# Exercise therapy for tendinopathy: a scoping review mapping interventions and outcomes.

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# Exercise therapy for tendinopathy: A scoping review mapping interventions and outcomes

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**Conflicts of Interest**

The authors declare no conflict of interest.

**ABSTRACT**

**Objective**

To comprehensively map exercise interventions and outcomes across all tendinopathies.

**Methods**

Design: Scoping review.

Eligibility criteria (PCC): *Participants*: any age or gender with any tendinopathy; *Concept*: supervised or unsupervised exercise of any type or format, delivered by any professional and any outcome used to evaluate any exercise intervention; *Context*: any setting in any country listed as very high on the human development index.

Data sources: nine databases, four trial registries and six grey literature sources. At least two reviewers independently conducted title, abstract and full text screening. Data extraction was conducted using a bespoke tool developed for this review, informed by the TIDieR checklist and ICON health-related domains, to interpret exercise reporting and outcomes across included studies.

**Results**

Extracted data from 555 included studies from 31 countries incorporated 25,490 participants with mean study ages ranging from 15-65 years. A range of exercise interventions including strengthening, flexibility, aerobic, proprioceptive, and motor control were identified; showing rotator cuff-related shoulder pain, Achilles, patellar and lateral elbow tendinopathies were most studied. A range of health-related domains were measured by numerous outcome tools, with little consistency within domains or tendinopathies. Reporting of participant characteristics, interventions and adherence was highly variable.

**Conclusion**

This first comprehensive map of exercise and outcomes for tendinopathy has identified four recommendations to be considered for future tendinopathy research: 1) Specific robust high quality research study designs; (2) Comprehensive research reporting; 3) Patient/practitioner lived experience; and 4) comprehensive high quality evidence synthesis.

**Key words –** tendinopathy, exercise, physiotherapy, outcome assessment, scoping review

## 1.0 INTRODUCTION

Tendinopathy is a musculoskeletal condition frequently experienced by athletic, active and sedentary adult populations, characterised by discomfort, reduced function and disability [1]. Management of tendinopathy includes a range of interventions, with exercise the most common [2,3]. Exercise for tendinopathy can involve one or more of strength (e.g., eccentric, concentric, isometric, heavy slow resistance); flexibility (e.g., stretching, range of motion); proprioception or motor control exercises. However, the effectiveness of specific types as stand-alone treatments, in combination with each other, or with other interventions, is not fully established. Further work is required to determine the short and long-term effects of exercise types across upper and lower-limb tendinopathies [4–8].

Exercise is often described as the gold standard intervention for tendinopathy, but the certainty with which this can be claimed is unclear. Despite the range of exercise interventions available, many patients continue to experience pain and disability after interventions end [3]. The reason for this is unclear, but it may be due to inappropriate selection of treatment parameters such as exercise type, dose, and supplementary treatment modalities. However, low certainty evidence, due to limitations in study quality, has also contributed to uncertainty in exercise intervention outcomes [7,9,10]. Given the substantial body of evidence on exercise interventions for tendinopathies, it is important to map what is, and is not, currently known, that can then inform meaningful future research and evidence synthesis on this important topic. Scoping review methodology is best placed to enable this comprehensive mapping, and no such scoping review has been conducted previously. Therefore, the aim of this scoping review was to comprehensively map the existing evidence on exercise for the treatment of tendinopathies, addressing two specific questions: 1) What exercise interventions have been reported in the literature and for which tendinopathies? 2) What outcomes have been reported in studies investigating exercise interventions for tendinopathies? The results of this scoping review will inform subsequent systematic reviews to be conducted by this review team.

## 2.0 METHOD

### 2.1 Design

This review was conducted in accordance with JBI scoping review methodology [11] and the objectives and methods were registered and published as an *a-priori* protocol [12]. Scoping review methodology enables Reporting of this review was guided by the PRISMA extension for scoping reviews [13].

### 2.2 Inclusion criteria

Inclusion criteria for this review were classified using the "PCC" (Participants, Concept, Context) mnemonic.

*Participants*: People of any age or gender with a diagnosis of tendinopathy of any severity or duration and at any anatomical location were included. Large, full-thickness or massive tears were excluded, as were groups where tear size could not be determined [14]. Plantar heel pain was excluded as it is not a true tendinopathy and may respond differently to exercise compared with other common tendinopathies [15]. Wrist and hand tendinopathy were also excluded for this reason.

*Concept*: Exercise interventions that could be categorised as one or more of strengthening, flexibility, aerobic, proprioception or motor control were included. They could be first or second-line interventions and could be used in isolation or in combination with other interventions such as injection, extracorporeal shockwave therapy (ESWT), or manual therapy. Studies focussing on exercise following surgical repair were excluded as the review concerned non-surgical management of tendinopathy. Exercise interventions delivered by any health or exercise professional (e.g., physiotherapist, strength & conditioning coach, personal trainer) or support worker, either supervised or unsupervised were included. Any outcomes used to evaluate exercise interventions were included.

*Context*: All settings including primary care, secondary care, community locations or people's homes in any developed nation (defined as the top 62 countries in the Human Development Index; HDI [16]) were included.

### 2.3 Types of sources

To produce a comprehensive map of exercise interventions we included a range of study designs including experimental, observational, pilot, mixed-methods, qualitative and systematic reviews. Systematic reviews were included to map previous evidence syntheses and avoid replication in

future reviews. Opinion, narrative or other non-systematic reviews, protocols, and case studies were excluded.

**2.4 Search Strategy**

A three-step search strategy was employed. Firstly, a limited search of CINAHL and Medline was conducted using exercise and tendinopathy terms. By reviewing the titles, abstracts and index terms of search results, a full search strategy using a combination of subject headings and keywords was constructed and adapted for each database before being applied to: MEDLINE, CINAHL, AMED, SPORTDiscus (all EBSCOhost), EMBase (Ovid), Cochrane library (Controlled trials, Systematic reviews), JBI Evidence Synthesis, PEDRo, and Epistemonikos. Grey and unpublished literature was searched for in trial registries (ClinicalTrials.gov, ISRCTN Registry, The Research Registry, EU-CTR [European Union Clinical Trials Registry], ANZCTR [Australia and New Zealand Clinical Trials Registry]), Open Grey, MedNar, The New York Academy Grey Literature Report, Ethos, CORE, and Google Scholar using modified search terms. Full search strategies are presented in Supplementary file 1 (SF1). Four tendinopathy experts external to the review team reviewed the included study list for completeness. We included sources published in any language where a translation was accessible via Google Translate or the review team's international networks. Searches were limited to 1998 onwards following the seminal publication of Alfredson et al.'s [17] eccentric protocol for Achilles tendinopathy.

