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The effectiveness of home hand exercise programmes in rheumatoid arthritis: a systematic review.

Alison Hammond and Yeliz Prior

Centre for Health Sciences Research, University of Salford, Salford, UK.

Address for Correspondence:

Prof. Alison Hammond,

Centre for Health Sciences Research,

L701 Allerton (OT),

University of Salford,

Frederick Road,

Salford M6 6PU.

Tel: 0161 295 0038

e-mail: a.hammond@salford.ac.uk and hammond116@btinternet.com

Fax: 0161 295 2432

SHORT title of paper: Home hand exercises in RA

Abstract [150 words]

Introduction: Rheumatoid arthritis (RA) commonly reduces hand function. We systematically reviewed trials to investigate effects of home hand exercise programmes on hand symptoms and function in RA.

Sources of Data: We searched: Medline (1946-), AMED, CINAHL, Physiotherapy Evidence Database, OT Seeker, the Cochrane Library, ISI Web of Science from inception to January 2016.

Areas of Agreement: Nineteen trials were evaluated. Only three were randomised controlled trials with low risk of bias (n=665). Significant short-term improvements occurred in hand function, pain and grip strength, with long term improvements in hand and upper limb function and pinch strength.

Areas of controversy: Heterogeneity of outcome measures meant meta-analysis was not possible.

Growing Points: Evaluation of low and moderate risk of bias trials indicated high intensity home hand exercise programmes lead to better short-term outcomes than low intensity programmes. Such programmes are cost-effective.

Areas timely for developing research: Further research is needed to evaluate methods of helping people with RA maintain home hand exercise long-term.

Keywords: rheumatoid arthritis; hand; upper limb; exercise; rehabilitation

Introduction

Most people with rheumatoid arthritis (RA) develop hand symptoms early in their disease. Pain, stiffness and joint swelling reduce range of movement (RoM), muscle strength and hand function. [1,2] Rheumatoid cachexia (loss of muscle mass from inflammatory changes) further contributes to muscle wasting.[3] Within six months of diagnosis, women's grip strength reduced to, on average, 12 kg force, compared to the norm for a similar age range of 28 kg force (i.e. only 40% of normal), and remains lower.[1,4] Activity limitations and participation restrictions are common and hand problems contribute to work disability. Within 10 years, 59% developed hand deformities (ulnar deviation, button hole and/or swan-neck finger deformities), [5] further reducing grip strength.[6]

Although medication improves hand symptoms, and tighter disease control may limit deformities in future, muscle function is not regained when disease activity is controlled. Disease modifying drugs do not reverse muscle wasting and even those with well-controlled RA have less muscle mass than healthy age-matched controls. [3] Hand exercise programmes are therefore a standard component of RA management, to improve range of motion, muscle strength, sensorimotor control, hand function, activities and participation. [7] Once an exercise programme stops, gains can be progressively lost. Accordingly, many with RA need to continue hand exercises at home as part of self-management. To this end, occupational therapists and physiotherapists often teach people with RA a home hand exercise programme. However, clinical practice varies in the number of sessions to teach this and the number, type and intensity of RoM and resistance exercises included.

A systematic review of eight studies (published between 2000-2014) concluded hand exercise, improves grip strength but the effects on hand RoM are unclear.[8] However, only four were randomised controlled trials (RCTs).[9,10,11,12] Three of these were of: short-term intensive hand rehabilitation programmes (i.e. 10 to 15 therapy sessions evaluated over two or three weeks [9,10]); or 20 therapy sessions over 2 months, with home exercises between twice-weekly therapy.[12] Most people with RA do not receive such high levels of supervised hand exercise therapy in the United Kingdom (UK), Western Europe and North America, due to service constraints. Therefore this review specifically investigates home hand exercise programmes as commonly taught by therapists, i.e. over one or several sessions. The aims are to identify:

- What are the short- and long-term effects of home hand exercise programmes (plus usual care) on hand function and hand symptoms in adults with RA compared to those receiving usual care only?
- Are home hand exercise programmes cost-effective?
- Which type of home hand exercise regimen is most effective?
- What strategies can facilitate people with RA adhering to performing home hand exercises?
- Are there any safety concerns arising from performing home hand exercises?

Methods

Search strategy

We searched electronic databases from inception until January 2016: MEDLINE; CINAHL (Cumulative Index to Nursing and Allied Health Literature); AMED (Allied and Complementary Medicine); PEDro (Physiotherapy Evidence database), OT Seeker; Cochrane Library; and ISI Web of Science. The search terms included were: rheumat$ or reumat$; arthrit$ or diseas$ or condition$; hand$, wrist$, finger$, thumb$, joint$, upper limb; occupational therapy; rehabilitation; therapy; Physical Therapy Modalities, Exercise Therapy, exercis$; Physical therap$; isometric, resistance or strength$, muscle$, stretch$, manipulat$, range of mo$; randomized controlled trial; controlled clinical trial; cost-effectiveness or cost effectiveness or cost analysis. We also hand searched reference lists of reviews.[8, 13,14,15]

Eligibility criteria

Studies had to be trials describing: the effects of home hand exercise programmes provided by health professionals as part of conservative management; to adults with RA diagnosed by a physician, recruited from either in- or out-patient or community settings; and at least one of the following outcomes were measured: hand function, pain, grip strength and/or RoM. Studies were excluded if: not published in English; evaluated post-surgery hand exercise; reported only in abstracts, poster presentations or conference proceedings; or were case reports, descriptive articles, commentaries, letters, or literature reviews.

