Exercise reduces impairment and improves activity in people after some upper limb fractures: a systematic review

Exercise reduces impairment and improves activity in people after some upper limb fractures: a systematic review

Andrea Bruder, Nicholas F Taylor, Karen J Dodd and Nora Shields

School of Physiotherapy, and Musculoskeletal Research Centre, La Trobe University Australia

Question: What is the effect of exercise on reducing impairment and increasing activity in the rehabilitation of people with upper limb fractures? **Design**: Systematic review of controlled trials. **Participants**: Adults following an upper limb fracture. **Intervention**: Any exercise therapy program, including trials where exercise was delivered to both groups providing there was an expectation of different amounts of exercise. **Outcome measures**: Body structure and function, and activity limitations. **Results**: 13 relevant trials involving 781 participants with an upper limb fracture were identified. 12 of the 13 trials included exercise of different duration and administration in both intervention and comparison groups. In support of the role of exercise there is evidence that: exercise and advice compared to no intervention reduce pain and improve upper limb activity in the short term after distal radius fracture; starting exercise earlier after conservatively managed proximal humeral fractures can reduce pain and improve shoulder activity; and physiotherapy that included supervised exercise and home exercise increased wrist movement after distal radius fracture when compared to home exercise alone. There is contrary evidence from two trials one after distal radius fracture and one after proximal humeral fracture that a home exercise program was superior to a supervised plus home exercise program. Only a single meta-analysis was conducted due to clinical heterogeneity and a lack of common outcome measures among the included trials. **Conclusion**: There is evidence to support the role of specific exercise regimens in reducing impairments and improving upper limb function following specific upper limb fractures. **[Bruder A, Taylor NF, Dodd KJ, Shields N (2011) Exercise reduces impairment and improves activity in people after some upper limb fractures: a systematic review. *Journal of Physiotherapy* 57: 71–82]**

Key words: Upper limb fracture, Exercise, Rehabilitation, Physiotherapy

Introduction

Upper limb fractures are common and affect all age groups (Bradley and Harrison 2004, Court-Brown et al 2001, Larsen and Lauritsen 1993). In younger adults, upper limb fractures are usually sustained from high-energy trauma such as a motor vehicle accident, whereas in older adults with osteoporotic changes these fractures are usually sustained from a fall (Bradley and Harrison 2004, Court-Brown et al 2001, Kelsey et al 1992, Larsen and Lauritsen 1993). Due to an ageing population, the number of the most common upper limb fractures – proximal humeral fractures and distal radius fractures – are expected to increase by about 10% every five years to 2036 (Sanders et al 1999).

Following an upper limb fracture, patients are often referred to physiotherapy for rehabilitation to reduce pain, improve range of movement and strength, and to regain function (AIHW 2008). Even though the aims of physiotherapy are clear, the interventions used during the rehabilitation phase can vary greatly. These interventions can include thermal modalities, ultrasound, electrical stimulation, continuous passive movement, electromyographic biofeedback, soft tissue mobilisation, mobilising and strengthening exercises, application of resting or dynamic splints, advice, and education (Bertoft et al 1984, Clifford 1980, Lundberg et al 1979, Michlovitz et al 2001).

Exercise is a common intervention after upper limb fracture. For example, Michlovitz et al (2001) found that exercise was prescribed to at least 90% of patients receiving rehabilitation after distal radius fracture. The application of exercise is also consistent with the third key principle of fracture management – movement (Adams and Hamblen 1995). Previous research has identified that therapeutic exercise is beneficial across a broad range of health conditions (Taylor et al 2007). However, previous systematic reviews of trials of upper limb fracture management have not focused on the effect of exercise (Handoll et al 2003, Handoll et al 2006). In addition, clinical practice guidelines for the treatment of distal radius fractures concluded that there was weak evidence to support the use of a home exercise program (Lichtman et al 2010). New trials of physiotherapy rehabilitation have been published since the two reviews were completed in 2003 and 2006.

Physiotherapists need current evidence about the effectiveness of treatment techniques to help them make clinical decisions about patient care and to allocate limited therapy resources for people with upper limb fractures. Therefore, the specific research question for this systematic review was:

> What is the effect of exercise on reducing impairment and increasing activity in the rehabilitation of people with upper limb fractures?

Method

Identification and selection of studies

Relevant randomised and quasi-randomised controlled trials were identified using a search strategy (See Appendix 1 on the eAddenda for full search strategy) from the earliest date possible until January 2011 in the following electronic databases: CINAHL, MEDLINE, Embase, AMED, SPORT Discus, PubMed, PEDro and the Cochrane Central Register of Controlled Trials. To ensure all relevant studies were captured, manual reference list checks and citation tracking of included studies using Web of Science were performed. One reviewer examined the study titles and abstracts to determine if they satisfied the inclusion criteria. A second reviewer was consulted if the primary reviewer had doubts about inclusion. Where eligibility was not clear, the full text was obtained for more detailed assessment. Studies that clearly did not meet the inclusion criteria were eliminated at this point. Titles of journals, names of authors, or supporting institutions were not masked during the selection process.

The inclusion criteria for studies are presented in Box 1. The exercise therapy program did not need to be carried out by a physiotherapist provided that the program could be regarded as one that a physiotherapist might employ. Trials that were not published in full were excluded. Trials that examined interventions for major complications of fractures such as non-union or delayed union were excluded on the basis that these interventions aimed to treat the fracture itself rather than rehabilitate the individual.

Box 1. Inclusion criteria

Design
- Published randomised or quasi-randomised controlled trial

Participants
- Participants who had reached skeletal maturity
- Participants who had sustained any degree of upper limb fracture (scapula, clavicle, humerus, radius, ulna, carpal, phalanx)
- Human

Intervention
- Any exercise therapy program

Outcome measures
- Any outcome measure (classified by World Health Organization 2001)

Comparisons
- Exercise therapy program versus no exercise therapy program/placebo
- Exercise therapy program plus other therapy versus other therapy
- Exercise therapy program versus an alternative therapy program that differs in duration, frequency, intensity or method of administration

Assessment of characteristics of studies

Quality: All included studies were assessed for quality by two reviewers independently using the PEDro scale. The PEDro scale has demonstrated moderate levels of inter-rater reliability (ICC = 0.68, 95% CI 0.57 to 0.76) (Maher et al 2003), and demonstrated evidence of construct reliability in evaluating the methodological quality of clinical trials (de Morton 2009). Studies were not excluded on the basis of quality because it was thought that setting a cut-off value to exclude studies of lesser quality could potentially bias the results of the systematic review (Juni et al 1999).

Participants: Age, sex, and type of fracture were recorded to enable comparisons of participants between trials.

Intervention: A description of the exercise therapy program (including timing, intensity, frequency, duration, exercises performed, equipment, total time of each session, number of sets and repetitions), the setting in which the program was performed, and the qualifications of the person administering the intervention were recorded.

Outcome measures: Outcome measures that assessed body structure and function, activity limitations, and participation restrictions were examined in accordance with the International Classification of Functioning, Disability and Health (ICF) framework (World Health Organisation 2001). This framework defines functioning and disability as a multi-dimensional concept according to body functions (eg, loss of muscular strength) and structures (eg, change to the skeletal system such as a fracture), activities (eg, unable to dress self), and social participation (eg, unable to continue employment).

Data analysis: Summary data for each study, including means and standard deviations of the post-intervention group, were extracted independently by two reviewers. Study characteristics, patient demographic data, and results were summarised and presented in a tabulated format. For continuous data, standardised mean differences (otherwise known as effect sizes), with 95% CIs were calculated by dividing the post-intervention means by the pooled standard deviation (Hedges *g*). Where means and standard deviations were not reported, data were estimated according to recommendations outlined by Higgins and Deeks (2009) (see Appendix 2 on the eAddenda for statistical equations). A meta-analysis was conducted where a minimum of two trials were clinically homogenous. To account for clinical, methodological, or statistical heterogeneity, a pooled random effects model was applied using RevMan 5[a]. Statistical heterogeneity was examined by calculating the quantity I^2 where a value of 0% indicates no observed heterogeneity, less that 25% is considered to have low levels, and a value of 100% indicates a completely heterogeneous sample (Higgins et al 2003).