**2.5 Study selection**

Following the search, all identified sources were collated and uploaded into ProQuest® RefWorks and duplicates removed. Sources were then imported to Covidence (Melbourne, Australia) for two-level screening. Firstly, titles and abstracts were screened independently by two reviewers with conflicts identified by the management software and resolved by a third reviewer. Secondly, full-text copies of all sources included at title and abstract screening stage were then screened using the same processes. Excluded sources at full-text screening and reasons for exclusion are reported in Supplementary file 2 (SF2).

**2.6 Data extraction**

A data extraction tool developed for this review was used to extract the following information from primary studies: author(s); year of publication; country; aims/purpose including the author's focus on exercise i.e. primary (exercise as the novel intervention being studied), secondary (exercise as the control arm to another novel intervention), neutral (exercise being compared with other intervention/s where neither is the novel intervention or main focus of study); setting; population;

study design; tendinopathy type; exercise intervention details including reporting and monitoring; outcomes including domains and tools used to evaluate interventions, and key findings. Data extraction from systematic reviews was limited to year of publication, aims/purpose, and tendinopathy type, as information on interventions and outcomes were extracted from the primary studies. Piloting and iterative development of the data extraction tool was conducted among the review team prior to commencing final extraction. Ten percent of data extraction was replicated in an informal assessment of consistency that was identified as appropriate and reflected the extensive piloting and discussions among the review team. In accordance with scoping review methodology, critical appraisal was not conducted [11].

**2.7 Data synthesis**

The extracted data were synthesised and integrated into a series of visual outputs to present a comprehensive map of exercise interventions and outcomes; data are presented alongside an accompanying narrative. Exercise intervention components were mapped against the template for intervention description and replication (TIDieR) checklist [18] to identify consistency in reporting of interventions. Outcomes were recorded as domains informed by the International Scientific Tendinopathy Symposium Consensus (ICON) health related domains [19]. For completeness, we adopted the 24 candidate domains identified at stage 1 of the ICON Delphi process to fully map all domains reported in the included sources, rather than the nine core domains finally recommended by Vicenzino et al. [19]. Data were imported from MS Exceland analysed in the R programming environment. A citation analysis was conducted using citation, bibliographical, author and keyword information obtained from Scopus and Bibliometrix [20].

## 3.0 RESULTS

The search identified 22,550 sources, of which 1,994 were obtained in full text following deduplication and title and abstract screening. A further 1,439 sources were excluded following full-text screening, leaving 548 studies from a total of 555 total sources as seven studies were reported in more than one source. The main reasons for exclusion at full-text screening were ineligible study design (n=600, 42%), duplicate study (n=351, 24%), ineligible population (n=150, 10%), ineligible concept (n=101, 7%) or not originating from a developed country (n=99, 7%) (see SF2). The study selection process is presented in Figure 1 and a reference list of included sources is presented in Supplementary file SF3.

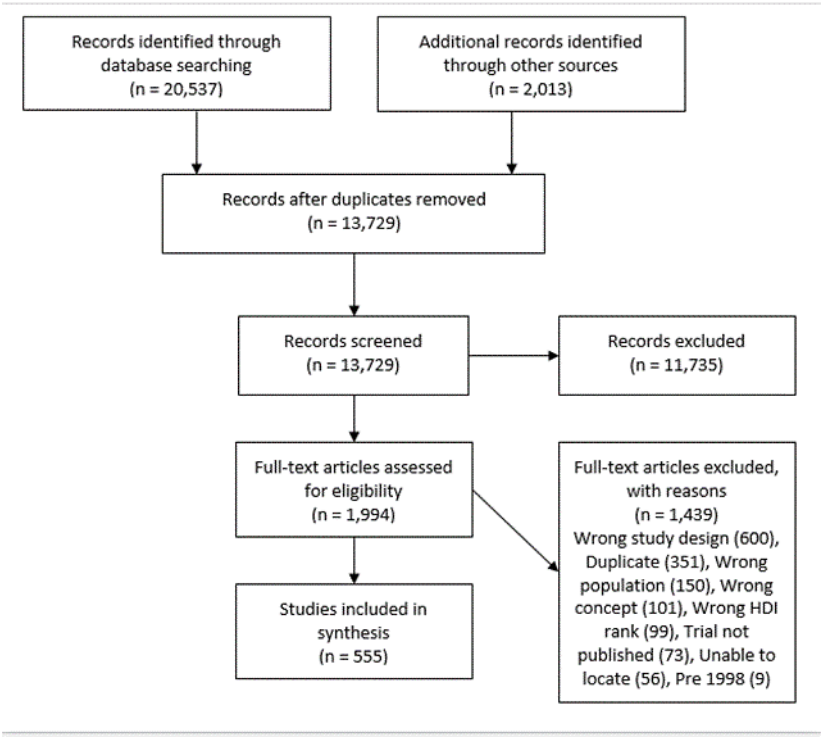


**Figure 1:** Study selection process – PRISMA flow chart (37)

The 555 included sources comprised 119 (21%) systematic reviews and 436 (79%) primary studies. A summary of study characteristics of the included studies is presented in an interactive and searchable table (Supplementary file SF4). Assessment of the included studies publication dates identified a consistent increase in the volume of research from 1998, reaching a peak of 50 studies published in 2019 and an average of 37 studies published each year between 2010 -2019 (Figure 2).