Study selection and assessment of study quality

After removing duplicates, we independently screened titles and abstracts using these criteria. If met, we retrieved full-text articles, re-checked for eligibility and assessed methodological quality using the PEDro scale, resolving disagreements when necessary.[17] This is a reliable, valid scale assessing 11 criteria (see Table 1).[18,19] The first criterion, participant eligibility, assessing external validity, is not included in the total score, which is a maximum of 10 if all criteria are met. As it is difficult to blind therapists and/or participants in most rehabilitation trials, most cannot obtain the maximum score. High quality trials with low risk of bias score 7 or more and low quality trials with high risk of bias score 3 or less. [19]

To evaluate home hand exercise effects on hand symptoms and function, trials were included if these: had low risk of bias; were randomised; had an RA control group receiving no treatment or usual care; and the home hand exercise programme was reproducible. Trials were excluded if they: had a moderate or high risk of bias; were not randomised; had a control group of people without arthritis; compared hand exercise regimens without a control group; or did not include home hand exercises.

To investigate different home hand exercise regimens effects, adherence strategies and safety additional trials were reviewed if these: had a comparator group of people with RA (receiving usual care or an alternate exercise regimen); and had moderate risk of bias.

Data extraction and analysis

A predefined data extraction form was devised including: participant characteristics, intervention groups, exercise regimens (type, intensity and duration), outcome measures and results. Effects were summarized descriptively.

Results

Study selection

The search resulted in 3456 articles after duplicates were removed (see Figure 1). Following title/abstract review, 3433 articles were removed as either: not specifically about hand exercises in

RA; protocol articles; commentaries on hand exercise trials; or systematic or narrative reviews of hand exercises.[8,13,14,15] Twenty three articles were selected for full text review, of which three were excluded because they evaluated: general exercise programmes [20,21] or a combined therapy intervention,[22] from which hand exercise effects specifically could not be identified.

Nineteen articles were assessed using the PEDRo scale, designed to assess rehabilitation trials (see Table 1). Three RCTs with low risk of bias met criteria and were included in all evidence syntheses. [11,23,24,] Four moderate risk of bias trials were excluded from the effects of the home hand exercise synthesis but included in the types of exercise, adherence and safety syntheses. [25,26,27,28]

Four moderate risk of bias trials were excluded from all evidence syntheses. Buljina et al evaluated immediate effects of 15 therapy sessions of daily exercise, thermotherapy, faradic, radon and wax baths (a regimen rarely used in Western countries) without home exercise afterwards.[9] Piga et al evaluated a purpose-built device, with integrated exercise tools and remote telemonitoring, which is not commercially available and not reproducible as a home programme.[29] Two further trials were excluded as they had healthy controls. [30, 31] The remaining eight studies were excluded because of high risk of bias, [10,12,32,33,34,35,36,37] six of which did not include home programmes. [10,33,34,35,36,37] In addition, a cost-effectiveness study [38] of the trial led by Manning et al[23] as well as cost-effectiveness being reported within the study by Lamb et al. [24].

Evidence for the effects of hand exercise on hand function and hand symptoms

Study features and methodological quality

Three prospective randomised controlled trials were included, with PEDro scores of 7 or 8. [11,23,24] All had external validity and their methodological limitations were due to lack of blinding of therapists and participants (see Table 1).

Demographic data

The total number of participants was 665 (range 67- 490), including 163 men and 502 women, with a mean age of 59 years and disease duration of 8.39 years. Two included mainly people with established RA [11,24] and one early RA (ie less than 2 years since diagnosis). [23]

Control groups

Control participants continued to receive usual care from their rheumatology team[11,23,24] In two studies, this also included provision of an Arthritis Research UK booklet about joint protection [11,23] and in the third up to 1.5 hours of joint protection education and, if applicable, functional splinting.[24]

Intervention groups

All three trials evaluated usual care (as above) plus RoM and resistance hand exercises (see Table 2),[11,23,24] Participants attended one, [11] four, [23] or five[24] sessions of therapist-supervised exercise therapy, followed by a daily home exercise programme. O'Brien et al evaluated five RoM and three light resistance hand exercises, [11] Lamb et al five RoM and four medium resistance hand exercises plus two upper limb RoM exercises. [24] Manning et al evaluated six medium resistance exercises selected from 16 (six hand and 10 arm) standardised exercises to meet individual's needs.[23] The number of hand exercises thus varied. However, most arm exercises involved gripping a resistance band whilst pulling, involving finger and wrist flexor muscles.[24]

Follow-up

Follow-up also varied with short-term assessments at 2.5,[23] 3[11] and 4[24] months and long-term assessments at 6,[11] 8,[23] and 12 months.[24]

Outcome measures and outcomes

Pooling of data was not possible as outcome measures usually differed between studies (see Table 2).