Results

Flow of studies through the review

The search strategy identified 2375 papers. Following removal of duplicates, screening of titles and abstracts, and the inclusion of one paper identified through citation tracking and one through hand searching of reference lists, 29 potentially relevant papers remained. After re-application of inclusion criteria to full-text copies of these 29 papers, 14 papers remained (Figure 1). These 14 papers represented 13 separate trials because two papers reported data from the same trial at different time points. The other 15 studies obtained as full text were excluded. Five were not randomised or quasi-randomised controlled trials (Altissimi et al 1986, Amirfeyz and Sarangi 2008, Clifford 1980, Liow et al 2002, MacDermid et al 2001), one was not available in English (Grønlund et al 1990), one was published only as an abstract (Bache et al 2000), and eight had insufficient

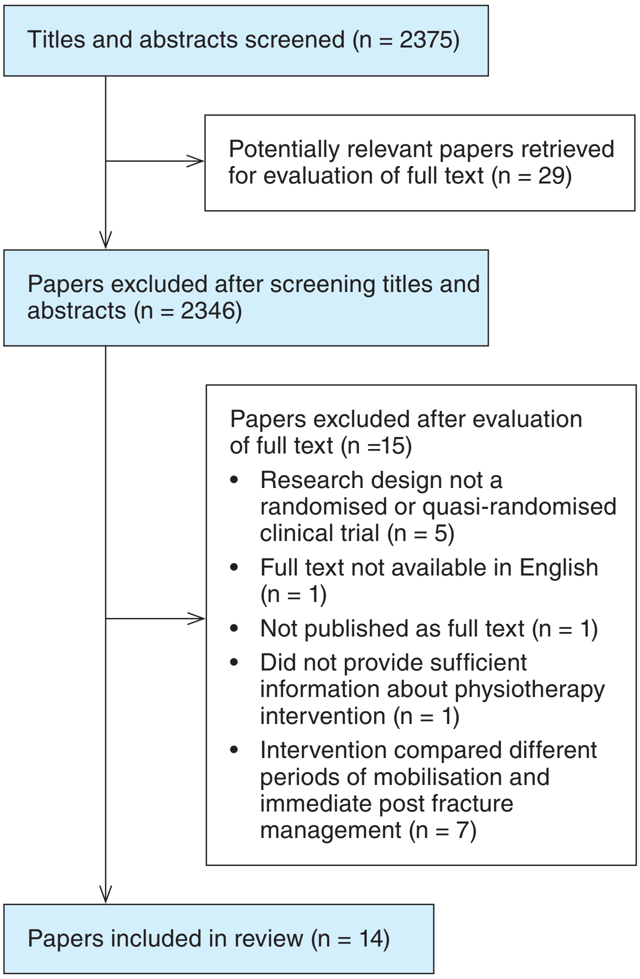

Figure 1. Flow of studies through the review.

information about the exercise therapy intervention (Davis and Buchanan 1987, de Bruijn 1987, Dias et al 1987, Gaine et al 1998, Lozano Calderón et al 2008, McAuliffe et al 1987, Millett and Rushton 1995, Oskarsson et al 1997).

Characteristics of included studies

Design: A single trial evaluated the effects of exercise and home advice compared to a no-intervention control group in patients with a distal radius fractures (Kay et al 2008). In the remaining 12 trials, differing amounts of exercise and advice were incorporated in both control and intervention groups. Three trials compared exercise introduced earlier in rehabilitation with delayed introduction of exercise following a proximal humeral fracture (Agorastides et al 2007, Hodgson et al 2003, Lefevre-Colau et al 2007), while in four trials patients received supervised exercise in addition to a home exercise program compared to simply a home exercise program (Christensen et al 2001, Maciel et al 2005, Pasila et al 1974, Revay et al 1992). Five trials compared physiotherapy, which included supervised exercise plus a home exercise program, with a home exercise program (Bertoft et al 1984, Krischak et al 2009, Lundberg et al 1979, Wakefield and McQueen 2000, Watt et al 2000).

Quality: Quality assessment PEDro scores ranged from 2 to 8 out of 10 with a median score of 6 (see Table 1). Due to

Table 1. PEDro scores of included studies (n = 13).

Study	Random allocation	Concealed allocation	Groups similar at baseline	Participant blinding	Therapist blinding	Assessor blinding	< 15% dropouts	Intention-to-treat analysis	Between-group difference reported	Point estimate and variability reported	Total (0 to 10)
Agorastides et al (2007)	Y	Y	Y	N	N	Y	N	N	Y	Y	6
Bertoft et al (1984)	Y	Y	Y	N	N	Y	Y	N	N	Y	6
Christensen et al (2007)	Y	Y	Y	N	N	N	N	N	Y	N	4
Hodgson et al (2003, 2007)	Y	Y	Y	N	N	Y	Y	N	Y	Y	7
Kay et al (2008)	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8
Krischak et al (2009)	Y	N	Y	N	N	N	Y	N	Y	Y	5
Lefevre-Colau et al (2007)	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8
Lundberg et al (1979)	Y	N	N	N	N	N	N	N	N	Y	2
Maciel et al (2005)	Y	Y	Y	N	N	Y	Y	Y	N	Y	7
Pasila et al (2000)	Y	N	N	N	N	N	N	N	N	Y	2
Revay et al (1992)	Y	Y	Y	N	N	Y	N	N	Y	N	5
Wakefield & McQueen (2000)	Y	N	Y	N	N	Y	Y	Y	Y	Y	7
Watt et al (2000)	Y	N	Y	N	N	Y	N	N	Y	Y	5

Table 2. Summary of included studies (n = 13)

