol*. 2018;35(6):481-484. doi:10.1097/WNP.0000000000000519

221. KOÇ F, YERDELEN D, SARICA Y, SERTDEMİR Y. MOTOR UNIT NUMBER ESTIMATION IN CASES WITH CARPAL TUNNEL SYNDROME. *Int J Neurosci*. 2006;116(11):1263-1270. doi:10.1080/00207450500516479

222. Arendt-Nielsen L, Gregersen H, Toft E, Bjerring P. Involvement of thin afferents in carpal tunnel syndrome: Evaluated quantitatively by argon laser stimulation. *Muscle Nerve*. 1991;14(6):508-514. doi:10.1002/mus.880140604

223. de Tommaso M, Libro G, Difruscolo O, et al. Laser evoked potentials in Carpal Tunnel Syndrome. *Clin Neurophysiol*. 2009;120(2):353-359. doi:10.1016/j.clinph.2008.11.017

224. Padua L, LoMonaco M, Aulisa L, et al. Surgical prognosis in carpal tunnel syndrome: usefulness of a preoperative neurophysiological assessment. *Acta Neurol Scand*. 1996;94(5):343-346. doi:10.1111/j.1600-0404.1996.tb07077.x

225. Chalupa CPTRL, Aberle C, Johnson LTCPAE. The united states army medical department. 2016.

226. Lee S, Kim D, Cho H. Diagnostic Value of the Second Lumbrical-Interosseous Distal Motor Latency Comparison Test in Severe Carpal Tunnel Syndrome. 2016;40(1):50-55.