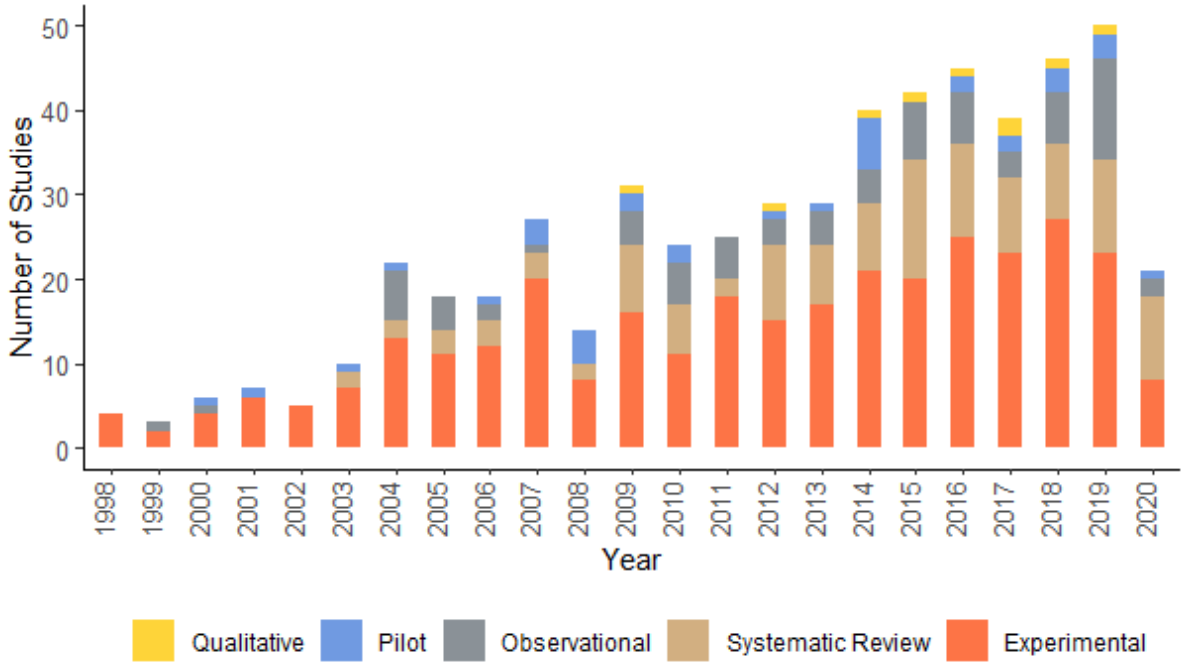


**Figure 2:** Number of included studies published over time and their study design composition.

**3.1 Systematic reviews:**

A total of 119 systematic reviews were included, comprising 72 (61%) systematic reviews without meta-analysis, 45 (37%) systematic reviews with meta-analysis, and two (2%) umbrella reviews. The number of studies included in the systematic reviews ranged from two to 84 with a median of 12 (IQR: 8-19). A total of 43 (36%) systematic reviews synthesised findings from studies solely investigating rotator cuff-related shoulder pain (RCRSP). The next most common tendinopathy types investigated were the Achilles (26; 22%), lateral elbow (14; 12%) and patellar (14; 12%). Five (4%) systematic reviews synthesised information related to both Achilles and Patellar tendinopathies, three (3%) focussed on gluteal or posterior tibial tendinopathies, two (2%) on the hamstring or medial elbow, and one (1%) on the quadriceps. Most systematic reviews were conducted by research teams located primarily in four countries; UK (28; 23%), Australia (17; 14%), USA (14; 12%) and Netherlands (13; 11%). Exercise was the primary focus in 46 (38%) included systematic reviews, a secondary focus (e.g., control) in 49 (42%), and a neutral focus (i.e., equivalence between exercise and other interventions) in 24 (20%). Exercise was more commonly the primary focus of systematic reviews investigating Achilles (46%) and patellar (43%) tendinopathies, compared with RCRSP (34%) and lateral elbow tendinopathy (29%).

**3.2 Primary studies:**

*Study demographics*

The predominant design for the 436 included primary studies was randomised controlled trial (RCT) (236; 54%), followed by quasi-experimental (81; 19%), observational (75; 17%), pilot (35; 8%) and qualitative (9; 2%). The studies comprised information obtained from 25,490 participants (male = 10,463; female = 10,734), with study mean age ranging from 15-65 years. Most studies were conducted in a mixed setting (116; 27%), with clinic (91; 21%) and home settings (61; 14%) reported. A total of 31 countries were identified with most studies conducted in four countries including Turkey (60; 14%), USA (48; 11%), UK (43; 10%) and Australia (32; 7%). A range of additional participant characteristics were recorded across 362 studies (83%) with the most frequently reported including symptom duration (253; 70%), weight (115; 32%), stature (113; 31%), affected side (including bilateral) (105; 29%), BMI (102; 28%), hand/limb dominance (86; 24%), activity level (82; 23%), employment status (50; 14%), previous treatment (34; 9%), number of activity sessions (hours of sport/week, mileage/week, training/week: (28; 7%), education level (22; 6%), co-morbidities (21, 6%), smoking status (18; 5%), analgesic/NSAID use (16; 4%), mechanism of injury/causation (15; 4%), previous history/episodes (14; 4%), interference with sports participation (13; 4%), location of symptoms (13; 4%), manual work (11; 3%), and ethnicity (9; 2%). Of the nine studies reporting ethnicity, European/Caucasian participants were included in them all, with African American (4 studies), Hispanic/Latino (3 studies), Asian (1 study) and Māori (1 study) also reported. Sixty studies (17%) did not report any additional characteristics.

Four tendinopathy types accounted for over 90% of the research with 167 (38%) studies focusing on RCRSP, 103 (23%) Achilles, 82 (19%) lateral elbow, and 53 (12%) patellar tendons. Less frequently investigated tendinopathies included gluteal, tibialis posterior and hamstring which were the focus of 9 (2%), 7 (2%) and 3 (1%) studies, respectively. The study design composition for the four most common tendinopathy types is illustrated in figure 3. Experimental studies were most common with few, or no qualitative studies conducted on each of the common tendinopathies.