Study	Design	Participants	Intervention	Outcome measures
Agorastides et al (2007)	RCT	n = 49 Age (yr) = Exp 72 (SD 12), Con 67 (SD 14) Gender = 10 M, 39 F Diagnosis = Proximal humerus fracture Fracture Type = 3-part Neer: 9, 4-part Neer: 39	Exp = Advice and exercise program (supervised and HEP), arm immobilised (sling) x 2 wk, then exercises commenced and progressed every 2 wk after commencement for 10–12 wk Con = Advice and exercise program (supervised and HEP), arm immobilised (sling) x 6 wk, then exercises commenced and progressed every 2 wk after commencement for 10–12 wk	• Constant Shoulder Assessment Score, Oxford Score • Follow-up = 24, 52 wk (from injury)
Bertoft et al (1984)	RCT	n = 18 Age (yr) = Exp 62, Con 66, range 50–75 Gender = Not avail Diagnosis = Proximal humerus fracture Fracture Type = non-displaced or slightly displaced	Exp = Exercise program (supervised and HEP), advice, passive joint mobilisation, commenced following immobilisation in sling 10–12 days post injury, 9 x over 10–12 wk Con = 3 x Instructed to perform same HEP as intervention group, 5–10 min following immobilisation in sling 10-12 days post injury, 4–5 x/day	• Shoulder ROM, isometric strength, subjective assessment ADLs • Follow-up = 3, 8, 16, 24, 52 wk (from injury)
Christensen et al (2001)	RCT	n = 30 Age (yr) = Exp 66 (range 46–82), Con 66 (range 57–79) Gender = 3 M, 27 F Diagnosis = Distal radius fracture Fracture Type = Older Type I: 2, Type II: 11, Type III: 9, Type IV: 4, unclassified: 3	Exp = Exercise program (supervised by occupational therapist and HEP), heat, advice commenced following removal of POP, occupational therapy 2/wk, HEP 3/day, duration not specified Con = 1 x Instructed to perform same HEP (with heat) as intervention group, 3/day, duration not specified	• Mod Solgaard & Werley Functional Score, grip strength • Follow-up = 0, 7, 31 wk (from removal of POP)
Hodgson et al (2003, 2007)	RCT	n = 86 Age (yr) = Exp 71 (SD 13), Con 67 (SD 12) Gender = 16 M, 70 F Diagnosis = Proximal humerus fracture Fracture Type = Neer group 1	Exp = Exercise program (supervised and HEP), advice, immediate mobilisation and exercise program with physiotherapist within 1 x wk of injury Con = Exercise program (supervised and HEP), advice, immobilised (collar and cuff sling) for 3 wk from injury then commenced exercise program with physiotherapist	• Constant Shoulder Score, Short Form 36, Croft shoulder disability questionnaire • Follow-up = 8 wk, 16 wk, 1 yr, 2 yr (from injury)
Kay et al (2008)	RCT	n = 56 Age (yr) = Exp 55 (SD 20), Con 56 (SD 20) Gender = 17 M, 39 F Diagnosis = Distal radius fracture Fracture Type = AO system: ea: 20, pa: 8, ca: 11	Exp = 1 x Instructed to perform exercise program (HEP), advice, compression commenced after removal of POP Con = Usual care. No physiotherapy intervention (natural recovery)	• Wrist ROM, grip strength, PRWE, QuickDASH • Follow-up = 0, 3, 6 wk (from removal of POP)
Krischak et al (2009)	RCT	n = 48 Age (yr) = Exp 56 (SD 11), Con 54 (SD 18) Gender = 16 M, 30 F Diagnosis = Distal radius fracture Fracture Type = AO system: ea: 14, pa: 1, ca: 31	Exp = Exercise program (supervised and HEP), advice, other interventions (at discretion of physiotherapist), commenced 1 wk post volar plating, 20–30 min x 12 for 6 wk Con = Exercise program (detailed HEP and guidance booklet), commenced 1 wk post volar plating, HEP 20 min x 2 x/day for 6 wk provided by a physician	• Wrist ROM, grip strength, PRWE • Follow-up = 1, 7 wk (from injury)
Maciel et al (2005)	RCT	n = 41 Age (yr) = Exp 56 (SD 18), Con 56 (SD 19) Gender = 10 M, 31 F Diagnosis = Distal radius fracture Fracture Type = AO system: ea: 29, pa: 1, ca: 10, unclassified: 1	Exp = Exercise program (supervised and HEP), advice, manual therapy commenced after removal of POP, regular treatments for 6 x wk Con = 1–2 x Instructed to perform same HEP as intervention group with advice, commenced after removal of POP	• Wrist ROM, grip strength, PRWE • Follow-up = 0, 6, 24 wk (from removal of POP)

Lefevre-Colau et al (2007)	RCT	n = 74 Age (yr) = Exp 63 (SD 18), Con 63 (SD 18) Gender = 20 M, 54 F Diagnosis = Proximal humerus fracture Fracture Type = 1-part Neer: 34, 2-part Neer: 16, 3-part Neer: 24	Exp = Exercise program (supervised and HEP), advice, ice, massage, passive joint mobilisation and sling between sessions (4–6 wk), treatment commenced 72 hrs post fracture, 2 hrs x 5 x/wk, frequency reduced over 3 months Con = Exercise program (supervised and HEP), advice, ice, massage, passive joint mobilisation, and sling between sessions (1–3 wk), treatment commenced after immobilisation in sling for 3 wk, 2 hrs x 4 x/wk for 4 wk frequency reduced until 6 mths	• Pain, shoulder ROM • Follow-up = 6, 12, 24 wk (from injury)
Lundberg et al (1979)	RCT	n = 42 Age (yr) = 65 (range 30–89) Gender = 5 M, 37 F Diagnosis = Proximal humerus fracture Fracture Type = Neer group 1	Exp = Exercise program (supervised and HEP), advice, passive joint mobilisation, immobilised in sling 1 wk then commenced physiotherapy 20–30 min x 1–2 x /wk x 8–12 wk. Con = 2 x Instructed to perform same HEP 5–10 min 4–5 x/day with advice, immobilised in sling 1 wk.	• Pain, shoulder ROM, strength (grip and shoulder lifting power) • Follow-up = 4, 12 wk (from injury)
Pasila et al (1974)	RCT	n = 96 Age (yr) = Not specified Gender = 7 M, 89 F Diagnosis = Distal radius fracture Fracture Type = Older Type II: 9, Type III: 66, Type IV: 18	Exp = Exercise program (supervised and HEP) and advice commenced during immobilisation period 1–12 x (4 on average), discharge at discretion of treating physiotherapist Con = 1 x Instructed to perform same HEP and advice provided by physician	• Wrist ROM, grip strength, oedema, subjective questions • Follow-up = 5, 8, 12 wk (from injury)
Revay et al (1992)	RCT	n = 48 Age (yr) = 62 Gender = 9 M, 39 F Diagnosis = Proximal humerus fracture Fracture Type = Neer group 1	Exp = Exercise program (supervised hydrotherapy and HEP) and advice, immobilised in sling 1 wk, hydrotherapy 30 min x max 20 and HEP 10–15 min x 4 x/day Con = 2 x Instructed to perform same HEP, immobilised in sling 1 wk, HEP 10–15 min x 4 x/day	• Pain, shoulder ROM, subjective assessment of 9 ADL items and 4 functional tests measured ad modum Bertoft-Solem • Follow-up = 4, 8, 12, 52 wk (from injury)
Wakefield et al (2000)	RCT	n = 96 Age (yr) = Exp 72 (SD 10), Con 74 (SD 9) Gender = 9 M, 87 F Diagnosis = Distal radius fracture Fracture Type = AO system: predominantly ea	Exp = Exercise program (supervised and HEP), advice and passive interventions at discretion of physiotherapist, HEP 3/day duration and frequency at the discretion of physiotherapist Con = 1 x Instructed to perform same HEP 3/day	• Pain, wrist ROM, grip strength, scoring system to assess ADL, SF 36 • Follow-up = 6, 12, 24 wk (from injury)
Watt et al (2000)	RCT	n = 18 Age (yr) = Exp 74 (SD 10), Con 77 (SD 5) Gender = 1 M, 17 F Diagnosis = Distal radius fracture Fracture Type = Frykman I–III: 6, Frykman IV–VI: 5, Frykman VII–VIII: 7	Exp = Exercise program (supervised and HEP), advice and passive joint mobilisation, attended ~5 times Con = 1 x Instructed by orthopaedic surgeon to perform same HEP	• Wrist ROM, grip strength • Follow-up = 0, 6 wk (from removal of POP)

ADL = activities of daily living, Con = control group, Exp = experimental group, HEP = home exercise program, RCT = randomised controlled trial, ROM = range of motion, POP = plaster of paris, PRWE = patient rated wrist evaluation, SF36 = short form 36