Self-reported hand function (the primary outcome in all three studies): was evaluated using the AIMS2 Hand and Upper Limb Function scales,[11] the Disabilities of the Hand, Arm and Shoulder questionnaire (DASH),[23] and the Michigan Hand Outcomes Questionnaire (MHQ).[24] In the short term, compared to the control groups, Manning et al [23] and Lamb et al [24] showed significant improvements. In the long-term, only Lamb et al showed significantly improved hand function (effect size 0.3),[24] and O'Brien et al significantly improved upper limb function.[11]

Objective hand function: was measured using the Jebsen Hand Function Test,[11] the Grip Ability Test (GAT)[23] (both timed tests of hand grip function) and the Nine Hole Peg Test, a timed finger dexterity test.[24] In the short-term, significant improvements were found in only one study,[23] but Lamb et al showed long-term significant improvements in dexterity.[24]

Hand grip strength: two studies used the Jamar dynamometer but with different methods and units: mean grip force in pounds[11] and peak force in Newtons.[23] The third measured maximum grip force in Newtons using the MIE Digital Grip Analyser.[24] In the short-term, one study showed significantly improved dominant [24] and one non-dominant hand grip strength. [23] In the longer-term, grip strength improvements were maintained and better than the control groups but not significantly so.[23,24]

Pinch strength: two studies used the: B&L pinch gauge (lbs)[11]; and the MIE Digital Analyser (Newtons).[24] In the short-term there were no differences in pinch strength. In the longer-term, it was significantly improved in both studies.[11, 24]

Finger RoM: two studies measured this using: a goniometer[11] ; and composite finger flexion and extension with a ruler.[24] In the short and long-term, significant improvements were found in finger extension,[24] whilst finger flexion did not improve.[11,24]

Hand pain: was measured in two studies, using a 100mm VAS [23] and the MHQ Pain scale. [24] Significant improvements were identified in both studies in the short-term [23,24] and in one in the long-term. [23]

Other symptoms: were also measured differently and not in all three studies: tender and swollen joint counts,[11,24] morning stiffness[23] and fatigue.[23] In the short-term, joint counts improved only in one[25] and not in the long-term. Morning stiffness and fatigue did not differ significantly.[23]

Disease activity: Two studies measured disease activity, although differently: DAS28[23] ; and C-reactive protein levels.[24] Both showed significant improvements in the short- but not long-term. [23, 24]

Self-efficacy for managing pain: In the short-term, this significantly improved[23,24] and remained higher in the long-term in one study[23] and almost significantly improved in the other. [24]

Health: one study measured health related quality of life[23] and another health status [24] with no significant changes in either.

Cost-effectiveness of home hand exercise programmes

Cost-effectiveness was evaluated in only two studies. The exercise programmes, plus other health care use during follow-up, were identified as £82 [39] and £103 [24] more expensive than usual care but led to an increase in 0.03 [39] and 0.01 [24] QALYs respectively. Both concluded the exercise programmes were cost-effective. [24,38]

Effectiveness of different home hand exercise regimens

A wider range of trials were included to review the effectiveness of different types of home exercise regimens. Seven studies were therefore included, i.e**.** the three above plus the four moderate level of bias studies meeting this evidence synthesis' entry criteria. These four additional studies included people with established RA and had short-term follow-ups of between four to 14 weeks. [25,26,27,28] (See Table 2). Exercise regimens can be considered in terms of their content, intensity and provision method.

Exercise programme content

All seven studies included resistance exercises. [11,23,24,25,26,27,28] Five included between two to six resistance exercises using therapeutic putty and resistance bands: squeezing putty in a full fist, a hook fist and/ or between fingers; pinching putty; stretching the fingers out against putty; rolling putty; and wrist extension exercises using resistance bands. [15,23,24,25, 27, 28] One used a Theraband hand exercise ball [26] and one used rolling /pinching a towel and resistance bands. [11] Three specified exercises were held at the position of maximum effort for two to five seconds. [16, 23, 24, 28] Only Manning et al also included arm resistance exercises. [23]

Five studies also included RoM exercises (median six RoM exercises; range one to nine) [11, 24,25, 27, 28] The hand RoM exercises commonly included were: wrist flexion, extension and circumduction, pronation and supination; finger tendon gliding, radial walking and abduction; touching the tip of each finger to the thumb; and thumb extension, opposition and thumb interphalangeal joint flexion. [11, 15,24,25,27, 28] Only Lamb et al included arm RoM exercises (i.e. internal and external shoulder rotation). [15,24]

Three studies had no explanation for choice of exercise content, [25,26,28] although frequency met "general recommendations for resistance programmes." [26] One was based on "new research." [27] Manning et al adapted a knee pain self-management and exercise programme, with upper limb exercise content determined collaboratively with clinicians.[23] O'Brien et al surveyed 60 hand therapists about their exercise provision, although how the exercise programme was defined from this was not explained. [11] Finally, Lamb et al identified potential exercises through systematic review and a consensus meeting of hand therapists. Exercises were then selected by the research team based on including all functionally relevant movements/ muscle actions at the hand and wrist, avoiding replication and ensuring convenience. [15,24]