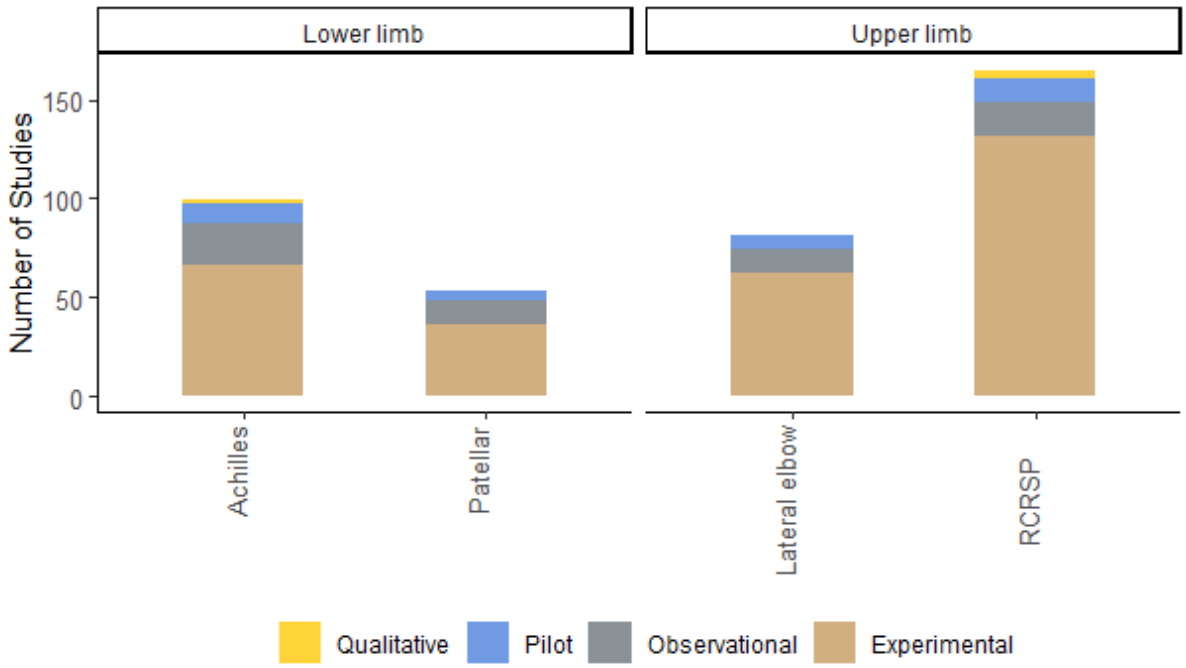


**Figure 3:** Study designs across main tendinopathy types.

*Exercise interventions investigated*

Exercise interventions were reported as the primary focus of 161 (37%) studies, the secondary focus of 188 (43%) studies, and a neutral focus in 87 (20%) studies. Components of the different exercise interventions were categorised as strengthening, flexibility, aerobic, proprioception or motor control and determined by the authors stated purpose. A mapping of the different exercise intervention components and subcomponents across different tendinopathy types is presented in table 1. The most common exercise type reported across tendinopathies was strengthening (84%), followed by flexibility (48%). All patellar tendinopathy studies reported the use of strengthening exercise, compared to 77 to 93% of studies for other tendinopathies. While eccentric was the most common strengthening exercise reported for Achilles (89%), patellar (85%) and lateral elbow tendinopathy (44%), RCRSP studies reported isometric (21%) followed by a combination of eccentric and concentric (19%) as most common. For flexibility exercise, this was mostly reported for upper limb tendinopathies (RCRSP 62%; lateral elbow 65%) compared to lower limb (patellar 25%; Achilles 20%). Flexibility exercise was poorly described across all tendinopathies with 17% of studies not providing sufficient detail to categorise the type of flexibility exercise included. Dynamic range of motion was the most common form of flexibility exercise used for RCRSP (38%), with traditional stretching (such as static sustained) most common for all other tendinopathies (6 to 37%). Patellar tendinopathy studies reported greater use of aerobic exercise (17%) compared to other tendinopathies (0 to 13%). Motor control exercise was mainly reported in RCRSP studies (40%).

**Table 1:** Exercise types reported across tendinopathies

| | All (n = 436) | Rotator cuff (n=165) | Achilles (n=99) | Lateral Elbow (n=81) | Patellar (n=53) | Other (n=38) |
|---|---|---|---|---|---|---|
| **Strengthening** | 367 (84%) | 128 (78%) | 92 (93%) | 62 (77%) | 53 (100%) | 32 (84%) |
| Eccentric | 205 (47%;56%) | 21 (13%;16 %) | 88 (89%;96 %) | 36 (44%;58 %) | 45 (85%;85 %) | 15 (39%;47 %) |
| Concentric | 37 (8%) | 12 (7%) | 4 (4%) | 5 (6%) | 9 (17%) | 7 (18%) |
| Eccentric + Concentric | 49 (11%;13%) | 32 (19%;25 %) | 1 (1%;1 %) | 6 (7%;10 %) | 2 (4%;4 %) | 8 (21%;25 %) |
| Isometric | 68 (16%;19%) | 34 (21%;27 %) | 5 (5%;5 %) | 11 (14%;18 %) | 10 (19%;19 %) | 8 (21%;25 %) |
| Progressive | 28 (6%;8%) | 19 (12%;15 %) | 0 (0%;0%) | 5 (6%;8%) | 1 (2%;2%) | 3 (8%;9%) |
| Isotonic | 15 (3%;4%) | 11 (7%;9%) | 1 (1%;1%) | 2 (2%;3%) | 1 (2%;2%) | 0 (0%;0%) |
| Isokinetic | 17 (4%;5%) | 6 (4%;5%) | 1 (1%;1%) | 1 (1%;2%) | 3 (6%;6%) | 6 (16%;19 %) |
| HSRT | 4 (1%;1%) | 0 (0%;0%) | 0 (0%;0%) | 1 (1%;2%) | 3 (6%;6%) | 0 (0%;0%) |
| Plyometric | 12 (3%3%) | 2 (1%;2%) | 4 (4%4%) | 3 (4%;5%) | 1 (2%;2%) | 2 (5%;6%) |
| | | | | | | |
| **Flexibility** | 208 (48%) | 103 (62%) | 20 (20%) | 53 (65%) | 14 (26%) | 18 (47%) |
| Traditional stretching | 95 (22%;46%) | 42 (25%;41%) | 6 (6%;30%) | 30 (37%;57%) | 6 (11%;43%) | 11 (29%;61%) |
| Dynamic/ROM | 72 (17%;35%) | 63 (38%;61%) | 0 (0%;0%) | 5 (6%;9%) | 1 (2%;7%) | 3 (8%;17%) |
| PNF | 14 (3%;7%) | 8 (5%;8%) | 0 (0%;0%) | 4 (5%;8%) | 0 (0%;0%) | 2 (5%;11%) |
| No detail | 75 (17%;36%) | 32 (19%;31%) | 12 (12%;60%) | 17 (21%;32%) | 7 (13%;50%) | 7 (18%;39%) |
| | | | | | | |
| **Proprioception** | 21 (5%) | 10 (6%) | 2(2%) | 2(2%) | 2 (4%) | 5(13%) |
| | | | | | | |
| **Motor control** | 73 (17%) | 66 (40%) | 0 (0%) | 1 (1%) | 1 (2%) | 5 (13%) |
| | | | | | | |
| **Aerobic** | 24 (6%) | 4 (2%) | 6 (6%) | 0 (0%) | 9 (17%) | 5(13%) |

Key: HSRT – Heavy slow resistance training; ROM – range of motion; PNF – proprioceptive neuromuscular facilitation; Traditional Stretching – static and sustained hold. % - Percentage of column total. (%; %) - Percentage of column total and percentage of strengthening/flexibility total.

*Exercise intervention reporting*

All exercise interventions were mapped to the TIDieR checklist [18] and are presented for all tendinopathies in Figure 4 and for individual tendinopathies in Figure 5. The intervention setting was often not reported (51%) or only partially reported (19%). Additionally, over a third of studies did not report the how (mode of delivery, 38%), who (intervention provider expertise, 37%), why (rationale, theory, or goal, 36%), or what (physical or informational materials used, 35%) components of interventions. Data from the TIDieR checklist was used by the review team to categorise study interventions as fully reproducible (all details reported to enable reproduction of the exercise), partially reproducible (some but not all details of exercise reported to enable partial reproduction of the exercise) or not reproducible (Figures 4 & 5). Reproducibility was assessed across different tendinopathies with the majority of interventions (56 to 74%) categorised as partially reproducible, and only a minority (4 to 15%) categorised as fully reproducible.