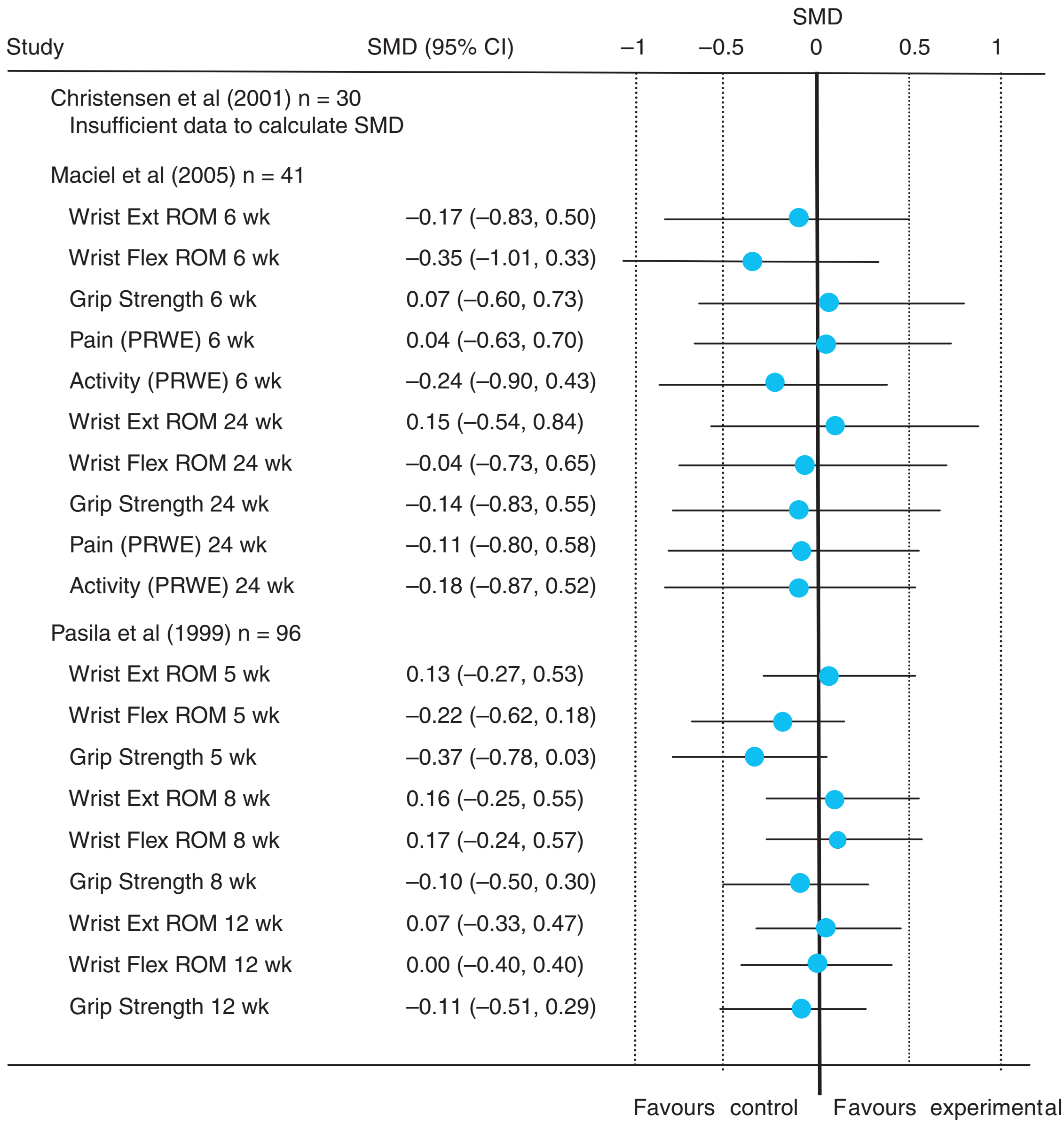

Figure 2. SMD (95% CI) of effect of supervised exercise plus a home exercise program compared with home exercise program alone after distal radius fracture. Ext = extension, Flex = flexion, PRWE = patient rated wrist evaluation, ROM = range of motion, SMD = standardised mean difference

the nature of the interventions, none of the trials was able to blind the participants or therapists to the intervention. Eight trials blinded the assessor, four trials used intention-to-treat analysis, and eight trials concealed allocation.

Sufficient data in the form of means and standard deviations were provided in six trials to allow calculation of effect sizes (Agorastides et al 2007, Bertoft et al 1984, Hodgson et al 2003, Kay et al 2008, Lefevre-Colau et al 2007, Maciel et al 2005). For an additional trial, the mean and standard deviations were imputed from a graph (Pasila et al 1974). Five trials provided adequate data to estimate means and standard deviations by providing median and interquartile ranges (Krischak et al 2009, Watt et al 2000), means with *p* values (Revay et al 1992), and means with standard errors (Lundberg et al 1979, Wakefield and McQueen 2000). Two trials provided insufficient data to calculate standardised mean differences (Christensen et al 2001, Hodgson et al 2007).

Participants: The 13 trials included in the analysis provided data from 781 participants aged from 32 to 82 years, of whom about 80% were female (see Table 2). Participants had sustained either a distal radius fracture (7 trials) or a proximal humeral fracture (6 trials) (see Table 2). No other upper limb fractures were included.

Synthesis: Only one meta-analysis could be performed. Clinical heterogeneity between trials precluded further meta-analysis. The results are presented according to the interventions being compared and the type of fracture.

Effect of advice and exercise versus no intervention

Distal radius fractures: There is preliminary evidence from a single trial that exercise combined with advice can improve upper limb activity and reduce pain in the short term after distal radius fracture. A single session of advice and exercise compared to no intervention found