Intensity and provision method of exercise regimens

High intensity therapist supervised exercise regimens

Four exercise programmes were considered high intensity. Two included 10 repetitions of four to six light progressing to medium resistance exercises for 10 to 20 minutes daily [28] or most days [27] (i.e. between 40 to 60 medium resistance exercise repetitions). Two included 10 progressively up to 3 x 10 repetitions of four to six light progressing to medium resistance exercises (i.e. potentially up to 120 or 180 repetitions) performed daily.[23,24] Therapeutic putty and resistance bands were initially graded to suit individuals' abilities, then resistance increased to medium.[23,24,27,28] Two studies asked participants to set their effort level during exercise at moderate progressing to hard on the Borg Scale of Perceived Exertion. [23,24] Three included RoM exercises. [24,27,28] All four were therapist-supervised programmes with a median six (range four to ten) sessions. [23,24,27,28] Two stated the time taken was four to five hours.[23,24]

All resulted in short-term significant improvements in hand function, dominant and/or non-dominant hand grip strength and pain. [23,24,27,28] Only Lamb et al evaluated RoM and no change was identified. [23] One study compared an intensive regimen (a total of 60 repetitions of resistance exercises most days) to a conservative regimen (a total of 21 repetitions of resistance exercises several days a week), identifying better short-term outcomes with the intensive programme. [27] Only two included longer-term follow-ups, with continued improvements in self-reported hand function, [24] pinch strength [24] and pain. [23]

Low intensity single training session exercise regimens

Three studies were considered lower intensity. One evaluated one medium resistance exercise (squeezing a Theraband Hand Exerciser [26]) performed ten times for 5 minutes daily. Two included 2 x 10 repetitions of three light resistance exercises (using either medium soft putty [25] or rolling/ pinching a towel and resistance bands [11]) i.e. 60 light resistance repetitions daily. Both were performed for 15 to 20 minutes daily. Two included RoM exercises. [11, 25] All three programmes were taught via one individual training session of up to one hour, [11, 25,26] two of which also added either a 15 minute review [11] or a reminder. [26]

Two of these lower intensity studies resulted in short-term significant improvements in finger RoM, [11,25] one in hand function (dexterity) [25] and one in pain. [26] None showed improvements in grip or pinch strength. Only O'Brien et al had a longer-term follow-up, demonstrating improved self-reported upper limb (not hand) function at six months. [11]

RoM only exercise regimens

Three studies included RoM only exercise programmes as comparator groups.[11,25,28] Two studies identified no changes, both of which were taught in single therapy sessions. [11, 25] However, similar improvements in hand function, pain and grip to the RoM and resistance exercise programme were found in one high intensity 10 session therapist-supervised programme. [28]

Strategies to enhance adherence with hand and upper limb home exercises

Six studies included self-report daily exercise diaries to monitor progress. [11,23,24,25,26,27] Four reported adherence achieved: three that exercises were completed by between 73 to 95% of participants who returned diaries [23,25,26]; and one that there was greater compliance with exercise at 4 months compared to the control group. [24] Exercise intensity (daily repetitions or time) was not reported.

Six studies provided a booklet containing exercise instructions with photographs or drawings. [11,23,24,25,27,28] Three included either a review appointment [11] or a telephone call(s) to remind participants to perform exercises. [26,28]

The two studies with longer-term follow-ups included behaviour change strategies to facilitate longer-term adherence. [23,24] These included: enhancing self-efficacy to perform exercises, discussing exercise barriers, problem-solving, using exercise diaries, goal-setting, verbal and written contracting. Therapists were trained in using these cognitive behavioural approaches for either two[23] or four hours.[24] Both trials used therapist manuals to support standardising exercise programme delivery.[23,24] Therapists also taught participants to use the Borg Perceived Rate of Exertion scale to monitor and progress the resistance applied during their home exercise programmes.[23,24]

Safety concerns

No adverse effects occurred in four studies. [23,24,27,28] One did not include adverse effect reporting. [11] Two reported some problems with hand pain. In one, participants temporarily reduced the number of repetitions or days exercising and most were then able to continue. [27] In the other, six withdrew due to pain from exercise or flare-ups and were not included in analyses. [26] Ronningen et al compared high and low intensity resistance exercise regimens, identifying better short-term outcomes from the high intensity programme, with no negative effects.[27] Of the three studies evaluating disease activity, all reported short-term improvements. [23,24,28] Ellegard et al evaluated blood flow in the wrist joints using Doppler ultrasound, identifying there was no significant increase in synovial perfusion (reflecting disease activity) following 8 weeks of low intensity daily exercise. [26]

Discussion

This is the first systematic review to evaluate the effects of home hand exercise programmes in RA. In the short-term, resistance exercises, with or without RoM exercises, improve self-reported hand function,[23.24] pain,[23,24] self-efficacy [23,24] grip strength[24] and RoM. [11] However, in the longer term (i.e. six to 12 months), benefits were less consistent but still found in hand [24] or upper limb function,[11] pain, [23] pinch strength [11,24] and self-efficacy [23] but not RoM. [11,24] Hand exercises were also cost-effective.[23,24,38] Whilst there are only three high quality RCTs published to date,[11,23,24] the evidence is that home hand exercise programmes are effective in people with RA.