Monitoring adherence to exercise was planned by authors in 152 studies and comprised eight different methods: exercise diaries (71% of the methods), summary records from therapist (8%), self-report (7%), therapist individual session records (6%), follow-up phone calls to monitor attendance (4%), follow-up appointments to monitor adherence (3%), and adherence reported by family member (1%). However, adherence data were only reported in 89 (59%) of the 152 studies that stated they had planned to do so (20% of all primary studies). Reported adherence means ranged from 16% to 100% in individual studies and was 77% across all studies. Authors also used varied grading of adherence from subjective terms such as “high,” “good”, and “adherent” to aligning frequencies to rankings of poor to excellent (e.g., >75% “good”, 70% “good/excellent”, 25-75% “moderate to excellent”, 50% “good”, 27% “moderate to poor”). Studies also reported a reduction in adherence over time with 12-week adherence ranging from 27% to 94.2% and two-year adherence ranging from 41% to 87.4%.

Reporting of modifications (any modifications to the intervention during the study) and tailoring (planned personalisation, titration, or adaptions) of exercise interventions were also recorded. Tailoring was reported in 247 (56%) studies. Tailoring involved personalised progression of exercise via increasing sets, number of sessions per day, repetitions, resistance/load, speed, duration of muscle contraction, time spent on exercise, range of motion, difficulty (up to 13-15 rating of perceived exertion), addition of new exercises, reducing base of support/stability, gradual increase in other physical and sporting activities, and progression from low to higher impact activities. These progressions were determined by the physiotherapist/exercise professional, improved quality of movement control, full range of movement, ratings of participant perceived effort (Borg 1982) (e.g., less than 7, up to 11-14), fatigue, the absence of pain, pain rated as no more than 3-5/10 on a pain scale, or as “pain allowed”. Tailoring also involved decrements in exercise via reduced loading and

range of motion due to participant-reported pain, including pain greater than 4-5/10 or pain that did not subside immediately (or within 10-15 minutes post exercise). Modifications were reported in only 20 (5%) studies. These included participants being withdrawn and referred for further investigation, follow-up appointments for participants as required to facilitate self-management or for any difficulties, alternative planes of motion or training technique modifications that were more comfortable for participants or due to additional musculoskeletal problems occurring during the study.

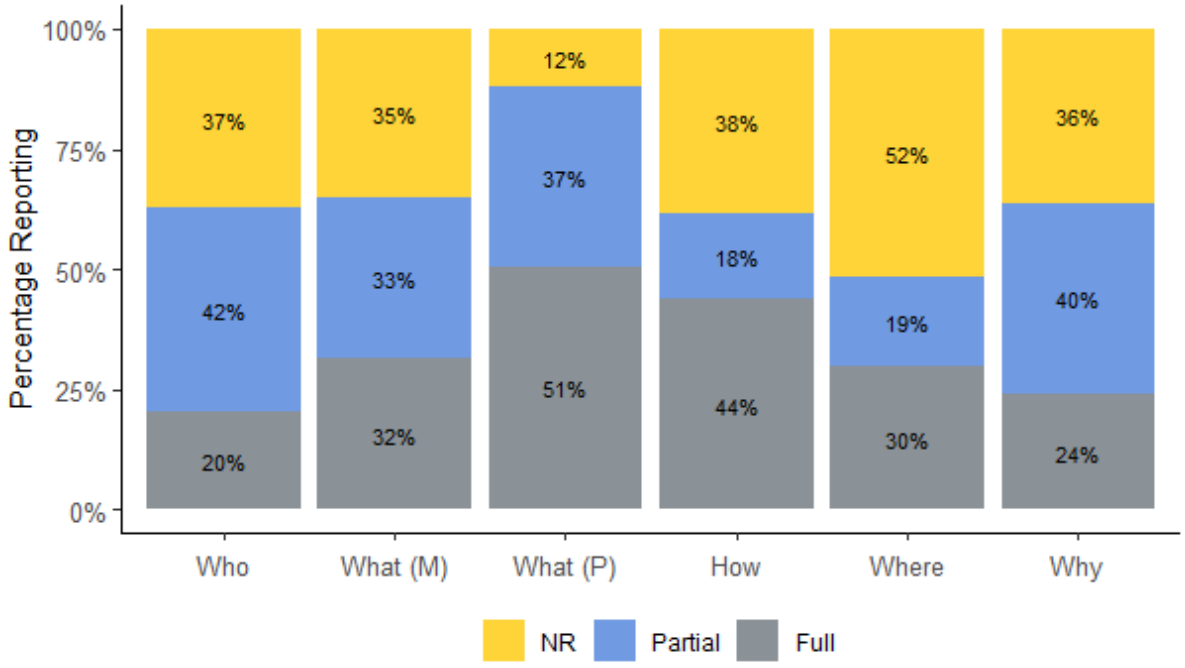


**Figure 4:** Exercise therapy reporting across all tendinopathy types using the TIDieR checklist.

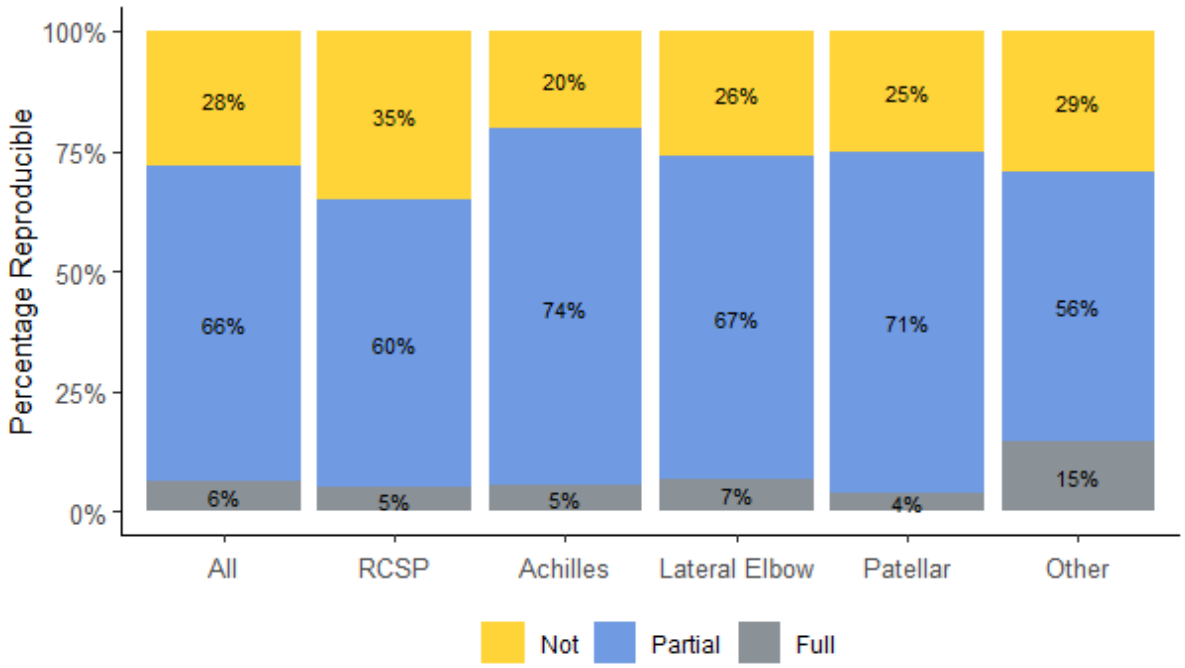


**Figure 5:** Reproducibility of exercise therapies across tendinopathy types using the TIDieR checklist.

*Exercise therapy adjuncts*

Treatment adjuncts (non-exercise treatments in addition to the exercise component of their intervention) alongside exercise were included in 140 studies (44%) whereas 109 did not (67 were not applicable due to study design). The main treatment adjuncts included injection, laser, ESWT, manual therapy and splinting/taping. Additionally, of the 316 experimental studies included, 49 (16%) included a specific non-exercise arm (whereby one, or more, of the groups were not prescribed any exercise as part of their intervention) whilst 184 did not (83 were not applicable).