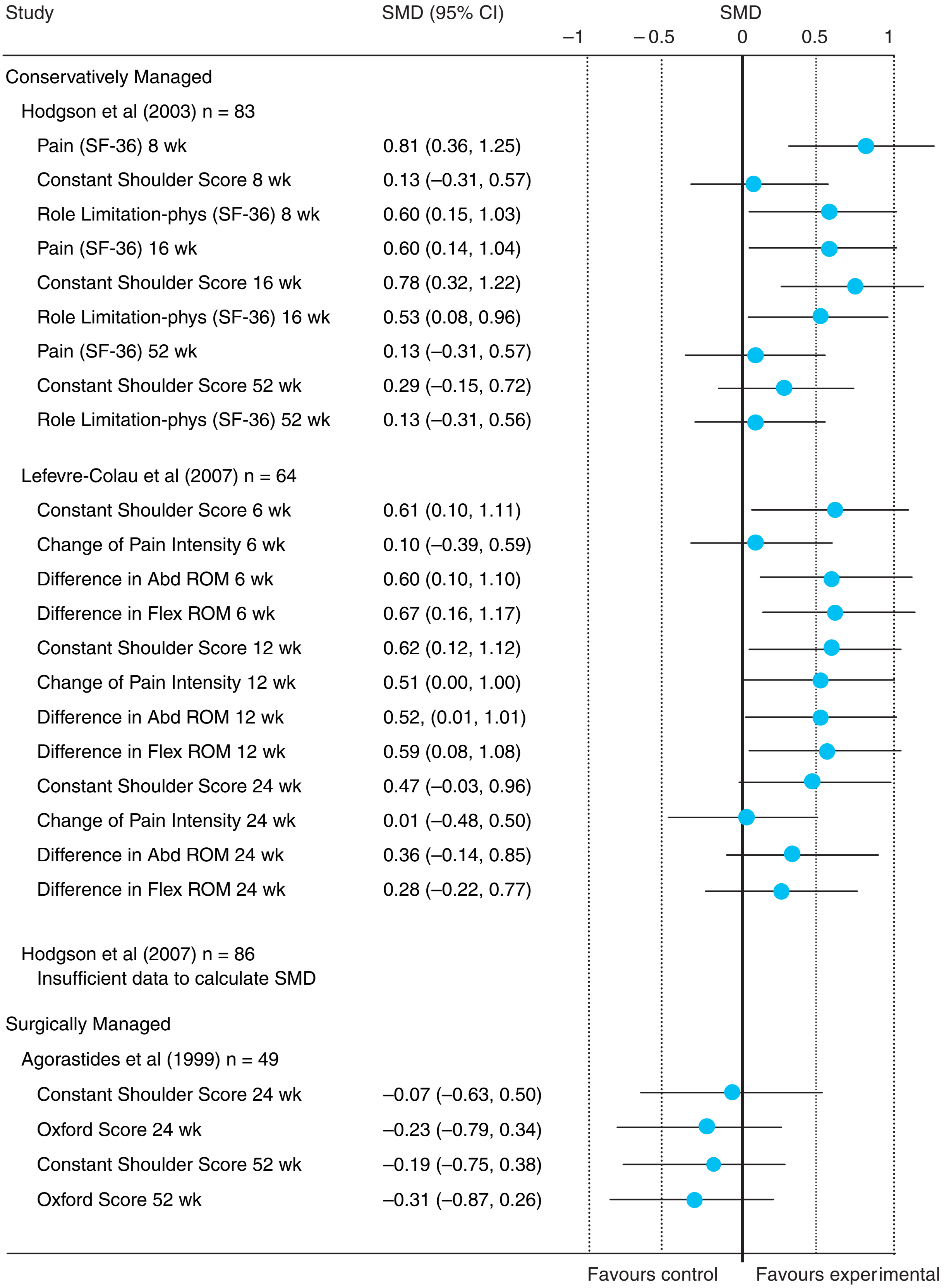

Figure 3. SMD (95% CI) of effect of early exercise and mobilisation compared with delayed exercise and immobilisation after proximal humeral fracture. Abd = abduction, Flex = flexion, phys = physical domain, ROM = range of motion, SF-36 = Short Form 36, SMD = standardised mean difference

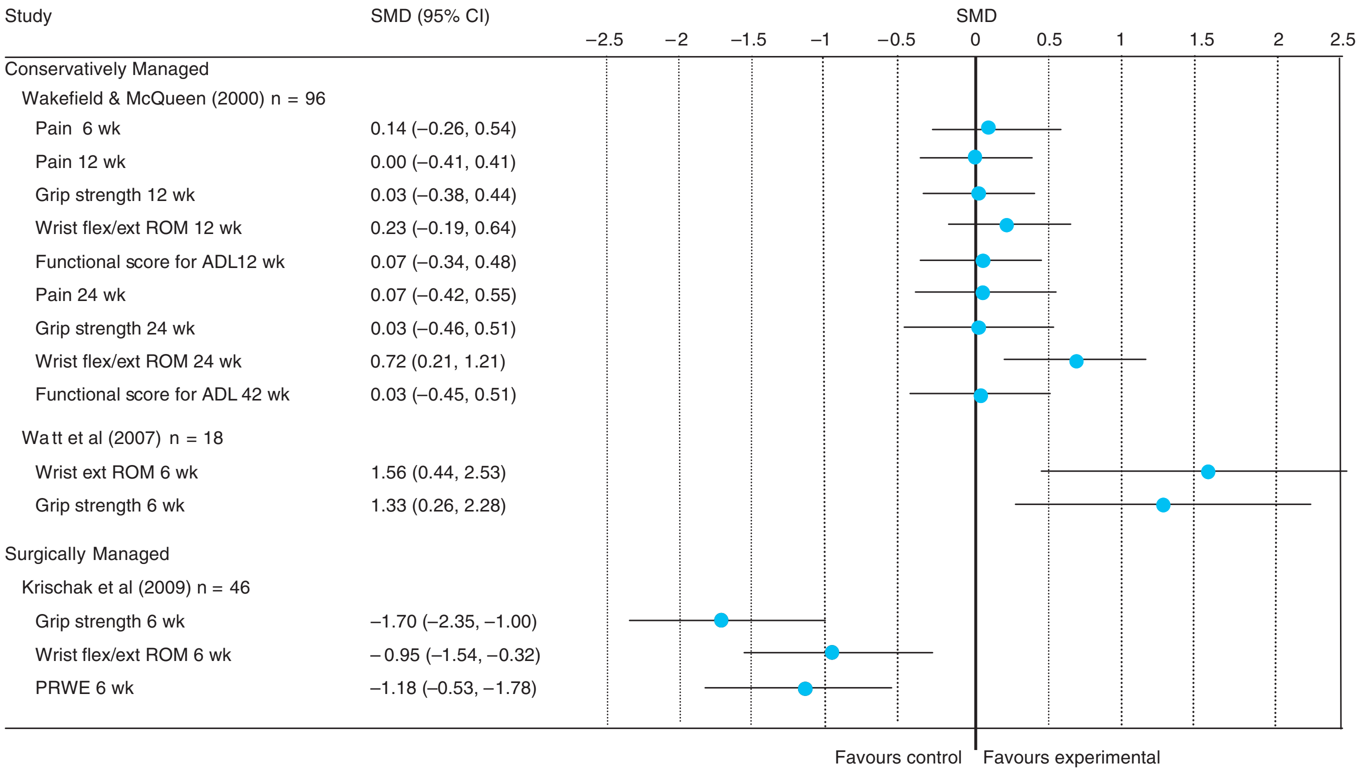

Figure 4. SMD (95% CI) of effect of physiotherapy including supervised exercise and a home exercise program compared to a home exercise program after distal radius fracture. ADL = activities of daily living, Ext= extension, Flex = flexion, ROM = range of motion, SMD = standardised mean difference

improvements in upper limb activity at 3 weeks (SMD 0.61, 95% CI 0.03 to 1.19), and reduced pain at 3 weeks (SMD 0.77, 95% CI 0.18 to 1.36) and 6 weeks (SMD 0.63, 95% CI 0.04 to 1.04) (Kay et al 2008). There were no other statistically significant between-group differences for the primary outcome measure of wrist extension or for the secondary outcomes of other ranges of motion and grip strength at weeks three or six.

Proximal humeral fractures: No trials examined exercise and advice compared to no intervention after proximal humerus fracture.

Supervised and home exercise versus home exercise

Distal radius fractures: There is no evidence to support adding supervised exercise to a home exercise program after distal radius fracture (Figure 2). None of the three trials that investigated the effect of physiotherapy-supervised exercise plus a home exercise program compared to a home exercise program alone reported statistically significant between-group differences for any impairment or activity outcome measures (Christensen et al 2001, Maciel et al 2005, Pasila et al 1974).

Two trials were similar in that the supervised therapy program commenced six weeks following distal radius fracture and involved activity focused exercises, however no common outcome measures were used (Christensen et al 2001, Maciel et al 2005). The third trial (Pasila et al) was not comparable to the other two trials as the intervention was implemented to non-splinted joints during the immobilisation period.

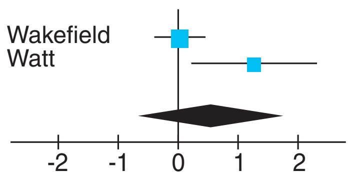

Figure 5. SMD (95%) CI) of effect of physiotherapy (including supervised exercise plus home exercise program) on grip strength compared with a home exercise program at 12 weeks after immobilisation. HEP = home exercise program.

Proximal humeral fractures: There is preliminary evidence from a single trial that adding supervised exercise to a home exercise program may *reduce* upper limb activity, and *increase* impairment in the short term after proximal humeral fracture when compared with home exercise alone. Compared to supervised exercise in a swimming pool (20 classes of 30 minutes duration) plus home exercise, a control group performing home exercise only demonstrated improvement at two months in self-reported assessments including taking an object from a shelf (SMD –1.02, 95% CI –1.61 to –0.40), hanging the laundry (SMD –0.65, 95% CI –1.22 to –0.06), washing the opposite axilla (SMD –0.70, 95% CI –1.27 to –0.10) and making a bed (SMD –0.78, 95% CI –1.35 to –0.18) (Revay et al 1992). The control group also had greater improvements in active shoulder abduction, flexion, and internal rotation at 2 months, and active shoulder abduction and internal rotation at 3 months were also reported. There were no significant between-group differences at one year follow up.