In clinical practice, therapists need to know what exercise regimens to provide and how. By including both low and moderate risk of bias studies, we identified that in the short-term, the most effective programmes were all high intensity and therapist-supervised for four or more sessions. These

consistently resulted in improved hand function, grip strength and pain, with minimal or no adverse effects. [23,24,27,28] In contrast, lower intensity programmes taught in one session (with or without reminders) were less consistent in demonstrating short-term improvements in either RoM, [11,25] hand function [25] or pain [26] and did not result in improved grip strength. [11,25,26.] RoM only programmes were found to have no effect apart from in one trial with a high level of initial therapy (10 sessions) which is not usual practice in the UK.

These findings indicate home hand exercise regimens should include at least four and up to six light progressing to medium resistance hand exercises using therapeutic putty and resistance bands performed at high intensity (i.e. 10 repetitions of each exercise most days/daily, repeated twice daily as hands improve). Including some hand and upper limb RoM exercises may also be helpful. Home programmes should be taught initially with therapist support over at least four sessions, either in groups or individually. It is unclear if a high intensity programme taught over one session (with or without review) would be as effective, as no trial has evaluated this. It is more likely several sessions are more effective than one only, because many with RA have concerns about hand exercise increasing pain. Repeated supervision enables people with RA to develop the skills and confidence to perform exercises correctly and progress resistance and intensity. Including education about RA and hand exercises also helps allay fears and improve self-efficacy.[23,24] These intensive programmes are cost-effective.[24,38]

Helping people long-term continue performing hand exercises at effective levels is a major challenge. The most successful, and largest, study trained therapists in using cognitive-behavioural approaches and integrated these in programme delivery.[15,24] As 17 sites were involved, this suggests such training can be disseminated into practice. Research evaluating self-management and joint protection programmes also demonstrates such approaches are significantly more effective in improving outcomes than brief therapy. [39,40] At present, these approaches are not commonly used in practice and there is a need to increase therapists' skills. Interestingly, Manning et al also used similar approaches but with less effect.[23] This may have been due to the different exercises included. Most arm exercises were performed whilst standing, requiring full attention and higher time demands. People successfully continuing with home hand exercises explained they integrated these into their daily routines.[27] For example, performing RoM exercises as a rest from other activities and resistance

exercises when watching television. Potentially, Manning et al's programme required too much time away from other activities.

Further research is needed to identify the optimum type and number of resistance hand exercises, repetitions and days performed to be effective but still achievable for people with RA. Given that home programmes seem to have less effect on hand RoM, research is needed to determine whether, or how many, RoM exercises to include. Programmes with too many exercises, taking up too much time, are less likely to be followed. No studies successfully monitored how much and which types of exercise were being performed and thus what level provides optimum results. Further consensus study with clinicians is needed to determine which resistance exercises, based on systematic review and practice surveys, are best included. Qualitative research is needed to investigate people with RA's views of home hand exercise programmes, which resistance exercises they can most easily continue to perform, how much exercise they can realistically integrate into their lives and the best methods to support them in continuing to exercise, as only one small study has been conducted to date.[27] This will help determine an optimum resistance exercise programme. Given that regular follow-up therapy appointments are now less common in practice, other methods to remind people to do hand exercises are needed. The development and evaluation of an App, including demonstrations of exercises, with self-monitoring of frequency and intensity of hand exercises and providing positive messages when goals are achieved, may have potential to support people longer-term. Home hand exercises are relevant for other conditions, such as hand osteoarthritis, meaning a hand exercise App could have a wider client base and also enable remote data collection in trials. Only one study recruited people with early RA [23] and thus further research is needed into the effectiveness of home programmes in this group. Therapists also have concerns about the use of hand exercises when people have inflamed or deformed joints. Very few adverse effects were reported in these studies but most people had established RA and were on stable drug therapy regimens, meaning further evaluation of the effects of home programmes in these groups is also needed. Comparisons between trials would also be easier of a core set of outcome measures is agreed. Little attention to date has been focused on the impact of hand exercises on participation and this also should be considered.

Conclusion

Home hand exercise programmes are effective at improving hand function, grip strength and pain in RA. High intensity resistance exercise programmes taught by therapists over at least several sessions including strategies to promote longer-term adherence seem to be most effective and are cost-effective.

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Figure 1: Flow diagram of the results of the study selection procedure, in accordance with Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines.