*Health domains and outcomes*

Primary and secondary health domains were extracted across all tendinopathy types and are presented in Table 2. Disability was the most common primary health domain (n=282) for RCRSP (123), Achilles (67), and patellar (40) tendinopathies (see Table 2); for lateral elbow, physical function capacity was most common (40). Secondary health domains also varied across tendinopathies with Achilles and patellar both reporting participant rating of overall condition most frequently (15 and 8 respectively), with disability the most common secondary domain for RCRSP

(27), and physical function capacity (14) for lateral elbow. Across tendinopathies, adverse effects or cost effectiveness were rarely the primary or secondary focus.

**Table 2:** Instances of primary and secondary health domains reported according to tendinopathy type

| ICON domain | | All (n = 436) | Rotator cuff (n=165) | Achilles (n=99) | Lateral Elbow (n=81) | Patellar (n=53) | Other (n=38) |
|---|---|---|---|---|---|---|---|
| Adverse effects/events | Primary | 11 | 1 | 6 | 1 | 2 | 1 |
| | Secondary | 13 | 4 | 2 | 2 | 5 | 0 |
| Clinical examination findings | Primary | 19 | 10 | 1 | 2 | 0 | 6 |
| | Secondary | 6 | 5 | 0 | 1 | 0 | 0 |
| Disability | Primary | 282 | 123 | 67 | 35 | 40 | 17 |
| | Secondary | 53 | 27 | 5 | 11 | 6 | 4 |
| Drop out or discontinued treatment | Primary | 7 | 1 | 1 | 3 | 2 | 0 |
| | Secondary | 0 | 0 | 0 | 0 | 0 | 0 |
| Economic impact costs | Primary | 4 | 3 | 0 | 1 | 0 | 0 |
| | Secondary | 2 | 1 | 0 | 1 | 0 | 0 |
| Function | Primary | 21 | 7 | 1 | 7 | 2 | 4 |
| | Secondary | 13 | 6 | 3 | 2 | 0 | 2 |
| Medication use | Primary | 9 | 2 | 4 | 2 | 1 | 0 |
| | Secondary | 10 | 5 | 0 | 2 | 3 | 0 |
| Other | Primary | 24 | 6 | 8 | 7 | 3 | 0 |
| | Secondary | 17 | 5 | 6 | 3 | 2 | 1 |
| Pain - clinician applied stress/examination | Primary | 8 | 1 | 1 | 4 | 1 | 1 |
| | Secondary | 5 | 0 | 1 | 3 | 1 | 0 |
| Pain on loading/activity | Primary | 108 | 42 | 21 | 18 | 21 | 6 |
| | Secondary | 34 | 18 | 5 | 5 | 6 | 0 |
| Pain over a specified time | Primary | 63 | 30 | 5 | 19 | 4 | 5 |
| | Secondary | 38 | 21 | 6 | 8 | 2 | 1 |
| Pain without further specification | Primary | 90 | 41 | 13 | 18 | 10 | 8 |
| | Secondary | 16 | 5 | 4 | 3 | 2 | 2 |
| Palpation | Primary | 9 | 0 | 4 | 2 | 2 | 1 |
| | Secondary | 1 | 0 | 1 | 0 | 0 | 0 |
| Participant/patient rating overall condition | Primary | 66 | 15 | 20 | 17 | 8 | 6 |
| | Secondary | 46 | 13 | 15 | 6 | 8 | 4 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Participation | Primary | 25 | 8 | 6 | 5 | 4 | 2 |
| | Secondary | 18 | 8 | 5 | 3 | 2 | 0 |
| Physical activity | Primary | 6 | 0 | 5 | 0 | 0 | 1 |
| | Secondary | 4 | 0 | 2 | 0 | 0 | 2 |
| Physical function capacity | Primary | 100 | 30 | 13 | 40 | 8 | 9 |
| | Secondary | 44 | 18 | 7 | 14 | 4 | 1 |
| Psychological factors | Primary | 5 | 4 | 1 | 0 | 0 | 0 |
| | Secondary | 9 | 5 | 2 | 0 | 0 | 2 |
| Quality of Life | Primary | 17 | 10 | 3 | 4 | 0 | 0 |
| | Secondary | 26 | 11 | 3 | 7 | 2 | 3 |
| Range of Motion | Primary | 56 | 44 | 3 | 4 | 1 | 4 |
| | Secondary | 18 | 14 | 3 | 1 | 0 | 0 |
| Sensory modality specific pain | Primary | 11 | 3 | 3 | 4 | 1 | 0 |
| | Secondary | 6 | 1 | 1 | 4 | 0 | 0 |
| Structure | Primary | 56 | 9 | 32 | 4 | 10 | 1 |
| | Secondary | 18 | 5 | 10 | 1 | 2 | 0 |

*Outcome measurement tools*

An extensive range of primary and secondary outcome tools were reported across tendinopathies. A comprehensive mapping of the tools relative to health domains and tendinopathy types is provided in interactive searchable tables in Supplementary files SF5 and SF6. The most frequently reported tools included visual analogue scales (VAS) (RCRSP 73, lateral elbow 44, Achilles 29, patellar 22); Victorian Institute of Sport Assessment questionnaires (Achilles VISA-A 59, patellar VISA-P 39); Shoulder Pain and Disability Index (SPADI) (RCRSP 45); Dynamometer (lateral elbow 39, RCRSP 17); Goniometer (RCRSP 39); Constant Murley Score (CMS) (RCRSP 36); Disabilities of the Arm, Shoulder and Hand questionnaire (DASH/Quick DASH) (RCRSP 35); Ultrasonography (Achilles 20, patellar 11); Patient rated tennis elbow evaluation questionnaire (lateral elbow 17), and numerical pain rating scale (NPRS) (RCRSP 14). The main secondary outcome tools were dynamometer (lateral elbow 15, RCRSP 13), VAS (RCRSP 15, Achilles 10, lateral elbow 8, patellar 8), NPRS (RCRSP 13, Achilles 5), Ultrasonography (Achilles 11), Goniometer (RCRSP 9), DASH (RCRSP 8), SF-36 (RCRSP 7), EQ-5D (Gluteal 6), CMS (RCRSP 6), Western Ontario Rotator Cuff Index (RCRSP 6) and Algometer (lateral elbow 5).