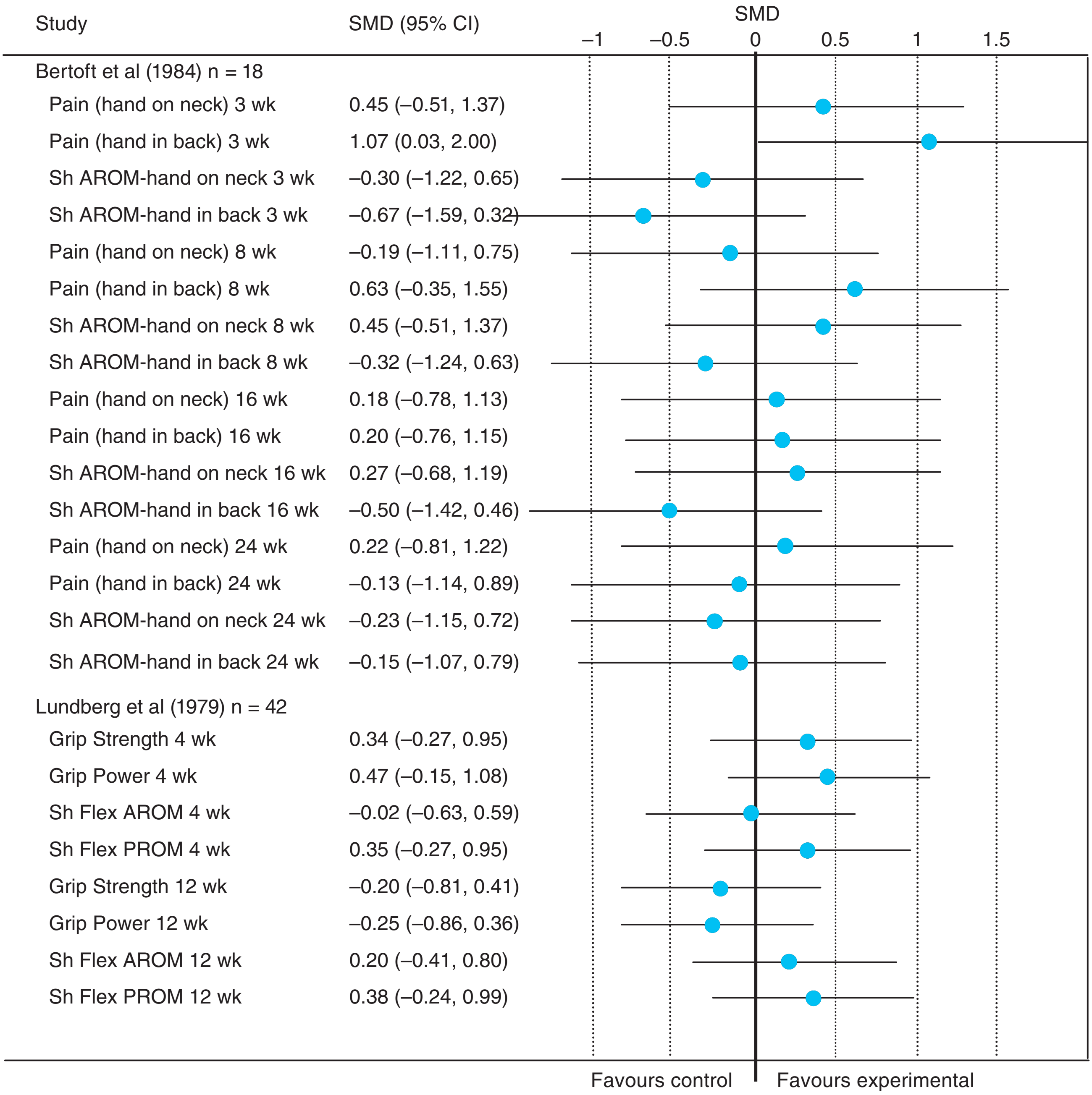

Figure 7. SMD (95% CI) of effect of physiotherapy including supervised exercise and a home exercise program compared to a home exercise program after proximal humeral fractures. AROM = active range of motion, Flex = flexion, Sh = shoulder, SMD = standardised mean difference

Early versus delayed exercise

Distal radius fractures: No trials examined starting exercise earlier after immobilisation compared with delayed exercise after distal radius fracture.

Proximal humeral fractures: There is evidence that starting exercise earlier after conservatively managed proximal humeral fractures can reduce pain in the short term and improve shoulder activity in the short and medium term (Figure 3). The trials by Hodgson et al (2003) and Lefevre-Colau et al (2007) started exercise within the first week after fracture compared to starting exercise at 3 weeks. Meta-analysis was not conducted as the two trials differed in that Lefevre-Colau et al (2007) included other physiotherapy modalities in addition to supervised exercise and home exercise program in both the intervention and control groups. At one year follow-up, total shoulder disability as measured on the Croft Shoulder Disability Questionnaire was 43% compared to 73% in the early exercise group compared to the delayed exercise group (Hodgson et al 2007).

In one trial involving surgically managed proximal humeral fractures, starting exercise earlier did not improve shoulder activity (Figure 3). Agorastides et al (2007) included more severe fracture types (Neer 3- and 4-part fractures) managed by hemiarthroplasty, comparing exercises started at 2 weeks with exercises started after 6 weeks immobilisation. There were no significant between-group differences on the Constant Shoulder Assessment Score or Oxford Score.

Physiotherapy with supervised and home exercise versus home exercise

Distal radius fractures: Two trials found that adding supervised exercise to a home exercise program as part of physiotherapy for conservatively managed distal radius fractures can improve wrist range of motion in the short term (Figure 4). In contrast, a meta-analysis did not demonstrate any effect of physiotherapy including supervised exercise plus a home exercise program on grip strength following distal radius fracture (d = 0.55, 95% CI –0.65 to 1.75, I^2 = 79%) (Wakefield and McQueen 2000, Watt et al 2000) (Figure 5, see also Figure 6 on the eAddenda for detailed forest plot). No further meta-analyses could be conducted due to the use of different outcome measures.

One trial reported that adding supervised exercise to a home exercise program as part of physiotherapy after surgically managed distal radius fractures *reduces* upper limb function and *increases* impairment in the short term when compared with home exercise alone (Krischak et al 2009) (Figure 4). Krischak et al (2009) commenced mobilisation of patients two weeks after volar plating for a distal radius fracture. Patients randomised to the control group received detailed instructions and a home exercise program.

Proximal humeral fractures: There is no available evidence that adding supervised exercise to a home exercise program as part of physiotherapy compared to a home exercise program alone can improve upper limb activity, or reduce impairment after proximal humeral fracture (Figure 7). Two trials investigated physiotherapy which included supervised exercise plus a home exercise program compared with a home exercise program on patients with conservatively managed proximal humeral fractures, with removal of sling between days 7 to 12 (Bertoft et al 1984, Lundberg et al 1979). No significant between-group differences were identified on any impairment (shoulder range of movement, muscle strength, pain) or activity measure (activities of daily living) in the short or medium term (Bertoft et al 1984, Lundberg et al 1979).

Adherence to an exercise program: Three of the 13 trials reported adherence to the supervised exercise sessions or to the prescribed home exercise program. Adherence was reported for the entire study cohort in one trial (70% attended the supervised exercise sessions) (Lefevre-Colau et al 2007), the intervention group in one trial (85% completed their exercises at least once a day) (Kay et al 2008), and the control group in one trial (97% rated the home exercise program as being completed) (Krischak et al 2009).

Adverse events: In general, adverse events were not reported systematically. One trial explicitly stated that no adverse events were related to the intervention (Maciel et al 2005). Another trial did report complications associated with the wrist fracture, but most of these were noted at the time of initial assessment (Kay et al 2008), and another reported complications but these related more to the surgical approach than the physiotherapy interventions (Agorastides et al 2007).