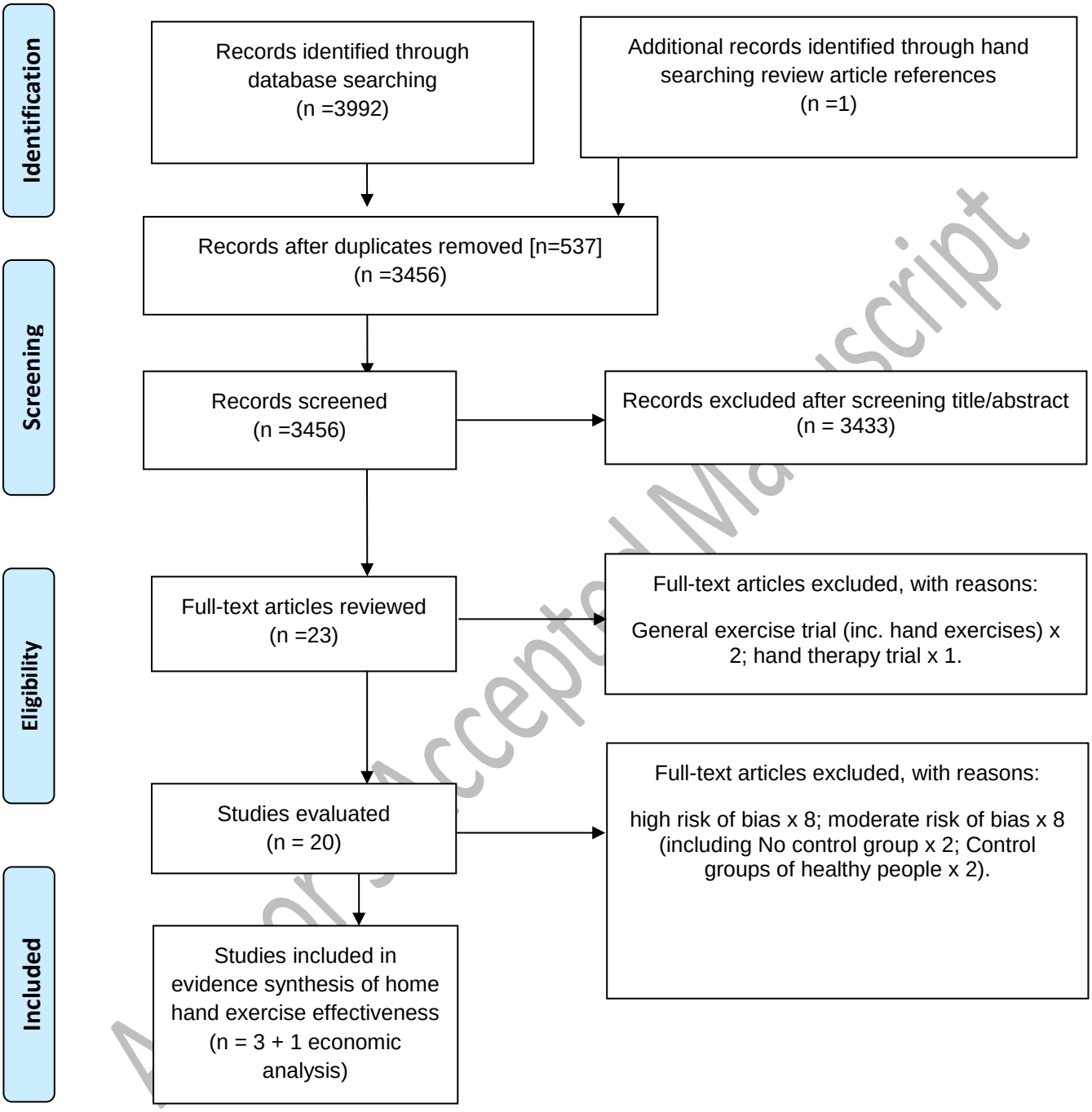

Table 1: Quality ratings of evaluated studies according to the PEDro methodology scoring system.

	1*	2	3	4	5	6	7	8	9	10	11	PEDro score	Risk of bias
Manning et al [23]	✓	✓	✓	✓	x	x	✓	✓	✓	✓	✓	**8**	**Low**
Lamb et al [24]	✓	✓	✓	✓	x	x	✓	✓	✓	✓	✓	**8**	**Low**
O'Brien et al [11]	✓	✓	✓	✓	x	x	✓	x	✓	✓	✓	**7**	**Low**
Dogu et al [28]	✓	✓	x	✓	x	x	✓	✓	x	✓	✓	**6**	Moderate
Hoenig et al [25]	✓	✓	x	x	x	✓	✓	x	x	✓	✓	**5**	Moderate
Brorssen et al [30]	✓	x	x	✓	x	x	x	✓	✓	✓	✓	**5**	Moderate
Ellegaard et al [26]	✓	x	x	✓	x	x	x	✓	✓	✓	✓	**5**	Moderate
Piga et al [29]	✓	✓	x	✓	x	x	x	x	✓	✓	✓	**5**	Moderate
Buljina et al [9]	✓	✓	x	✓	x	x	x	x	x	✓	✓	**4**	Moderate
Ronningen and Kjeken [27]	✓	x	x	✓	x	x	x	x	✓	✓	✓	**4**	Moderate
Speed and Campbell [31]	✓	x	x	x	x	x	x	✓	✓	✓	✓	**4**	Moderate
Brighton et al [32]	✓	✓	x	✓	x	x	✓	x	x	x	x	**3**	High
Byers [34]	✓	x	x	✓	x	x	x	✓	x	x	✓	**3**	High
Hawkes et al [35]	✓	✓	x	x	x	x	✓	x	x	✓	x	**3**	High
Dellhag et al [36]	✓	✓	x	x	x	x	x	✓	x	✓	x	**3**	High
Cima et al [12]	x	✓	x	x	x	x	x	✓	x	x	✓	**3**	High
Rapoliene et al [10]	x	x	x	✓	x	x	x	x	x	x	✓	**2**	High
McLaughlin and Reynolds [33]	✓	x	x	✓	x	x	x	x	x	x	x	**1**	High
Bromley et al [37]	x	x	x	x	x	x	x	x	x	x	x	**0**	High

Key: 1 = PEDro Scale criteria; External validity: 1 = eligibility criteria were specified*; Internal validity: 2 = random allocation; 3= concealed allocation; 4 = similarity at baseline; 5 = blinding of participants; 6 = blinding of therapists; 7 = blinding of assessors; 8 = measures of at least one key outcome from at least

85% of participants initially allocated to groups;9 = intention to treat principle; 10= results of between group comparisons; 11 = point measures and measures of variability reported. Maximum score = 10 (*criterion 1 is not included in scoring).