Of the nine qualitative studies included, the majority were on RCRSP (5 studies) followed by Achilles (2), tibialis posterior (1) and a mixed group (1: Achilles/patellar/RCRSP). These studies represented 114 participants (people with tendinopathy and physiotherapists), of whom 68 were female and 45

male. The studies reported participants' barriers and facilitators to exercise interventions, which included psychosocial impact, treatment burden, motivation, confidence, coping, pain, socialisation, and benefits of group exercise, recognising the challenges of exercise interventions and self-management. They also reported on a range of physiotherapist-related factors including views, clinical reasoning, perceived barriers and facilitators, and treatment awareness.

*Citation Analysis*

A citation analysis was conducted on the Scopus information obtained from 450 (81%) of the included sources, generating 14860 references. The full citation analysis is presented in the Supplementary file SF7. Of the 450 citations used to complete the analysis, they were published in: British Journal of Sports Medicine (39, 9%), American Journal of Sports Medicine (28, 6%), Journal of Orthopaedic and Sports Physical Therapy (15, 3%), Clinical Journal of Sports Medicine (14, 3%) and Knee Surgery Sports Traumatology Arthroscopy (14, 3%). Based on citations per year, the top ranked studies included De Vos et al. (49 citations per year) [21], Alfredson et al. (30 citations per year) [17], De Jonge et al. (21 citations per year) [22], Malliaras et al. (21 citations per year) [23] and Thanasas et al. (20 citations per year) [24]. Across the 14860 references identified, they were obtained from the American Journal of Sports Medicine (655, 4%), British Journal of Sports Medicine (628, 4%), Journal of Orthopaedic Sports Physical Therapy (304, 2%) and British Medical Journal (262, 2%). A country collaboration network diagram of the included references is provided in Figure 6, illustrating extensive collaborations across many countries especially the UK, USA, and Australia.

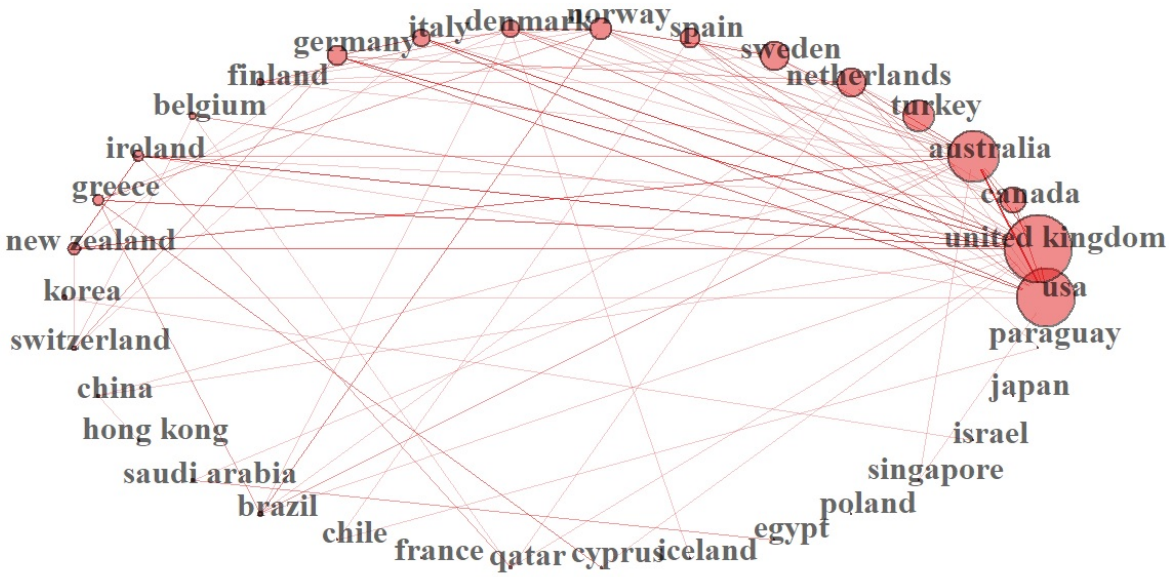


**Figure 6:** Country collaboration network diagram of the included references.

## 4.0 DISCUSSION

This is the first scoping review to comprehensively map existing evidence on exercise interventions and outcomes for the treatment of tendinopathies. A total of 555 sources were included, demonstrating the abundance of research and the need for it to be mapped in this review, to identify gaps and inform future research and evidence synthesis. There are clear implications for further vital research and evidence synthesis to enhance exercise interventions for people with tendinopathy. The review also raises practice implications. However, due to this being a scoping review, with no quality appraisal of included studies, further work is required before recommending significant changes to practice.

Although there has been a trend to increased numbers of RCTs over time, there were relatively large numbers of quasi-experimental and observational studies identified, which have more limited ability to draw clear conclusions on the effectiveness of exercise interventions. This finding, along with the variable sample sizes of included studies, emphasises the need for researchers to cease the conduct of small, poor-quality studies, and for researchers and funders to focus on adequately powered rigorous studies of effectiveness that can influence practice [6,25]. The inclusion of very few qualitative studies emphasises the need for further research to fully understand patients' and practitioners' perceptions and experiences of exercise for tendinopathy to guide intervention development and assist with real-world implementation of findings from trials.

*Exercise for tendinopathy*

The findings that strengthening exercise was the most commonly reported exercise type across all tendinopathies, particularly the lower limb, and that eccentric strengthening exercise was most common for three tendinopathies (Achilles, patellar, lateral elbow) is in keeping with previous evidence [26]. However, due to highly variable levels of reporting, it would be difficult to determine whether many interventions described as strengthening would in fact lead to the required overload for strengthening to occur; this has implications for both practice and reporting of interventions in future studies. The findings related to RCRSP demonstrated the most clinical heterogeneity, with greater variation in strengthening exercise type, and exercise type *per se*, with flexibility, motor control and proprioceptive exercise reported in addition to strengthening. The shoulder was the only tendinopathy to report the use of dynamic ROM exercise for flexibility more frequently than traditional active or passive stretching. This more nuanced approach to the management of RCRSP

may reflect the view that there is, as yet, no consensus on how best to manage this complex tendinopathy [3,10].

Reporting of interventions was highly variable, with 15% or fewer included interventions classed as fully reproducible using the TIDieR checklist. This finding has implications for practice, as it would be challenging, if not impossible, for practitioners to adopt interventions demonstrated as effective in research studies. This may result in suboptimal exercise prescription and patient outcomes. This finding also supports the call for clear and transparent reporting of tendinopathy interventions, using available reporting guidelines such as TIDieR to assist the process [25,27].