Discussion

Exercise (often in conjunction with other interventions) is one of the most common physiotherapy interventions used to reduce impairment and increase activity in the rehabilitation of people with upper limb fractures (Michlovitz et al 2001). Prescription of exercise after upper limb fracture is also consistent with the key principle of fracture management, movement (Adams and Hamblen 1995), and adherence to prescribed home exercise has been found to be moderately-to-strongly associated with short-term outcomes of impairment and activity after distal radius fracture (Lyngcoln et al 2005). Despite this there are currently no high quality trials that have evaluated the effects of exercise alone on rehabilitation outcomes. For this reason it is not possible to strongly advocate the routine use of exercise for all upper limb fractures. Having said that, there is preliminary evidence to support the role of exercise in the rehabilitation of specific upper limb fractures, which provides support for particular protocols. Exercise and advice was found to be beneficial compared to no intervention in the short term in the management of patients with a distal radius fracture (Kay et al 2008); early commencement of exercise was found to be beneficial in patients with conservatively managed proximal humeral fractures (Hodgson et al 2007, Lefevre-Colau et al 2007); and supervised exercise in addition to home exercise as part of physiotherapy was found to increase wrist range of movement in patients with conservatively managed distal radius fractures (Wakefield and McQueen 2000, Watt et al 2000). In contrast, however, a program of supervised exercise in addition to home exercise was found to result in poorer short-term outcomes of range of movement and upper limb activity after surgically managed distal radius fractures (Krischak et al 2009) and proximal humeral fractures (Revay et al 1992).

One factor that makes interpretation of the results of this review difficult is the use of co-interventions in the designs of the included trials. Apart from one trial that found exercise and advice compared to no intervention beneficial (Kay et al 2008), all trials included exercise in both the intervention and control group, albeit with differences in the duration or number of supervised sessions. Further investigation with controlled trials that investigate exercise as the only intervention versus a no-intervention control group is warranted to explore the role of exercise in upper limb fracture rehabilitation.

The evidence demonstrating short- and medium-term improvement in upper limb function and reduced impairment with early commencement of exercise after fracture, is an example of how the use of co-interventions can make interpretation difficult (Hodgson et al 2003, Lefevre-Colau et al 2007). One explanation could be that the benefits may be attributable to exercising for a longer duration. However, an alternative explanation for the positive outcomes could be that the participants benefited from the reduced time of immobilisation rather than from implementing exercise earlier. Several trials indicate that reducing immobilisation time alone after an upper limb fracture without therapy intervention could be beneficial (Davis and Buchanan 1987, Dias et al 1987, McAuliffe et al 1987).

A theme that emerged from the review was that the trials that reported contrary findings or lack of effect included more severe fractures that had been surgically managed (Agorastides et al 2007, Krischak et al 2009). In these trials the group that received more exercise (ie, supervised exercise in addition to home exercise program or earlier commencement of exercise) had poorer observed outcomes than the group that received less exercise (ie, home exercise program alone or delayed exercise). These results lead to the speculation that the amount of inflammation and tissue damage from the severity of the fracture and surgery might mean that a period of relative rest or controlled movement may be an important part of recovery during rehabilitation. However, further research that controls for co-interventions and closely monitors the amount of exercise completed would be needed to confirm this.

Another theme that emerged was that exercise may be more likely to lead to reduction in impairment, particularly range of movement, than improvements in activity limitations. A number of trials reported short-term improvements in range of movement in the group receiving more exercise (Lefevre-Colau et al 2007, Wakefield and McQueen 2000, Watt et al 2000), but there were few examples where the improvements carried over into an improved ability to complete daily activities. Given the principle of specificity of training, it is perhaps not surprising that exercises for upper limb fracture rehabilitation that focus on repeated movements or repeated contractions might lead, when effective, to increased range of movement and increased strength. A couple of trials attempted to address this possible limitation by implementing 'activity-focused' exercises, but the content of the interventions were not well described and the investigators did not detect any beneficial effect (Christensen et al 2001, Maciel et al 2005).

The findings of this review are similar to two previously published systematic reviews that concluded there was insufficient evidence to determine which rehabilitation interventions may be useful for the management of distal radial fractures (Handoll et al 2006) and proximal humeral fractures (Handoll et al 2003). The current systematic review adds to the literature by focusing on exercise and including recently published studies (Agorastides et al 2007, Hodgson et al 2007, Kay et al 2008, Krischak et al 2009).

A strength of this systematic review was its comprehensive search strategy which included eight electronic databases, citation tracking, and manual reference list checks with no included trials identified outside the database searches. A strict inclusion criterion was used to include only randomised controlled trials or quasi randomised controlled trials as they are less subject to bias than other designs (Khan et al 2001).

A limitation of this systematic review is that only a single meta-analysis could be conducted. No other meta-analyses were conducted due to clinical heterogeneity and a lack of common outcome measures among the included trials. We may have missed some trials due to language restrictions. Incomplete data required the authors to interpret data from Figures in some trials, which could have been a source of error. Methodological flaws were also identified among the included trials. Some trials consisted of small sample sizes, there was lack of use of reliable and valid outcome measures, and a lack of blinding. Trial reports frequently did not clearly define the exercises included in the interventions and the prescribed regimen. From the trials that did outline the intensity of the program, adherence to the protocols was poorly reported. Further research is needed that is methodologically sound and clearly describes the exercise program to allow for study comparison including reporting of exercise adherence.

In conclusion, this systematic review suggests there is inconclusive evidence to support the role of exercise during rehabilitation following an upper limb fracture. This is not consistent with previous research demonstrating the effectiveness of exercise in other conditions. There is some evidence that conservatively managed fractures of the distal radius and the proximal humerus may benefit from exercise, which is consistent with the theoretical benefits associated with movement. However, the use of co-interventions in the trials makes a more definite conclusion difficult. Given that exercise is a common intervention used after an upper limb fracture, controlled trials are needed to provide stronger evidence about the role of exercise in upper limb fracture rehabilitation. ■

Correspondence: Andrea Bruder, School of Physiotherapy and Musculoskeletal Research Centre, La Trobe University, Australia. Email: a.bruder@latrobe.edu.au

Footnotes: [a]Review Manager 5 (2008) http://ims.cochrane.org/revman.

eAddenda: Appendix 1 and 2, and Figure 6 available at jop.physiotherapy.asn.au

References

Adams JC, Hamblen DL (1995) Outline of Orthopaedics (12th edn). Edinburgh: Churchill Livingston.

Agorastides I, Sinopidis C, El Meligy M, Yin Q, Brownson P, Frostick SP (2007) Early versus late mobilization after hemiarthroplasty for proximal humeral fractures. Journal of Shoulder and Elbow Surgery 16: S33–S38.

Altissimi M, Antenucci R, Fiacca C, Mancini GB (1986) Long-term results of conservative treatment of fractures of the distal radius. Clinical Orthopaedics and Related Research 206: 202–210.

Amirfeyz R, Sarangi P (2008) Shoulder hemiarthroplasty for fracture with a conservative rehabilitation regime. Archives of Orthopaedic and Trauma Surgery 128: 985–988.

Australian Institute of Health and Welfare (2008) Arthritis and osteoporosis in Australia 2008. Canberra.

Bache SJ, Ankorn L, Hiller L, Gaffey A (2000) Two different approaches to physiotherapeutic management of patients with distal radial fractures. Physiotherapy 86: 383.

Bertoft ES, Lundh I, Ringqvist I (1984) Physiotherapy after fracture of the proximal end of the humerus. Comparison between two methods. Scandinavian Journal of Rehabilitation Medicine 16: 11–16.

Bradley C, Harrison J (2004) Descriptive epidemiology of traumatic fractures in Australia. Injury Research and Statistics Series Number 17. Canberra: Australian Institute of Health and Welfare.

Christensen OM, Kunov A, Hansen FF, Christensen TC, Krasheninnikoff M (2001) Occupational therapy and Colles' fractures. International Orthopaedics 25: 43–45.