Table 2: Summary of low to moderate bias trials of home hand exercise programmes in rheumatoid arthritis.

Authors	**Participants**	**Intervention Groups**	**Exercise regimen; delivery method, intensity and duration**	**Outcome measures and results:** (Significant results in italics;% score changes or actual changes for strength and RoM)
RCTs: Low risk of bias				
O'Brien et al[11]	N=67; mean age 59.6y; mean disease duration 13.5y; M:F = 21:46	E1 Hand and wrist RoM +LR (pinching towel/ resistance bands) E2 Hand and wrist RoM C Usual care.	1x 30 minute individual training session (+ 15 minute review at 2 weeks) followed by home exercise programme: E1: 5x RoM + 3x LR exercises E2: 8 xRoM exercises Both groups 1 and 2: initially 5 reps; x10 reps at 1 month; x 20 reps at 3 months. 10-20 minutes 2x/day; 6 months.	**At 6 months: in favour of E1 (RoM + LR)*** UL/Hand Function: *AIMS 2 Upper Limb Function:* 3m NS*; 6m p = 0.002 (E1 +17%; E2 -4%; C -6%);* AIMS 2 Hand Function: 3m and 6m NS Jebsen Hand Function Test: 3m and 6m NS Dominant Grip (Jamar dynamometer: lbs): 3m and 6m NS Key pinch (B&L gauge):3m NS; *6m p = 0.01 (E1 +1kg; E2 +0.3kg; C -1kg).* Finger flexion (goniometer): *3m p=0.05 (E1 +20°; E2 +15°; C -3°);* 6m NS Tender and swollen joint count: 3m (not reported); 6m NS
Manning et al [23]	N=108; mean age = 55 (SD	E Hand and arm LR and MR C Usual care.	Group programme: 4x1 hour 2x/week for 2 weeks	**At 2.5 (12 weeks) and 8 months (36 weeks) in favour of E (LR + MR):**

	15)y; mean disease duration = 1.67 (SD 1.58)y; M:F = 26:82		followed by daily home exercise: 6 LR and MR exercises (therapist-selected from 16 options), x10 reps, increasing to 3x10 reps; increasing resistance; 15 minutes daily; 12 weeks.	UL/Hand Function: DASH*: 12w p = 0.02 (E -12%; C +4%; ES = 0.5)*; 36w NS Grip Ability Test*: 12w p = 0.01 (E -12%; C +2.5%)*; 36w NS Dominant Grip (Jamar: Newtons): 12w and 36w NS Non-dominant Grip: *12w p = 0.005 (E +22.4N; C -9N)*; 36w NS Overall Pain (VAS): *12w p = 0.01 (E -26%; C +4%); 36w p = 0.05 (E -16%; C+9%)* Overall Fatigue (VAS): 12w and 36w NS Morning stiffness (mins.): 12w and 36w NS DAS28: *12w p = 0.05 (E -15%; C -2%);* 36w NS Self-efficacy (pain): *12w p = 0.02 (E +8%; C -10%); 36w p = 0.05 (E -16%; C +9%)* Self-efficacy (symptoms): *12w p = 0.04 (E +8%; C -8%)*; 36w NS RAQoL: 12w and 36w NS
Lamb et al[24]	N=490; mean age = 62.4 (SD 11.5)y; median disease	E Hand, wrist, elbow, shoulder RoM + Hand/wrist LR and MR; C Usual care.	5 x individual supervised exercise sessions followed by daily home exercise: 7 RoM (x10 reps) and 4LR/MR	**At 4 and 12 months in favour of E (RoM+LR+MR):** UL/Hand Function: *MHQ (overall hand function):4m p = 0.0001 (E +17%; C +8%); 12m p = 0.003 (E +15%; C +7%; ES =0.3)* Dexterity (9 hole peg test): 4m NS; *12m p = 0.02 (E -5%; C-*

	duration = 10 (IQR 4,22)y. M:F =116: 374		exercises (x10 reps increasing to 3x10 reps), increasing resistance; 15+ minutes daily; 52 weeks.	*0.3%)* Dominant Grip (MIE analyser): *4m p = 0.01 (E +15.5N; C +7.4 N)*; 12m NS Pinch grip (MIE*)*; 4m NS; *12m p = 0.04 (E +5.3N; C +2.4N)* Finger flexion (mm): 4m and 12m NS Finger extension (mm):*4m p = 0.05 (E +4mm; C +1.5mm); 12m p = 0.007 (E +4.8mm; C +1.4mm)* MHQ (pain): *4m p = 0.04 (E -15%; C -10%)*; 12m NS Tender joint count: *4m p = 0.007 (E -25%; C -8%)*; 12m NS Self-efficacy pain: *4m p = 0.02 (E +8%; C +3%)*; 12m NS EQ5D health status: 4m and 12m NS
RCTs and CCT with moderate risk of bias				
Hoenig et al[25]: RCT	N=57; mean age = 57; mean disease duration = 11.3y; M:F = ?	E1 RoM (tendon gliding) E2 LR E3 RoM+ LR C Usual care	1 x individual exercise training session followed by home exercise: E1 and 3: 1x RoM; E2 and 3: 3 x LR exercises. Each x 10 reps, twice daily 10-20 minutes home	**At 12 weeks, in favour of Groups E2/3 ie LR with/without RoM compared to controls:** Hand function: *Group E3(RoM+LR) Dexterity (9 hole peg test):p <0.05 left hand only (E3 -17%; C +3%)* Grip (aneroid manometer): *Groups E1,2,3 combined v C) p<0.05 (larger increase in Groups E2 and 3 of +22% vs Group E1 +6%)*