Adherence was reported in only 20% of included primary studies, despite the intention to collect adherence measures being reported in 35% of studies, which is similar to previous adherence reports three decades ago [28]. Adherence monitoring relied primarily on a range of participant self-report instruments with wide variation in scoring methods, which would make pooling of adherence data challenging. Although practical, there are widely documented limitations to these types of measures for reporting exercise adherence. Future research should consider including more accurate objective measurement of exercise and strategies to address non-compliance [29]. Around half of the studies included personalised tailoring of exercise guided by pain, in keeping with the evidence that adherence to interventions that require exercising into or through pain (e.g., Alfredson protocol) will typically be lower [30]. The small body of included qualitative studies suggest that there are several barriers to adherence (e.g., treatment burden, pain, psychosocial factors, motivation, confidence, and coping); these are important issues that affect implementation and patient outcomes and should be further explored in future research.

*Outcomes*

The finding that numerous primary (335) and secondary (194) outcomes were reported across a range of 22 health domains highlights the lack of consensus to date on outcome measurement for tendinopathy. This makes generation of recommendations and practice guidelines in this field challenging, due to the difficulties of pooling such heterogeneous data. The work of Vicenzino et al. [19] should reduce such heterogeneity in future tendinopathy research; however, it will take some time for this to be realised. Although nine core health-related domains for tendinopathy were recommended in the ICON consensus statement [19], we found it necessary to map outcomes to the 24 domains considered at stage 1 of the ICON Delphi process in order to fully map all the measures and domains reported in our included studies. Our findings indicate that there is a wide gap between

outcomes reported in the evidence base and those currently recommended. For example, ROM was the second most commonly reported domain for RCRSP, yet is not considered a core domain by ICON [19]. Of the six core ICON domains agreed on by health care professionals and patients, only two (rating of condition and physical function capacity) were reported as primary or secondary domains in this review. This may reflect the disconnect between what researchers' focus on and what health professionals and patients feel are important in practice [19], also indicated by low reporting of quality of life outcomes. Adverse events and cost-effectiveness were outcomes rarely reported; this should be urgently addressed in future research, in order that safe and affordable practice recommendations can be made for effective interventions.

The finding that numerous outcome measurement tools were used across each health domain highlights the need for core outcome sets to be agreed for both research and practice. The ongoing international work on developing core outcome sets for Achilles, gluteal, lateral elbow and proximal hamstring tendinopathies (COMET initiative 2021) and shoulder disorders [31] will enhance standardisation of outcomes and enable future pooling of findings in systematic reviews. Outcomes reported for RCRSP in this review were not congruent with the core set endorsed by OMERACT participants [31]; only pain was common to both OMERACT and this review. This may reflect that the OMERACT set relates to all shoulder disorders rather than just RCRSP, not only making comparison difficult but suggesting that a core set is required specifically for RCRSP.

The finding that physical outcomes (e.g. pain, disability) were dominant, with infrequent reporting of psychosocial outcomes (e.g. psychological factors) conflicts with practice, where managing tendinopathy, where the duration can be long and impact on peoples' lives significant, can be challenging [32]. This finding further emphasises the need for further qualitative research, and the use of more holistic, patient-centred outcomes in tendinopathy research [8,33]. This scoping review clearly demonstrates that research to date is skewed towards physical interventions and outcomes. We propose that there is a need for practitioners and researchers to consider combined interventions which might combine exercise with components such as education, psychology, social and lifestyle considerations and pain management approaches, in keeping with the management of other long-term musculoskeletal conditions such as low back pain [34].

*Reporting in tendinopathy*

Reporting of interventions and adherence is discussed above. However, reporting of participant demographics was also highly variable, with very low reporting rates for some potentially important

comorbidities and confounders such as age, gender, cardio vascular conditions, diabetes and non-Caucasian ethnicities). For example, low to moderate quality evidence has demonstrated a link between metabolic syndrome, obesity and RCRSP but this was not well reported in studies [35]. This limits the ability to pool findings, evident in the small number of included systematic reviews that have conducted meta-analyses. There is therefore an urgent need for full and transparent reporting in tendinopathy research [4,7,25] and to continue the development of the ICON standards for reporting participant characteristics [36]. The wide age range reported across included studies and the lack of reporting of co-morbidities (particularly in older populations) lends support to demographic sub-grouping of participants to lessen the impact of confounders and to identify different responses to exercise across groups.

### 4.1 Limitations

There are some inevitable limitations to this scoping review. The use of the HDI [16] ensured that the international evidence gathered is compatible with the UK context; however, some pertinent evidence may have been excluded as a result. However, we are confident that including studies form non-HDI countries would not significantly affect the results of this review as a comprehensive search was conducted and the translations were sourced for all included non-English language studies.

## 5.0 CONCLUSIONS

This scoping review provides the first map of exercise interventions and outcomes for tendinopathy research. Several important recommendations for future research have emerged from this review and are detailed next. Practice recommendations are limited from scoping reviews, due to the lack of study quality assessment; however, practitioners may wish to reflect on dosage for strengthening exercise, and the consideration of a more holistic approach to managing tendinopathy. The results from this scoping review will inform subsequent evidence synthesis on this topic.

**Recommendations for research:**

1. Research study types
   a. There is a need for adequately-powered, methodologically-sound studies that can truly demonstrate the effectiveness of interventions.

b. To achieve (a) we recommend that intervention development studies are conducted prior to moving to trials, including feasibility and acceptability studies. Qualitative studies (stand-alone or embedded within other designs) should explore participants' perceptions and experiences of exercise for tendinopathy. There is an urgent need for cost-effectiveness analyses and for studies on the implementation of effective interventions in practice.

2. Research reporting
    a. Full reporting of participant characteristics including psychological factors, ethnicity, co-morbidities, and activity level is required in future tendinopathy research
    b. Future research should consider sub-groups such as gender, age, sedentary/active/performance populations
    c. Full adherence to checklists for reporting exercise interventions is required to assist with both planning and reporting of interventions
    d. Future research should apply the ICON core health domains to ensure full reporting of all relevant biopsychosocial outcomes
    e. Future research should carefully consider adequate monitoring and reporting of adherence to exercise. This will require refinement of data collection methods, and we recommend considering objective monitoring
3. Patient/practitioner lived experience
    a. There is a need for research on participants' views and experiences of exercise interventions across tendinopathies and populations. There is also a need for research on practitioners' views of management approaches for different tendinopathies, how to navigate the research-practice gap and address barriers to exercise intervention implementation.
4. Future evidence synthesis by researchers should focus on conducting high quality systematic reviews (such as quantitative, qualitative, mixed method and cost-effectiveness) and combining high quality reviews into umbrella reviews. For this to occur, there is an urgent need for further high-quality primary studies that address the limitations identified in this review.

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**Ethics**

This project involved secondary research and as such did not require ethical approval.

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