Clifford PC (1980) Fractures of the neck of the humerus: a review of the late results. Injury 12: 91–95.

Court-Brown CM, Garg A, McQueen MM (2001) The epidemiology of proximal humeral fractures. Acta Orthopaedica Scandinavica 72: 365–371.

Davis TR, Buchanan JM (1987) A controlled prospective study of early mobilization of minimally displaced fractures of the distal radial metaphysis. Injury 18: 283–285.

de Bruijn HP (1987) Functional treatment of Colles fracture.

Acta Orthopaedica Scandinavica 223: 1–95.

de Morton NA (2009) The PEDro scale is a valid measure of the methodological quality of clinical trials: a demographic study. Australian Journal of Physiotherapy 55: 129–133.

Dias JJ, Wray CC, Jones JM, Gregg PJ (1987) The value of early mobilisation in the treatment of Colles' fractures. Journal of Bone and Joint Surgery–British Volume 69-B: 463–467.

Gaine WJ, Beardsmore J, Fahmy N (1998) Early active mobilisation of volar plate avulsion fractures. Injury 29: 589–591.

Grønlund B, Harreby MS, Kofoed R, Rasmussen L (1990) The importance of early exercise therapy in the treatment of Colles' fracture. A clinically controlled study. Ugeskr Laeger 152: 2491–2493.

Handoll HH, Gibson JN, Madhok R (2003) Interventions for treating proximal humeral fractures in adults.[update of Cochrane Database Syst Rev. 2002;(2):CD000434; PMID: 12076396]. Cochrane Database of Systematic Reviews: CD000434.

Handoll HH, Madhok R, Howe TE (2006) Rehabilitation for distal radial fractures in adults[update in Cochrane Database Syst Rev. 2006;3:CD003324; PMID: 16856004]. Cochrane Database of Systematic Reviews: CD003324.

Higgins J, Thompson S, Deeks J, Altman D (2003) Measuring inconsistency in meta-analysis. BMJ 327: 557–560.

Hodgson SA, Mawson SJ, Saxton JM, Stanley D (2007) Rehabilitation of two-part fractures of the neck of the humerus (two-year follow-up). Journal of Shoulder and Elbow Surgery 16: 143–145.

Hodgson SA, Mawson SJ, Stanley D (2003) Rehabilitation after two-part fractures of the neck of the humerus. Journal of Bone & Joint Surgery–British Volume 85-B: 419–422.

Juni P, Witschi A, Bloch R, Egger M (1999) The hazards of scoring the quality of clinical trials for meta-analysis. JAMA 282: 1054–1060.

Kay S, McMahon M, Stiller K (2008) An advice and exercise program has some benefits over natural recovery after distal radius fracture: a randomised trial. Australian Journal of Physiotherapy 54: 253–259.

Kelsey JL, Browner WS, Seeley DG, Nevitt MC, Cummings SR (1992) Risk factors for fractures of the distal forearm and proximal humerus. American Journal of Epidemiology 135: 477–489.

Khan KS, ter Riet G, Popay J, Nixon J, Kleijnen J (2001) Stage II Conducting the Review. Phase 5–Study quality assessment. In, Khan KS, ter Riet G, Glanville H, Sowden AJ, Kleijnen J (Eds) CRD Report Number 4. York: NHS Centre for Reviews and Dissemination, University of York.

Krischak GD, Krasteva A, Schneider F, Gulkin D, Gebhard F, Kramer M (2009) Physiotherapy after volar plating of wrist fractures is effective using a home exercise program. Archives of Physical Medicine Rehabilitation 90: 537–544.

Larsen CF, Lauritsen J (1993) Epidemiology of acute wrist trauma. International Journal of Epidemiology 22: 911–916.

Lefevre-Colau MM, Babinet A, Fayad F, Fermanian J, Anract P, Roren A, et al (2007) Immediate mobilization compared with conventional immobilization for the impacted nonoperatively treated proximal humeral fracture. Journal of Bone and Joint Surgery–American Version 89-A: 2585–2590.

Lichtman DM, Bindra RR, Boyer MI, Putnam MD, Ring D, Slutsky DJ, et al (2010) American Academy of Orthopaedic Surgeons clinical practice summary: treatment of distal radius fractures. Journal of the American Academy of Orthopaedic Surgeons 18: 180–189.

Liow RY, Cregan A, Nanda R, Montgomery RJ (2002) Early mobilisation for minimally displaced radial head fractures is desirable. A prospective randomised study of two protocols. Injury 33: 801–806.

Lozano Calderón SA, Souer S, Mudgal C, Jupiter JB, Ring D (2008) Wrist mobilization following volar plate fixation of fractures of the distal part of the radius. Journal of Bone and Joint Surgery–American Version 90: 1297–1304.

Lundberg BJ, Svenungson-Hartwig E, Wikmark R (1979) Independent exercises versus physiotherapy in nondisplaced proximal humeral fractures. Scandinavian Journal of Rehabilitation Medicine 11: 133–136.

Lyngcoln A, Taylor N, Pizzari T, Baskus K (2005) The relationship between adherence to hand therapy and short-term outcome after distal radius fracture. Journal of Hand Therapy 18: 2–8.

MacDermid JC, Richards RS, Roth JH (2001) Distal radius fracture: a prospective outcome study of 275 patients. Journal of Hand Therapy 14: 154–169.

Maciel JS, Taylor NF, McIlveen C (2005) A randomised clinical trial of activity-focussed physiotherapy on patients with distal radius fractures. Archives of Orthopaedic Trauma Surgery 125: 515–520.

Maher CG, Sherrington C, Herbert RD, Moseley AM, Elkins M (2003) Reliability of the PEDro scale for rating quality of randomized controlled trials. Physical Therapy 83: 713–721.

McAuliffe TB, Hilliar KM, Coates CJ, Grange WJ (1987) Early mobilisation of Colles' fractures. A prospective trial. Journal of Bone and Joint Surgery–British Volume 69-B: 727–729.

Michlovitz SL, LaStayo PC, Alzner S, Watson E (2001) Distal radial fractures: therapy practice patterns. Journal of Hand Therapy 14: 249–257.

Millett PJ, Rushton N (1995) Early mobilization in the treatment of Colles' fracture: a 3 year prospective study. Injury 26: 671–675.

Oskarsson GV, Hjall A, Aaser P (1997) Physiotherapy: an overestimated factor in after-treatment of fractures in the distal radius? Archives of Orthopaedic Trauma Surgery 116: 373–375.

Pasila M, Karaharju EO, Lepisto PV (1974) Role of physical therapy in recovery of function after Colles' fracture. Archives of Physical Medicine Rehabilitation 55: 130–134.

Revay S, Dahlstrom M, Dalen N (1992) Water exercise versus instruction for self-training following a shoulder fracture International Journal of Rehabilitation Research 15: 327–333.

Sanders KM, Nicholson GC, Ugoni AM, Pasco JA, Seeman E, Kotowicz MA (1999) Health burden of hip and other fractures in Australia beyond 2000: Projections based on the Geelong Osteoporosis Study. The Medical Journal of Australia 170: 467–470.

Taylor NF, Dodd KJ, Shields N, Bruder A (2007) Therapeutic exercise in physiotherapy practice is beneficial: a summary of systematic reviews 2002–2005. Australian Journal of Physiotherapy 53: 7–16.

Wakefield AE, McQueen MM (2000) The role of physiotherapy and clinical predictors of outcome after fracture of the distal radius. Journal of Bone and Joint Surgery–British Volume 82-B: 972–976.

Watt CF, Taylor NF, Baskus K (2000) Do Colles' fracture patients benefit from routine referral to physiotherapy following cast removal? Archives of Orthopaedic Trauma Surgery 120: 413–415.

World Health Organisation (2001) ICF: international classification of functioning, disability and health. Geneva: World Health Organization.

Websites

www.pedro.org.au