			exercise: 12 weeks	RoM: *Finger (PIP) extension: Group E2 (LR) p <0.05 left hand only;* MCP flexion: NS; Ulnar deviation: NS Swelling: PIP circumference: NS Joint count (pain): *Group E1 (RoM) p<0.05 right hand only (E1 -15%; C +80%)*
Ellegaard et al[26]: CCT	N=36; mean age = 61y; mean disease duration = 9y; M;F 0:36	E MR (Theraband Hand Exerciser: therapist choice from 4 resistance levels) C RA age-matched controls.	1 x individual exercise training session followed by home exercise. E: 1 x MR wrist exercise only; squeeze Exerciser (selected at 60% max. grip strength) for 10s; 2x5reps daily; 8 weeks	**At 8 weeks: in favour E (MR)** Between group: Ultrasound: NS synovial perfusion (i.e. exercise not detrimental as no increase in inflammation) Within group: Grip (dynamometer): NS Wrist joint pain on motion (VAS): *p = 0.04 (E -36%)* (C: data not reported)
Trials with moderate risk of bias comparing exercise regimens (no control group)				
Ronningen and Kjeken[27]: (not randomised)	N=60; mean age 46.5y; mean disease duration = 10.5y; M:F =	E1 RoM + LR (variable intensity) E2 RoM + LR (high intensity)	7x daily group in-patient exercise sessions, followed by home exercise: 1: 4x RoM + 7x LR x 3 reps; 10 minutes. Home exercise	**At 2 weeks, in favour of Group E2 (intensive RoM + LR); at 14 weeks, more in favour E2:** Hand function*: Grip Ability Test: 2w p = 0.02 (E1 -7%; E2 -21%)*; 14w NS Dominant Grip (Grippit): 2w and 14w NS

	10:50		as many days as patient wishes. 2: 3x RoM + 6x LR x10 reps, 10-20 minutes; minimum 5x/week home exercise. 14 weeks.	Non-dominant grip (Grippit): *2w p=0.04 (E +18N; C-3N); 14w p = 0.04 (E +28N; C -6N)* Dominant Pinch (Grippit):*2w p = 0.01 (E +9N; C -1N)*; 14w NS Non-dominant Pinch (Grippit):*2w p = 0.05 (E +8N; C 0N)*; 14w NS Hand pain resisted grip (VAS*):2w p = 0.04 (E -24%; C +24%)*; 14w NS
Dogu et al [28]	N=47; mean age 52.6y; mean disease duration 9.41y, M:F = 0:47	E1 RoM E2 LR	10 x supervised individual exercise sessions + wax baths followed by home exercise: 1: 6 x RoM 2: 6 x LR exercises; Both groups: 10 reps x 5 days/week for 2 weeks; followed by x 10 reps 15-20 minutes daily home exercise for 4 weeks.	**At 6 weeks: NS differences between; <u>both</u> groups improved (within- group E1 and E2 differences shown).** Hand function*: DHI: p=0.002 (E1 -27%; E2 -27%); Dexterity (9 hole peg test): p<0.005) (E1 -7%; E2 -22%).* Dominant Grip (dynamometer): *Group E2 only p = 0.03 (E1 +1kg; E2 +3.5kg)* Non-dominant Grip (dynamometer): *Group E1 only p = 0.01 (E1 +1kg; E2 -0.5kg)* Hand pain (VAS); *p<0.02 (E1 -40%; E2 -14%)* Disease activity (DAS28): *p<0.002 (E1 -20%; E2 - 25%)* RAQoL: *p<0.003 (E1 -21%; E2 -20%)*

Key: E = Experimental group (1, 2,3: if more than 1 group); C = Control Group; ES = Effect Size; RoM= Range of movement exercises; LR = light resistance exercises (soft therapeutic putty, salt dough or soft rubber objects, unless otherwise stated); MR=moderate resistance (medium to firm therapeutic putty and elastic resistance bands, unless otherwise stated); reps = repetitions; UL = upper limb; RCT = randomised controlled trial; CCT = case controlled trial; AIMS2 (Arthritis Impact Measurement Scale 2; MHQ = Michigan Hand Outcomes Questionnaire: DASH = Disabilities of the Arm, Shoulder and Hand questionnaire; DHI = Duruoz Hand Index questionnaire; RAQoL = RA Quality of Life questionnaire; VAS = visual analogue scale.